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Three Studies in Epicurean Cosmology

Drie Studies in Epicureïsche Kosmologie

(met een samenvatting in het Nederlands)

Proefschrift

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te Amsterdam

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For Ruthie

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ABBREVIATIONS

In this work the following abbreviations will be used:

Arr.	G. Arrighetti, *Epicuro, Opere*, Torino 1960, revised 1973.
B-L	J. Bollack & A. Laks, *Epicure à Pythoclès: Sur la cosmologie et les phénomènes météorologiques*, Cahiers de Philologie de Lille, vol.3, Villeneuve d'Ascq 1978.
D-K	H. Diels / W. Kranz, *Fragmente der Vorsokratiker*, 3 vols., Berlin 1960[10].
D.L.	Diogenes Laërtius, *Lives of the philosophers.*
E-K	L. Edelstein & I.G. Kidd, *Posidonius, I. The Fragments*, Cambridge 1972, 1989[2].
FHS&G	W.W. Fortenbaugh, P.M. Huby, R.W. Sharples & D. Gutas (eds.), *Theophrastus of Eresus: Sources for his life, writings, thought and influence*, Pt. I, Philosophia antiqua Vol. LIV, 1, Leiden 1992.
M&R 1	J. Mansfeld & D.T. Runia (1997), *Aëtiana, the Method and Intellectual Context of a Doxographer, vol. 1: The Sources,* Philosophia Antiqua, vol. LXXIII, Leiden 1997.
M&R 2	J. Mansfeld & D.T. Runia (2009a), *Aëtiana, the Method and Intellectual Context of a Doxographer, vol. 2 (in two parts): The Compendium,* Philosophia Antiqua, vol. CXIV, Leiden 2009.
OLD	*Oxford Latin Dictionary*, Oxford 1968.
SVF	J. von Arnim, *Stoicorum Veterum Fragmenta*, 3 vols., Leipzig 1903-5; vol.4 with indices by M. Adler, Leipzig 1924.
TLG	*Thesaurus Linguae Latinae*, Munich 1894-present.
Us.	H. Usener, *Epicurea*, Leipzig 1887, repr. Rome 1963.

"A cosmos is a circumscribed portion of sky, containing heavenly bodies and an earth and all the phenomena, …."

- Epicurus, *Letter to Pythocles* 3 [88].[1]

"The cosmos is a system composed of heaven, earth and the natures contained in these."

- Chrysippus, *SVF* II 527 (Ar. Did. 31).[2]

GENERAL INTRODUCTION

By 'cosmos' (κόσμος: literally 'order', 'ornament') the ancient Greeks denoted the orderly whole comprising everything within the confines of the outer heavens, or that part of the heavens to which the fixed stars were supposed to be attached. To some, like the Stoics, our cosmos was unique and included everything there is; others, like the Epicureans, believed that there were innumerable such *cosmoi* beyond the limits of the outer heavens. The word 'cosmology', coined by Christian Wolff in 1731 to refer to the study of the cosmos,[3] is often used retrospectively to denote that branch of ancient philosophy which occupied itself with the cosmos. In view of the definition given above, it might be thought that ancient cosmology dealt with everything there is, but in practice ancient writings purporting to deal with the cosmos were more limited in scope. Ancient cosmology dealt with the cosmos as a whole, its origin and arrangement and the positions of its major parts. Very often the study of the cosmos blended into a more detailed study of its outer portion, discussing the nature and appearance and the various motions of the planets and fixed stars, and all those phenomena we would call astronomical. Sometimes cosmology also included phenomena closer to home, such as rain and thunder and wind, which we would call meteorological, and finally it might even include phenomena on and below the surface of the earth, such as earthquakes, volcanic eruptions, springs, rivers, the sea. This is true of the only ancient work which explicitly claims to be dealing with the cosmos: Pseudo-Aristotle's *On the cosmos* discusses astronomy, meteorology and

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[1] Κόσμος ἐστὶ περιοχή τις οὐρανοῦ, ἄστρα τε καὶ γῆν καὶ πάντα τὰ φαινόμενα περιέχουσα, ...

[2] Κόσμος ἐστὶ σύστημα ἐξ οὐρανοῦ καὶ γῆς καὶ τῶν ἐν τούτοις φύσεων. The same definition in Posidonius fr. 14 E-K; Pseudo-Aristotle *De mundo* 391b9-10; Cleomedes I 1, 3-10; etc.

[3] Christian Wolff, *Cosmologia generalis*, Frankfurt / Leipzig 1731.

geography.[4] Much the same applies to Epicurus' *Letter to Pythocles*: although its subject matter is explicitly stated as 'lofty things' (μετέωρα), the actual discussion starts with the definition of 'cosmos' quoted above, followed by a few other cosmic questions, and then moves on – without indicating any break – to astronomical and meteorological matters. What all these phenomena – astronomical, meteorological and geographical – have in common is that they are both *observable* and *non-biological*. Ancient cosmology then, may be defined as the study of the cosmos as a whole as well as all phenomena contained in it, insofar as these are observable and non-biological.

This dissertation consists of three more or less independent studies of various aspects of Epicurean cosmology, which appeared to me to be in need of further clarification or re-examination in the light of recent insights or – conversely – on account of the uncritical persistence of old interpretations. The emphasis in all three studies will be on historical interpretation: to understand Epicurean cosmological theories in their own historical context. The first study concerns the Epicurean use of multiple alternative theories to account for astronomical and meteorological phenomena. The second deals with the range and order of subjects in Epicurean meteorology as compared to other ancient meteorological texts. The third and final study is concerned with the Epicurean view of the shape of the earth.

Before introducing each of the three studies in some more detail, I will first sketch the outlines of Epicureanism, dealing briefly, first with Epicurus himself, then with a number of later Epicureans, such as Lucretius, and their value as sources for a reconstruction of Epicurean theory, and finally with the most relevant parts of Epicurus' philosophy.

Circa 305 BC, Epicurus (341-270 BC) established a new school of philosophy around his newly acquired estate in Athens. Like the competing school of the Stoics, founded around the same time, Epicurus and his followers were principally concerned with ethics, to which other branches of philosophy, such as physics, were subordinate. According to Epicurus, the life of man was oppressed by unfounded fears – of the gods, of illness, of death – which stood in the way of real happiness. It was in order to eradicate these fears and replace them with a true understanding of nature that physics came in, which was largely based on the atomism of Democritus (ca. 460-370). Yet,

[4] On the probable inauthenticity of *On the cosmos (De mundo)* see n.204 on p.76 below.

despite its ultimately subservient role, physics was no small matter to Epicurus, who devoted the 37 books (!) of his *On nature* to it.[5]

Today the bulk of Epicurus' writings is lost. Only three works have come down more or less complete, having been quoted as part of the account of Epicureanism in book X of Diogenes Laërtius' *Lives of the philosophers*. These three are the *Letter to Herodotus*, a summary of Epicurean physics; the *Letter to Pythocles*, a summary of Epicurean cosmology (in the sense indicated above); and the *Letter to Menoeceus*, an overview of Epicurean ethics. Of his other works only scorched fragments – dug up in Herculaneum, where they were buried during the famous eruption of Vesuvius in 79 AD – and a large number of quotations and paraphrases by later authors remain.

The fullest account of Epicurean physics we possess today is the Latin didactic poem *De rerum natura*, 'On the nature of things', by the Roman Epicurean Lucretius (ca. 99-55 BC). In six books,[5] and over 7,000 verses, Lucretius deals with every aspect of the physical world, from the invisible smallness of atoms to the infinite extent of the universe, and from sex and conception to inevitable death, which he diversifies with ethical exhortations and eulogies of Epicurus.

Other Epicureans whose works we can still partly read are Philodemus of Gadara and Diogenes of Oenoanda. Philodemus, a Greek philosopher roughly contemporary with Lucretius, was based in Herculaneum in southern Italy, where many of his works, scorched and buried by the eruption of Vesuvius in 79 AD, were found during excavations in the 1750s, eventually resulting in a number of fairly readable, though fragmentary, editions.[6] Diogenes of Oenoanda was a wealthy Greek from Oenoanda in Lycia (southern Turkey), living in the second century AD, who in his old age erected a wall in the town centre which he inscribed with a summary of Epicurean philosophy, many fragments of which can still be read and are available in modern editons.[7]

Between Epicurus and these three followers considerable time had elapsed and it is only natural to ask whether their teachings were still the same as Epicurus'. Especially Lucretius has become the object of an ongoing debate, in which one side detects traces of later intellectual and philosophical developments throughout his poem, while the other camp with equal vigour interprets any such sign as a reference to philosophical positions that would have been relevant to Epicurus himself. In this work I will try to avoid both

[5] 'Book' is the standard translation of Greek ἡ βίβλος / τὸ βιβλίον and Latin *liber*, i.e. a scroll, the size of which may be compared to a chapter of a modern book.

[6] Works to which I will be referring are Philodemus Περὶ θεῶν (*On the gods*, ed. Diels, 1916-7) and Περὶ σημείων (*On signs*, ed. E. & P. De Lacy, 1978).

[7] See now Smith (1993) and (2003).

extremes. Lucretius' explicit claim to be following Epicurus' writings[8] should deter us from looking for later developments when we can do without them, but on the other hand we should not reject an obvious interpretation because it might conflict with Lucretius' supposed intellectual isolation.

The basic tenets of Epicurean physics are not difficult to summarize, and here at least Lucretius is in complete agreement with Epicurus. According to the Epicureans there are two basic entities – bodies and space, while everything else is either a property of these or non-existent. Bodies are either compounds or atoms. The latter are imperceptibly small, indivisible and incompressible particles out of which compounds are made and into which they are eventually dissolved again. Among compounds Epicurus also numbers souls and the gods. There are many types of atoms, differing from each other in shape, size and weight. Beside these, atoms possess none of the qualities that belong to perceptible bodies, such as colour, temperature or smell. The number of atoms and the extent of space are infinite. Atoms are forever moving at a constant but inconceivable speed. Left to their own devices the atoms move either downwards by the force of their own weight or they swerve ever so little from their course, but if they collide with other atoms they may rebound in any direction, while in compounds they are reduced to vibrating. Every compound body is constantly shedding imperceptibly thin membranes which preserve its outward shape and texture. When these membranes, which are called 'images' (*eidōla*), enter our eye we *see* the compound body. The Epicureans also distinguished a kind of 'mental perception' which is transmitted by still finer images that impinge directly on the mind, and there produce a kind of 'mental picture' which we call a memory, a dream or a thought. Other forms of sense-perception, such as hearing and smell, are brought on in a similar fashion by other kinds of effluences. Although the images and these other effluences are capable, because of their extreme subtlety, to travel almost unimpeded, they can become confused. Yet, by itself every perception is true, because it accurately reports the way it is affected by the external object. It is only when we start interpreting our perceptions and form opinions about the external object that falsehood may arise. For instance, when an oar standing in the water appears broken to us, this perception is *true* in the sense that the images really convey this impression to us, but when we infer from this that the oar is really broken, this inference may well be *false*. The only way to find out for sure is by making another observation (which in itself is no more true than the other one) under circumstances where we know impressions to generally correspond to

[8] Lucr. *DRN* III 9-12, quoted on p.131, n.331 below. See also *DRN* V 55-6.

their objects. We might, for instance, handle the oar, or pull it out of the water and look again.

Starting from these basic tenets Epicurus constructed a complex theory that could account for every aspect of reality, and throughout Epicurus' *Letters to Herodotus* and *Pythocles* and throughout Lucretius' *De rerum natura* we see these principles being put to work to explain specific phenomena. An important class of such phenomena are the so-called *meteōra* or 'lofty things', to which Epicurus devoted his *Letter to Pythocles*, and which comprise both astronomical and meteorological phenomena. Lucretius too deals with these phenomena in books V and VI of his *De rerum natura*. A characteristic feature of these *meteōra* is that they can only be observed from afar and do not admit of more reliable observations. In these circumstances it is impossible to falsify our hypotheses about them, and we are forced to accept every theory that does not somehow conflict with the basic tenets of Epicureanism. Far from deploring this conclusion, Epicurus and Lucretius blithely embrace it, accounting for almost every astronomical and meteorological phenomenon with a list of alternative explanations.

In the first chapter of this dissertation I will explore some general aspects of this method of multiple explanations. In the first place there is the epistemological point of view. Nobody will object to the view that a theory that cannot be falsified must be held *possible*. There are indications, however, that Epicurus went further than that and claimed that any such theory is *true*. This would imply that in these cases several, sometimes conflicting, *truths* exist side by side. The evidence for asscribing this position to Epicurus is not unambiguous, though, and modern scholarship is divided on whether Epicurus really made this claim and how it should be interpreted. I will critically review the relevant textual evidence as well as these modern interpretations and propose a compromise. Another epistemological problem concerns the claim, made by Diogenes of Oenoanda, that among alternative explanations some are more probable than others. I will argue that this claim finds no support in the writings of Epicurus and Lucretius and actually constitutes a departure from Epicurus' views, for which I will suggest a possible motive. A related question concerns Bailey's observation that Lucretius, in his astronomical passages, usually placed the view of the astronomers first, 'as though he really preferred these.' In a section devoted to this question I will propose a different interpretation, which will be more in line with Lucretius' and Epicurus' statements concerning the use of multiple explanations, and with Epicurus' general attitude to mathematical astronomy.[9] The remainder of the chapter is devoted to the question of Epicurus' sources for the alternative explanations, firstly for the individual explanations, which are thought to have been largely

[9] See esp. Sedley (1976).

drawn from *doxography*,[10] and secondly for the systematic use of multiple alternative explanations, partial anticipations of which are suspected in Democritus, Aristotle and Theophrastus. In this context I will also deal with the '*Syriac meteorology*', a meteorological treatise preserved in Syriac and Arabic, which consistently offers multiple alternative explanations. Although the manuscripts are unanimous in naming Theophrastus as its author, I think this ascription has been too readily accepted and the alternative hypothesis of an Epicurean origin, suggested by the earlier commentators, too readily rejected. Yet, the question of its authorship is important because the answer to this question largely determines our view as to the extent of Epicurus' dependence on Theophrastus. A thorough comparison of the way multiple explanations are employed in the *Syriac meteorology*, in Epicurus' *Letter to Pythocles* and Lucretius' *De rerum natura*, and in the undisputed writings of Theophrastus, may bring us closer to an answer.

Epicurus' *Letter to Pythocles* and the sixth book of Lucretius' *De rerum natura* are sometimes described as meteorological treatises. In this respect they can be compared with a number of other ancient texts, first and foremost Aristotle's *Meteorologica*, but also the *Syriac meteorology*. Chapter two of my dissertation will be devoted to such a comparison, with a view to establishing the relations of these texts to one another. I will start with a thorough comparison of nine meteorological texts with regard to the range and subdivision of their subject matter, in order to distinguish the various traditions and the place of Epicurus and Lucretius therein. A characteristic feature of Lucretius' meteorology is the attention he pays to exceptional local phenomena, which are either absent or far less conspicuous in other meteorologies and belong more properly to *paradoxography*.[11] I will therefore continue the investigation with a comparison of the latter part of Lucretius' book VI with a number of meteorological *and* paradoxographical works, with regard to the inclusion and treatment of exceptional local phenomena. Next I will deal with the order of meteorological subjects in Lucretius' book VI, Aëtius' book III, the *Syriac meteorology*, and Epicurus' *Letter to Pythocles*. The large degree of correspondence between the first three works has often been observed, but never thoroughly examined; and the not-so-obvious resemblance of Epicurus' *Letter* to the other three has generally been

[10] Doxography = a genre of writings devoted to the collection of *doxai* or philosophical opinions: for a quick reference see Runia (1997b) or Mansfeld (2008).

[11] Paradoxography = a genre of writings devoted to the collection of *paradoxa* or marvellous stories: see Ziegler (1949); Schepens & Delcroix (1996), Wenskus & Daston (2000).

overlooked. I will therefore carry out a more thorough comparison of all four works with due attention to the similarities and differences in the order of their subjects, and try to establish an original order from which they all derive. This will be capped by an attempt to determine the precise relations between these four works and to identify possible missing links. In this context I will also continue my investigation into the authorship and identity of the *Syriac meteorology* by comparing its theories with, on the one hand, Epicurus and Lucretius, and, on the other hand, Theophrastus and Aristotle.

In my third and final chapter I turn to one very specific cosmological problem: the shape of the earth. Although many scholars confidently claim that Epicurus and Lucretius believed the earth to be flat, and some of them even scorn them for having clung to such an antiquated idea, in reality no explicit statements about the shape of the earth can be found in their works. In this chapter I will consider this problem from various angles. I will re-examine the evidence that has been adduced so far for attributing a flat-earth cosmology to the Epicureans, and I will do so in the light of the two ancient cosmological systems distinguished by David Furley.[12] In addition, I will discuss every passage in the works of Epicurus and Lucretius, as well as other Epicureans, that may be relevant to the question of the shape of the earth. I will also inventory the ancient proofs of the earth's sphericity and search for clues that the Epicureans may have known, and responded to, these proofs. In the concluding section of this chapter I will bring all the evidence together and state my own opinion concerning the Epicurean view of the earth's shape, a view which I shall also try to connect with the Epicureans' general attitude towards astronomy.

Although the three chapters of this dissertation constitute three separate studies, they are connected by several recurrent themes. One of these is the identity of the *Syriac meteorology*, which will be addressed in Chapters One and Two. Another is the Epicureans' attitude towards mathematical astronomy, which will be addressed in a more general sense in Chapter One, while Chapter Three will deal with some particular instances. Yet another theme concerns the degree of Lucretius' dependence on Epicurus: all three chapters touch upon passages in Lucretius that cannot be reduced to, or derived from, Epicurus: Lucretius' passage on particular local phenomena in *DRN* VI 608ff (discussed in Chapters One and Two); his refutation of centripetal downward motion in *DRN* I 1052-93, and his cosmogonical account in *DRN* V 449-508 (both discussed in Chapter Three).

[12] Furley (1986) and (1989a).

"I have devised seven separate explanations, each of which would cover the facts as far as we know them. But which of these is correct can only be determined by the fresh information which we shall no doubt find waiting for us."

- Sir Arthur Conan Doyle (1891-2), *The Adventures of Sherlock Holmes:* 'The Adventure of the Copper Beeches'.

"That process," said I, "starts upon the supposition that when you have eliminated all which is impossible, then whatever remains, however improbable, must be the truth. It may well be that several explanations remain, in which case one tries test after test until one or other of them has a convincing amount of support."

- Sir Arthur Conan Doyle (1921-7), *The Case-Book of Sherlock Holmes:* 'The Adventure of the Blanched Soldier'.

1 MULTIPLE EXPLANATIONS

1.1 Introduction

According to Epicurus and Lucretius, sunset and sunrise can be explained not only on the assumption that the sun passes unaltered below the earth and then emerges again, but equally well by its extinction and subsequent rekindling. Both options are retained because neither can be eliminated on the evidence of the senses, which is the Epicureans' principal criterion of truth.

This approach is typical of the way Epicurus, in the *Letter to Pythocles*, and Lucretius, in books V and VI of the *De rerum natura*, deal with astronomical, meteorological and terrestrial phenomena. Just like sunrise and sunset almost every one of these problems is accounted for with a number of alternative explanations, sometimes two, sometimes more. In defense of this method of multiple explanations Epicurus points out that in these fields of inquiry single explanations are neither possible nor necessary. They are not possible because the objects in question cannot be clearly observed because of their distance, and they are not necessary because the main aim of studying celestial and atmospherical phenomena is to rule out divine influence, for which it is enough to show that every phenomenon can be explained physically, although absolute certainty as to the actual cause is not needed.

The method of multiple explanations depends on earlier philosophy in various ways. It has long been known that Epicurus and Lucretius derived the

vast majority of their alternative theories from the views of earlier philosophers, and there is good reason to believe that they learned of these views not from the original works but from doxographies, thematically organized collections of opinions of earlier thinkers. Nor were Epicurus and Lucretius the first to apply multiple explanations to certain problems. One notable instance is found among the fragments of Democritus and several occasional instances are found in the works of Aristotle and Theophrastus. The most complete parallel as to the use of multiple explanations is a meteorological treatise ascribed to Theophrastus and preserved in Syriac and Arabic, which employs multiple explanations on a similar scale as Epicurus and Lucretius, and which, if the ascription is correct, would make Theophrastus the real 'inventor' of the method of multiple explanations.

In this chapter I propose to investigate the method of multiple explanations from several angles. First (in §1.2) I will briefly set out a number of variations in the use of multiple explanations. Then (in §1.3) I will deal at some length with a number of epistemological problems concerning the method, such as whether all alternative explanations are true, on what grounds theories are rejected or retained and what role analogy plays in all this, further whether the Epicureans allowed different degrees of probability, and whether in his astronomical passage Lucretius secretly preferred the theories of mathematical astronomy.

In the middle part of the chapter (in §1.4) I will look into the relation of multiple explanations to doxography, and in the final part (§1.5) into the possible antecedents of the method of multiple explanations in Democritus, Aristotle and the undisputed writings of Theophrastus. In the same section I will also deal with the *Syriac meteorology* commonly ascribed to Theophrastus, and review the arguments for and against this ascription.

1.2 Variations in the use of multiple explanations

Epicurus' own methodological remarks on multiple explanations (*Hdt*. 78-80 and *Pyth*. 2 [85-88]) seem to suggest that the method constitutes one unified and homogeneous whole. In fact, however, the lists of multiple explanations offered by Epicurus and Lucretius vary in several respects, the most important being number, exhaustivity, mutual exclusivity, subsidiarity and type-differentiation. Below I will briefly review these five kinds of variation and their possible significance for the present investigation.

1. Number. The total number of alternative explanations for a single problem varies from *two* to *nine*.[13] For sunset and sunrise, for instance, both

[13] See APPENDICES A & B on p.243 and p.245 below.

Epicurus and Lucretius offer *two* possible explanations.[14] Thunder, on the other hand, is accounted for with no less than *nine* different explanations by Lucretius, though Epicurus gives only five.[15]

A few of the astronomical, meteorological and terrestrial problems discussed by Epicurus and Lucretius, e.g. the size of the heavenly bodies,[16] the stability of the earth,[17] and the temperature fluctuation in wells,[18] are accounted for with only one explanation. In these cases we should distinguish between problems that may be open to other explanations and those which exclude them (see further below).

2. Exhaustivity. In most cases the lists of alternative explanations are not exhaustive, but appear to be open to other options as well, and Epicurus often tells us so explicitly.[19] Only rarely do the alternative explanations seem to exhaust the entire range of possibilities, as when the moon is said to shine with either its own or with reflected light,[20] or when the sun at sunset is said either to pass unaltered below the earth, or to be extinguished.[21]

This distinction of exhaustivity and inexhaustivity may perhaps be applied to single explanations as well (see above). Sometimes, although only one explanation is given, there is no need to suppose that this is the only one possible. This seems to be the case with a number of terrestrial phenomena discussed by Lucretius in the latter part of his book VI. Perhaps, because he was one of the first to discuss these problems, there was no anterior tradition from which he could derive his explanations (see p.113ff below), and he therefore contented himself with providing just one, and sometimes two. However, other instances of single explanations seem to exclude alternative views. Epicurus' and Lucretius' emphatic claim that the sun, the moon and the stars are the size they appear to be rules out all other options,[22] and so does Epicurus' account of the formation of the heavenly bodies out of windy and

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[14] Epic. *Pyth.* 7 [92]; Lucr. *DRN* V 650-679.

[15] Lucr. *DRN* VI 96-159: Ernout-Robin and Bailey distinguish only seven explanations, but admit that some of them are subdivided. I prefer to devide the account into nine separate explanations: (1) 96-115; (2) 116-120; (3) 121-131; (4) 132-136; (5) 137-141; (6) 142-144; (7) 145-149; (8)150-155; (9) 156-159. Cf. Epic. *Pyth.* 18 [100].

[16] Epic. *Pyth.* 6 [91] and Lucr. *DRN* V 564-591.

[17] Lucr. *DRN* V 534-563.

[18] Lucr. *DRN* VI 840-7.

[19] See APPENDIX A on p.243 below: a '+'-sign after the number indicates that the list is explicitly inexhaustive.

[20] Epic. *Pyth.* 11 [94-95].

[21] See n.14 above.

[22] See n.16 above. For a different interpretation of this theory see n.543 on p.214 below.

fiery matter.[23] These two types of single explanations may perhaps be distinguished as *accidentally* single and *necessarily* single, only the latter being truly opposed to multiple explanations.

3. Mutual exclusivity. In some cases the alternatives offered seem to exclude each other: the sun is either extinguished at sunset or it is not, and the moon's light is either borrowed or its own property.[24] In most cases, however, nothing impedes the alternative explanations from obtaining at the same time. Once, in *Pyth*. 13 [96-97] on solar and lunar eclipses, Epicurus even tells us so explicitly: eclipses may be caused by extinction or interposition of another body, or both at the same time.

4. Subsidiarity. There are even some explanations that not merely allow, but actually require the simultaneous occurrence of another cause: a number of phenomena discussed in the latter part of *DRN* VI are accounted for with one principal explanation and one or two that are merely subsidiary to the first, and not capable of producing the desired effect on their own.[25] Eruptions of the Etna, for instance, are said to be caused by wind blowing in caverns beneath the mountain, catching fire and then violently escaping, an effect that is further strengthened by incursions of the sea into these caverns.[26]

5. Type-differentiation. While in most cases any instance of a certain phenomenon can be accounted for by any one of the alternative explanations, sometimes – especially in meteorology – different explanations seem to apply to different types of the same phenomenon.[27] Thunder, for instance, is explained according to the nature of its sound,[28] lightning according to the presence or absence of thunder,[29] and earthquakes according to their effects.[30]

Although Epicurus does not remark upon these differences, but presents multiple explanations as a single method, it seems useful to keep them in mind.

1.3 Truth, probability and personal preferences

1.3.1 Introduction

Epicurus' and Lucretius' consistent use of multiple explanations in astronomy and meteorology is epistemologically very interesting if not

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[23] Epic. *Pyth*. 5 [90-91].
[24] See n.14 and n.20 above.
[25] See APPENDIX B on p.245 below. Cf. Bailey (1947) pp. 1655, 1684, 1704.
[26] Lucr. *DRN* VI 639-702
[27] Bailey (1947) 1567.
[28] Lucr. *DRN* VI 96-159; cf. Bailey (1947) 1575.
[29] Lucr. *DRN* VI 160-218; cf. Bailey (1947) 1578, 1586.
[30] Lucr. *DRN* VI 535-607.

problematic. There is, for instance, a continuing debate on whether Epicurus and Lucretius considered all alternative explanations merely possible or actually true, and, if true, how these simultaneous truths should be conceived of, and on what grounds Epicurus felt he could pronounce some explanations true and others false. Conversely, if alternative explanations are only possible, are they all equally possible or do they admit different degrees of probability, and is it permitted for an Epicurean to prefer one explanation over another? These are some of the problems I propose to deal with below. The section will be structured as follows. First (in §1.3.2) I will discuss the question whether Epicurus considered all alternative explanations true. Then I will deal with the grounds for rejecting theories (in §1.3.3) and the role played by analogy in accepting theories (in §1.3.4). Following this (in §1.3.5) I will consider whether or not the Epicureans allowed different degrees of probabilities and personal preferences, and having answered this in the negative I will (in §1.3.6) critically examine Bailey's claim that in astronomy Lucretius had a secret preference for the views of the mathematical astronomers.

1.3.2 Are all alternative explanations true?

It is often claimed that Epicurus considered all alternative explanations true. Although we do not have any explicit statement by Epicurus to this effect, it seems to follow logically from his use of *non-contestation* to confirm individual alternative theories and his claim that *non-contestation* establishes *truth*.[31] On the other hand, the simultaneous truth of several, often mutually exclusive, explanations seems to violate the principle of *non-contradiction*, to which Epicurus was also committed.[32]

In this subsection I propose to examine whether or not Epicurus might have claimed that all alternative explanations are true. In order to do so I will first (in 1.3.2.1) review the relevant ancient texts, then (in 1.3.2.2) present and assess the most important modern theories and formulate a provisional conclusion, then (in 1.3.2.3) voice some reservations about this conclusion, and finally (in 1.3.2.4) present a more definitive conclusion.

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[31] On *non-contestation* and multiple explanations in Epicureanism see e.g. Striker (1974) and (1996); Sedley (1982) 263-72; Long & Sedley (1987), vol. I, 90-97; Asmis (1984) 178-80, 193-96, 211, 321-36; *id.* (1999) 285-94; and Allen (2001) 194-205 & 239-41; Fowler (2002) 191-92.

[32] See Asmis (1984) 194. See also n.35 below.

1.3.2.1 Ancient texts and testimonies

The various modern views concerning the truth-value of multiple explanations are based on a number of ancient texts and testimonies, the most important of which will be presented below.

A. The principles of Epicurean epistemology

According to our sources,[33] Epicurus acknowledged three criteria of truth: perceptions (αἰσθήσεις), preconceptions (προλήψεις) and affections (πάθη). Perceptions are the raw data presented to us by the senses; in addition Epicurus distinguished a kind of 'mental perception', called φανταστικὴ ἐπιβολὴ τῆς διανοίας ('impressional projection of the mind'), which directly affects the mind, without the mediation of the senses, such as we experience in dreams; later Epicureans made this into a separate criterion of truth. Preconceptions are general notions naturally formed in our minds in response to repeated perceptions, and affections are the primary emotions – pleasure and pain – by which choice and avoidance are determined. These three, or four, types of data, which are themselves incontrovertibly true, serve as the criteria by which the truth and falsity of opinions are established.

For the investigation of physical reality not all criteria are equally relevant. Affections are mainly of use in ethics. 'Mental perceptions' are useful insofar as they help us to form a preconception of the gods, including the realisation that the gods are in no way responsible for the occurrences in our world. Preconceptions provide us with the necessary notions to be able to formulate opinions at all: we can only investigate the causes of thunder if we have a clear notion of what thunder is. However, supposing that the necessary preconceptions are there, and that hypotheses concerning physical reality can be formulated, the criteria by which these are tested are perceptions and 'things perceived', i.e. *appearances* (φαινόμενα).[34]

Opinions are either true or false.[35] An opinion is true when it is *attested* (ἐπιμαρτυρῆται) or *not contested* (μὴ ἀντιμαρτυρῆται) by appearances, and false when it is *not attested* (μὴ ἐπιμαρτυρῆται) or when it is *contested* (ἀντιμαρτυρῆται) by appearances.[36] Opinions to be tested fall into one of two

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[33] The most important sources for Epicurus' epistemology are Diog. Laërt. X 31-34 and Sext. Emp. *Math.* VII 203-211, supplemented at crucial points by quotations from Epicurus himself.

[34] I translate φαινόμενα as 'appearances', which captures the general sense better than 'phenomena'.

[35] Diog. Laërt. X 34; Sext. Emp. *Math.* VII 211. See, however, Cic. *De fato* 19, 21, 37; *Acad. pr.* II 97; *De nat. deor.* I 70 (collected as Epic. fr.376 Us.), where it is stated that Epicurus refused to assign any truth value to opinions *about the future*.

[36] Epic. *Hdt.* 51: ἐὰν μὲν μὴ ἐπιμαρτυρηθῇ ἢ ἀντιμαρτυρηθῇ, τὸ ψεῦδος γίνεται· ἐὰν δὲ ἐπιμαρτυρηθῇ ἢ μὴ ἀντιμαρτυρῇ, τὸ ἀληθές. – "if it is not attested, or is contested,

categories: the προσμένοντα, those 'awaiting' confirmation by a closer and clearer observation, and the ἄδηλα, the 'unclear' or 'non-apparent', which do not allow closer observation.[37] The latter can be further subdivided into those which can only be observed from afar, such as astronomical and meteorological phenomena (μετέωρα),[38] and those which cannot be observed at all, such as the existence of atoms and void, and other theories fundamental to Epicurean physics.[39] Of the two categories mentioned above, the προσμένοντα are typically tested by *attestation* and *non-attestation*,[40] the ἄδηλα by *non-contestation* and *contestation*.[41]

B. Sextus Empiricus on Epicurus' conditions of truth and falsehood

The only complete account of Epicurus' four methods of verification and falsification that has come down to us is provided by Sextus Empiricus in *Math.* VII 211-216.[42] According to Sextus, *attestation* occurs when a hypothesis about something is confirmed by a closer observation of the object in question, e.g. when we see someone approaching from afar and hypothesize that it is Plato, this hypothesis is confirmed when he has come closer and is seen to be really Plato.[43] When, on the other hand, on approaching he turns out not to be Plato, the hypothesis is rejected by *non-attestation*.[44] Note that Sextus' use of the term *non-attestation* is more restrictive than the words themselves suggest: *non-attestation* seems to denote not merely the *negation or absence of attestation* but rather the *attestation of the negated hypothesis*.

Of *contestation* Sextus gives the following account (214):

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falsehood arises; but if it is attested or not contested, truth." Cf. Diog. Laërt. X 34; Sext. Emp. *Math.* VII 211 & 216. The translations of the technical terms are those of Sedley (1982), Long & Sedley (1987) and Allen (2001). Asmis (1984) & (1999) prefers *witnessing, no-counterwitnessing, no-witnessing, counterwitnessing*.

[37] Epic. *Hdt.* 38; *id*. *RS* 24. Cf. Diog. Laërt. X 34.

[38] Epic. *Hdt.* 80 (... αἰτιολογητέον ὑπέρ τε τῶν μετεώρων καὶ παντὸς τοῦ ἀδήλου ...).

[39] Epic. *Hdt.* 38, introducing the fundamental theories of *Hdt.* 38-44.

[40] Epic. *RS* 24. Cf. Diog. Laërt. X 34.

[41] Epic. *Pyth.* 2 [88], 3 [88], 7 [92] (*non-contestation* applied to astronomical and meteorological phenomena); Sext. Emp. *Math.* VII 213-14 (*contestation* and *non-contestation* applied to what is by nature unobservable).

[42] = Long & Sedley 18A = Usener 247 (part).

[43] Sext. Emp. *Math*. VII 212.

[44] Sext. Emp. *Math.* VII 215.

Ἡ μέντοι ἀντιμαρτύρησις {...} ἦν γὰρ ἀνασκευὴ τοῦ φαινομένου τῷ ὑποσταθέντι ἀδήλῳ, οἷον ὁ Στωικὸς λέγει μὴ εἶναι κενόν, ἄδηλόν τι ἀξιῶν, τούτῳ δὲ οὕτως ὑποσταθέντι ὀφείλει τὸ φαινόμενον συνανασκευάζεσθαι (φημὶ δ' ἡ κίνησις)· μὴ ὄντος γὰρ κενοῦ κατ' ἀνάγκην οὐδὲ κίνησις γίγνεται.

Contestation {...} was the elimination of the appearance with the hypothesized non-evident fact, as for instance, when the Stoic says there is no void, claiming something non-evident, the appearance (I mean motion) must be co-eliminated with what is thus hypothesised, for if there is no void, by necessity motion doesn't occur either.

A hypothesis about something non-evident (ἄδηλον) is proved wrong by *contestation* when its acceptance would lead to the elimination or cancellation of an evident fact. The argument can be set out as follows:

¬v → ¬m	if there were no void, there would be no motion
m	but there is motion
v	therefore there is void

If the necessity of the first premise, and the evidence of the second are accepted, the conclusion must be true.

Non-contestation is explained by Sextus as follows (213-4):

Οὐκ ἀντιμαρτύρησις δέ ἐστιν ἀκολουθία τοῦ ὑποσταθέντος καὶ δοξασθέντος ἀδήλου τῷ φαινομένῳ, οἷον ὁ Ἐπίκουρος λέγων εἶναι κενόν, ὅπερ ἐστὶν ἄδηλον, πιστοῦται δι' ἐναργοῦς πράγματος τοῦτο, τῆς κινήσεως· μὴ ὄντος γὰρ κενοῦ οὐδὲ κίνησις ˘˘ώφειλεν εἶναι, τόπον μὴ ἔχοντος τοῦ κινουμένου σώματος εἰς ὃν περιστήσεται διὰ τὸ πάντα εἶναι πλήρη καὶ ναστά, ὥστε τῷ δοξασθέντι ἀδήλῳ μὴ ἀντιμαρτυρεῖν τὸ φαινόμενον κινήσεως οὔσης.

Non-contestation is the attendance of the hypothesized and supposed non-evident fact upon the appearance, as for instance, when Epicurus says there is void, which is non-evident, this is proved by an evident thing, motion: for if there were no void, there shouldn't be motion either, as the moving body wouldn't have a place into which to come round, because everything would be full and packed; therefore the appearance does *not contest* the supposed non-evident thing, since there *is* motion.

A hypothesis about something non-evident (ἄδηλον) is proved right by *non-contestation* when it can be shown to 'attend upon', or be implied by, an evident appearance, as, for instance, the non-evident existence of void follows from the evident existence of motion. Sextus' general account of *non-contestation* suggests the following schema (*modus ponens*):

m → v	if there is motion, there is void
m	there is motion
v	therefore there is void

This schema, however, fails to make clear the function of the negation in ***non****-contestation*. If we follow Sextus' example rather than his theoretical

account, we find a different, though logically equivalent, schema (*modus tollens*):

$\neg v \rightarrow \neg m$	if there were no void, there would be no motion
m	but there is motion
v	therefore there is void

This schema is exactly identical to that of *contestation*. The only difference is one of focus: *contestation* is about *falsifying* a hypothesis (viz. the *non*-existence of void), whereas *non-contestation* is about *verifying* a hypothesis (viz. the existence of void), *by falsifying its negation* (viz. the *non*-existence of void). In other words, according to Sextus' account, *non-contestation* does not just denote – as the name suggests – the absence of *contestation*, but *contestation* of the *negated* hypothesis.

C. Epicurus' account of the fundamental theories of physics

In *Hdt*. 38-44, Epicurus discusses, under the general heading of ἄδηλα, i.e. *non-evident* things, the principal and fundamental tenets of his physical theory (e.g. that nothing comes from nothing, that the sum total of things is unchanging, that everything consists of bodies and void, etc.). One of the subjects discussed is the existence of void, which Epicurus sets out as follows (*Hdt.* 40)[45]:

εἰ δὲ μὴ ἦν ὃ κενὸν καὶ χώραν καὶ ἀναφῆ φύσιν ὀνομάζομεν, οὐκ ἂν εἶχε τὰ σώματα ὅπου ἦν οὐδὲ δι' οὗ ἐκινεῖτο, καθάπερ φαίνεται κινούμενα.

and if there were not what we call void and space and intangible nature, bodies would have no place to be or through which to move, as they are observed to move.

Except for the suppressed conclusion, viz. that void exists, this argument is identical, both in subject and structure, to Sextus' example of *non-contestation* (item B on p.14 above), and most of Epicurus' other arguments in this section exhibit the same structure. Epicurus does not, however, in this context speak of *non-contestation*, nor does he provide any other name for the procedure.

A little further on Epicurus discusses the sizes of atoms (*Hdt.* 55-56):

[45] Cf. Lucr. *DRN* I 334-45. On this argument see Allen (2001) 195-6; Furley (1971), and Furley's response to Schrijvers in Gigon (1978), 117-8.

᾽Αλλὰ μὴν οὐδὲ δεῖ νομίζειν πᾶν μέγεθος ἐν ταῖς ἀτόμοις ὑπάρχειν, *ἵνα μὴ τὰ φαινόμενα ἀντιμαρτυρῇ*, {...} πᾶν δὲ μέγεθος ὑπάρχον οὔτε χρήσιμόν ἐστι πρὸς τὰς τῶν ποιοτήτων διαφοράς, ἀφῖχθαί τε ἅμ᾽ ἔδει καὶ πρὸς ἡμᾶς ὁρατὰς ἀτόμους, ὃ οὐ θεωρεῖται γινόμενον, ...	Nor, moreover, must we suppose that every size exists among the atoms, *lest the appearances contest this*, {...} but the existence of every size of atoms is not required for the differences of their qualities, and at the same time visible atoms would have to come within our ken, which is not observed to happen, ...

Here Epicurus has interwoven two different arguments. In the first place the existence of atoms of every size is unnecessary for his physical theory, and in the second place it would entail the existence of observable atoms,[46] which is in conflict with the evidence of the senses. This second part of the argument can be set out schematically as follows:

$p \rightarrow q$	if atoms could have every size, some atoms would be observable
$\neg q$	but there are no observable atoms
$\neg p$	therefore atoms cannot have every size

The argument closely matches Sextus' account of *contestation*, and – what is more – this time Epicurus himself refers to the argument by this very term: μὴ τὰ φαινόμενα ἀντιμαρτυρῇ – 'lest the appearances *contest* this'. May we then conclude that Sextus has correctly reported Epicurus' views on *contestation* and *non-contestation*?

D. Epicurus' use of non-contestation in astrononomy and meteorology

Until now *contestation* and *non-contestation* have only been applied to fundamental physical theories. It remains to be seen how they are used in astronomy and meteorology.

In *Pyth.* 7 [92], Epicurus offers two alternative explanations to account for the risings and settings of the sun, the moon and the stars:

[46] Epicurus has 'visible atoms', but on his own theory (cf. *Hdt.* 46-50 and Lucr. IV 54-216) even enormous atoms would not be directly 'visible', since being atomic they would not be able to shed the necessary images, but they would be indirectly 'visible', by blocking other things from view, and also tangible because of all the senses touch alone does not require the shedding of particles.

’Ανατολὰς καὶ δύσεις ἡλίου καὶ σελήνης καὶ τῶν λοιπῶν ἄστρων	Risings and settings of the sun and the moon and the other heavenly bodies
(1) καὶ κατὰ ἄναψιν γίνεσθαι δύνασθαι καὶ κατὰ σβέσιν, τοιαύτης οὔσης περιστάσεως καὶ καθ’ ἑκατέρους τοὺς τόπους, ὥστε τὰ προειρημένα ἀποτελεῖσθαι· *οὐδὲν γὰρ τῶν φαινομένων ἀντιμαρτυρεῖ*·	(1) may come about by kindling and extinction, the circumstances at both places [i.e. the places of rising and setting] being such as to produce the afore-mentioned results: *for nothing in appearances contests this*.
(2) ⟨καὶ⟩ κατ’ ἐκφάνειάν τε ὑπὲρ γῆς καὶ πάλιν ἐπιπροσθέτησιν τὸ προειρημένον δύναιτ’ ἂν συντελεῖσθαι· *οὐδὲ γάρ τι τῶν φαινομένων ἀντιμαρτυρεῖ.*	(2) and by their appearance above the earth and again the (earth’s) interposition the afore-mentioned result might be produced: *for not a thing in appearances contests this.*

According to Epicurus, the heavenly bodies are either repeatedly extinguished and then rekindled, or they pass unaltered below the earth and then emerge again.[47] Both options must be accepted, because ‘*nothing in appearances contests*’ either one of them. The same or similar terms, expressing either the absence of disagreement[48] or the presence of (positive) agreement with appearance,[49] occur throughout the *Letter to Pythocles*, often to account for each one of a number of alternative explanations. If, as Epicurus claims,[50] *non-contestation* establishes truth, then each one of the alternative explanations must be true. It should be noted, however, that Epicurus’ argument in these passages is not at all like Sextus’ account of *non-contestation* (item B on p.14 above); nowhere in the *Letter to Pythocles* do we encounter anything that resembles the syllogistic structure of *non-contestation* as set out by Sextus and as applied (though without this ‘label’ of *non-contestation*) by Epicurus in the *Letter to Herodotus* to prove his fundamental physical theories. In the present context *non-contestation* seems to be nothing more than the absence of *contestation* by appearances, or – in other words – the (positive) agreement with appearances.

E. Epicurus on the distinction between single and multiple explanations

It would seem then, that Epicurus dealt differently with the fundamental physical theories and the more specialised theories concerning astronomical

[47] Similarly Lucr. *DRN* V 650-679 on the causes of nightfall and dawn.

[48] *Pyth.* 2 [88] « οὐκ ἀντιμαρτυρεῖται », *Pyth.* 3 [88] « τῶν γὰρ φαινομένων οὐδὲν ἀντιμαρτυρεῖ », *Pyth.* 9 [93] « οὐθενὶ τῶν ἐναργημάτων διαφωνεῖ », *Pyth.* 11 [95] « οὐθὲν ἐμποδοστατεῖ τῶν ἐν τοῖς μετεώροις φαινομένων », *Pyth.* 16 [98] « οὐ μάχεται τοῖς φαινομένοις ».

[49] *Pyth.* 2 [86] « τοῖς φαινομένοις συμφωνίαν »; *Pyth.* 2 [87] « συμφώνως τοῖς φαινομένοις » and « σύμφωνον ... τῷ φαινομένῳ »; *Pyth.* 9 [93], 12 [95], 32 [112] « τὸ σύμφωνον τοῖς φαινομένοις ».

[50] See n.36 on p.13 above.

and meteorological phenomena. Whereas the first are proved to be uniquely true by showing that their negation is contested by appearances, the second are accounted for with a number of alternative theories which must all be accepted because none of them is contested by appearances. Epicurus explicitly contrasts the two types of problems in *Pyth*. 2 [86]:

Μήτε τὸ ἀδύνατον [καὶ] παραβιάζεσθαι, μήτε ὁμοίαν κατὰ πάντα τὴν θεωρίαν ἔχειν ἢ τοῖς περὶ βίων λόγοις ἢ τοῖς κατὰ τὴν τῶν ἄλλων φυσικῶν προβλημάτων κάθαρσιν, οἷον ὅτι τὸ πᾶν σῶμα καὶ ἀναφὴς φύσις ἐστίν, ἢ ὅτι ἄτομα στοιχεῖα καὶ πάντα τὰ τοιαῦτα δὴ ὅσα μοναχὴν ἔχει τοῖς φαινομένοις συμφωνίαν· ὅπερ ἐπὶ τῶν μετεώρων οὐχ ὑπάρχει, ἀλλὰ ταῦτά γε πλεοναχὴν ἔχει καὶ τῆς γενέσεως αἰτίαν καὶ τῆς οὐσίας ταῖς αἰσθήσεσι σύμφωνον κατηγορίαν.

We must not try to force an impossible explanation, nor employ a method of inquiry similar in every respect to our reasoning either about the modes of life or with respect to the sorting-out of other physical problems, such as our statement that 'the universe consists of bodies and the intangible', or that 'the elements are indivisible', and all such statements which exhibit a singular agreement with appearances. For this is not so with the things above us: they admit of a plural account of their coming-into-being and a plural expression of their nature which agrees with our sensations.

Althought the fundamental physical theories (just like the theories concerning the modes of live) no less than astronomical and meteorological theories need to fulfill the requirement of agreement with appearances, the method of inquiry by which they are approached is different. In other words: Epicurus explicitly recognizes the existence of two different methods of inquiry, one that is applied to such problems as admit only one answer (such as the fundamental physical theories), and one that is applied to those problems that admit several answers (such as we find in astronomy and meteorology).

F. Lucretius on the truth of all alternative explanations (1)

Lucretius too offers multiple explanations to account for astronomical (*DRN* V 509-770) and meteorological (*DRN* VI) phenomena. Close to the beginning of his astronomical section, having just offered a number of alternative explanations for the movements of the stars, he states his view on the epistemological status of these explanations (V 526-33):

nam quid in hoc mundo sit eorum ponere certum
difficilest; sed quid possit fiatque per omne
in variis mundis varia ratione creatis,
id doceo plurisque sequor disponere causas,
motibus astrorum quae possint esse per omne;
e quibus una tamen siet hic quoque causa necessest,
quae vegeat motum signis; sed quae sit earum
praecipere haudquaquamst pedetemptim progredientis.

for to state with certainty which of these causes holds in our world is difficult; but what can and does happen throughout the universe in the various worlds created in various ways, this I teach, and I proceed to set forth several causes for the motions of the stars, which may apply throughout the universe; one cause out of this number, however, is necessarily the case here too, which gives force to the motion of the stars, but which of them it is, is not for them to lay down who proceed step by step.

Although in our world each explanation can at best be called possible, in the universe at large, given the infinity of space and matter and hence of

worlds, any given possibility cannot fail to be realised (the 'principle of plenitude'),[51] and so every possible explanation is also 'true', if not here, then somewhere else. This may also explain why Epicurus in his *Letter to Pythocles* sometimes speaks of the alternative explanations as all being actually the case and coexisting rather than being merely possible and mutually exclusive.[52]

G. Lucretius on the truth of all alternative explanations (2)

There is a second passage where Lucretius deals with the method of multiple explanations. In VI 703-711, preceding his account of the summer flooding of the Nile, Lucretius writes:

Sunt aliquot quoque res quarum unam dicere causam	There are also a number of cases for which naming one cause is
non satis est, verum pluris, unde una tamen sit;	not enough, but several, one of which is nevertheless the case;
corpus ut exanimum siquod procul ipse iacere	just as, if you should yourself see a person's dead body lying
conspicias hominis, fit ut omnis dicere causas	at a distance, it happens to be fitting to name all the causes of
conveniat leti, dicatur ut illius una;	death, to make sure that the one cause of this death be named;
nam <ne>que eum ferro nec frigore vincere possis	for you could not prove that he died from the sword
interiisse neque a morbo neque forte veneno,	or from cold or from disease or perchance from poison,
verum aliquid genere esse ex hoc quod contigit ei 710	but we know that it was something of this sort that
scimus. item in multis hoc rebus dicere habemus.	befell him. Similarly we must say this in many cases.

Although this passages is not incompatible with the earlier one, there is an interesting shift of focus. This time we hear nothing of the infinite number of worlds, nothing of the principle of plenitude, and nothing of the truth of all explanations, and, although the event is still viewed as a particular instant of a certain class of events, the emphasis seems to be on the particular instance, to which only one explanation applies (although we do not know which one), rather than the whole class of events, to which many explanations apply. Moreover, the chosen example, a dead body, seems strangely inappropriate. While multiple explanations are typically applied to things that can *only* be

[51] Cf. Lucr. *DRN* V 422-31 and Epic. fr.266 Us. (both referring to the infinity of *time* rather than matter and space). On the Epicurean use of the principle of plenitude see e.g. Sedley (1998a) 175, n.29. A precursor of this principle (based on the infinity of space and matter) is described by Aristotle (*Phys*. III, 4,203b25-30), who may be rendering a Democritean view: see Asmis (1984) 264-5.

[52] In the *Letter to Pythocles* I have counted 34 cases where multiple explanations are offered. 20 of these are accompanied by some verb or expression denoting possibility (ἐνδέχεται, δύναται, οὐκ ἀδύνατον, etc.). Of the 14 remaining cases, 5 exhibit a purely *disjunctive* list of alternative explanations (ἤτοι A ἢ B ἢ Γ). The 9 remaining cases are either *conjunctive* (καὶ A καὶ B καὶ Γ) or *mixed* (καὶ A καὶ B ἢ Γ): in these 9 cases the language seems to suggests that several explanations may be true at the same time. For more details see APPENDIX A on p.243 below.

seen from a distance, there does not seem to be any cogent reason why the dead body could not be approached and examined more closely, so as to eliminate certain explanations and perhaps even arrive at the one true cause of death (concerning this example see also §1.3.2.3, fourth paragraph, below).

1.3.2.2 Three different modern theories

The main problem with the above texts and passages concerns items B and D (p.14 and p.17 respectively): Sextus' account of *non-contestation* (B) and Epicurus' use of *non-contestestion* in the *Letter to Pythocles* (D) seem to be incompatible. According to Sextus, *non-contestation* is *contestation* of the negated hypothesis, which by means of a syllogism establishes the exclusive truth of its hypothesis, thus satisfying Epicurus' claim (item A on p.13 above) that *non-contestation* establishes truth. In the *Letter to Pythocles*, on the other hand, *non-contestation* seems to mean nothing more than the absence of *contestation*, which – common-sense suggests – can only establish the possibility of each of a number of alternative explanations. Yet, Lucretius (item F on p.19 above) suggests a way in which possibility may actually amount to truth, to the effect that even *non-contestation* in this weak sense might satisfy Epicurus' claim (item A) about *non-contestation* being a condition of truth. Several ways to resolve the observed incompatibility can be and have been devised:

1. Sextus' account of *non-contestation* is correct, and Epicurus' use of *non-contestation* in the *Letter to Pythocles* must be interpreted accordingly: *non-contestation* does not apply to each alternative explanation in isolation, but to the entire disjunction of alternative explanations.
2. *Non-contestation* as explained by Sextus and *non-contestation* as applied in Epicurus' *Letter to Pythocles* are two different things: Sextus' account is about *non-contestation* in the strong sense which establishes the truth of a proposition, whereas Epicurus' *Letter to Pythocles* refers to *non-contestation* in the weak sense which only establishes possibility.
3. Sextus' account of *non-contestation* is incorrect or at least incomplete. Epicurus' own use of *non-contestation* in the *Letter to Pythocles* is our only certain guide to the working of *non-contestation* as perceived by Epicurus.

Below I will examine each of these three approaches more thoroughly.

Ad 1. An interesting solution to the problem is offered by Jim Hankinson.[53] According to Hankinson, an Epicurean explanation of an atmospherical or

[53] Hankinson (1999a) 221-23, and (1999b) 505-7.

celestial phenomenon takes the form of a disjunction of possible explanations: "x occurs because either E_1 or E_2 or ... E_n. At most one of the E_i's can be the true explanation (cf. Lucretius 6. 703-4); but if the disjunction is sufficiently all-embracing, one of them will be: and that is all that is required." Tad Brennan,[54] elaborating on Hankinson's remark, adds: "the point could be strengthened by reflecting that the actual reference in DL 10.86 [*Pyth.* 2] does not mention multiple "*aitiai*", plural, but a "*pleonachên aitian*",[55] i.e. a single explanation with a complex, manifold structure. This is why the assertion of the whole disjunction is safe but the isolated assertion of any one disjunct is not (DL 10.87) [*Pyth.* 2]." In other words, if complete, the whole disjunction, i.e. the entire range of possible explanations, can be called *true*, and could in principle be demonstrated to be so by *non-contestation* (as interpreted by Sextus Empiricus). In this context Brennan might also have quoted *Pyth*. 2 [88], where *non-contestation* seems to be applied to the fact of there being multiple explanations, not to any single explanation in particular:

Τὸ μέντοι φάντασμα ἑκάστου τηρητέον καὶ ἐπὶ τὰ συναπτόμενα τούτῳ διαιρετέον, ἃ *οὐκ ἀντιμαρτυρεῖται* τοῖς παρ' ἡμῖν γινομένοις πλεοναχῶς συντελεῖσθαι.	Yet the appearance of each appearance must be preserved, and, as regards what is associated with it, those things must be distinguished whose production in a multiple way is *not contested* by phenomena here with us.

Hankinson's account, even when supplemented by Brennan's remarks, is disappointingly short. It would be interesting to see their interpretation of *non-contestation* applied to a specific case in the *Letter to Pythocles*. Unfortunately it is very hard to find a case where the disjunction of possible explanations logically follows from an evident fact, as Sextus' account of *non-contestation* prescribes. It is at this point that we may call another text to our aid. Among the many papyri which have been unearthed at Herculaneum, there is one which preserves part of a treatise by Philodemus on the Epicurean theory of signs.[56] In one of the fragments two different types of inference are distinguished.[57] The first type, which is called *method of elimination* (ὁ κατὰ τὴν ἀνασκευὴν τρόπος), is illustrated by the following example: 'if there is motion, there is void'. This is the type which, we have seen, underlies Sextus' accounts of *contestation* and *non-contestation*. Beside this, there is another type, which is called *method of similarity* (ὁ κατὰ τὴν ὁμοιότητα τρόπος),

[54] Brennan (2000) commenting on Hankinson (1999b) 505-7.
[55] See the text quoted in item E on p.18 above.
[56] Philodemus *De signis*: complete edition with English translation in De Lacy (1978).
[57] *De signis* xi 32 – xii 31 (= Long & Sedley 18F) et passim.

which is illustrated by the following example: 'if Plato is a human being, Socrates is a human being'. Although Socrates' humanity does not strictly *follow* from Plato's, it is inconceivable that the one should be human and the other not. Another, more general example of this type of inference is: 'if men here with us are mortal, then men everywhere are mortal'.[58] Philodemus argues against certain opponents that both types are equally valid as methods of inference. For the present purpose I will assume that not only Philodemus' *method of elimination*, but also his *method of similarity* can provide a valid basis for *non-contestation* as described by Sextus.[59] It is now time to return to the promised example of *non-contestation* being applied to the whole disjunction of possible explanations. In *Pyth.* 11 [94-5] Epicurus writes about the light of the moon:

Ἔτι τε ἐνδέχεται ⟨μὲν⟩ τὴν σελήνην ἐξ ἑαυτῆς ἔχειν τὸ φῶς, ἐνδέχεται δὲ ἀπὸ τοῦ ἡλίου. καὶ γὰρ παρ' ἡμῖν θεωρεῖται πολλὰ μὲν ἐξ ἑαυτῶν ἔχοντα, πολλὰ δὲ ἀφ' ἑτέρων.	Next, the moon may have her light from herself or may have it from the sun. For *here with us*, too, we see many things having light from themselves, and many having it from something else.

If we accept that no other explanations but these two are possible, we can formulate the following disjunction: 'the moon has its light either from itself or from something else'. On the basis of this disjunction we can now construct the following implication (of the *similarity* type): 'if light-giving objects here with us do so either because they have light from themselves or from something else, then the moon (being a light-giving object) does so either because it has light from itself or from something else'. If we accept the implication, then, as the antecedens is evident, the consequens must be true as well. The truth of the disjuntion has been verified by *non-contestation* (according to Sextus). This can be set out schematically as follows (*modus ponens*):

$p \rightarrow (q_1 \vee q_2)$	if the moon gives light (p), it has this light either from itself (q_1) or from something else (q_2)
p	the moon gives light (p)
$(q_1 \vee q_2)$	the moon has its light either from itself (q_1) or from something else (q_2)

This procedure can also be applied to most other cases where multiple explanations are in order, not only those with a limited number of alternatives, but also the inexhaustive disjunctions, where Epicurus explicitly tells us that still other explanations can be added.[60]

[58] *De signis* xvi 5-29 et passim.
[59] See Asmis (1984) 202.
[60] See APPENDIX A on p.243 ff below.

However, there is one major problem to this interpretation of *non-contestation* as applied to multiple explanations: it does not take into account the fact that in the *Letter to Pythocles non-contestation* is sometimes invoked to prove each one of a number of alternative explanations rather than the disjunction as a whole (cf. item D on p.17 above).

Ad 2. Another approach, proposed by Gisela Striker and followed by Don Fowler,[61] is to simply acknowledge the existence, in Epicurean epistemology, of two different kinds of *non-contestation*. On the one hand there is *non-contestation in the strong sense*, meaning *contestation* of the negated hypothesis, which is described by Sextus Empiricus (item B on p.14 above) and repeatedly applied (though not by name) by Epicurus himself in the *Letter to Herodotus* (item C on p.16 above). It is with reference to this type of *non-contestation* that Epicurus calls *non-contestation* a condition of truth (item A on p.13 above). On the other hand there is *non-contestation in the weak sense*, which is simply the negation or absence of *contestation*, and which is invoked several times in Epicurus' *Letter to Pythocles* to establish the possibility of each of a number of alternative explanations of astronomical and meteorological phenomena (item D on p.17 above). Only with reference to the 'principle of plenitude' (item F on p.19 above) can all these alternative explanations also be called true, if not in this world, then in another.[62]

This approach has the great advantage of preserving all available evidence: it allows us to accept Sextus' account of *non-contestation* and at the same time do justice to Epicurus' own use of *non-contestation* in the *Letter to Pythocles*. The great drawback is that it leaves us with two different kinds of *non-contestation* not distinguished by name, but having quite different logical outcomes, despite Epicurus' unqualified claim that non-contestation establishes truth.

Ad 3. A third approach is to simply dismiss Sextus' account of *non-contestation* as incorrect or inaccurate. This has been, with minor variations, the approach of David Sedley, Elizabeth Asmis and James Allen.[63] According to this approach, there is only one kind of *non-contestation*, viz. the method which Epicurus himself employs several times in his *Letter to Pythocles*, where *non-contestation* amounts to nothing more specific than agreement or

[61] Striker (1974) 76; *id*. (1996) 45; Fowler (2002) 191-92.
[62] Striker (1974) 78-9; *id*. (1996) 47-8.
[63] Sedley (1982) 263-72; Long & Sedley (1987), vol. I, 90-97; Asmis (1984) 178-80, 193-96, 211, 321-36; *id*. (1999) 285-94; and Allen (2001) 194-205 & 239-41.

compatibility with appearances and may result in the acceptance of several theories at the same time. It is to this procedure that Epicurus' claim that *non-contestation* establishes truth must be applied.

It cannot be denied that the method which Sextus Empiricus describes under the heading of '*non-contestation*' corresponds very well to the way Epicurus, in the *Letter to Herodotus*, proves many of his fundamental physical theories by showing that *their contradictories* are *contested* by the appearances (item C on p.16 above). It is also true, however, that in the *Letter to Pythocles* Epicurus makes the fundamental physical tenets, no less than astronomical and meteorological theories, subject to agreement with appearances (item E on p.18 above). This apparent contradiction can be explained, basically, in two ways: either (a) Epicurus did not consider *contestation of the contradictory* a real proof, despite his repeated use of this method in the *Letter to Herodotus*, believing that the real proof consisted only in *non-contestation*, i.e. agreement with appearances, which – curiously – he often fails to invoke in the *Letter to Herodotus*, or (b) he though that *contestation of the contradictory* by itself somehow implied, and therefore could be subsumed under, *non-contestation*.

The first option is chosen by Sedley, who tries to minimize the importance of *contestation of the contradictory* for Epicurus, pointing out that the logical implication on which this procedure rests, e.g. 'if there is no void, there is no motion', must itself be proved by *non-contestation*, i.e. agreement with appearances,[64] and therefore cannot count as a condition of truth. Against this position I would like to stress the following two points: firstly that Epicurus in the *Letter to Herodotus* (see item C on p.16 above) repeatedly uses *contestation of the contradictory* as a proof in its own right, presenting the underlying implications as self-evident, rather than requiring further proof; and secondly that Epicurus in the *Letter to Pythocles* (2 [86]: see item E on p.18 above) explicitly distinguishes two methods of inquiry, one applied to the fundamental physical problems and resulting in single explanations, the other to meteorological and astronomical problems and resulting in multiple explanations.

The second option, or something like it, is advocated by Asmis and Allen. Asmis acknowledges the importance of *contestation of the contradictory*, but generally refers to it as a kind of (positive) *contestation* (rather than *non-contestation* as Sextus does) which she opposes to the method of 'induction' (i.e. agreement with appearances, or *non-contestation*).[65] In a later publication, however, Asmis seems to subsume both types of scientific inference under the general heading of *non-contestation*, which makes her position come very

[64] Sedley (1982) 269 with n.70; cf. Allen (2001) 203.
[65] Asmis (1984) 211 et passim.

close to Gisela Striker's (see Ad 2 above).[66] Allen suggests that for Epicurus proofs by *contestation of the contradictory* would have been a special case of the more common proof by agreement with appearances.[67] Asmis' and Allen's view may perhaps be summarized as follows: Epicurus claims that in matters of the non-evident truth is established by *non-contestation*, by which he means agreement with appearances. This agreement with appearances may be singular, as with the fundamental physical theories, or plural, as with most astronomical and meteorological phenomena. To establish a theory's singular agreement with appearances Epicurus uses a method that may be described as *contestation of the contradictory hypothesis*, which he seems to have considered a special kind of *non-contestation*. Sextus' report would then be inaccurate insofar as it identifies this *contestation of the contradictory hypothesis* with *non-contestation*, of which it is only a special kind.

Having reviewed a number of modern views concerning the truth of multiple explanations it is now time to summarize the results. The first approach, defended by Jim Hankinson and Tad Brennan, claiming that *non-contestation* does not apply to, and therefore does not establish the truth of, individual alternative explanations, but applies only to the complete disjunction of alternatives, is refuted by the evidence. A second approach, defended by Gisela Striker, assuming two different kinds of *non-contestation*, one of which establishes the truth of single theories, while the other only establishes the possibility of each one of a number of alternative explanations, introduces a distinction that seems unwarranted by Epicurus' unqualified claim that *non-contestation* establishes truth.[68] This leaves us only the third approach, which maintains that Epicurus really claimed the truth of all alternative explanations. As we saw above two varieties of this approach can be distinguished. The first variety, defended by David Sedley, rejects not only Sextus' account of *non-contestation* as contestation of the contradictory hypothesis, but also minimizes the importance of Epicurus' frequent use of contestation of the contradictory hypothesis to prove the most fundamental physical theories. At the same time it seems to ignore Epicurus' explicit distinction of *two* methods of inquiry, instead suggesting that truth is utimately always established by agreement with appearances. The second variety, which may be attributed to Elizabeth Asmis and James Allen, deals more cautiously with the available evidence. It provides a plausible way in which contestation

[66] Asmis (1999) 289.
[67] Allen (2001) 200.
[68] See n.36 on p.13 above.

of the contradictory hypothesis may at once be separate from, and yet subsumed under, *non-contestation*. On this interpretation Sextus' report of *non-contestation* can be retained as long as we realise that it only applies to one special kind of *non-contestation*.

In sum, on the basis of the evidence we have thus far examined the conclusion that Epicurus really held all alternative explanations to be *true* seems inevitable.

1.3.2.3 Some reservations

Those who maintain the truth of all alternative explanations (third option above), generally explain this *truth* by means of the *principle of plenitude*, referring to Lucretius' testimony in *DRN* V 526-33 (item F on on p.19 above), which is usually taken to mean that, although for each individual event only one explanation can be true (though we do not know which one), with respect to the general type of event that is being explained every alternative explanation that is *not contested* by the appearances is *true*.[69] I have a number of reservations about this claim, however.

My first reservation concerns the meaning of the word 'true'. Although the principle of plenitude provides a way in which each one of a number of alternative explanations may be called *true*, it must be observed that this *truth* is something very different from the universal and ubiquitous truth attaching to those theories which exhibit a singular agreement with the appearances, and – despite his unqualified claim that *non-contestation* establishes *truth* – Epicurus does seem to acknowledge the difference. Why else would he, in the introduction of his *Letter to Pythocles* (2 [86]; see item E on on p.18 above), oppose plural to singular agreement with appearances? In order to serve as the foundation of a systematic physical theory some tenets not only allow but actually require not just *agreement* but *singular agreement* with appearances, so as to be pronounced universally true, and this singular agreement with appearances can only be established by contestation of the contradictory hypothesis. It is almost as if Epicurus were saying that all explanations are true, but some (viz. singular explanations) are more true than others. In this respect Gisela Striker's division of Epicurean *non-contestation* into a strong kind which establishes truth and a weak kind which establishes only possibility (second option above) is actually a good approximation of Epicurus' use of *non-contestation*.

My second reservation is about the general application of the principle of plenitude to all cases of multiple explanations. It seems to be universally agreed upon that Lucretius' account of the principle may be generalised in this

[69] Asmis (1984) 322, 324-25; *id.* (1999) 289; Sedley (1982) 270 with n.72; Long & Sedley (1987) vol.1, 95-96; Allen (2001) 197-198.

way, but in fact his account is appended to, and only explicitly refers to, the alternative explanations of the motions of the stars. Yet, even if we allow that his words have a broader application, it seems legitimate to investigate the scope of their applicability. In order to be able to apply the *principle of plenitude* each phenomenon under investigation needs to be viewed as an instance of a general type of events. In the case of meteorological phenomena this general type can be easily envisaged even without reference to the infinity of worlds. Thunder, for instance, is accounted for by Lucretius with nine different explanations.[70] Only one of these will be true with respect to one particular thunderclap (although we do not know which one), but all of them are true with respect to thunder in general. In the case of astronomical phenomena, which are often concerned with unique objects, it is harder to accept them as instances of some general type. Only if we are prepared to accept 'sun' and 'moon' as generic terms for objects of which there may be only one in this world but infinetely many in the universe at large, can we claim that each possible explanation is also *true*. Yet, what are we to do with multiple explanations for exceptional local phenomena such as eruptions of the Etna, the summer flooding of the Nile, the anomalous daily temperature fluctuation of the spring near the shrine of Hammon, etcetera, which Lucretius discusses in the second part of book VI (see also p.99ff below)? Are we to suppose that in the universe at large there are infinitely many Niles flowing down from infinitely many Aethiopian mountain-ranges each overflowing in summer to irrigate infinitely many Egypts? That is, in fact, a logical outcome of the assumption of an infinity of worlds. Yet, if Lucretius had wished us to think of a general type of event, he would not have emphasized all these inessential particulars, but he would have spoken about rivers that overflow in summer, of which the Nile only presents the most notable example.[71] It is clear, then, that here Lucretius was not thinking of general types of events, but of particular and in some cases even unique[72] local phenomena, to which the 'principle of plenitude' does not apply. In these cases each of the alternative explanations can at best be called possible, not true.[73]

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[70] *DRN* VI 96-159. Cf. Epic. *Pyth* 18 [100].

[71] Seneca, *N.Q.* III 26, 1, informs us that, according to Theophrastus, a number of rivers in Pontus showed this same behaviour.

[72] In *DRN* VI 712-13 Lucretius calls the Nile *unique* ('unicus') for overflowing in summer (but see n.71 above).

[73] It must be noted that for phenomena of this class Lucretius most often provides only one explanation, sometimes plus a subsidiary one. The summer flooding of the Nile, with four explanations, is exceptional in this respect too: see APPENDIX B on p.245 below.

There is another reason why in some of these cases the alternative explanations cannot all be called true. Whereas astronomical and meteorological phenomena cannot be physically approached, and therefore rightly belong to the class of *non-evident* things (ἄδηλα) which are typically tested by *contestation* and *non-contestation* (see item A on p.13 above), some of the exceptional local phenomena described in *DRN* VI do not necessarily defy closer observation, and so may seem open to testing by *attestation* and *non-attestation* (see item A on p.13 and item B, first paragraph, on p.14 above). One could simply go to Egypt and observe whether the annual flooding of the Nile is somehow correlated to the onset of the etesian winds (715-23), or to the formation of sandbanks in the mouths of the river (724-28), or to the onset of seasonal rains upstream (729-34), or to the melting of snow in the Aethiopian mountains (735-37).[74] So, rather than being *true* for *not being contested by appearances*, these phenomena may be said to be still *waiting* (προσμένοντα) to be *attested* or *not* by closer observation (see item A on p.13 above), and so be neither true nor false. In this respect the example Lucretius has chosen to illustrate the method of multiple explanations in book VI is very appropriate after all. In VI 703-11 (item G on p.20 above), immediately preceding the account of the Nile flood, Lucretius compares the use of multiple explanations to the procedure one should adopt when viewing a dead body from afar: since no cause of death can be excluded all causes should be accepted as possible. Yet, just like the Nile, a dead body can be examined at closer range, and so (to a certain extent) reveal the causes. In cases like these, then, we may not be justified in calling every alternative explanation *true*.

In sum: all alternative explanations are true, (1) *insofar as* they concern *non-evident* phenomena which are subject to *contestation* and *non-contestation*, and (2) insofar as these phenomena are conceived of as instances of a *general type of event*, and even then we have to subscribe to a very meagre conception of *truth*, which common parlance would rather refer to as *possibility*. Gisela Striker's interpretation (see option 2 above) turns out to be not so bad after all.

I would like to add one final observation concerning *the principle of plenitude*. This principle, on which the truth of all alternative explanations rests, itself depends on the assumed existence of an infinite number of worlds, which in turn depends on the assumed existence of an infinite number of

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For the general scarcity of alternative explanations for phenomena of this class see the second paragraph of § 2.3.3 on p.113 below.

[74] Or, to be more precise: one might have done so before the completion of the Aswan Dam in 1970 which effectively cancelled the Nile's annual flooding.

atoms in infinite space. However, as we shall see in the final chapter (see p.189 below), Lucretius' argument for an infinite number of atoms may not be as strong as he would have wished.

1.3.2.4 Conclusion

Although the conclusion that Epicurus considered all alternative explanations true follows logically from his use of *non-contestation* to support individual alternative explanations and his claim that *non-contestation* establishes truth, there turns out to be much that detracts from this conclusion. His efforts to provide a more certain basis than mere *non-contestation* for his fundamental physical theories show that he did not set much value on the *truth* of multiple explanations, and Lucretius' failure to generalize the *principle of plenitude* to all instances of multiple explanations clearly shows the limitations of identifying *possibility* with *truth*. It need not surprise us therefore that Epicurus himself in the *Letter to Pythocles* most often speaks of the alternative explanations as being merely *possible*.[75]

1.3.3 Contestation

The Epicureans' criterion for rejecting theories is pretty straightforward: a theory is false if it disagrees with, or is *contested* by, the appearances (see item B on p.14 above). In practice Epicurus and Lucretius only rarely reject theories. Epicurus does, however, repeatedly mention one kind of explanations that should never be admitted in physical enquiry and especially astronomy and meteorology, viz. those explanations which attribute these phenomena to the involvement of the gods. Such an involvement, Epicurus holds, would be in conflict with the blessed nature of the gods and therefore must be rejected.[76] Several examples of such theories are mentioned by Lucretius, who in VI 379-422 argues against the popular view that thunderbolts are Jupiter's work, in VI 753-4 against the myth that crows avoid the Athenian Acropolis because of Pallas Athena's wrath, and in VI 762-6 against the belief that Avernian places are the gates to the Underworld. Yet, even explanations which do not rely on divine interference may sometimes be rejected. One example of this is, again, provided by Lucretius. In *DRN* VI 848-78 he discusses the curious behaviour of the spring near the shrine of Hammon, whose water is cold during the day and hot at night. Before embarking on his own account of the matter, he first describes and rejects a theory brought forward by 'people' (homines), who

[75] See APPENDIX A on p.243 below.

[76] Epic. *RS* 1; *Hdt.* 76-7; 81; *Pyth*. 14 [97]; 33 [113]; 36 [115-6]. Cf. Lucr. II 1090-1104; V 156-234; 1183-1240; VI 50-79; 379-422; Cic. *ND* I, 52.

claim that the sun heats the spring from below during its nocturnal passage under the earth. Lucretius rejects this theory on the ground that, if the sun were able to affect the spring from below through the vast body of the earth, it would affect the spring even more when shining down on it unimpeded by the earth. But then the spring would have to be even hotter during the day, which is not observed to happen. Although the explanation is free from religious superstition, it fails to explain the actual phenomenon and therefore must be rejected.

While for the Epicureans incompatibility with appearances is a sufficient and necessary ground for rejecting a theory, incompatibility with other theories is not. In an article written in 1978, Abraham Wasserstein faults the Epicureans for this.[77] If the Epicureans had been truly committed to science, he writes, they should have paid attention to the fact that many of their theories are interdependent so that elimination of one theory may bring along the elimination of another. For instance, the theory that the sun is extinguished at night[78] is incompatible with the theory that the moon receives its light from the sun,[79] and consequently with those explanations of the moon's phases and eclipses which presuppose that the moon shines with reflected light.[80] Although Wasserstein's observations are correct, I do not entirely agree with his point. It is true that in the *Letter to Pythocles* and in the astronomical and meteorological sections of the *DRN* phenomena are generally presented in isolation,[81] but from an Epicurean-epistemological perspective it makes no difference for a theory's possibility if it logically depends on another possible theory. It would only matter if this second theory turned out to be in conflict with appearances: in that case every theory that depends on it would share its downfall. What Wasserstein has shown, then, is not so much a flaw, as a vulnerability of Epicurus' and Lucretius' multiple explanations: if one explanation were to be eliminated – because of an inconsistency with appearances which E. and L. might have overlooked – this could lead to an avalanche of further eliminations, in some cases – where the explanations are exhaustive – even resulting in single explanations.

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[77] Wasserstein (1978) 490-4.

[78] Epic. *Pyth*. 7 [92] 1st explanation; Lucr. V 650-3, 660-2.

[79] Epic. *Pyth*. 11 [94-5] 2nd explanation; Lucr. V 705.

[80] Lucr. V 705-14 and 762-7.

[81] A salient example is Epicurus' and Lucretius' separate treatment of thunder (*Pyth*. 18 [100]; *DRN* VI 96-159), lightning (*Pyth*. 19 [100-1]; *DRN* VI 160-218) and thunderbolts (*Pyth*. 21 [103-4]; *DRN* VI 219-422), as if they were three independent phenomena, rather than symptoms of a single phenomenon. On the other hand in the *DRN* explanations of lunar phases (705-50) and eclipses (762-70) are explicitly distinguished according to whether they assume that the moon shines with its own or with reflected light.

1.3.4 Non-contestation and analogy

Until now I have managed to evade the question of how *non-contestation* establishes the *possibility* (or *truth*) of multiple explanations. Above I have argued for the existence of two kinds of truth; now it will be necessary to distinguish two kinds of possibility as well. If *non-contestation* is the absence of *contestation*, and if *contestation* of a theory consists in tracing a fatal incompatibility with the appearances (as Sextus explains), then *non-contestation* might be interpreted as the failure to trace such an incompatibility. In that case we would have established the theory's *subjective possibility*: the theory is possible as far as our knowledge goes; it cannot be excluded that at some later point in time new information may force us to reconsider and reject the theory. However, Epicurus' equation of *possibility* with *truth* clearly shows that he had in mind something more fundamental than that, viz. *objective possibility*, a possibility beyond the limitations of our knowledge, residing in the structure of the universe itself.[82] However, in order to establish such an objective possibility we would need not just the absence of *contestation*, but the certainty that the theory will *never be contested* by appearances. How can such a certainty be obtained?

In the astronomical and meteorological accounts of Epicurus and Lucretius an important role is assigned to analogy. The astronomical and meteorological sections of Lucretius' *DRN* abound in specific analogies (as does the rest of his work).[83] Almost every single explanation is illustrated by a specific analogy from everyday experience. Although, as a poet, Lucretius knows how to exploit these analogies poetically, the fact that many of his particular analogies are identical to those known from other, non-poetical, works on these subjects (like the *Syriac meteorology*[84] (see p.64 below) and Seneca's *Naturales Quaestiones*[85]) suggests that their primary role was scientific. Lucretius does not tell us what this role is, but we may perhaps learn more from Epicurus.

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[82] Allen (2001) 197.

[83] On Lucretius' use of analogies see e.g. Schrijvers (1978) and Garani (2007).

[84] Many of the parallels are noted in Daiber (1992) 272-82. The degree of correspondence is variously assessed: while Kidd (1992), 301, observes 'close parallels including the illustrative analogies' between Lucretius and the *Syriac meteorology*, Garani (2007), 97, instead notes 'the remarkable lack of correspondence between Theophrastean [this is a reference to the *Syriac meteorology*] and Lucretian analogies.'

[85] See e.g. Bailey's commentary on Lucretius book VI.

Although the number of specific analogies in the *Letter to Pythocles* is very limited[86] (probably due to its being a summary),[87] Epicurus does provide some useful theoretical remarks about the use of analogy in general. According to Epicurus (*Hdt.* 80), "we must carefully consider in how many ways a similar phenomenon is produced here with us, when we reason about the causes of the phenomena above as well as everything non-evident", and (*Pyth*. 2 [87]) "signs of what happens in the sky can be obtained from some of the phenomena here with us: for we can observe how they come to pass, though we cannot observe the phenomena in the sky: for they may be produced in several ways".[88] Even more explicit is *Pyth.* 10 [94], on the phases of the moon, which, according to Epicurus, may be accounted for "in all the ways in which phenomena here with us, too, invite us to explanations of this appearance".[89]

In these passages analogy seems to be presented as a *heuristic device*: its purpose is to *provide signs*, or to *invite us* to consider certain explanations.[90] We might be tempted at this point to ascribe to Epicurus a scientific method consisting of two neatly distinguished stages, with analogy *providing* hypotheses, and non-contestation *proving* them.[91] However, this is not the whole story. Sometimes analogy appears to be used not merely as a heuristic device, but as a *proof* in its own right.[92] This can be seen e.g. in *Pyth.* 11 [95], where two alternative theories about the light of the moon are backed up in the following way:

Καὶ γὰρ παρ' ἡμῖν θεωρεῖται πολλὰ μὲν ἐξ ἑαυτῶν ἔχοντα, πολλὰ δὲ ἀφ' ἑτέρων. καὶ οὐθὲν ἐμποδοστατεῖ τῶν ἐν τοῖς μετεώροις φαινομένων, ἐάν τις τοῦ πλεοναχοῦ τρόπου ἀεὶ μνήμην ἔχῃ καὶ τὰς ἀκολούθους αὐτοῖς ὑποθέσεις ἅμα καὶ αἰτίας συνθεωρῇ καὶ μὴ ἀναβλέπων εἰς τὰ ἀνακόλουθα ταῦτ' ὀγκοῖ ματαίως καὶ καταρρέπῃ ἄλλοτε ἄλλως ἐπὶ τὸν μοναχὸν τρόπον.	*For here with us, too, we see many things having light from themselves, and many having it from something else.* And nothing in the phenomena in the sky impedes this, if one always remembers the method of manifold causes and investigates hypotheses and explanations consistent with them, and does not look to inconsistent notions and emphasize them without cause and so fall back in different ways on different occasions on the method of the single cause. (tr. Bailey, modified, my emphasis)

[86] In *Pyth.* 6 [91] the sun is compared to terrestrial fires (οὕτω γὰρ καὶ τὰ παρ' ἡμῖν πυρὰ ... θεωρεῖται), and in 18 [100] (1) thunder-production due to the wind whirling about in a hollow cloud is compared to a similar effect occurring in vessels (καθάπερ ἐν τοῖς ἡμετέροις ἀγγείοις).

[87] On the character and structure of Epicurus' *Letter to Pythocles* see p.85ff below.

[88] Translations by Bailey, with modifications.

[89] Translation by Bailey, with modifications. A further example is found in *Pyth*. 19 [101].

[90] Allen (2001) 196-97.

[91] Allen (2001) 197.

[92] Allen (2001) 197.

The analogy with what happens 'here with us' is clearly presented as a *proof*. It is true that immediately afterwards Epicurus invokes *non-contestation* ('nothing impedes') as well, but significantly he restricts its use to 'phenomena *in the sky*' only, thereby suggesting that the 'phenomena *here with us*' have already been covered by the analogy. Apparently then, *analogy* with phenomena *here with us* implies agreement (συμφωνία) with phenomena *here with us*. If it is subsequently found that none of the phenomena *in the sky* contests either, i.e. if the explanations are not at variance with the original (celestial) object of inquiry, the explanations must be accepted as objectively possible. Other examples of this probative, as opposed to heuristic, use of analogy are found in *Pyth*. 6 [91], on the size of the sun ("for so too fires on earth ...") and *Pyth*. 15 [98], on the length of nights and days ("as we observe occurs with some things on earth, with which we must be in harmony (συμφωνία) in speaking of celestial phenomena").

According to Epicurus, then, analogy performs two functions, a heuristic and a probative one.[93] The first function logically precedes the second. If an explanation is needed, it must first be found, and then be verified. One and the same analogy may perform both functions, but not simultaneously. Once an explanation has been found, the analogy has performed its heuristic function, and can no longer serve in that capacity. Of course one may still report the specific analogy that led to the discovery of a certain theory, but such a report can no longer be called heuristic but at best historical and anecdotal. The actual heuristic use of analogy is therefore rather limited. It can never be linked with specific theories, which, after all, have been found already. Epicurus does seem to realise this. In those passages which appear to be dealing specifically with analogy in its heuristic capacity (*Hdt.* 80; *Pyth*. 2 [87] and 10 [94]), he never refers to specific explanations.[94] We might of course still view Epicurus' and Lucretius' lists of alternative explanations as the *outcome* of an extensive heuristic use of analogy on Epicurus' part, but even that isn't exactly true. As will be demonstrated below (see §1.4 on p.53ff), almost all alternative explanations offered by Epicurus and Lucretius appear to derive from earlier thinkers. Not *analogy*, it turns out, but *doxography* seems to have been Epicurus' favourite heuristic device.

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[93] See Allen (2001) 195ff

[94] At *Pyth.* 10 [94] καὶ κατὰ πάντας καθ' οὓς ... κτλ. ["*and* in all ways in which" ... etc.] does not refer back to the three explicit explanations already given, but to other explanations that may at some point in the future be added to the list.

In explaining the many specific analogies in books V and VI of the *DRN* we may therefore disregard their *heuristic* function. The main purpose of these analogies is *probative*: they *prove* the possibility of an explanation.[95]

1.3.5 Degrees of probability and personal preferences

Above we concluded that, at least with respect to a particular event, each one of a number of alternative explanations can at best be called possible. Yet, the question remains whether they are all *equally* possible. The only explicit statement on this subject is found in the Epicurean inscription of Diogenes of Oenoanda, fr.13 III 2-13, in the middle of a discussion of astronomical phenomena:

Τὸν ζητοῦντά τι περὶ τῶν ἀδήλων, ἂν βλέπῃ τοὺς τοῦ δυνάτου τρόπους πλείονας, περὶ τοῦδέ τινος μόνου τολμηρὸν καταποφαίνεσθαι· μάντεως γὰρ μᾶλλόν ἐστιν τὸ τοιοῦτον ἢ ἀ⟨ν⟩δρὸς σοφοῦ. τὸ μέντοι λέγειν πάντας μὲν ἐνδεχομένους, πιθανώτερον δ' εἶναι τόνδε τοῦδε ὀρθῶς ἔχει.	If one is investigating things that are non-evident, and if one sees that several explanations are possible, it is reckless to make a dogmatic pronouncement concerning any single one; such a procedure is characteristic of a seer rather than a wise man. It is correct, however, to say that, while all explanations are possible, *this one is more plausible than that*. (tr. Smith, slightly modified, my Italics)

The first part of this statement corresponds exactly to what we already know about Epicurus' method.[96] The last sentence, however, is not paralleled in any of Epicurus' surviving works, nor in Lucretius'.[97] Besides, there is something self-contradictory about Diogenes' words, for, after denouncing as 'seers' those who opt for a single explanation, he himself seems to be singling out one explanation under the guise of plausibility. It would have been interesting to know on what grounds Diogenes would have us consider one explanation more plausible than another, but unfortunately he either failed to inform the reader, or the relevant part of the inscription is lost. As neither Epicurus nor Lucretius have left us any explicit theoretical considerations about the admissibility or inadmissibility of applying different degrees of probability, we cannot know for certain how Diogenes' remark relates to Epicurean orthodoxy. In the absence of theoretical considerations any practical application of the principle would be of help too.

In the *Letter to Pythocles*, however, Epicurus nowhere expresses a preference for any particular explanation. We do, however, have one

[95] This does not mean that they may not perform other functions too; many of the analogies in Lucretius seem to have an illustrative function as well: they help the reader form a mental picture by providing a conceptual model. Besides they often provide Lucretius with an excellent excuse to show off his poetic genius.

[96] For parallels in Epicurus and Lucretius, see Smith (1993), 455, n.8.

[97] So Algra (2001) n.28.

testimony which might be interpreted as attributing to Epicurus just such a personal preference. In the *Naturales Quaestiones*, VI 20, 7, Seneca, having just reported a whole list of alternative explanations of earthquakes as brought forward by Epicurus, concludes with the following words:

Nullam tamen illi {sc. Epicuro} placet causam motus esse *maiorem* quam spiritum.	No cause of an earthquake, however, Epicurus deems to be *greater* than wind.

One's interpretation of these lines depends strongly on the meaning one wishes to attribute to *maiorem*, '*greater*'. One possible meaning in this context would indeed be '*more likely*'. Epicurus might have said that, although there are many possible causes, those involving wind are the *most likely*. However, as with most meteorological occurrences, an earthquake is not a single, recurrent, phenomenon, but every earthquake stands alone. It is perfectly possible, therefore, that one earthquake is brought about by cause A, while another is caused by B. Under these circumstances '*more likely*' is almost equivalent with '*more frequent*', which – in this context – is another possible interpretation of *maiorem*. So, Epicurus might have said that, although earthquakes can be, and are, produced by many different things, they are *most often* produced by wind. Yet, there is another possible interpretation. Different causes may have different effects. *Maiorem* in this context may also mean '*more powerful*'. Epicurus may have said that, although earthquakes can be, and are, produced by many different things, the *strongest* ones are produced by wind. That this is in fact the correct interpretation is borne out by the way in which Seneca continues (VI 21, 1):

Nobis quoque placet hunc spiritum esse qui possit tanta conari, quo nihil est in rerum natura potentius, nihil acrius, sine quo ne illa quidem quae uehementissima sunt ualent.	We (i.e. the Stoics) too believe that it is this wind, which can attempt so much, which is mightier and fiercer than anything in nature, without which not even those things which are strongest have power.

So, according to Seneca, Epicurus held that wind is the *most powerful* cause of earthquakes. Like Seneca himself, Epicurus may have been brought to this view by Aristotle.[98] Be that as it may, Seneca's testimony cannot serve

[98] Arist. *Mete.* II 8, 365b29 – 366a5: "Our next step should therefore be to consider what substance has the greatest motive power. This must necessarily be the substance whose natural motion is most violent. The subsance most violent in action must be that which has the greatest velocity, as its velocity makes its impact most forcible. The farthest mover must be the most penetrating, that is the finest. If, therefore, the natural constitution of wind is of this kind, it must be the substance whose motive power is the greatest. For even fire when conjoined with wind is blown to flame and moves quickly.

to confirm that Epicurus himself admitted different degrees of probability, or ever voiced personal preferences for any one of the alternative explanations. So much for Epicurus himself.

As for Lucretius: there is one instance in the *DRN* where Lucretius seems to express a preference for a particular explanation. At V 621-2 he introduces his first explanation of the yearly and monthly motion of the sun and the moon with the following words:

Nam fieri vel *cum primis* id posse videtur,	For, *in the first place* it seems that this may be the case,
Democriti quod sancta viri sententia ponit: …	what the sacred opinion of the man Democritus states: …

There is some ambiguity in the words 'cum primis'. 'Cum primis' or 'cumprimis' literally means: *with* or *among the first*. This can in principle be interpreted in two ways:

1. Most often 'cum primis' or 'cumprimis' (like the synonymous 'in primis' or 'imprimis') is used to indicate that what is said is so *in the highest degree,* or *particularly*.[99] On this interpretation 'vel' is best understood as an intensifying particle[100] with 'cum primis': '*among the* ***very*** *first'*. In the present case this would mean that Democritus' theory seems to be possible in the highest degree. This interpretation underlies the translations of e.g. Rouse & Smith ('For among the *most likely* causes is that ...') and Leonard ('Yet *chief in likelyhood* seemeth the doctrine ...').

2. Occasionally 'cum primis' or 'cumprimis' is used to indicate *the first item in a series*.[101] (Its synonym 'in primis' or 'imprimis' is actually used in this sense quite often).[102] Interpreted in this way the expression may be rendered as *for a start* or *to begin with*. 'Vel' may again be an intensifier with 'cum primis',[103] or it may be used to imply "that other instances might be mentioned at will".[104] Used in this sense 'vel' may be rendered as 'for instance' or 'for example'. This second interpretation is followed by e.g. Bailey ("For, *first and foremost*, it is clear that it may come to pass ...") and Ernout ("*Tout d'abord* il est possible semble-t-il, que les choses se passent

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So the cause of earth tremors is neither water nor earth but wind, which causes them when the external exhalation flows inwards" (transl. Lee).

[99] Lewis & Short 'primus' II B & '1. cum' II D; *OLD* 'cum[1]' 6e & 'primus' 15c (cf. *OLD* 'imprimis' 1).

[100] Lewis & Short 'vel' II B 1&2; *OLD* 'vel' 5c.Cf. Lucr. VI 1237 "vel in primis".

[101] *Not* in the *OLD* and Lewis & Short, but see Plaut. *Truc*. 660-1: "eradicarest certum *cumprimis* patrem,/ *post id locorum* matrem." and Apul. *Flor.* 16, 36: "*cum primis* commemorauit inter nos iura amicitiae {…}; *tunc postea* uota omnia mea {…} recognouit." *TLG* 'cumprimis' fails to distinguish different meanings.

[102] *OLD* 'imprimis' 2.

[103] See note 100.

[104] Lewis & Short 'vel' II C. Cf. *OLD* 'vel' 4 a&b.

...”). See also Bailey’s comment at V 621: “This makes it clear that Lucr. intends to expound *the first of a series* of alternative causes {...}”.

Which of these two interpretations is the right one? The first interpretation attributes to Lucretius a preference for Democritus’ view. Such a preference, however, seems to be unmotivated. The only way in which the present account differs essentially from other explanations in the astronomical and meteorological sections of *DRN*, is the explicit attribution to Democritus, whom Lucretius clearly admires. Yet admiring Democritus does not necessarily imply a preference for his theories: in III 370-3 another theory of Democritus, introduced with the same words of admiration (III 371 = V 622), is flatly rejected! It remains unclear, therefore, why in this case Democritus’ view should be considered to be *among the most likely causes*. Besides, such a preference for a single theory is also quite unprecedented in the *DRN*. Books V and VI contain scores of problems for which several alternative explanations are offered. Why should Lucretius in this one case express his preference, and nowhere else? Finally, such a preference seems also to be unwarranted by Lucretius’ own methodological remarks. Less than 100 lines earlier Lucretius stressed that out of several possible causes “one {...} is necessarily the case here, / {...} but which of them it is, / is not for them to lay down who proceed step by step.” (V 531-3).[105] If Lucretius had thought it permissible to assign different degrees of probability to the alternative explanations *this* would have been the place to say so. But he did not. For these reasons I think this interpretation should be rejected. The second interpretation, although based on a less frequent use of the expression ‘cum primis’, provides a good alternative, which avoids all of the above problems.

This brings us back to Diogenes of Oenoanda’s assertion that “it is correct {...} to say that, while all explanations are possible, *this one is more plausible than that*.” Not only is the claim itself without precedent in earlier Epicurean writings, but now our search for *applications* of this principle has yielded nothing either. It seems safe to assume, therefore, that Diogenes’ assertion is a later innovation. We do not know what the reason for this innovation was, nor how Diogenes himself applied it, but perhaps one example of its application can be unearthed from the ruins of his inscription.

Diogenes’ claim is part of a fragment (fr.13) that begins with a promise to deal with the risings and settings of the sun, a problem for which Epicurus (*Pyth*. 7 [92]: see p.17 above) and Lucretius (V 650-79) had proposed two possible explanations. Unfortunately Diogenes’ fragment breaks off before he

[105] For a fuller quotation, see above, p.19.

can deal with this specific problem. The same problem, however, is also discussed in another fragment (fr.66), where Diogenes criticises certain adversaries for "dismissing the unanimous opinion of all men, both laymen and philosophers, that the heavenly bodies pursue their courses round the earth both above and below ..." (tr. Smith). It is clear that Diogenes himself shares this 'unanimous opinion of all men', silently passing by Epicurus' alternative explanation according to which the heavenly bodies are extinguished at night.

It is possible that with other astronomical problems too Diogenes preferred to follow the generally accepted view, and he may have found this appeal to greater and lesser plausibility a convenient way to express these preferences without explicitly rejecting Epicurus' alternative explanations, thus reconciling Epicurean orthodoxy with the accepted astronomical views of his time.[106]

1.3.6 Lucretius' supposed preference for the theories of the mathematical astronomers.

Although in the astronomical sections of Epicurus' and Lucretius' works we have found no *explicit* preferences for any one of a number of alternative explanations, there are some passages in the *De rerum natura* where Lucretius is believed to betray at least an *implicit* preference for a certain class of explanations. If true, this observation would contradict our earlier conclusion that Lucretius, like Epicurus, was impartial to the individual alternative explanations. It will be necessary therefore to deal with this claim as well.

On p.58 of his commentary Bailey writes: "in the astronomical passages he [i.e. Lucretius] frequently places the right explanation first, as though he had a personal preference for it". The point is repeated on p.1394, in the introduction to Lucretius' astronomical section of V 509-770: "It should, however, be noticed that Lucr. usually places the true explanation first, as though he really preferred it." Out of context, Bailey's observation seems a bit trivial, for: who wouldn't prefer the *right* and *true* explanation? In order to understand what Bailey really means by these terms, we must have a closer look at his comments on the individual sections of Lucretius' astronomical passage.

On p.1439, commenting on Lucretius' discussion of the phases of the moon in V 705-50, Bailey writes: "This [i.e. the first] view {…} is clearly the view of the astronomers to whom Lucr. refers as his authorities in 713-14, and again as the *astrologi* in 728. {...} Lucr. therefore included it, and probably by placing it first meant to suggest that he believed it to be the right explanation

[106] With respect to meteorological phenomena Diogenes seems to have had no qualms about offering alternative explanations: see fr.14 on the causes of hail, and fr.98.8-11 on the causes of earthquakes.

...", and on pp.1446-7, commenting on Lucretius' discussion of solar and lunar eclipses in V 751-70: "This [i.e. the first] theory, which was no doubt that of the 'astronomers' and is in fact the true explanation {…} is to be compared with the first theories put forward in 682-95 and 705-14. {…} Once again Lucr. by putting this theory first appears to give it the preference ..."

Apparently then, when Bailey speaks of the 'right' and the 'true' explanation he means the explanation of the mathematical astronomers, *which happens to be the true explanation*. But Lucretius couldn't have known that. That is precisely the point of his offering multiple explanations: that one cannot know for certain which is the right one.[107] What he could have known, and did know, is that certain explanations came from the stock of the (mathematical) astronomers or 'astrologi' as he calls them. We may therefore rephrase Bailey's observation as follows: "In the astronomical passages Lucretius frequently places the explanation of the mathematical astronomers first, as though he had a personal preference for it."

Now there are two sides to this observation: (a) the observed fact, and (b) Bailey's interpretation of the fact. Let us first turn to the observed fact: "in the astronomical passages Lucretius frequently places the explanation of the mathematical astronomers first."

In the astronomical section Lucretius covers the following eleven subjects:

1. Motions of the stars (509-533)
2. Immobility of the earth (534-563)
3. Size of the sun, moon and stars (564-591)
4. Source of the sun's light and heat (592-613)
5. Turnings of the sun, moon and planets (614-649)
6. Causes of nightfall (650-655)
7. Causes of dawn (656-679)
8. Varying lengths of day and night (680-704)
9. Phases of the moon (705-750)
10. Solar eclipses (751-761)
11. Lunar eclipses (762-770)

Two of these subjects (2 and 3) do not, apparently, admit of more than one explanation, and the explanation given in each case is certainly not that of the mathematical astronomers. Lucretius explains the immobility of the earth on the assumption that it floats on a cushion of air, a view not easily reconciled with the spherical earth of mathematical astronomy (see Chapter 3 and esp.

[107] See e.g. *DRN* V 526-33 (see text on p.19 above).

§3.3.6 below), and the heavenly bodies he claims to be the size they appear to be, which is usually interpreted as being very small, whereas the mathematical astronomers, for all their different estimates, at least agreed that the sun and the stars are much larger than the earth, and only the moon somewhat smaller.[108] That leaves us with nine cases where we can test Bailey's observation.

The first of these, about the (daily?) motions of the stars, is problematic. Lucretius offers *five* possible explanations in all, which – however – fall into *two* main divisions: either (a) the whole sphere of the sky revolves, carrying the heavenly bodies along, or (b) the sky stands still, while the heavenly bodies move independently. The first option was – in fact – the view of the mathematical astronomers.[109] Lucretius, however, goes on to subdivide these main divisions, offering two possible physical explanations for the first option, and three for the second, in a way that goes beyond the constraints of mathematical astronomy, which only concerned itself with the mathematical, i.e. quantitative and geometrical, aspects of astronomy.[110] It remains unclear, therefore, whether we should consider this passage a case in point. Bailey himself does not seem to have viewed it as such, for in his commentary to this passage he makes no reference to his own observation.

The next subject where a plurality of explanations comes into play is item 4, on the source of the sun's light and heat. Lucretius offers three explanations, none of which can be related to the mathematical astronomers. In fact the ancient astronomers have left us no view on this subject at all, which falls outside the scope of their competence, i.e. the quantitative and geometrical aspects of astronomy (see above).

The following subject (5), the turnings of the sun, moon and planets, falls well within the competence of the mathematical astronomers and we know what their solution to this problem was. According to the astronomers, the sun, the moon and the planets exhibit a slower, secondary, east-ward motion on top of the daily, west-ward, revolution of the fixed stars. This secondary motion they all perform more or less along the same circular path, the so-called zodiac. The zodiac is not parallel to the equator but inclined to it by an angle of about 23.5°. This fact was referred to in antiquity as *the obliquity of the zodiac* – ἡ λόξωσις τοῦ ζῳδιακοῦ / obliquitas signiferi (sc. orbis /

[108] Cf. Cleomedes II 1-3 (esp. II 3.68ff). See also Heath (1913) 328-350, esp. the tables on p.332 and p.350.

[109] Evans (1998), p.75 with nn.3 and 4.

[110] See e.g. Arist. *Ph.* II 2, 193b22ff; Stoics apud D.L. VII 132; Posidonius F18 E-K (= Geminus apud Alexandrum apud Simplicium *In phys*. 291.21-292.21); Sen. *Ep.* 88.25-28; Strabo 1.1.20 & 2.5.2; etc. For modern views on the matter see e.g. Bowen-Todd (2004), 6 & 193-9, and Evans (1998), 217-219.

circulus). In Epicurus' own treatment of the subject, in the *Letter to Pythocles* 9 [93], this explanation is the first to be mentioned.[111] Lucretius too shows himself to be aware of the existence of this explanation, for, in a later passage (8), when discussing the related problem of the varying lengths of day and night, he clearly alludes to it.[112] In the present passage, however, he doesn't say a word about it. So, far from placing the mathematical astronomers' view first, Lucretius chooses to ignore it. Instead, as we have seen, he starts with an explanation explicitly ascribed to Democritus.

The first instance where Lucretius *does* include the view of the mathematical astronomers among a number of possible explanations is subject 6, on the causes of nightfall. Night ensues, he says, either because the sun, upon reaching the westernmost point of its orbit, is extinguished, or because the sun, upon reaching this point, passes out of sight below the plane of the earth. Once again Lucretius does *not* conform to Bailey's observation: the view of the mathematical astronomers is presented second, not first.

The next subject (7), on the causes of dawn, is the mirror image of the previous subject. Again Lucretius gives us two explanations, which correspond *chiastically* to the two possible causes of nightfall: either the same sun, having reached the easternmost limit of its orbit, emerges again above the plane of the earth, or a new sun is born from small fires which collect in the eastern sky each morning. This time, at last, the view of the mathematical astronomers is presented first.

The rest of the subjects (8-11) also follow this pattern, thereby conforming to Bailey's observation. Mathematical astronomers explained (8) the seasonal variation of the length of nights and and days with reference to the sun's position in the slanting zodiacal belt, (9) the phases of the moon with reference to the relative positions of the sun and the moon – assuming that the latter shines with light reflected from the former –, (10) solar eclipses as the moon blocking the sun from our view, and (11) lunar eclipses as the moon falling into the earth's conical shadow and so being deprived of the sun's light. In Lucretius' account each of these theories is the first of a number of alternative explanations. The following table sums up our findings:

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[111] Τροπὰς ἡλίου καὶ σελήνης ἐνδέχεται μὲν γίνεσθαι κατὰ λόξωσιν οὐρανοῦ οὕτω τοῖς χρόνοις κατηναγκασμένου ...

[112] *DRN* V 691-3: ... propter signiferi posituram totius orbis, / annua sol in quo concludit tempora serpens, / obliquo terras et caelum lumine lustrans ...

Table 1-1: Place of the mathematical astronomers' explanations in the astronomical section of *DRN*

Passage	Subject	Number of explanations	View of the mathematical astronomers
509-533	1. Motions of the stars	5	-
534-563	2. Immobility of the earth	1	-
564-591	3. Size of the sun, moon and stars	1	-
592-613	4. Source of the sun's light and heat	3	-
614-649	5. Turnings of the sun, moon and planets	2	-
650-655	6. Causes of nightfall	2	2
656-679	7. Causes of dawn	2	1
680-704	8. Varying lengths of day and night	3	1
705-750	9. Phases of the moon	4	1
751-761	10. Solar eclipses	3	1
762-770	11. Lunar eclipses	3	1

Only 5 out of 11 cases seem to conform to Bailey's thesis. If, however, we confine ourselves to those subjects where the view of the mathematical astronomers is included at all, the ratio becomes 5 to 6, which seems significant enough. We may safely conclude therefore that the explanations of the mathematical astronomers *were* somehow privileged, although we do not yet know why or in what way.

In only two of these cases the mathematical astronomers are explicitly mentioned or implied in a meaningful way. In lines 694-5, at the end of his first explanation of (8) the variation of day-length, Lucretius speaks of those "who have mapped the places of the sky, / all adorned with stars properly arranged",[113] which is a clear reference to the mathematical astronomers, who typically demonstrated their theories by means of celestial globes and planetaria.[114] In lines 727-8, at the end of the *third* explanation of (9) the phases of the moon Lucretius speaks of the "art of the astronomers" (*astrologorum artem*), by which he appears to be referring back to the *first* explanation of that section. Apparently Lucretius assumes his reader to be familiar enough with contemporary astronomy to recognize this reference. In the same way the reader may be assumed to recognize the other, unidentified, references to the mathematical astronomers as well.

[113] *DRN* V 694-5: ... qui loca caeli / omnia dispositis signis ornata locarunt.

[114] Plato, *Ti*. 40c-d, claims that the planetary motions can be properly demonstrated by means of a visible model only, and Epicurus, *Pyth*. 9 [93] (cf. *On nature* XI fr.38 Arr. with Sedley (1976), 32, 37-39), seems to associate the use of such models with mathematical astronomy. On the use of visibile model in astronomy see Cornford (1937) 74-6; and Evans (1998) 78-84.

According to Bailey, the privileged position of the mathematical astronomers' explanations indicates that Lucretius himself preferred these over the other views, believing them to be the right ones. To Bailey this is so self-evident that he doesn't even bother to defend this assertion. In fact, his claim is quite unfounded. Not only is such a preference, as we have seen, hard to reconcile with Lucretius' insistence that all explanations offered have an equal claim to the truth (526-33), but it actually fails to take into account certain clues provided by Lucretius himself in several of the relevant passages.

The first of these clues is at 713-14, where Lucretius concludes his first explanation of the phases of the moon (i.e. the explanation of the mathematical astronomers) with the following words:

ut faciunt, lunam qui **fingunt** esse pilai consimilem cursusque viam sub sole tenere.	as they hold, who **imagine** the moon to be like a ball and to keep the path of her course below the sun.

Throughout the *DRN* the verb 'fingere' is used to stress the *unfoundedness* and even *falsehood* of theories,[115] which are subsequently rejected. It would be most surprising if Lucretius would now use this same verb to refer to a theory which, in Bailey's words, "he believed [..] to be the right explanation."

Another clue, which will require a bit more work, but may also help us to find the real reason why Lucretius gives priority to the explanations of the mathematical astronomers, is found at the end of the astronomical passage (lines 751-770), where Lucretius discusses the causes of (10) solar and (11) lunar eclipses. In his discussions of other astronomical phenomena Lucretius simply enumerates his multiple explanations, saying something like: 'phenomenon X may be caused by A, or B, or C, etc.', where A most often represents the view endorsed by mathematical astronomy. However, in his discussions of solar and lunar eclipses Lucretius employs a slightly different structure. This is Lucretius' account of solar eclipses (753-761):

[115] See e.g. I 371, I 842, I 847, I 1083, II 175 and V 908.

A	nam cur luna queat terram secludere solis lumine et a terris altum caput obstruere ei, obiciens caecum radiis ardentibus orbem,	For why should the moon be able to shut off the earth from the sun's light and obstruct the sun's high source from the earth, by interposing her dark orb to his burning rays,
B	tempore eodem aliut facere id non posse putetur corpus, quod cassum labatur lumine semper?	and not at the same time some other body, which always glides with unseen light, be thought able to achieve this?
C	solque suos etiam dimittere languidus ignis tempore cur certo nequeat recreareque lumen, cum loca praeteriit flammis infesta per auras, quae faciunt ignis interstingui atque perire?	and why could not the sun at a certain time from wearyness dismiss his fires and then again renew his light, when he has passed the regions harmful to his flames, which make his fires go out and die?

And this is how Lucretius explains lunar eclipses (762-770):

A	et cur terra queat lunam spoliare vicissim lumine et oppressum solem super ipsa tenere, menstrua dum rigidas coni perlabitur umbras,	And why should the earth in turn be able to rob the moon of light, and keep the sun oppressed, being herself above, while in its monthly course the moon glides through the rigid shadows of the cone,
B	tempore eodem aliud nequeat succurrere lunae corpus vel supra solis perlabier orbem, quod radios inter rumpat lumenque profusum?	and not at the same time some other body be able to pass beneath the moon or glide above the solar orb, to interrupt his rays and flood of light?
C	et tamen ipsa suo si fulget luna nitore, cur nequeat certa mundi languescere parte, dum loca luminibus propriis inimica per exit?	and if, after all, the moon shines of herself with her own light, why could she not grow faint in a certain part of heaven, while passing through regions hostile to her own light?

For each of the two phenomena Lucretius offers three possible explanations, but, instead of simply enumerating them, as he usually does, he now marshals them into the format of a rhetorical question. The structure is the same in both cases: 'Why should the (solar/lunar) eclipse be caused by 'A', and not by 'B' or 'C'?' The implied answer is, of course, that there is *no good reason* to prefer A over B and C. (So much for Bailey's interpretation!) Yet, the way the question is put also suggests something else. Lucretius seems to be particularly worried that someone might consider 'A', i.e. the mathematical astronomers' view, the only possible explanation. That someone might single out 'B' or 'C' in this manner does not seem to worry him at all! Why is that? Is it intrinsically worse to accept the view of the astronomers rather than any of the other theories? That is *not* what Lucretius is saying. Throughout the astronomical passage he has insisted upon the *equal* plausibility of each alternative explanation: no explanation is better or worse than any other. So, why then does Lucretius single out the explanation of the mathematical astronomers?

An account with a somewhat similar rhetorical structure is found in the astronomical passage of Epicurus' *Letter to Pythocles*. Here, in chapter 32 [112] Epicurus writes:

	Τινὰ ⟨ἄστρα⟩ στρέφεται αὐτοῦ, ὃ συμβαίνει	Some stars revolve in their place, which comes to pass
A	οὐ μόνον τῷ τὸ μέρος τοῦτο τοῦ κόσμου ἑστάναι, περὶ ὃ τὸ λοιπὸν στρέφεται, καθάπερ τινές φασιν,	not only because this part of the world is stationary and round it the rest revolves, as some say,
B	ἀλλὰ καὶ τῷ δίνην ἀέρος ἔγκυκλον αὐτοῖς περιεστάναι, ἣ κωλυτικὴ γίνεται τοῦ περιπολεῖν ὡς καὶ τὰ ἄλλα,	but also because a whirl of air is formed in a ring round it, which prevents their moving about as do the other stars,
C	ἢ καὶ διὰ τὸ ἐξῆς μὲν αὐτοῖς ὕλην ἐπιτηδείαν μὴ εἶναι, ἐν δὲ τοῦτῳ τῷ τόπῳ ἐν ᾧ κείμενα θεωρεῖται,	or else it is because there is not a succession of appropriate fuel for them, but only in this place in which they are seen fixed,
	καὶ κατ' ἄλλους δὲ πλείονας τρόπους τοῦτο δυνατὸν συντελεῖσθαι, ἐάν τις δύνηται τὸ σύμφωνον τοῖς φαινομένοις συλλογίζεσθαι.	and there are many other ways in which this may be brought about, if one is able to infer what is in agreement with appearances. (tr. Bailey, slightly modified)

This passage is concerned with the problem (not discussed by Lucretius) why some stars (e.g. those of Ursa Major and Minor) never set but revolve in their place. The first option, 'A', corresponds to what the mathematical astronomers said. Although Epicurus – like Lucretius – is normally perfectly happy to present his alternative explanations in the form of an uncomplicated disjunction ('either A or B or C'),[116] this time he has chosen a slightly more complex formulation: 'not only A, but also B and C'. This formulation implies that Epicurus in reality only contemplates the possibility that someone might say 'A', *not* that someone might say 'B' or 'C'. This is confirmed by the words "as some say" («καθάπερ τινές φασιν»), which Epicurus adds to explanation A. Apparently, explanation A had some actual support, which B and C, as far as we are told, had not.

Something similar seems to be the case with Lucretius' account of eclipses. In order to confirm this I will try to establish the extent of the contemporary support for view A, and the lack of such support for the alternative views, B and C. I will start with Lucretius' account of *lunar* eclipses (V 762-770). A useful piece of information is provided by Aëtius, who in his chapter on the phases and eclipses of the moon (II 29), also reports a view that can be identified with Lucretius' first explanation of lunar eclipses (together with an account of the phases):

[116] See note 53 above, and the text thereto. For the various connectors used by Epicurus to articulate his lists of alternative explanations, see APPENDIX A on p.243ff below.

Θαλῆς ’Αναξαγόρας Πλάτων ’Αριστοτέλης οἱ Στωικοὶ τοῖς μαθηματικοῖς συμφώνως τὰς μὲν μηνιαίους ἀποκρύψεις συνοδεύουσαν αὐτὴν ἡλίῳ καὶ περιλαμπομένην ποιεῖσθαι, τὰς δ’ ἐκλείψεις εἰς τὸ σκίασμα τῆς γῆς ἐμπίπτουσαν, μεταξὺ μὲν ἀμφοτέρων τῶν ἀστέρων γινομένης, μᾶλλον δὲ τῆς σελήνης ἀντιφραττομένης.	Thales, Anaxagoras, Plato, Aristotle and the Stoics (declare) in agreement with the mathematical astronomers that it (the moon) produces the monthly concealments by travelling together with the sun and being illuminated by it, and the eclipses by descending into the shadows of the earth which interposes itself between the two heavenly bodies, or rather when the moon is obstructed (by the earth).[117]

According to this report, Lucretius’ first explanation, which Bailey attributed to the astronomers, was also accepted by Thales, Anaxagoras, Plato, Aristotle and the Stoics. Thales and Anaxagoras, who had been long dead and left no schools to continue their thought, are irrelevant for the present purpose, but Plato and Aristotle, whose teachings were still followed in Lucretius’ time, and the Stoics, who had become the most influential philosophical sect of the period, are very relevant. From Aëtius’ report, which is confirmed by many other sources,[118] it appears that Lucretius’ first explanation was the view, not just of the mathematical astronomers, but of every major school of philosophy still in existence in Lucretius’ day, Epicureanism excepted. The second and third explanations, on the other hand, do not seem to have been entertained by anyone later than Anaxagoras, who believed that lunar eclipses were also caused by interposition of other, unseen, heavenly bodies beside the earth, and Xenophanes, who ascribed all such phenomena to extinction and rekindling.[119]

Much the same can be said about Lucretius’ treatment of solar eclipses (V 753-561): his first explanation can again be attributed, not just to the mathematical astronomers, but to Aristotle and the Stoics and probably Plato

[117] I have basically followed the reconstruction offered by Mansfeld & Runia (2009a), 613-23, although I have opted for Stobaeus’ *lectio difficilior* «τοῖς μαθηματικοῖς συμφώνως» (‘in agreement with the mathematical astronomers’) instead of Plutarch’s «οἱ μαθηματικοὶ συμφώνως» (‘and the mathematicians in agreement’), a variation which M&R do not comment upon. The translation is freely adapted from M&R to suit my different reading of the text as well as my personal taste.

[118] The attribution of this theory to Plato cannot be verified from his own works, but that he accepted the view that the moon is illuminated by the sun is clear from *Resp.* X 617a (with Heath (1913) 158); cf. *Cra*. 409a-b. Aristotle refers to the theory in *Cael.* II 14, 297b24-31, *Mete*. II 8, 367b20-22; *Metaph*. VIII 4, 1044b9-15; *An. Post.* I, 31, 87b39-a2; II 2, 90a15-18; et passim. For the Stoics see e.g. *SVF* I 119, 120; II 676, 678 and Cleomedes II 6.

[119] For attempts to identify Lucretius’ theories with those of his predecessors see the various commentaries.

too,[120] while the second cannot be related to anyone at all, and the third to no-one later than Xenophanes.[121]

In sum, Epicurus in the passage just quoted and Lucretius in his account of solar and lunar eclipses both start with the view of the astronomers, because that was the view that most people, including the other major philosophical schools, believed to be uniquely true. To this view Epicurus and Lucretius oppose other views that may not be current and popular, but which they consider equally possible.

It seems reasonable to suppose that the same pattern applies also to the other cases in the astronomical section of the *DRN* where Lucretius starts with the view of the astronomers:

(7) The view that dawn is caused by the same sun re-emerging from below the horizon can safely be attributed to Plato, Aristotle and the Stoics,[122] all of whom conceived of the heavenly bodies as permanent entities, and we even have the explicit statement of a later Epicurean, Diogenes of Oenoanda (fr.66), that this was 'the *unanimous* opinion of all men, both laymen and philosophers'. On the other hand, the alternative view that the sun is rekindled every morning can at best be assigned to Xenophanes, and perhaps Heraclitus and Metrodorus of Chios as well, but to no one later.[123]

(8) The theory that the annual variations in day-length are caused by the obliquity of the zodiac was at least maintained by the later Stoic Cleomedes,[124] while the theory of the obliquity of the zodiac as such is attributable to Plato,

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[120] Plato, *Ti*. 40c-d, rightly attributes (solar and lunar?) eclipses to the interposition of another heavenly body (see also Cornford (1937) 135-6); for Aristotle see *Div. Somn*. 1 462b28-29; for the Stoics see *SVF* I 119; II 650 etc.

[121] For attempts to identify Lucretius' theories with those of his predecessors see the various commentaries.

[122] For the Stoics see also Ar. Did. fr.32 (= *SVF* II 683) and Cleom. II 1.426-466.

[123] Xenophanes A32, A33, A38, A40; Heraclitus B6; Metrodorus of Chios A4 D-K. On the other hand, the theory that the sun is quenched and rekindled is explicitly rejected by the Peripatetic Eudemus apud Theon phil. *Expos.* 199.21-22; and the Stoic Cleomedes II 1.426-466; further by Ptol. *Alm.* I 3, 11.24 – 12.18 (= I 1, 12 Heiberg); and Theon math. *Comm. in Ptol. synt.* 340-1 (Rome).

[124] Cleom. I 3.76 – 4.1-17. See also Gem. 6,29ff, Vitruv. IX 3, 1-3 and Plin. *N.H.* II 17, 81.

Aristotle and the Stoics in general.[125] The two alternative views, on the other hand, do not seem to have been held by anyone at all.[126]

(9) The section on the phases of the moon presents a slightly different story. Lucretius offers four alternative explanations. The first explanation – according to which the moon is illuminated by the sun, and the phases result from the changing relative positions of the two bodies – is easily recognized as the view of the mathematical astronomers.[127] Lucretius does not, at this point, explicitly identify them, apart from the vague reference to those "who imagine the moon to be like a ball".[128] Yet, the use of present tense and plural already suggests that the theory did at least have some advocates in Lucretius' day. In this particular case, however, the astronomers' view seems to have met with a more serious challenge: at the end of his *third* explanation – according to which the moon is a sphere, one half of which is fiery, and which by revolving around its own axis produces the phases – Lucretius writes (727-730)[129]:

ut Babylonica Chaldaeum doctrina refutans astrologorum artem contra convincere tendit, proinde quasi id fieri nequeat quod pugnat uterque aut minus hoc illo sit cur amplectier ausis.	as the Babylonian doctrine of the Chaldeans, refuting the science of the astronomers, strives to uphold against them; just as if that which each of them fights for could not be, or as if there were less reason to embrace this than that.

The Babylonian theory is presented differently from the other two alternative explanations. Whereas the second and fourth explanations are, as we have come to expect, mere museum pieces, the view of the Chaldeans still

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[125] Ascription to Plato and Aristotle in Aët. II 23.5, and to the Stoics in *SVF* I 542, II 650.3 & 651.5 (= D.L. VII 144.3 & 155.9). For Plato see also *Ti.* 36b-d & 38e-39a (with Heath (1913) 159-60; or Cornford (1937) 72ff). For Aristotle see *Gen. Corr.* I 10.336a32-b24, 337a8 and *Metaph.* XII 5.1071a16 & 8.1073b17ff. The theory is also described by Aratus 525-544 and Vitr. IX 1,3.

[126] See the various commentaries *ad loc.*

[127] Aëtius II 29 (see p.47 above) ascribes the theory to the mathematical astronomers, Plato, Aristotle and the Stoics. The attribution of this theory to Plato cannot be verified from his own works, but he certainly accepted the view that the moon is illuminated by the sun (see n.118 above). Aristotle alludes to the astronomical theory of the lunar phases in *Cael.* II 11, 291b18-21 and *An. post.* I 13, 78b4-11. For the Stoics cp. D.L. VII 145 (= *SVF* II 650). Later Stoics (perhaps from Posidonius onwards: see Bowen-Todd (2004) 138 n.8, 141 n.19) held a slightly different theory, maintaining that the moon, on the side where it is touched by the rays of the sun, responds by emitting its *own* light: see Cleom. II 4, 21-32. On this later Stoic view see also p.49 (following n.130) below.

[128] *DRN* V 713-4: lunam qui fingunt esse pilai / consimilem ...

[129] The language used to describe this clash of opinions (esp. 'convincere') is the language of a law court. For other instances of conflicting views being described in judicial terms cf. Epic. *Pyth.* 10 [94] ἀποδοκιμάζῃ (Bailey (1926): 'put out of court'), Sen. *NQ* IVB 5.1 'litigant' (Corcoran: 'pleading in court'), and Hor. *AP* 78 'grammatici certant, et adhuc sub iudice lis est'.

seems to have been able to muster some real support among Lucretius' contemporaries and later. This is confirmed by several other sources. In Vitruvius' *De architectura* IX 2, written several decades after the death of Lucretius, two different theories of the phases of the moon are presented. The first, which corresponds to Lucretius' third explanation, is attributed to Berosus *the Chaldean*, and the second, which corresponds to Lucretius' first explanation, is attributed to the *mathematician* Aristarchus of Samos. It is significant that Vitruvius does not choose between the two. The same impartial attitude towards these two explanations we also encounter in Apuleius' *De deo Socratis* 1.14-30 and Augustine's *Enarratio in Psalmos 10, 3*. According to Augustine, both theories are probable, but it is humanly impossible to know which one is true. A different approach is found in the work of the Stoic Cleomedes, who may have lived some time around 200 AD.[130] In II 4.1, Cleomedes discusses no less than *three* different theories concerning the phases of the moon. The first is again that of Berosus, the second the traditional view of the astronomers and the Peripatetics,[131] and the third a Stoic modification of the former, according to which the moon, on the side where it is touched by the rays of the sun, responds by emitting its own light. As a Stoic, Cleomedes of course opts for the third alternative, but what is significant here is that he feels compelled to refute not only the theory of traditional astronomy, but also that of Berosus, as if *both* theories were *equally* relevant. We may assume therefore that Berosus' theory was widely regarded as a reasonable alternative to the view of the astronomers, and one which could not be discarded as easily as other alternative theories. Lucretius shows himself to be aware of this. He chooses, however, to stick to his usual pattern, starting with the theory of the astronomers, and leaving the competing view of the Chaldeans for later.

We have now established that Lucretius, when choosing to include the explanation of the mathematical astronomers, usually mentions it first. By doing so, Lucretius demonstrates both his awareness of the predominant position of their theories, and his determination to combat this predominance by pointing out that other solutions, whether newly invented or long-forgotten or still in vogue (like the Chaldean theory of lunar phases), are just as plausible.

In the discussion above we have also examined one passage in Epicurus' *Letter to Pythocles*, viz. ch.32 [112], which – like Lucretius, and for probably

[130] For Cleomedes' dates, see Bowen-Todd (2004) 2-4.
[131] See n.127 above.

similar reasons – starts with the view of the astronomers. It would be interesting to see whether in Epicurus' *Letter* this is a sustained practice, like in Lucretius' astronomical passages, or just an isolated case.

In the following table I have set out the astronomical subjects of Epicurus' *Letter to Pythocles* (excluding chapters 31 [111] on comets and 35 [114-5] on shooting stars, which, in antiquity, were not generally considered astronomical), each with the number of explanations given,[132] and the place of the astronomers' explanation, if included:

Table 1-2: Place of the astronomers' explanations in the astronomical passages of the *Letter to Pythocles*

Chapter	Subject	Number of explanations	View of the mathematical astronomers
7 [92]	Risings and settings	2	2
8 [92-3]	Motions of the stars	3	1
9 [93]	Turnings of the sun and moon	4	1
10 [94]	Phases of the moon	3+	-
11 [94-5]	Origin of the moon's light	2	2
12 [95-6]	Face in the moon	2+	-
13 [96-7]	Solar and lunar eclipses	2	2
14 [97]	Regularity of periods	1	-
15 [98]	Varying lengths of day and night[133]	2	2
32 [112]	Stars turning in their place	3+	1
33 [112-3]	Planets	2	1
34 [114]	Stars lagging behind	3	2

The total number of astronomical subjects in the *Letter* is 13. In 9 cases we find the view of the astronomers included among a number of possible explanations.[134] In only 4 of these cases the view of the astronomers is presented first. The general pattern Bailey had detected in the astronomical passages of the *DRN* does not seem to apply to the corresponding portion of Epicurus' *Letter to Pythocles*.

Yet, Lucretius' critical attitude towards the views of the astronomers is not unlike Epicurus'. The *Letter to Pythocles* contains two explicit references to the (mathematical) astronomers (both in chapters where their view *is* presented first): in chapter 9 [93] Epicurus says:

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[132] A '+'-sign after the number indicates that Epicurus explicitly tells us that there may be still more explanations.

[133] Sections 16-31 are devoted to subjects which traditionally belonged to meteorology and are therefore irrelevant for the present subject.

[134] For identification of the individual explanations see the commentaries to the *Letter to Pythocles*.

Πάντα γὰρ τὰ τοιαῦτα καὶ τὰ τούτοις συγγενῆ οὐθενὶ τῶν ἐναργημάτων διαφωνεῖ, ἐάν τις ἀεὶ ἐπὶ τῶν τοιούτων μερῶν ἐχόμενος τοῦ δυνατοῦ εἰς τὸ σύμφωνον τοῖς φαινομένοις ἕκαστον τούτων δύνηται ἐπάγειν, μὴ φοβούμενος τὰς ἀνδραποδώδεις ἀστρολόγων τεχνιτείας.

For all these and kindred explanations are not at variance with any clear-seen facts, if one always clings in such departments of inquiry to the possible and can refer each point to what is in agreement with appearances without fearing the slavish artifices of the *astronomers*. (tr. Bailey, slightly modified, my Italics)

And in chapter 33 [113]:

Τὸ δὲ μίαν αἰτίαν τούτων ἀποδιδόναι, πλεοναχῶς τῶν φαινομένων ἐκκαλουμένων, μανικὸν καὶ οὐ καθηκόντως πραττόμενον ὑπὸ τῶν τὴν ματαίαν ἀστρολογίαν ἐζηλωκότων καὶ εἰς τὸ κενὸν αἰτίας τινῶν ἀποδιδόντων, ὅταν τὴν θείαν φύσιν μηθαμῇ λειτουργιῶν ἀπολύωσι.

But to assign a single cause for these phenomena, when the appearances demand several explanations, is madness, and is quite wrongly practised by persons who are partisans of the foolish notions of *astronomy*, and who give futile explanations of the causes of certain phenomena, whenever they do not by any means free the divine nature from the burden of responsibilities. (tr. Bailey, slightly modified, my Italics)

In his article 'Epicurus and the mathematicians of Cyzicus',[135] David Sedley argues that such references should be viewed in the light of Epicurus' rather personal feud with the Eudoxan school of mathematics and astronomy at Cyzicus. Although I agree that such personal animosity may certainly have added to the vehemence of Epicurus' attacks, I think that here these attacks must be seen as having a broader application. In *Pyth.* 33 [113] Epicurus speaks of τῶν τὴν ματαίαν ἀστρολογίαν ἐζηλωκότων: 'the partisans of the foolish notions of astronomy'. This is certainly an odd way to refer to just the astronomers, let alone such a specific group of astronomers. In fact the expression applies just as well, if not more, to all those who, while not being astronomers themselves, passionately embraced their findings, like e.g. Plato and Aristotle and their followers, and later the Stoics. At any rate, the second part of Epicurus' criticism, that 'they do not by any means free the divine nature from the burden of responsibilities', applies more naturally to these philosophers, who made the gods responsible for the heavenly motions, than to the mathematical astronomers.[136]

[135] Sedley (1976) 26-43; see esp. p.43 above.

[136] In Cic. *ND* I 30-39 the Epicurean spokesman Velleius explicitly criticises, among others, Plato (30), Aristotle (33), Theophrastus (35) and the early Stoics (36-9) for assigning divinity to the heavens and the heavenly bodies. For Plato's views see e.g. *Ti*. 40a-d; *Resp*. VI 508a; *Leg*. VII 821b-c, X 899a-b, XII 950d; *Epin*. 981e, 983a-b, 984d (cf. Barnes (1989) 41); for Aristotle's see e.g. *Metaph*. XII 8, 1074a38-b14, *Cael*. I

In *Pyth.* 33 [113] the 'partisans of the foolish notions of astronomy' are attacked, among other things, for assuming a single explanation, when the appearances call for several. The same criticism occurs throughout the *Letter to Pythocles*,[137] but only here the target is specified. Yet, it is very likely that in the other instances too Epicurus was thinking in particular about these devotees of astronomy. Perhaps Anaxagoras in his time had been a proponent of single causes, or Empedocles, or Democritus, but that was a long time ago. In Epicurus' days the only advocates of single explanations to be reckoned with were the astronomers and their partisans. In this respect Epicurus seems to have had the same reasons as later Lucretius for attacking their views, and Lucretius turns out the be firmly rooted in Epicurus' track.

Bailey's observation that Lucretius in his astronomical passage usually presents the view of the astronomers first, appears to be basically correct. However, Bailey's interpretation of the fact is wrong. Far from actually *preferring* the views of the astronomers, as Bailey supposed, Lucretius, like Epicurus before him, singles them out as the principal representatives of the *wrong attitude* towards the explanation of the non-evident. While the appearances call for several explanations and do not permit us to choose between them, the astronomers and their followers idly opt for a single explanation.

1.4 Multiple explanations and doxography

Although, as Epicurus claimed, the appearances themselves invite us to adopt certain explanations,[138] many of Epicurus' and Lucretius' alternative explanations were actually derived from earlier thinkers. For instance, to take our stock example, the theory that the sun is extinguished at sunset and rekindled at sunrise, which Epicurus and Lucretius consider a viable alternative for the common view that it passes unaltered below the earth, can be confidently identified with the view espoused by Xenophanes.[139] Although the sources of individual alternative explanations are generally left unspecified, Lucretius does occasionally identify them: Democritus (V 621-2), the Chaldeans (V 727) and the 'astrologi' (V 728).[140] We have also seen that in his astronomical section Lucretius often consciously (although mostly without explicit reference) starts his lists of alternative explanations with the

3.270b6-25, 9.278b14-16, II 1.284a12-14 & 284b3-5, 3.286a10-13, 12.292b32-293a1; for the Stoics see e.g. Cic. *ND* I 36-39, II 39, 42, 44, 54, 80.

[137] *Pyth.* 2 [87], 10 [94], 15 [98], 33 [113], 34 [114]. See also *Hdt.* 80.5-6.

[138] Epic. *Pyth.* 10 [94]. Cf. also 2 [86], 18 [100] and 33 [113].

[139] See n.123 above.

[140] As noted by Runia (1997a) 95.

views of the mathematical astronomers. In addition, the commentators of Epicurus and Lucretius have traced the ultimate sources of many more of the alternative explanations. It appears that almost every one of their alternative explanations has been borrowed, sometimes with minor modifications, from one or other of their predecessors.

Epicurus' dependence on earlier theories was already recognised in antiquity. In doxographical reports Epicurus' opinion, if included, is usually mentioned last,[141] and expressed in terms which relate it to the preceding views. For instance, in Aët. II 13.15 (on the substance of the stars) we read:

Ἐπίκουρος οὐδὲν ἀπογινώσκει τούτων ἐχόμενος τοῦ ἐνδεχομένου.[142]	Epicurus rejects none of these (explanations), clinging to what is possible.

And in Aët. II 22.4 (on the shape of the sun):

Ἐπίκουρος ἐνδέχεσθαι τὰ προειρημένα πάντα.	Epicurus holds all the afore-mentioned (explanations) to be possible.

A similar report is found in Seneca's *Naturales Quaestiones* VI 20.5 (on earthquakes):

Omnes istas esse posse causas Epicurus ait pluresque alias temptat.	Epicurus says that all these causes may apply and he tries his hand at several more.

Judging from these testimonies one gets the impression that Epicurus himself must have had before him some doxographical work, very much like Aëtius' *Placita*, where he would have found all the relevant theories on each topic neatly listed side by side, which he could have simply copied out, striking the names of the original authors, expressing his consent with all of them, and sometimes adding a few of his own. That Epicurus might have followed such a procedure was first suggested by Diels and Usener, and has

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[141] Runia (1992) 135, n.76.

[142] For the formula "clinging to what is possible", cp. Epicurus himself in *Pyth.* 9 [93]: πάντα γὰρ τὰ τοιαῦτα καὶ τὰ τούτοις συγγενῆ οὐθενὶ τῶν ἐναργημάτων διαφωνεῖ, ἐάν τις ἀεὶ ἐπὶ τῶν τοιούτων μερῶν ἐχόμενος τοῦ δυνατοῦ εἰς τὸ σύμφωνον τοῖς φαινομένοις ἕκαστον τούτων δύνηται ἐπάγειν. ["For all these and kindred explanations are not at variance with any clear-seen facts, if in such departments of inquiry one always clings to what is possible and can refer each point to what is in agreement with the appearances." (tr. Bailey, slightly modified)]

been generally accepted since.[143] For chronological reasons Aëtius' *Placita* – the only virtually complete doxographical work that has come down to us – cannot itself have been Epicurus' source (as is obvious from the inclusion of Epicurus' name in Aëtius' work), but it is believed that Aëtius' work derives from earlier works of a similar nature, having a similar structure and lay-out, which may have been used by Epicurus.[144]

There are two important arguments in favour of this theory. In the first place it is clear that Lucretius' representation of earlier views does sometimes depend on doxographical reports, rather than autopsy of the original works. This has been demonstrated convincingly by Wolfgang Rösler (1973) with respect to *DRN* I 635-920, where Lucretius successively deals with the views of Heraclitus, Empedocles and Anaxagoras concerning the ultimate constituents of reality. As Rösler pointed out, certain misrepresentations, generalisations and choice of terminology, such as the designation of the Anaxagorean first principles as *homoeomeria*,[145] betray Lucretius' dependence on a doxographical tradition that goes back to Aristotle and Theophrastus. In addition, David Sedley has pointed out that Lucretius' critical survey of these three doctrines, including the word *homoeomeria*, may well derive from books XIV and XV of Epicurus' *On nature*,[146] which suggests that it was Epicurus himself who derived his knowledge of these Presocratic theories from doxography,[147] and passed it on to Lucretius. This does not prove, of course, that Epicurus' and Lucretius' accounts of astronomical and meteorological theories, in the *Letter to Pythocles* and *DRN* V 509-770 and VI, depend on

[143] Diels (1879) 225: "Epicuri epistula ad Pythoclem {…} tanquam ex doxographis nominibus philosophorum omissis raptim corrasa est {…}." Usener (1887) xl-xli: "Elegisse autem Epicurum perquisitis omnium physiologorum libris quis credat? Quem etsi Democriti et Democriteorum, Anaxagorae et Archelai opiniones facile concedemus ipsum ex illorum libris novisse, reliquorum ut cognosceret rationes consentaneum est librum ei ad manum fuisse, quo conpositas et conparatas nullo negotio inveniret, hoc est Theophrasti φυσικῶν δόξας." See also Ernout-Robin (1925-28), III 201-2; and Runia (1997a).

[144] In Usener's and Diels' wake this earlier work, from which Aëtius' *Placita* is supposed to be ultimately derived, is often identified with Theophrastus' Φυσικαὶ δόξαι ('Physical Opinions'), a work of which only a single fragment remains (see Runia (1992) 117). However, following the important studies on these subjects by Jaap Mansfeld and David Runia it seems more prudent now to simply state that Aëtius' *Placita* is based on and influenced by, several works of Theophrastus as well as Aristotle. See e.g. Mansfeld (1989) esp. 338-42; Mansfeld (1992b) and Mansfeld (2005).

[145] Lucr. *DRN* I 830 & 835; on the provenance of this term see Rösler (1973), 67-68 with nn. thereto, and Sedley (1998a), 124-125.

[146] Sedley (1998a) 123-6 & 145-6.

[147] As Rösler (1973) 71-72 already suspected.

doxographical reports as well, but it certainly adds to the likelyhood of this hypothesis.

Another argument in favour of an ultimately doxographical origin of these passages is the close correspondence in the order of subjects that can be observed in – on the one hand – the meteorological sections of Lucretius' *DRN* and Epicurus' *Letter to Pythocles*, and – on the other hand – book III of Aëtius' doxography.[148] The question of the precise relations between these three texts is, however, complicated by the existence of a further parallel, a meteorological treatise ascribed to Theophrastus and preserved in Syriac and Arabic, which exhibits more or less the same order of subjects. We will examine this treatise and the nature of the complications involved more closely in §1.5.5 below, while the correspondences in the order and scope of subjects of these four works, as well as a number of other texts, will be investigated more thoroughly in Chapter Two.

It is remarkable, however, that the observed correspondence in the sequence of subjects does not extend to the astromical sections of these works – here Epicurus, Lucretius and Aëtius differ considerably from each other both in the range and the order of subjects – nor to the order of the indivual explanations per subject – in this respect too Epicurus, Lucretius, Aëtius and, in addition, the *Syriac meteorology* differ considerably from each other.[149]

One aspect of Epicurean multiple explanations does not seem to be accounted for by the assumption of a doxographical origin. As we saw above, analogy plays an important role in the validation of individual explanations. Accordingly, in the *DRN* many explanations of astronomical and especially meteorological phenomena are supported by references to similar appearances here with us. For instance, in *DRN* VI 121-31 one possible cause of thunder – wind being trapped in a hollow cloud and then violently bursting forth – is compared to the explosion of an air-filled bladder. As Epicurus' *Letter to Pythocles* and the corresponding books of Aëtius' *Placita* (book II, on cosmology and astronomy, and book III, on meteorology and terrestrial

[148] As observed by Reitzenstein (1924) 34-5; Runia (1997a) 97; Sedley (1998a) 158. See also Table 2-4 on p.117 below, where the order of subject of Lucretius VI, Epicurus *Pyth.*, Aët. III and the *Syriac meteorology* are compared.

[149] As observed by Sedley (1998a) 182. For instance, Lucretius' 'habit' of mentioning the views of the mathematical astronomers first (see §1.3.6 on p.39ff above) is quite unlike the way Aëtius structures his chapters according to *diaeresis* and *diaphonia*. Aëtius' method is becoming increasingly clear thanks to the works of David Runia and Jaap Mansfeld: see esp. Runia (1989) and (1992), and Mansfeld & Runia (2009a) part 1, pp.3-16 et passim, and part 2, passim.

phenomena) provide very few specific analogies, one might be tempted to ascribe the addition of such analogies to Lucretius himself rather than – through Epicurus' mediation – a doxographical source. As we have seen, however, the virtual absence of specific analogies from Epicurus' *Letter to Pythocles* may well be due to its being a summary of a more extensive work.[150] In fact, many of the analogies provided by Lucretius are old, much older even than Epicurus – the comparison of thunder with an exploding bladder, for instance, is found in Aristophanes' *Clouds* (lines 403-7) – and it seems unlikely that the theories and the accompanying analogies should have reached Lucretius by different roads. It also noteworthy that the *Syriac meteorology*, which I mentioned above, offers many of the same analogies as Lucretius, including the exploding bladder (1.18-20).

In sum, it is very likely that the meteorological and astronomical portions of Lucretius' *DRN* ultimately derive – probably for the most part through Epicurus' works – from a doxographical source, which in the sequence of its subjects may have resembled Aëtius, but which, in contrast with Aëtius, combined the naked *doxai* with explanative analogies. What place should be assigned to the *Syriac meteorology* in this transmission is as yet unclear.

1.5 The sources of the method of multiple explanations

1.5.1 Introduction

Epicurus and Lucretius may have derived most of their alternative explanations from doxography, but the result is something new and different. Stripped of their name-labels, theories devised by earlier thinkers have been transformed into truly alternative explanations endorsed by Epicurus and Lucretius themselves.[151] So, even though doxography may explain where the individual explanations came from, it does not explain how Epicurus and Lucretius came to use them as they did.

In this section I want to examine a number of other texts and authors who also sometimes resorted to the use of multiple explanations, and find out if and to what extent they resemble and may have influenced Epicurus. The examination will include Democritus, Aristotle, Theophrastus, and the *Syriac meteorology* commonly ascribed to Theophrastus. In order to be able to make a comparison, it will be useful first to indicate some general characteristics of the method as employed by Epicurus and Lucretius. The following features I consider typical of Epicurean multiple explanations:

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[150] See p.32 with notes 86 and 87 above.

[151] This is not always appreciated by the commentators: see Ernout-Robin (1925-28) 202: "c'est en somme une doxographie, mais sans nom propre."

1. They are applied to *non-evident* matters, such as the nature and causes of astronomical and meteorological phenomena.
2. In those fields of physical enquiry where multiple explanations are used (astronomy and meteorology) they are used *systematically*.
3. Lists of multiple explanations may consist of up to eight or nine explanations.[152]
4. Many explanations, especially in meteorology, are supported with analogies from everyday experience.
5. Most alternative explanations can be related to the views of earlier thinkers.

Armed with these five distinctive features we may now proceed to investigate possible parallels to Epicurus' and Lucretius' method of multiple explanations.

1.5.2 Democritus

Already in antiquity Epicurean physics was often viewed as a modernised version of the teachings of Democritus.[153] It is not unreasonable therefore to start our investigation into the origins of Epicurus' method of multiple explanations with Democritus.

A very promising testimony in this respect is provided by Seneca. In *NQ* VI 20 (Democritus fr.A98 D-K), having just presented an overview of ancient theories on earthquakes, Seneca continues thus:

[1] Veniamus nunc ad eos qui *omnia* ista quae rettuli in causa esse dixerunt aut ex his *plura*. Democritus *plura* putat. Ait enim motum (i) aliquando spiritu fieri, (ii) aliquando aqua, (iii) aliquando utroque, et id hoc modo prosequitur: …	Let us now come to those who said that *all* these causes, which I recounted, are responsible or *several* of these. Democritus thinks *several*. For he says that an earthquake (i) sometimes happens because of wind, (ii) sometimes of water, (iii) sometimes of both, and he pursues this in the following manner: …

Seneca goes on to describe each of these three explanations in some detail – first explanation (ii) and then (iii) and (i) – after which he continues, picking up the reference at the beginning of the chapter to 'those who said that all these causes … are responsible':

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[152] Epic. *Pyth.* 19 [101-2] offers *eight* causes of lightning, and *DRN* VI 96-159 *nine* causes of thunder.

[153] Cf. Cic. *N.D.* I 73 "quid est in physicis Epicuri non a Democrito?" See also Cic. *Acad. Post.* I 6; *De fin.* I 17-18, 21; II 102; IV 13; and *N.D.* I 93 & 120; Diog. Laërt. X 4; Plut. *Adv. Col.* 3, 1108e-f.

[5]	*Omnes* istas esse posse causas Epicurus ait pluresque alias temptat ...	Epicurus says that *all* these causes may apply and he tries his hand at several more …

According to Seneca, then, both Democritus and Epicurus explained earthquakes with a number of alternative theories, but whereas Epicurus accepted all available theories, Democritus was more selective. This explicit contrast seems to suggest that Seneca knew something about Democritus' method and how this differed from Epicurus'. It is quite probable, however, that Democritus' selectivity is only apparent. Democritus wrote at a time when many of the theories later described by Seneca had not yet been devised and the major doxographical works reporting them not yet been written.[154] I am inclined to think, therefore, that Seneca had no positive information about Democritus' methodology at all, but simply inferred so much from the three alternative explanations he found attributed to Democritus, which he himself contrasted to the larger number of explanations offered by Epicurus.

The amount of detail with which Seneca is able to report Democritus' three explanations may suggest that he had a very good source for them, but in fact the wording of the text indicates that he may have filled in much of the detail by himself. At the beginning of section 2, for instance, he writes: 'And now, just as we spoke of wind, we must also speak of water',[155] as if he were describing his own theory, instead of someone else's.

Seneca's report on Democritus also strangely deviates from the account offered by Aristotle in *Mete.* II 7, 365b1-6 (Dem. fr.A97 D-K). According to Aristotle, Democritus held that earthquakes occur both (a) when the earth is full with water and its cavities overflow, and (b) when the earth is dried up and its cavities draw water from elsewhere. Aristotle's first explanation may perhaps be identified with Seneca's second, but Aristotle's second explanation has nothing to do with either Seneca's first or his third theory.

In sum, it is quite possible that Democritus offered more than one explanation for earthquakes, but in view of the discrepancy between Aristotle's and Seneca's accounts we cannot be certain which explanations were his. Yet, neither Aristotle nor Seneca tell us why Democritus resorted to multiple explanations. For all we know Democritus may have simply offered his two or three explanations by way of a hypothesis, without any strong epistemological motives. There is no indication, moreover, that Democritus extended this use of multiple explanations to other phenomena as well. On the

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[154] Jaap Mansfeld points out to me that the fifth century BC already knew some doxographical overviews, such as Hippias' presentation of related views and Herodotus' account of the Nile flood, although these overviews fall far short of the doxographical works and passages of later times. See also Mansfeld & Runia (2009) 154ff.

[155] Sen. *NQ* VI 20,2: "Etiam nunc, quomodo de spiritu dicebabus, de aqua quoque dicendum est."

contrary, although there are many ancient reports concerning Democritus' views on specific astronomical, meteorological and terrestrial problems, none of these (beside those on earthquakes) attribute to Democritus anything other than single explanations. There is no good reason therefore to consider Democritus a major source of inspiration for Epicurus' method of multiple explanations.[156]

1.5.3 Aristotle

A more promising candidate in this respect is Aristotle.[157] Several cases of multiple explanations are found in his works, especially in the *Meteorology*. Here, in I 3, 341a12-31, Aristotle gives *two* reasons why the sun, though not fiery in itself, produces heat on earth. In I 4, 341b36 - 342a13, he offers *two* explanations for the production of shooting stars and the like. Finally, in I 7, 344a5-b4 he gives *two* accounts of the production of comets, corresponding to two different *types* of this phenomenon. This last subject is introduced with the following lines (344a5-8):

Ἐπεὶ δὲ περὶ τῶν ἀφανῶν τῇ αἰσθήσει νομίζομεν ἱκανῶς ἀποδεδεῖχθαι κατὰ τὸν λόγον, ἐὰν εἰς τὸ δυνατὸν ἀναγάγωμεν, ἔκ τε τῶν νῦν φαινομένων ὑπολάβοι τις ἂν ὧδε περὶ τούτων μάλιστα συμβαίνειν.	For we consider that we have given a sufficiently rational explanation of things non-evident to sense-perception if we have referred them to what is possible; and, on the basis of the present appearances, one may assume that they are best accounted for as follows.

Here, just like Epicurus later, Aristotle applies multiple explanations to things *non-evident*, inferring the *possibility* of each explanation on the basis of the *appearances*.[158] It must be observed, though, that while Aristotle is here thinking of the appearances of the object of inquiry itself, Epicurus usually refers to the appearances of analogous phenomena here with us. Sometimes Aristotle too supports his alternative explanations by reference to appropriate *analogies*, as we can observe in his first account of the sun's heat-production (341a23-27):

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[156] *Pace* Asmis (1984) 328-9.

[157] Asmis (1984) 329-30, Mansfeld (1994) 33, n.18.

[158] Cf. Epic. *Pyth*. 9 [93]: πάντα γὰρ τὰ τοιαῦτα καὶ τὰ τούτοις συγγενῆ οὐθενὶ τῶν ἐναργημάτων διαφωνεῖ, ἐάν τις ἀεὶ ἐπὶ τῶν τοιούτων μερῶν ἐχόμενος τοῦ δυνατοῦ εἰς τὸ σύμφωνον τοῖς φαινομένοις ἕκαστον τούτων δύνηται ἐπάγειν. ["For all these and kindred explanations are not at variance with any clear-seen facts, if one always clings in such departments of inquiry to *what is possible* and can *refer* each point to what is in agreement with the appearances." (tr. Bailey, slightly modified)]

Τὸ δὲ μᾶλλον γίγνεσθαι ἅμα τῷ ἡλίῳ αὐτῷ τὴν θερμότητα εὔλογον, λαμβάνοντας τὸ ὅμοιον ἐκ τῶν παρ' ἡμῖν γιγνομένων· καὶ γὰρ ἐνταῦθα τῶν βίᾳ φερομένων ὁ πλησιάζων ἀὴρ μάλιστα γίγνεται θερμός.

That the heat is increased by the presence of the sun is easily enough explained by considering analogies from our own experience: for here too the air in the neighbourhood of a projectile becomes hottest. (tr. Lee)

Yet, in spite of these similarities there is still a huge gap between Epicurus' and Aristotle's approaches to multiple explanations. In the first place, Aristotle only very rarely recurs to multiple explanations: in the entire body of the *Meteorology*, only three clear cases are found. Most often Aristotle is perfectly happy to give just *one* explanation. Secondly, the number of alternatives offered is much smaller: in the *Meteorology* Aristotle in each case offers no more than *two* explanations, whereas Epicurus and Lucretius may offer up to *eight* or even *nine* possible causes. Thirdly, Aristotle only occasionally uses analogies to support an explanation, whereas for Lucretius and Epicurus analogy with everyday phenomena is essential for accepting an explanation. Finally, Aristotle's multiple explanations do not seem to relate to earlier views: his accounts of the sun's heat-production, of shooting stars and of comets proceed from Aristotle's own physical theory. When, on the other hand, Aristotle *does* engage with older theories, he usually rejects them, and substitutes them with a *single* theory of his own making.[159]

1.5.4 Theophrastus

With Theophrastus, Aristotle's successor as head of the Lyceum, the use of multiple explanations becomes much more prominent. Many instances are found in Theophrastus' minor treatises *De ventis*, *De lapidibus* and *De igne*, and many more in his botanical writings, especially his *De causis plantarum*.[160] Yet, even in these works multiple explanations, though by no means rare, are still the exception. When offering multiple explanations, Theophrastus most often gives two, but occasionally more; the maximum number I have found is five.[161]

Sometimes the explanations offered are explicitly linked to analogous occurrences within our sensory experience, as can be seen in *De igne* 1, 4-11:

[159] So Taub (2003) 94: "In the Meteorology, Aristotle does not usually accept the views of his predecessors, even when they are those of 'the majority or the wise'."

[160] Steinmetz (1964) 32-33, 46, 82, 88, 91, 103, 122-123, 132, 139; Eichholz (1965) 6; Wöhrle (1985) 145-8; Vallance (1988) 34-5; Daiber (1992) 285; Gottschalk (1998) 287.

[161] *CP* I 17.5.

Ἔτι δὲ αἱ γενέσεις αὐτοῦ {sc. τοῦ πυρὸς} αἱ πλεῖσταί [καὶ] οἷον μετὰ βίας, καὶ γὰρ ἡ πληγῇ τῶν στερεῶν ὥσπερ λίθων, καὶ ⟨αἱ⟩ τρίψει καὶ πιλήσει καθάπερ τῶν πυρείων ⟨καὶ πάντων⟩ ὅσα ἔχει φοράς, ὥσπερ τῶν πυρουμένων καὶ τηκομένων (ἐκ δ' αὐτοῦ τοῦ ἀέρος καὶ τοῖς νέφεσι συστροφαὶ καὶ θλίψεις· βίαιοι γὰρ δὴ αἱ φοραί, δι' ὧν δὴ οἱ πρηστῆρες καὶ κεραυνοὶ γίνονται), καὶ ὅσους δὴ τρόπους ἄλλους τεθεωρήκαμεν εἴθ' ὑπὲρ γῆς γινομένων εἴτ' ἐπὶ γῆς εἴθ' ὑπὸ γῆς. αἱ γὰρ πολλαὶ δόξειαν ἂν αὐτῶν μετὰ βίας.

Moreover, most forms of generation of fire take place by force, as it were; for instance, that caused by the striking of solids like stones, and those caused by friction and compression, as in firesticks and in all those substances which are in process, such as those which are ignited and fused (in fact, it is from air that the clouds undergo their concentrations and compressions, for of course the motions by which firewinds and thunderbolts are generated are forcible), and whatever other ways we have observed, whether above the earth, on it, or beneath it. Most of these appear to come about by force. (transl. Coutant)

Theophrastus only rarely comments on his motives for accepting several explanations; the only clear instance I have found is *De lapidibus* I 3, 1-3:

Ἡ δὲ πῆξις τοῖς μὲν ἀπὸ θερμοῦ τοῖς δ' ἀπὸ ψυχροῦ γίνεται. κωλύει γὰρ ἴσως οὐδὲν ἔνια γένη λίθων ὑφ' ἑκατέρων συνίστασθαι τούτων.

This solidification is due in some cases to heat and in others to cold, for there may be nothing to prevent certain kinds of stone from being formed either by heat or by cold. (transl. Eichholz).

It is interesting to note that – apart from the modest ἴσως ('perhaps') – Theophrastus' «κωλύει γὰρ οὐδὲν» ('for nothing prevents') is very similar to the formulas Epicurus later uses to signal the validity of his alternative explanations, like «οὐδὲν γὰρ ἀντιμαρτυρεῖ» ('for nothing contests') and «οὐθὲν ἐμποδοστατεῖ» ('nothing stands in the way').[162]

It must also be observed that, when Theophrastus offers multiple explanations, these hardly ever relate to earlier views, and when he does adduce older theories it is usually to reject them and replace them with a theory of his own.[163]

Until now we may have been comparing apples and oranges: Epicurus and Lucretius applied multiple explanations, not to fire or stones or different winds, but to astronomy and meteorology, and the few instances of multiple explanations in Aristotle's works also occur in his *Meteorology*. It would be interesting therefore to see to what extent Theophrastus used multiple explanations in *his* meteorological treatise. The *Syriac meteorology* which is commonly, but in my view prematurely, ascribed to Theophrastus will be dealt with in the next subsection. Here I will confine myself to Greek and Latin testimonies of Theophrastus' meteorological views. A very interesting

[162] See p.18 n.49 above.

[163] See e.g. Theophr. *De igne* 52-56; *HP* III 1, 4-5; III 2, 2. Cp. what was said about Aristotle in n.159 above and text thereto.

text in this respect is fr.211B FHS&G, preserved by Olympiodorus *In Arist. Mete.* I 9, 346b30 (p.80.30-81.1 Stüve):

᾽Ιστέον δέ, ὅτι μὲν ὁ ᾽Αριστοτέλης αἴτιον λέγει τῆς εἰς ὕδωρ μεταβολῆς τὴν ψύξιν μόνον. Θεόφραστος δὲ οὐ μόνον τὴν ψύξιν αἰτίαν φησὶ τῆς τοῦ ὕδατος γενέσεως, ἀλλὰ καὶ τὴν πίλησιν. ἰδοὺ γὰρ ἐν Αἰθιοπίᾳ μὴ οὔσης ψύξεως ὅμως ὑετὸς κατάγεται διὰ τὴν πίλησιν· φησὶ γὰρ ὄρη εἶναι ἔκεισε ὑψηλότατα, εἰς ἃ τὰ νέφη προσπταίουσι καὶ εἶθ᾽ οὕτως ὑετὸς καταρρήγνυται διὰ τὴν γινομένην πίλησιν. ἀλλὰ μὴν καὶ ἐπὶ τῶν λεβήτων ὑγρότης, φησίν, ἀντικατάρρει, ἐτὶ δὲ καὶ ἐπὶ τῶν θόλων τῶν λουτρῶν μὴ παρούσης ψύξεως, διὰ τὴν πίλησιν δηλονότι τούτου γινομένου.

One should known that Aristotle says that cooling alone causes the transformation into water. Theophrastus, however, says that not only cooling causes the generation of water, but also condensation. Note that in Aethiopia where there is no cooling, rain nevertheless pours down due to condensation. For he says there are very high mountains there, against which the clouds collide and that subsequently rain pours down because of the ensuing condensation. Yet also in the case of cauldrons, says he, moisture runs down, and also in the case of the vaults of baths, where there is no cooling, this obviously occurs due to condensation.

According to this report,[164] Theophrastus accepted two different causes of rain-production: cooling and condensation. The first view is authorized by Aristotle, for the second one example (rain in Aethiopia) and two supporting *analogies* (cauldrons and the vaults of baths) are adduced. Both views can be related to earlier theories: the first view is Aristotle's (*Mete*. I 9, 346b30-31), as Olympiodorus informs us, and the second corresponds to the views of several earlier thinkers.[165]

For rain production, then, Theophrastus accepted two explanations. There is one other meteorological problem for which Theophrastus' view is explicitly reported. In *NQ* VI 13.1 (fr.195 FHS&G), Seneca ascribes to Theophrastus and Aristotle the *single* view that earthquakes come about through exhalations rising from the earth and then, for lack of place, turning back on themselves. If this report is correct, Theophrastus did not use multiple explanations to account for every meteorological problem.

Our findings may be summarized as follows. In his meteorological treatise (to judge from Greek and Latin testimonies), as in his works on fire, stones, winds and plants, Theophrastus frequently uses multiple explanations, although single explanations remain the norm. When he does give several explanations, the number of alternatives rarely exceeds two, although cases

[164] Cf. Proclus *In Plat. Tim.* 22E (= Theophr. fr.211A FHS&G); Galen *In Hippocr. Aer*. 8.6 (= fr.211C *ibid.*), and Theophrastus *De ventis* 5.1-5.

[165] Anaximenes A17 D-K (= Aët. III 4.1), Xenophanes A46 D-K (= Aët. III 4.4), Hippocrates *Aer*. 8.7 (II 34 Littré) and Democritus *apud* Diod. I 39.3 (cf. fr.A99 D-K = Aët. IV 1.4) all ascribe rain formation to condensation of clouds; this condensation being due, according to Hippocrates, to compression by contrary winds and other clouds, and, according to Democritus, to the clouds being compressed against high mountains.

with up to five can be found. Alternative explanations are occasionally supported with analogies from everyday experience, but more often they are not. They may be derived from the views of earlier thinkers, but in general they are not. In short, most aspects of Epicurean multiple explanations can be found in Theophrastus, but on a far more modest scale.

1.5.5 The *Syriac meteorology*

In the previous subsection I have deliberately left out of account a treatise which most scholars now agree in identifying with (a part or a summary of) Theophrastus' lost meteorological treatise, the *Metarsiology*.[166] I have done so because I think there is still reasonable doubt about this identification. Since, however, this treatise furnishes the closest existing parallel to Epicurus' and Lucretius' use of multiple explanations, it must here be dealt with.

The treatise is preserved in three versions: two mutually independent Arabic translations of a Syriac original, and a single, badly mutilated, copy of this Syriac original.[167] In both Arabic versions the work is ascribed to *Theophrastus* (the corresponding section of the Syriac manuscript is lost). Together, the three versions seem to provide a good basis for a reconstruction of (the contents of) the Syriac original.[168] The treatise covers a range of meteorological phenomena,[169] explaining most of them with *a number of alternative explanations*.

This pervasive use of multiple explanations in a treatise purportedly written by Theophrastus caused some embarrassment to the earlier commentators. They could not believe that Theophrastus would have employed a method so radically different (as it appeared to them) from Aristotle's and Theophrastus' other works.[170] In fact, as Gotthelf Bergsträßer observed,[171] if the treasise had

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[166] E.g. Daiber (1992) 282ff; Mansfeld (1992a) 314-16; *id.* (1994) 30; Sedley (1998a) 158, 179; Sharples (1998) 17, 144; Taub (2003) 116.

[167] The Syriac version was first edited, with German translation and commentary, by Wagner & Steinmetz (1964). The Arabic version of Bar Bahlūl was first edited, with a German translation and commentary, by Bergsträßer (1918). The second Arabic version, probably made by Ibn Al-Khammār, was edited, with an English translation and commentary by Daiber (1992), who also offered improved editions of the other two versions, unfortunately without translation.

[168] *Not* necessarily of the *Greek* original, as Daiber (1992) claims on pp.219 & 282-3.

[169] The subjects are: (1) thunder, (2) lightning, (3) thunder without lightning, (4) lightning without thunder, (5) why lightning precedes thunder, (6) thunderbolts, (7) clouds, (8) rain, (9) snow, (10) hail, (11) dew, (12) hoar-frost, (13) winds (including an account of the πρηστήρ), (14) the halo around the moon, and (15) earthquakes.

[170] See e.g. Strohm (1937) 411: "daß die verworrene Folge von sieben Erklärungen des Donners und vier Gründen des Blitzes, die in einer an Epikurs Probabilismus

not been explicitly ascribed to Theophrastus, no one would have guessed that it was his. In view of its offering multiple explanations for most of the phenomena, and in view of the close parallels with *DRN* VI, both in the order of subjects (on which see pp.115ff below) and in the treatment of individual subjects, attribution to Epicurus or his school would have seemed obvious. For this reason Bergsträßer and Boll, and later Reitzenstein and a few others, felt compelled at least to consider the possibility of an Epicurean origin.[172] Unfortunately, they did not follow up on this hypothesis, but simply dismissed it in favour of another hypothesis, to the effect that the treatise's Greek original had been "a doxography or at least a discussion with a strong doxographical character [...], in which the excerptor had deleted the names of the inventors of each individual theory as being of no consequence, and rather blurred the traces of the author's own position." [173] In this way they were able to uphold Theophrastus' authorship, which has never been seriously doubted again,[174] even though the views about the treatise's real character have radically changed. Since Daiber's publication of the text with translation and commentary in 1992, it is generally accepted that the treatise really offers multiple alternative explanations, and not, as was previously believed, a (critical) doxography.[175] Yet, if this is true (as I believe it is), the grounds on which Bergsträßer and Reitzenstein were able to reject the possibility of an Epicurean rather than a Theophrastean origin of the treatise, seem to have been removed: Theophrastus' authorship can no longer be taken for granted. I will therefore refer to the treatise simply as the '*Syriac meteorology*' and from this neutral position try to establish how the treatise relates to Theophrastus on the one hand and Epicurus and Lucretius on the other.

Although, as we saw above, Theophrastus was not as averse to multiple explanations as the earliest commentators of the treatise believed, there is still

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gemahnenden Reihe nebeneinanderstehen, in dieser Form Theophrast fremd ist, liegt auf der Hand."

[171] Bergsträßer (1918) 28.

[172] Bergsträßer (1918) 28; Boll in his epilogue to Bergsträßer (1918) 30; Reitzenstein (1924) 7-11; Drossaert Lulofs (1955) 438. The question is wisely left open by Robin in Ernout-Robin (1925-28) III 200-1 and 249.

[173] Bergsträßer (1918) 28. See also Reitzenstein (1924) 8ff, Strohm (1937) 411; Wagner-Steinmetz (1964) 14, 34; Steinmetz (1964) 55.

[174] Bergsträßer (1918), 28, also advances the possibility of a late compendium, and so does Gottschalk (1965), 759-60, who identifies some passages as deriving from Strato rather than Theophrastus. Kidd (1992), 294, also leaves open the possibility of a late compendium, and Van Raalte (2003) believes that the so-called Theological Excursus cannot derive from Theophrastus. Doubts about the correctness of the attribution to Theophrastus also in Ernout-Robin III 200-1.

[175] Daiber (1992) 285; Kidd (1992) 303-4; Mansfeld (1992a) 325; Mansfeld (1994) 33; Sedley (1998a) 181; Sharples (1998) 17 with n.58; Taub (2003) 116-7.

a huge gap between the use of multiple explanations in the *Syriac meteorology* and in Theophrastus' undisputed writings:

1. While in Theophrastus' undisputed writings single explanations still seem to be the rule, in the *Syriac meteorology* most problems are explained in a number of ways.[176]
2. While in Theophrastus' undisputed writings the number of alternative explanations rarely exceeds *two*, the *Syriac meteorology* frequently offers *three* or more, the maximum number being *seven* (as in the case of thunder).[177]
3. While in Theophrastus' undisputed writings alternative explanations are only rarely supported with analogies, the *Syriac meteorology* abounds with them.[178]
4. While in Theophrastus' undisputed writings alternative explanations only rarely derive from earlier, Presocratic, theories, in the *Syriac meteorology* the vast majority of theories can be identified with specific views of earlier thinkers.[179]

In all these respects the *Syriac meteorology* is much closer to the meteorological sections of Epicurus' *Letter to Pythocles* and Lucretius' *De rerum natura* than to Theophrastus' undisputed works.

It has been observed that in the *Syriac meteorology* different explanations sometimes apply to different types of a certain phenomenon, each exemplified by a different analogy.[180] It has also been suggested that in this respect the use of multiple explanations in the *Syriac meteorology* differs from the way they are used by Epicurus and Lucretius, who typically conceived of their several explanations as equally possible alternative causes of a single undifferentiated phenomenon.[181] However, this supposed contrast between the *Syriac meteorology* and Epicurus / Lucretius is based on a misrepresentation of the latter: as we have seen above (p.11), in his meteorology Lucretius too occasionally differentiates phenomena by type, and Epicurus probably did so as well. With respect to meteorological phenomena, therefore, there is no

[176] See APPENDIX C on p.246 below: 26 cases of multiple explanations vs. 22 with single explanations.
[177] See APPENDIX C on p.246 below: 9 cases with three or more explanations vs. 17 with just two explanations.
[178] See Daiber (1992) 284, 285, 288 ('illustrative examples' or 'illustrative experiments') and esp. Taub (2003) 117-20.
[179] Daiber (1992) 287-88, 290; Taub (2003) 117.
[180] Daiber (1992) 279 (*ad* 13.22-32), 285, 288; Kidd (1992) 299-304; Sharples (1998) xv; Taub (2003) 117, 130-131; Garani (2007) 97.
[181] Kidd (1992) 303-4; Sharples (1998) xv; Taub (2003) 130-131; Garani (2007) 97.

observable difference between the application of multiple explanations in the *Syriac meteorology* and in the meteorological sections of Epicurus and Lucretius.

The real difference must be looked for outside the scope of meteorology. Although the *Syriac meteorology* only deals with meteorological phenomena (which traditionally included earthquakes), the treatise does contain an oblique reference to another branch of physical enquiry. In 14.14-17 we read the following:

> Neither the thunderbolt nor anything that has been mentioned [i.e. other meteorological phenomena] has its origin in God. For it is not correct (to say) that God should be the cause of disorder in the world; nay, (He is) the cause of its arrangement and order. And that is why we ascribe its arrangement and order to God (...) and the disorder of the world to the nature of the world. (transl. Daiber)

Whereas Epicurus and Lucretius do not acknowledge any basic distinction between (disorderly) meteorological and (orderly) astronomical phenomena, neither of which are the work of God, the *Syriac meteorology* leaves God in charge of everything orderly in the world, which probably refers to the orderly arrangement of the world as a whole, as well as the orderly motions of the heavenly bodies. This also settles part of the question about the *Syriac meteorology*'s authorship: the work as we have it, or at least the theological remark just quoted, could not have been written by Epicurus himself, although the work as a whole may still be influenced by him. The question of the treatise's origin and relations with Epicurus and Lucretius will be considered more thoroughly in Chapter Two (p.132ff) below.

1.5.6 Conclusions concerning the origins of multiple explanations

It is now time to formulate some conclusions concerning the possible origins of Epicurus' method of multiple explanations.

However great Democritus' influence on Epicurean physics may have been, there is little reason to assume that he was a major source of inspiration for Epicurean multiple explanations as well. Even if he gave two or three alternative explanations of earthquakes, there is nothing to suggest that this was the inevitable result of certain epistemological considerations, or that he extended the use of multiple explanations to other physical problems as well.

The first clear instances of multiple explanations are found in the (undisputed) writings of Aristotle and Theophrastus. Although in these works multiple explanations are not applied systematically, whenever they are, they seem to be confined to a certain class of phenomena. Aristotle remarks that

non-evident things need to be accounted for with reference to what seems *possible* on the basis of *the present appearances* – a procedure which, apparently, will sometimes result in the acceptance of multiple explanations –, and Theophrastus ascertains the validity of his alternative explanations from the observation that *nothing prevents* any one of them. Aristotle and Theophrastus (in his undisputed works) rarely derive their alternative explanations from doxography, and when they do deal with earlier views they usually refute them.

It is very likely that Epicurus' use of multiple explanations was somehow inspired by Aristotle and Theophrastus. Yet, the precise relationship between Epicurus and his two predecessors depends on our position with respect to the authorship of the *Syriac meteorology*.

If we assume that the *Syriac meteorology* is, as is commonly believed, either the whole or a part or a summary of Theophrastus' lost *Metarsiology*, we may conclude as follows. For some reason Theophrastus has decided that those epistemological conditions which invite the acceptance of multiple explanations and which occasionally obtain in other fields of physical inquiry, must be operative in meteorology most of the time. He must further have decided that alternative explanations in meteorology can be drawn from the works of earlier philosophers, whose views in other fields of inquiry he usually rejects. Epicurus' own special contribution would have been to extend the use of multiple explanations from meteorology to cosmology and astronomy (using a doxographical work, perhaps Theophrastus' *Physical opinions*,[182] as a source for individual explanations), and to provide the method with a rigorous epistemological justification.

If, on the other hand, the *Syriac meteorology* is assumed to somehow presuppose Epicurus' work and therefore postdate it, Epicurus' contribution must have been much more substantial. Perhaps taking his inspiration from the scattered instances of multiple explanations in the works of Aristotle and Theophrastus, and from the accompanying epistemological remarks, he himself fashioned them into a veritable method with a rigorous epistemological basis, and he himself decided that doxography might provide the necessary alternative explanations.

1.6 Conclusions

In this chapter various aspects of Epicurus' and Lucretius' method of multiple explanations have been explored. Section 1.2 provides a brief

[182] On Theophrastus' *Physical opinions* see §2.5.5 on p.141 below.

overview of the various uses of multiple explanations. Section 1.3 discusses some epistemological aspects of the method. Section 1.4 presents the main arguments for an ultimately doxographical origin of Epicurus' and Lucretius' alternative explanations, and section 1.5 discusses a number of ancient parallels for the use of multiple explanations outside Epicureanism. The most important findings of this chapter are the following.

In §1.3.2 three modern theories concerning the truth-value of multiple explanations have been investigated. One theory, according to which alternative explanations are only collectively true, could be rejected on account of the evidence. Yet, it appeared to be impossible to choose between the two remaining theories. Some of the evidence suggests that Epicurus claimed that all alternative explanations are true, while another part of the evidence favours the view that alternative explanations can at best be called possible. In §1.3.5 it has been argued that Diogenes of Oenoanda's claim that some explanations are more plausible than others is a departure from Epicurus and Lucretius for whom all alternative explanations have the same truth-value. In §1.3.6 Bailey's assertion that Lucretius, by his habit of mentioning the views of the mathematical astronomers first, betrays his preference for their views, has been refuted, and a polemical motive discovered instead. Finally, in §1.5, I have argued that Aristotle's and Theophrastus' occasional use of multiple explanations and their epistemological justifications for this use may have inspired Epicurus' method of multiple explanations. Theophrastus' influence on Epicurus may turn out to be even greater if the *Syriac meteorology* can be proved to be Theophrastus'. However, comparison of the use of multiple explanations in Theophrastus' undisputed works and the *Syriac meteorology* indicates that Theophrastus' authorship of the latter work is still far from certain. The question of the *Syriac meteorology*'s authorship will be further explored in the next chapter.

2 EPICURUS & LUCRETIUS AND THE SCOPE AND STRUCTURE OF ANCIENT METEOROLOGY

2.1 Introduction

The sixth book of Lucretius' *DRN* and Epicurus' *Letter to Pythocles* are often described as meteorological treatises.[183] I am not going to contend that they are not, but it is remarkable how ill-defined the word meteorology actually is, and how variable its subject matter. The *Letter to Pythocles*, whose subject matter is described as *ta meteōra*, 'the things above', discusses both atmospherical and astronomical phenomena and earthquakes. Lucretius' book VI, on the other hand, leaves out astronomy altogether but includes a number of terrestrial phenomena, such as the size of the sea, eruptions of Etna, the summer flooding of the Nile, poisonous places, curious wells and springs, magnets and diseases. The reason that both works are sometimes called 'meteorologies' seems to be that both of them give considerable space to those phenomena which we still designate as meteorological: i.e. weather phenomena. This characteristic they share with several other ancient writings, in particular Aristotle's *Meteorology*, which gave this branch of physical inquiry its name, and which is in fact the only ancient meteorological work to use this word. Other notable examples are Seneca's *Naturales Quaestiones* ('Natural Questions') and the *Syriac meteorology* ascribed to Theophrastus. Each of these works deals with a different selection of phenomena, but the core of their subject matter is meteorological in the modern sense of the word, and therefore they can be called meteorologies. However, although the precise boundaries of the subject matter may vary between one meteorology and the next, they are by no means arbitrary, but depend on certain underlying assumptions and traditions, which may be brought to light by a thorough comparison of the extant ancient meteorologies. Such a comparison could also shed light on the various ways in which the subject matter is sometimes subdivided.In this chapter I propose to carry out such a comparison of ancient meteorological writings, in order to elucidate the various traditions and the position of Lucretius and Epicurus therein.

Special attention will be given to the second part of Lucretius' book VI, which is largely devoted to exceptional local phenomena or *mirabilia*. Although such phenomena are mentioned in other meteorologies as well, they belong more properly to *paradoxography*. I will therefore extend my investigation to this genre as well, in order to define the precise relations and

[183] See e.g. Ernout-Robin III 199-200; Taub (2003) 127-37.

the division of labour between the two genres, and Lucretius' position vis-à-vis the two.

Another matter is the order in which the various meteorological subjects are discussed. It has often been observed that the order of subjects in Lucretius' book VI closely resembles those of the *Syriac meteorology* and Aëtius' book III, and to a lesser degree Epicurus' *Letter to Pythocles*, but the precise extent of these similarities and the exceptions to them have never been thoroughly assessed. In this chapter I will delve into this matter as well, with a view to establishing the relations between these four works. In this context it will also be necessary to deal with the question of the identity of the *Syriac meteorology*, which is generally – but in my view prematurely – identified with Theophrastus' *Metarsiologica,* but could in fact be a later work based largely on Epicurus' meteorology, which would turn the tables between the two works.

The structure of this chapter will be as follows. In §2.2, I will compare a number of ancient meteorological writings with respect to the range, delimitation and subdivision of their subject matter. Then, in §2.3, the second part of Lucretius' *DRN* VI, which is devoted to the explanation of predominantly exceptional local phenomena, will be compared to other meteorological as well as paradoxographical works. In §2.4 the order of subjects of Lucretius' *DRN* VI, Epicurus' *Letter to Pythocles*, the *Syriac meteorology*, and book III of Aëtius' *Placita* will be compared and an original order proposed. In §2.5 the question of the *Syriac meteorology*'s identity will be investigated, and possible relations between the four texts indicated. Finally, in §2.6, the major conclusions of the chapter will be summarized.

2.2 Range, delimitation and subdivisions of meteorology

2.2.1 Introduction

In this section I will compare a number of writings dealing exclusively or for the most part with meteorology. By meteorology I mean the study of atmospherical phenomena as well as such phenomena as were often associated with them, such as the Milky way, comets, shooting stars, earthquakes and terrestrial waters. The comparison in this section will be confined to such matters as the range of subjects of meteorology, its delimitation from astronomy and its major subdivisions. I will not, in this section, go into the the treatment of individual subjects or the theoretical background of each work,[184] unless these throw some light upon the reasons for including a certain subject in meteorology or in one of its major subdivisions. From this point of view I

[184] For individual subjects see the commentaries to the relevant passages. For ancient meteorology in general see Taub (2003).

am only interested in those works or testimonies that present a reasonably complete and coherent account of meteorology, and I will pass by the meteorological views, however interesting they may be, of e.g. Posidonius or Arrianus, which are known to us from scattered references only.[185] The writings that meet the above requirements are the following[186] (the page numbers indicate the beginning of my brief introduction of each work):

2.2.2 Ancient meteorological texts

Before I set out on my task, it will be expedient to offer something of a definition of meteorology, to state what it is, how it is delimited from other fields of investigation, notably astronomy, and how (if at all) it is subdivided.

The English word 'meteorology' derives from the Greek μετεωρολογία, which is the study of τὰ μετέωρα, the 'lofty' things. Before Aristotle the word μετέωρος and its derivatives appear to have been used indiscriminately to refer to both *astronomical* and *atmospherical* phenomena.[188] This does not necessarily mean that philosophers before Aristotle did not somehow distinguish between these two fields of physical inquiry.[189] That at least Democritus did, is suggested by the presence of two separate titles, Αἰτίαι

[185] Posidonius' meteorological fragments are collected in Edelstein & Kidd (1972) (frs.11, 15, 121 and 129-38; see also frs.214-29 on tides and hydrology and frs.12 and 230-2 on seismology) and Arrian's in Roos & Wirth (1967/8), vol. 2, pp.186-195.

[186] All these works but one (viz. Aëtius III) are discussed in Taub (2003), and all but one (viz. Pliny *NH* II) feature in the appendix 'On the Order of Presentation of Meteorological Phenomena' in Kidd (1992) 305-6.

[187] Passages in the *Letter to Pythocles* will be referred to by the chapter number of Bollack & Laks (1978), with the traditional numbering of Meibom's edition of Diogenes Laërtius in square brackets.

[188] Capelle (1912a) 421-41; *id.* (1935), col.316.

[189] As Capelle seems to think: see Capelle (1912a) 425, 427, 447-8; *id.* (1913) 322; *id.* (1935), col.316, lines 15-16, 22-28.

οὐράνιαι (celestial causes) and Αἰτίαι ἀέριοι (atmospherical causes), in the catologue of his writings in Diog. Laërt. IX 47. Yet, it is to Aristotle that we owe the first clear delimitation of the two fields with respect to each other, and the restriction of the terms μετέωρος and μετεωρολογία to *sublunary* phenomena only. Interestingly, in antiquity Aristotle's limitation of meteorology to the sublunary sphere was more influential than the name he gave to it: two generations later Epicurus could still use the word μετέωρος to refer to both meteorological and astronomical phenomena, and the famous Stoic scholar Posidonius too dealt with cosmological and astronomical matters under the single heading of meteorology,[190] while Aristotle's associate and successor Theophrastus found it necessary to introduce another word altogether (μετάρσιος and μεταρσιολογία) to refer to atmospherical phenomena.[191]

Aristotle *Meteorology*

In the opening chapter of his *Meteorology*[192] Aristotle defines the province of meteorology as 'everything which happens naturally, but with a regularity less than that of the first element of material things, and which takes place in the region which borders most nearly on the movements of the stars'.[193] Further down he says: 'The whole region around the earth, then, is composed of these bodies {i.e. earth, water, air and fire}, and it is the conditions which affect them which, we have said, are the subject of our inquiry'.[194] While thus delimiting meteorology from astronomy, at the same time Aristotle extends its subject matter to include not just atmospherical, but also fiery, watery and even earthly phenomena. Astronomy, which is the subject of his *De Caelo*, deals with the orderly and eternal movements of the heavens and the stars,

[190] Posidonius is reported to have defined 'cosmos' in a work called Μετεωρολογικὴ στοιχείωσις (D.L. VII 138 = fr.14 E-K), to have discussed the substance of the sun in his Περὶ μετεώρων (D.L. VII 144 = fr.17 E-K), and contrasted the physical and mathematical approaches to astronomy in his Μετεωρολογικά (Simpl. *In phys*. 291.21-292.21 = fr.18 E-K), all of which are either cosmological or astronomical matters. On the other hand he is reported to have discussed the rainbow in a work called Μετεωρολογική (D.L. VII 152 = fr.15 E-K). See also Capelle (1913) 337ff.

[191] See Capelle (1913) 333-6.

[192] For a general account of Aristotle's *Meteorology* see Taub (2003) 77-115.

[193] Arist. *Mete.* I 1, 338b1-3, ὅσα συμβαίνει κατὰ φύσιν μέν, ἀτακτοτέραν μέντοι τῆς τοῦ πρώτου στοιχείου τῶν σωμάτων, περὶ τὸν γειτνιῶντα ... μάλιστα τόπον τῇ φορᾷ τῇ τῶν ἄστρων. Transl. Lee (1952), slightly modified. According to Lee (1952), xii note *a*, this refers to the entire sublunary region, according to Capelle (1912b), 516-517, to its fiery upper part only.

[194] Arist. *Mete.* I 2, 339a19-21, ὁ δὴ περὶ τὴν γῆν ὅλος κόσμος ἐκ τούτων συνέστηκε τῶν σωμάτων· περὶ οὗ τὰ συμβαίνοντα πάθη φαμὲν εἶναι ληπτέον. Transl. Lee (1952), slightly modified.

which are made up of the 'first element' (a.k.a. *aether*); meteorology on the other hand studies the less orderly phenomena of the region around the earth, which is occupied by the four classic elements, earth, water, air and fire. The boundary between the two regions is marked by the orbit of the moon.

Yet, Aristotle's definition is not extremely precise and leaves open many questions. It is instructive therefore to have a closer look at the actual range of phenomena covered by Aristotle's *Meteorology*. I will leave book IV out of account, as it is generally agreed that it was not part of the original work.[195] In books I-III, then, the following subjects are discussed (I have Italicised those subjects we would nowadays no longer call meteorological)[196]:

A. PHENOMENA OF THE FIERY UPPER ATMOSPHERE		
Shooting stars	*I 4*	
Other luminary phenomena	*I 5*	
Comets	*I 6-7*	
The Milky way	*I 8*	
B. PRODUCTS OF MOIST EXHALATION		
Mist, clouds and rain	I 9	
Dew and hoar-frost	I 10	
Snow	I 11	
Hail	I 12	
C. PRODUCTS OF DRY EXHALATION (PLUS TERRESTRIAL WATERS)		
Winds I	I 13	
Springs and rivers	*I 13*	*TERRESTRIAL WATERS*
Climatic and coastal change	*I 14*	*TERRESTRIAL WATERS*
The sea	*II 1-3*	*TERRESTRIAL WATERS*
Winds II	II 4-6	
Earthquakes	*II 7-8*	
Thunder and lightning	II 9	
Thunderbolts and whirlwinds	III 1	
D. NON-SUBSTANTIAL PHENOMENA		
Rainbows I	III 2	
Haloes	III 2-3	
Rainbows II	III 4-5	
Rods and mock suns	III 6	
E. PHENOMENA OF THE EARTH		
Minerals and metals	*III 6*	

[195] As was observed already by Alexander of Aphrodisias (2nd cent. AD) *In Arist. Mete.* 4.1, 179.1-5 Hayduck. See refs. to modern literature in Taub (2003) 206 n.24.

[196] For the organization of *Meteorology* I-III see e.g. Capelle (1912b) or Louis (1982) XXVIII-XXXIV.

As the table shows, Aristotle's *Meteorology* covers more than just atmospherical phenomena. In the first place, it includes a number of subjects which we would nowadays call *astronomical*, like the Milky Way, comets and shooting stars, probably owing to their – real or apparent – irregularity, which to Aristotle seemed incompatible with the supposed orderly character of the supralunary world.[197] Although not *meteorological* in our sense of the word, these phenomena are at any rate μετέωρα, i.e. 'lofty things'.

This is not true of some other phenomena included in Aristotle's *Meteorology*, viz. rivers and the sea, earthquakes, and minerals and metals. Minerals and metals seem to be included because they too, just like some of the phenomena above the earth, are products of the two exhalations.[198] Earthquakes are more closely connected with the μετέωρα proper. They are treated right after winds, because they are themselves caused by subterranean winds.[199] Not so clear are Aristotle's motives for including rivers and the sea. As the table shows, the entire passage on rivers and the sea is inserted in the section on winds. This move seems to have been prompted by certain analogies between wind and flowing water. Such analogies, however, do not in themselves justify the classification of rivers and the sea as meteorological phenomena. A more plausible reason for their inclusion in a work on meteorology would be that rivers and the sea, being sustained by rain and melting snow, are an integral part of the hydrological cycle,[200] and thus intimately related to the subject of meteorology, but Aristotle does not adduce this justification. Whatever Aristotle's reasons were, from then on rivers and the sea were frequently included in works on meteorology.

Aristotle's *Meteorology* does *not* deal with volcanoes as a separate subject, although it occasionally refers to volcanic phenomena as by-products of earthquakes.[201] Neither does it concern itself with problems pertaining to the

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[197] Already in antiquity Aristotle was rightly criticised for assigning the Milky Way to meteorology. See e.g. Olymp. *In Arist. Mete.* [CAG 12.2] 10.33; 66.17-20; 75.24-76.5 (citing Ammonius); Philop. *In Arist. Mete.* [CAG 14.1] 113.33-118.26 (citing Damascius 116.36ff). It may therefore not be a coincidence that the Milky Way is absent from almost all subsequent writings on meteorology (Aëtius excepted). Based on Theophr. fr.166 FHS&G, Steinmetz (1964) 167-8 concludes that Aristotle's view was already rejected by Theophrastus; for a more critical attitude concerning the evidence see Sharples (1985) 584-5 and *id.* (1998) 108-111.

[198] Arist. *Mete.* III 6, 378a13 ff.

[199] Arist. *Mete.* II 7, 365a14-15 (quoted on p.94 below). Cf. *ibid*. II 8, 366a3-5, οὐκ ἂν οὖν ὕδωρ οὐδὲ γῆ αἴτιον εἴη, ἀλλὰ πνεῦμα τῆς κινήσεως {sc. τῆς γῆς}, ὅταν εἴσω τύχῃ ῥυὲν τὸ ἔξω ἀναθυμιώμενον. – "So the cause of an earthquake is likely to be neither water nor earth but wind, when the external exhalation happens to flow inwards".

[200] On the hydrological cycle see Arist. *Mete.* I 9, 346b22-347a8; I 13, 349b3-8; II 2, 354b28-34 and II 3, 356b22-357a2.

[201] See e.g. Arist. *Mete.* II 8, 367a1-11 on the eruption of the Aeolian island of Hiera.

earth as a whole, like its shape, position and stability, which had already been treated in Aristotle's *De Caelo*.[202]

[Aristotle] *De mundo* 4

Practically the same subject matter is also discussed in chapter 4 of the *De mundo*.[203] Although the work is clearly rooted in Aristotelian philosophy, most scholars reject Aristotle's authorship and date the work to some time between 50 BC and 150 AD.[204] The subject of chapter 4 is introduced as 'the most notable phenomena in and about the inhabited world (i.e. land and sea)'.[205] The structure of the chapter can be set out as follows:

[202] Arist. *Cael.* II 13-14. The occasional references to such matters in the *Meteorology* (I 3, 339b7-9 on the relatively small size of the earth; I 9, 346b24 on the earth being at rest; II 5, 362a33-b33 on the five terrestrial zones) merely serve as a background for real meteorological problems.

[203] See Taub (2003) 161-8.

[204] See Furley (1955) 337-341. Mainly on linguistic and stylistic grounds G. Reale en A.P. Bos believe that the work's ascription to Aristotle is correct (Reale (1974); Reale & Bos (1995); etc.), while J. Barnes (1977) and D.M. Schenkeveld (1991), though excluding Aristotle's authorship, argue for a much earlier date than has hitherto been accepted. Their arguments have failed to convince the majority of scholars: see esp. J. Mansfeld (1991), 541-3, and (1992c). Although the question of the work's authorship is no concern of the present work, it may yet contribute to an answer: it will be shown (see Table 2-1 below) that the *De mundo* differs from Aristotle's *Meteorology* in its subdivision of the subject matter, its omission of the Milky Way (see also n.197 above), and its inclusion of tides, volcanoes and poisonous exhalations (on the inclusion of the two last subjects in meteorology see p.107 below).

[205] 394a7-8: Περὶ δὲ τῶν ἀξιολογωτάτων ἐν αὐτῇ {sc. γῇ καὶ θαλάττῃ, ἥντινα καλεῖν εἰώθαμεν οἰκουμένην} καὶ περὶ αὐτὴν παθῶν νῦν λέγωμεν.

GENERAL INTRODUCTION	394a7-8
A. PHENOMENA OF THE AIR	394a9 – 395b17
1. The two exhalations	394a9-19
2. Products of the moist exhalation (mist, dew, ice, hoar-frost, dew-frost, cloud, rain, snow, hail)	394a19 – b6
3. Products of the dry exhalation (winds, violent winds, incl.: thunder, lightning, thunderbolt, πρηστήρ, τυφών)	394b7 – 395a28
4. Appearances vs. substantial {sc. luminary} phenomena	395a28-32
5. Appearances (rainbow, 'rod', halo)	395a32 – b3
6. Substantial {sc. luminary} phenomena (σέλας, shooting star, comet)[206]	395b3-17
B. PHENOMENA IN THE EARTH (hot springs, volcanoes, noxious exhalations, earthquakes)	395b18 – 396a16
C. PHENOMENA IN THE SEA (chasms, retreats and incursions of waves, submarine volcanoes, springs and rivers, trees growing in the sea (!), currents, eddies, tides)	396a17-27
GENERAL CONCLUSION	396a27-32

As the table shows the subject matter is basically divided into three parts: phenomena of the air, phenomena in the earth, and phenomena in the sea.[207] Unlike Aristotle's *Meteorology*, the *De mundo* seems to recognize volcanoes as phenomena to be studied in their own right, mentioning them (incl. the Etna) briefly but separately before a longish discussion of earthquakes. Like

[206] In *De mundo* 2, 392a32-b5 these same phenomena are referred to the layer of fire above the air, not to the air itself.

[207] In 395b17-18 we read: Τὰ μὲν τοίνυν **ἀέρια** τοιαῦτα. Ἐμπεριέχει δὲ καὶ ἡ **γῆ** πολλὰς ἐν αὐτῇ, and in 396a17 it says: Τὰ δὲ ἀνάλογον συμπίπτει τούτοις {sc. τοῖς ἐν **γῇ** πάθεσι} καὶ ἐν **θαλάσσῃ** ... Finally, in the general conclusion (396a27-32), we read: Ὡς δὲ τὸ πᾶν εἰπεῖν, τῶν στοιχείων ἐγκεκραμένων ἀλλήλοις ἐν **ἀέρι** τε καὶ **γῇ** καὶ **θαλάσσῃ** κατὰ τὸ εἰκὸς αἱ τῶν παθῶν ὁμοιότητες συνίστανται, τοῖς μὲν ἐπὶ μέρους φθορὰς καὶ γενέσεις φέρουσαι, τὸ δὲ σύμπαν ἀνώλεθρόν τε καὶ ἀγένητον φυλάττουσαι.
By the way, in chapters 2 and 3 the same subject matter is organized differently. There, having first dealt with a number of cosmological and astronomical issues (391b9 – 392a32), the author moves on to the phenomena of the sublunary sphere. This falls apart into three regions: that of **fire** (392a32-b5), that of **air** (392b5-13), and that of **earth and sea** taken together (392b14 – 394 a6). To the fiery region are attributed such phenomena as comets and shooting stars. The air is the abode of clouds, rain, snow, frost, hail, winds, whirlwinds (τυφῶνες), thunder, lightning and thunderbolts. In the subsequent section on the earth and the sea, the author, rather than enumerate the corresponding physical phenomena, offers a picturesque geographical description of the terrestrial sphere, which need not concern us here.

Aristotle's *Meteorology* the meteorological section of the *De mundo* excludes problems concerning the earth as a whole.

Aëtius *Placita* III

More or less the same subject matter is dealt with in the third book of Aëtius' *Placita*.[208] This work, to be dated most likely to the first century AD, has not come down to us directly, but can be reconstructed to a certain degree from two later works that largely derive from it: Pseudo-Plutarch's *Placita* and Stobaeus' *Eclogae Physicae*. Of these two Pseudo-Plutarch has most faithfully preserved the work's original division into books and chapters,[209] and it is this division which is generally followed and which we shall follow too.

Book III of the *Placita* is not a meteorology in the sense of the two works mentioned above. While Aristotle's *Meteorology* and the *De mundo* aim to give a coherent theory of the whole field of meteorology, Aëtius is concerned with presenting the various and often conflicting views brought forward by earlier thinkers. Yet the subject matter of the book coincides largely with, and betrays a strong dependence on, Aristotelian meteorology in the range, subdivision and order of its subjects.[210] The book lacks a single general heading: having dealt with cosmology and astronomy in the previous book, in book III Aëtius goes on to discuss, first, in chapters 1-8, what he calls τὰ μετάρσια (lofty phenomena),[211] and then, in chapters 9 and following, what he calls τὰ πρόσγεια (down-to-earth phenomena).[212] The latter section also

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[208] On Aëtius' work in general see now Mansfeld & Runia (1997) and *id.* (2009a). On book III in particular see Mansfeld (2005).

[209] Diels (1879) 61; Mansfeld & Runia (1997) 184-5.

[210] On Aristotle as a source for Aëtius as to methodology and contents see Mansfeld (1992b). On Aëtius III depending on, and deriving from, Arist. *Mete.* I-III see Mansfeld (2005). See also Mansfeld & Runia (2009a).

[211] Aëtius III 0: Περιωδευκὼς ἐν τοῖς προτέροις ἐν ἐπιτομῇ τὸν περὶ **τῶν οὐρανίων** λόγον, σελήνη δ' αὐτων τὸ μεθόριον, τρέψομαι ἐν τῷ τρίτῳ πρὸς **τὰ μετάρσια**· ταῦτα δ' ἐστὶ τὰ ἀπὸ τοῦ κύκλου τῆς σελήνης καθήκοντα μέχρι πρὸς τὴν θέσιν τῆς γῆς, ἥντινα κέντρου τάξιν ἐπέχειν τῇ περιοχῇ τῆς σφαίρας νενομίκασιν. Ἄρξομαι δ' ἐντεῦθεν. – "Having briefly traversed in the previous chapters the account of the *heavenly phenomena*, of which the moon is the border region, I shall in the third book turn to *lofty phenomena*. These are what is from the circle of the moon to where the earth is situated, which they are convinced occupies the position of the centre in relation to the circumference of the sphere. I shall begin from here." On this passage see now Mansfeld & Runia (2009a) 54, whose translation I have basically followed.

[212] Aëtius III 8.2: Περιγεγραμμένων δέ μοι **τῶν μεταρσίων**, ἐφοδευθήσεται καὶ **τὰ πρόσγεια**. – "The *lofty phenomena* having been described by me, the *down-to-earth*

includes a number of chapters, 9-14, dealing with the earth as a whole,[213] which are not part of the scope of Aristotle's *Meteorology* or chapter 4 of the *De mundo*. Their inclusion may have been prompted by Aëtius' wish to present his subjects in a rigorous top-down (or 'outside-in') order, based on the *location* of each cosmic part and each phenomenon rather than its *nature*. The structure of the book (as preserved by Pseudo-Plutarch) is as follows:

ΤΑ ΜΕΤΑΡΣΙΑ

1. milky way
2. comets, shooting stars and the like
3. thunder, lightning, thunderbolts and whirlwinds (*typhōnes* and *prēstēres*)
4. clouds, rain, snow and hail
5. rainbow
6. rods and mock suns
7. winds
8. winter and summer

ΤΑ ΠΡΟΣΓΕΙΑ

9.	the earth (being unique and limited)	⎫
10.	shape of the earth	⎪
11.	position of the earth	⎬ PROBLEMS PERTAINING TO
12.	inclination of the earth	⎪ THE EARTH AS A WHOLE
13.	motion of the earth	⎪
14.	division of the earth	⎭
15.	earthquakes	
16.	the sea: its origin and bitterness	
17.	the sea: ebb and flood	
18.*	halo	
IV 1.*	the flooding of the Nile	
(Stob. 39 water properties)*		

Two chapters appear to have been misplaced. Chapter 18 on the halo does *not* belong in the section on τὰ πρόσγεια, which it now concludes, but must have been part of the preceding section on τὰ μετάρσια. There is in fact quite some evidence to connect it more specifically with chapters 5 and 6, on the rainbow and 'rods and mock suns' respectively.[214] Also misplaced is the first chapter of book IV, which discusses the topic of the Nile flood. This subject

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phenomena, too, will be inspected." On this passage see now Mansfeld & Runia (2009a) 55.

[213] On Aëtius' inclusion of these subjects with meteorology see p.93 below.

[214] On the dislocation of Aët. III 18 see Diels (1879) 56, 60-61, Lachenaud (1993) 25, Mansfeld (2005) 26-27, 37 (n.52) and 56 and Mansfeld & Runia (2009a) 44. Note that in Arist. *Mete.* III 2-6, [Arist.] *De mundo* 4, 395a32-b3, and Sen. *NQ* I 2-13, the subjects of the rainbow, the halo and rods and mock suns are also discussed successively (see also p.121 below).

was clearly meant to go with τὰ πρόσγεια in the second part of book III, where also the origin and salinity of the sea and the causes of ebb and flood are dealt with.[215] It is quite out of place in book IV, which is otherwise about the soul and its functions.

It is possible that a further chapter existed, which is now missing. In Stobaeus' *Eclogae Physicae*, one of the two main sources for the reconstruction of Aëtius' text,[216] there is a chapter (39), titled Περὶ ὑδάτων ('On waters'),[217] which has no counterpart in Pseudo-Plutarch's *Placita*, the other main source for Aëtius and our principal guide as to the table of contents of Aëtius' work.[218] In its present state the chapter contains only one lemma reporting Aristotle's views on water properties, which probably derives not from Aëtius but from Arius Didymus (fragment 14a).[219] However, since the subjects covered by Stobaeus' *Eclogae Physicae* derive to a large extent from Aëtius[220] (even though Stobaeus often adds or substitutes lemmas from other sources), it is possible that this chapter's *title* and *subject* too derive from Aëtius. That the chapter in its present state contains no Aëtian material can be ascribed to the very selective transmission of that part of Stobaeus' work which corresponds to the second half of Aëtius book III.[221] Stobaeus' chapter 'On waters' follows immediately upon the chapter on tides and so has the same relative position as Aëtius' chapter on the flooding of the Nile, which only Pseudo-Plutarch has preserved. If, as I have suggested, Stobaeus' chapter 'On waters' derives from Aëtius, it will have immediately preceded, or followed on, the chapter on the Nile flood. It is worth noting at this point that in Seneca's *Naturales Quaestiones* (see below) a book dealing with

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[215] See Diels (1879) 56 and 61, Lachenaud (1993) 274.

[216] On Stobaeus as a source for the reconstruction of Aëtius, see Mansfeld & Runia (1997) 196-271.

[217] *Not* included in the list of possibly lost chapters in Mansfeld & Runia (1997) 186, but see the table printed *ibid*. pp.214-6.

[218] On Pseudo-Plutarch as a source for the reconstruction of Aëtius, see Mansfeld & Runia (1997) 121-195.

[219] Diels (1879) 854; see also Mansfeld & Runia (1997) 249 n.167.

[220] Mansfeld & Runia (1997) 216: "the topics covered by the book [i.e. Stobaeus' *Eclogae Physicae*] have been largely based on the subjects dealt with in the *Placita* [of Aëtius]. Only 7 or 8 of the 60 chapters find no equivalent in A[ëtius]."

[221] Mansfeld & Runia (1997) 202-3: "When we further examine the epitomized chapters ¶31-60 in Book I, we soon observe that a very one-sided selection has taken place. Only lemmata containing Platonica, Aristotelica, Pythagorica and Hermetica are retained. In various chapters that must have contained copious extracts from Aëtius just one or two lemmata containing the views of Plato and Aristotle are written out (¶32, 36, 38-**39**, 42-43, 45, 51-60)." (my emphasis).

(terrestrial) waters (III) is followed by a book on the summer flooding of the Nile (IVa).

Pliny *Naturalis Historia* II §§ 89-248

Roughly the same range of subjects, including (like Aëtius) a number of sections dealing with the earth as a whole,[222] is discussed in the second part of book II of Pliny's *Naturalis Historia*.[223] The first part of the book is devoted to cosmology and astronomy. Pliny devides astronomical and meteorological phenomena differently from Aristotle, Pseudo-Aristotle and Aëtius. Not only erratic celestial phenomena like comets and shooting stars, but also merely apparent phenomena like haloes, 'rods' and mock suns (but not the rainbow!) are classified by Pliny among the 'stars'. The text of book II (like every other book) abounds in repetitions, interruptions and all kinds of excursuses, which make it hard to summarize its contents. The following overview (from §89 onwards) is no more than an impression. For a more complete summary see Pliny's own table of contents in book I of the *Naturalis Historia*.

A. Cosmos/heavens and stars (i-xxxvii, §§1-101)

xxii-xxxvii	§§ 89-101	'Sudden stars' (incl. comets, shooting stars, but also haloes and other insubstantial luminary phenomena)

B. Atmospherical phenomena (xxxviii-lxii, §§102-153)[224]

xxxviii	§§ 102-4	Nature of air
xxxix-xli	§§ 105-10	Influence of astronomy on the weather and animals
xlii	§ 111	Rain, wind and clouds
xliii	§§ 112-3	Storm-winds and thunderstorms
xliv-l	§§ 114-134	Winds (incl. whirlwinds)
li-lvi	§§ 135-146	Thunderbolts
lvii-lix	§§ 147-150a	Miraculous phenomena in and from the sky
lx	§§ 150b-151	Rainbows
lxi	§ 152	Hail, snow, hoar-frost, mists, dew, clouds
lxii	§ 153	Particular local climates.

[222] On Pliny's inclusion of these subjects with meteorology see p.93 below.

[223] On Pliny's meteorology see Taub (2003) 179-187.

[224] At the beginning of §102, referring back to the previous sections, *including* those on comets, shooting stars, haloes and 'rods', Pliny writes: "Hactenus de *mundo* ipso *sideribusque*. Nunc reliqua caeli memorabilia: namque et hoc caelum appellavere maiores quod alio nomine *aëra*."

C. Earthly phenomena (lxiii-cxiii, §§154-248)[225]

lxiii-lxxx	§§ 154-190	The earth as a whole (shape, position, seasons)
lxxxi- lxxxvi	§§ 191-200	Earthquakes
lxxxvii - xciv	§§ 201-6a	Formation of new land
xcv	§§ 206b-208	Products of the earth (incl. mines, gems, peculiar stones, medicinal springs, volcanoes, poisonous exhalations)
xcvi	§ 209	Vibrating lands and floating islands
xcvii-xcviii	§§ 210-1	Local earth marvels
xcix-civ	§§ 212-23	Tides (and other effects of the moon and sun)
cv	§ 224a	Depth of the sea
cvi	§§ 224b-234a	Miraculous waters and some universal properties of springs
cvii-cix	§§ 234b-235	fiery phenomena
cx	§§ 236-8	volcanoes
cxi	§§ 239-241	marvels of fire
cxii-cxiii	§§ 242-248	size of the earth

In Table 2-1 below (p.91) I will not include every oneof the many subjects touched upon by Pliny, but only those which have a clear counterpart in one or more of the other texts.

Seneca *Naturales Quaestiones*

More or less the same range of subjects is also covered by Seneca's *Naturales Quaestiones*.[226] At the outset of the second book,[227] Seneca divides the study of natural phenomena into three parts: the *caelestia* (heavenly things), the *sublimia* ('lofty' things) and the *terrena* (earthly things). The term *caelestia* denotes the phenomena of the heavens and the heavenly bodies, i.e. cosmology and astronomy. The *sublimia* cover all phenomena occurring in the region between the heavens and the earth, i.e. atmospherical phenomena, but also earthquakes. Finally, among *terrena* are understood such subjects as waters, lands, trees, plants and 'everything contained in the ground'.[228] If we

[225] The last words of §153 are: "Haec sint dicta de *aëre*." §154 starts with: "Sequitur *terra*."

[226] See Taub (2003) 141-161. On the macro-structure of the *NQ* as compared to Seneca's own programmatic remarks at *NQ* II 1, 1-2 see Mansfeld & Runia (2009a) 46-48 and 119-121.

[227] According to Carmen Codoñer Merino (1979), xii-xxi, and independently Hine (1981), 6-19, originally the eighth and last book.

[228] Sen. *NQ* II 1, 1-2: "Omnis de uniuerso quaestio in *caelestia, sublimia, terrena* diuiditur. Prima pars naturam siderum scrutatur et magnitudinem et formam ignium quibus mundus includitur, solidumne sit caelum ac firmae concretaeque materiae an ex subtili tenuique nexum, agatur an agat, et infra sese sidera habeat an in contextu sui fixa, quemadmodum anni uices seruet, solem retro flectat, cetera deinceps his similia. |

compare the range of subjects actually covered in the *Naturales Quaestiones* with Seneca's theoretical division of natural phenomena, it appears that the work is concerned almost exclusively with *sublimia* and *terrena*. There is only one exception: comets, which according to Seneca should be classed with the *caelestia*.[229] However, in holding this view he is, as he himself admits, dissenting from the accepted Stoic (and Aristotelian) view that comets are irregular and therefore necessarily sublunary phenomena.[230] By including the subject in a treatise otherwise devoted to atmospherical and earthly phenomena, Seneca is simply following the tradition. In the *Naturales Quaestiones* Seneca does not deal with questions concerning the earth as a whole, but he informs us that some of these (esp. those concerning the earth's position) should be classified among the *caelestia*,[231] while the rest belong with the *terrena*.

Two parts of the work appear to be lost: book IVa, on the Nile flood, lacks its final part, and IVb, presently on hail and snow, its beginning. It is likely that IVb originally included such subjects as clouds and rain as well.[232] The work as it has come down to us covers the following subjects:

I	Lights in the sky (both substantial an insubstantial)
II	Lightnings and thunders
III	Terrestrial waters (almost entirely excluding the sea)
IVa	Nile
IVb	Hail and snow
V	Winds, incl. whirlwinds
VI	Earthquakes
VII	Comets

The overview of Stoic meteorology in Diogenes Laërtius VII 151-4

In chapters 151-154 of book VII of his *Lives of Eminent Philosophers*, Diogenes Laërtius offers an overview of the Stoic theories on 'things taking

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Secunda pars tractat inter caelum terramque uersantia. Hic sunt nubila, imbres, niues, <uenti, terrae motus, fulgura> et humanas motura tonitrua mentes; quaecumque aer facit patiturue, haec sublimia dicimus, quia editiora imis sunt. Tertia illa pars de aquis, terris, arbustis, satis quaerit et, ut iurisconsultorum uerbo utar, de omnibus quae solo continentur."

[229] Sen. *NQ* VII 22 1.1-3: "Ego nostris {sc. Stoicis} non assentior. Non enim existimo cometen subitaneum ignem sed inter aeterna opera naturae." See also VII 4 and 21.1.

[230] Comets are included unreservedly in Diogenes Laërtius' overview of Stoic meteorology (VII 151-154), in Aristotle's *Meteorology* (I 6-7), and in the meteorological sections of the *De mundo* (4, 395b8-9) and Aëtius (III 2).

[231] Seneca, *NQ* II 1, 5: "ubi quaeretur quis terrae situs sit, qua parte mundi consederit, quomodo aduersus sidera caelumque posita sit, haec quaestio cedet superioribus et, ut ita dicam, meliorem condicionem sequetur."

[232] Corcoran (1971/2), 'Introduction' xx; Hine (1981) 10, 29-30; Gross (1989) 185.

place in the air' (VII 151.1: τῶν δ' ἐν ἀέρι γινομένων).[233] The overview comprises the following subjects (I have numbered them as they occur in the text):

1. Seasons
2. Winds
3. The rainbow
4. Comets
5. Shooting stars
6. Rain
7. Hoar-frost
8. Hail
9. Snow
10. Lightning
11. Thunder
12. Thunderbolts
13. Whirlwinds (*typhōnes* & *prēstēres*)
14. Earthquakes.

As Table 2-1 (on p.91 below) will show, this range of subjects corresponds almost exactly to that of Seneca's *sublimia* (if we include comets).

The *Syriac meteorology*

In the previous chapter the *Syriac meteorology* has been introduced already (see §1.5.5 on p.64ff above). This work, which is preserved in one Syriac and two Arabic versions, is now commonly believed to be either the complete text of, or an extract from, Theophrastus' lost two-book treatise Μεταρσιολογικά.[234] For reasons explained above I am not convinced this identification is certain, although the work is obviously Greek in origin. In the treatise as we have it the following subjects are discussed:

1. Thunder
2. Lightning
3. Thunder without lightning
4. Lightning without thunder
5. Why lightning precedes thunder
6. Thunderbolts
7. Clouds
8. Rain
9. Snow
10. Hail
11. Dew
12. Hoar-frost
13. Wind, incl whirlwinds (*prēstēres*)
14a. Halo around the moon
14b. Theological excursus
15. Earthquakes

There has been much speculation about whether or not the treatise as we have it might be complete. It has been suggested that it might originally have included subjects like comets and shooting stars, the rainbow and a number of terrestrial phenomena other than earthquakes. In this section I will try to avoid

[233] On D.L.'s account of Stoic meteorology see Taub (2003) 137. On the origins of D.L.'s account of Stoic philosophy in general (VII 38-160) see Mansfeld (1986); Mejer (1978) 5-7; and *id*. (1992) 3579-82.

[234] Cited by Diogenes Laërtius (V 46) in his list of works by Theophrastus.

such speculation; instead I will compare the text as we have it with other Graeco-Roman meteorologies and see where that may lead us.

Epicurus *Letter to Pythocles*

The *Letter to Pythocles* is one of Epicurus' three doctrinal letters quoted in full in the tenth book of Diogenes Laërtius' work on the lives and doctrines of the philosophers.[235] In the introduction Epicurus claims that with this letter he is complying with Pythocles' request for a 'concise and well-described account of "lofty matters"' (περὶ τῶν μετεώρων σύντομον καὶ εὐπερίγραφον διαλογισμὸν). Pythocles had complained that what Epicurus had written elsewhere (τὰ γὰρ ἐν ἄλλοις ἡμῖν γεγραμμένα) on these matters was hard to remember.

The *Letter*'s subject, "lofty matters" (τὰ μετέωρα), is nowhere clearly defined, but appears to cover not just meteorological, but also cosmological and astronomical matters. Below I will provide a table of contents of the entire letter. The chapter numbers are those of Bollack & Laks (1978), which I think provide more insight into the structure of the text (in addition I have split chapters 17 and 27, which each deal with two separate subjects, into an A and a B part); the traditional numbering of Meibom's edition of Diogenes Laërtius will be added in the second column.

1.	Introduction	p.84-85	
2.	Method	p.85-88	
3.	Definition of 'cosmos'	p.88	⎫
4.	Number and origin of cosmoi	p.89-90	⎪
5.	Formation of the heavenly bodies	p.90-91	⎪
6.	Size of the heavenly bodies	p.91	⎪
7.	Risings and settings	p.92	⎪
8.	Motions of the heavenly bodies	p.92-93	⎪ COSMOLOGY &
9.	Turnings of the sun and moon	p.93	⎬ ASTRONOMY
10.	The phases of the moon	p.94	⎪
11.	The light of the moon	p.94-95	⎪
12.	The face in the moon	p.95-96	⎪
13.	Eclipses of the sun and moon	p.96-97	⎪
14.	The heavenly bodies' regular periods	p.97	⎪
15.	The length of nights and days	p.98	⎭

[235] The authenticity of the *Letter to Pythocles* has been a matter of some doubt: Usener (1887) xxxvii-xli; Reitzenstein (1924) 36-43; Bailey (1926) 275; Schmidt (1990) 34-7. Bollack & Laks (1978) 45-55 provide a good overview and a convincing refutation of the arguments against the *Letter's* authenticity. See also Mansfeld (1994) n.2 and Sedley (1998a) n.65.

16.	Weathersigns	p.98-99	⎫
17A.	Clouds	p.99	⎪
17B.	Rain	p.99-100	⎪
18.	Thunder	p.100	⎪
19.	Lightning	p.101-102	⎪
20.	Why lightning precedes thunder	p.102-103	⎪
21.	Thunderbolts	p.103-104	⎪
22.	Whirlwinds (*prēstēres*)	p.104-105	⎬ METEOROLOGY
23.	Earthquakes	p.105-106	⎪
24.	(Subterranean) winds	p.106	⎪
25.	Hail	p.106-107	⎪
26.	Snow	p.107-108	⎪
27A.	Dew	p.108	⎪
27B.	Hoar-frost	p.109	⎪
28.	Ice	p.109	⎪
29.	The rainbow	p.109-110	⎭
30.	The halo around the moon	p.110-111	→ ?
31.	Comets	p.111	→ ?
32.	Revolution of the stars	p.112	⎫
33.	Planets	p.112-113	⎬ ASTRONOMY
34.	Lagging behind of certain stars	p.114	⎭
35.	Shooting stars	p.114-115	→ ?
36.	Weathersigns from animals	p.115-116	→ METEOROLOGY
37.	Conclusion	p.116	

Many scholars have commented upon the *Letter*'s strange order of subjects.[236] At first the order is clear enough: chapters 1-2 are introductory, 3-5 deal with cosmological matters, 6-15 are astronomical, and 16-29 meteorological (including earthquakes). It is at this point that the confusion begins: some of the following chapters (32-34) deal with subjects that are undeniably *astronomical* again, while others (30, 31 and 35) are concerned with subjects that most ancient meteorologists considered *meteorological*, although Pliny classified them as *astronomical* (as Table 2-1 on p.91 below will show). Chapter 36 is again *meteorological* and seems in fact to be a supplement to what was said in chapter 16.

Although Epicurus does not formally distinguish between astronomical and meteorological phenomena, both of which he simply calls "lofty matters" (μετέωρα), the structure of the letter suggests that he did recognize some kind

[236] Usener (1887) xxxviii-xxxix; Reitzenstein (1924) 36, 40-3; Bailey (1926) 275; Arrighetti (1973) 524, 691ff; Bollack & Laks (1978) 11-18; Sedley (1998a) pp.122-3 with n.75, p.157.

of division. Unfortunately, the confused order at the end of the letter prevents us from establishing with certainty where Epicurus would have placed the dividing line: haloes (30), comets (31) and shooting stars (35) might all be either meteorological or astronomical. However, the way in which the sections on comets and shooting stars straddle three undeniably astronomical subjects seems to favour their classification as astronomical phenomena.[237] A comparison with a number of other texts may help us to decide this matter (see Table 2-1 on p.91 below).

In the introduction to the *Letter* Epicurus refers to what he had written elsewhere (τὰ γὰρ ἐν ἄλλοις ἡμῖν γεγραμμένα) on these matters. We do not know where exactly Epicurus had dealt with these subjects before, but from fragments and citations we do know that at least some cosmological and astronomical problems were discussed in books XI and XII of his *On nature*. There is no evidence of any actually meteorological phenomena being discussed anywhere in the *On nature*, although it is clear that Epicurus must have discussed at least some of them outside the *Letter to Pythocles* as well, witness e.g. the long Epicurean account of earthquakes in Seneca's *Naturales Quaestiones* VI 20.5-7, which cannot derive from the corresponding passage in the *Letter to Pythocles*. In his reconstruction of Epicurus' *On nature*, David Sedley suggests that meteorological phenomena may have been discussed in book XIII of this work, separated from the discussion of astronomical phenomena in books XI and XII by the interposition of a passage on other worlds and the origin of civilisation, which would have occupied the later part of book XII. If this reconstruction is correct, this would suggest that Epicurus did indeed distinguish between astronomy and meteorology. However, as Sedley himself admits, this part of his reconstruction is highly speculative, and it cannot be excluded that meteorological phenomena were dealt with in book XII immediately following the discussion of astronomical phenomena.[238]

In the *Letter to Pythocles* Epicurus does not deal with subjects concerning the earth as a whole, but we know that at least one such subject, the earth's stability, was discussed at the end of book XI of his *On nature*, following and preceding a number of astronomical subjects in books XI and XII.[239] This suggests that, as far as Epicurus did distinguish between astronomical and meteorological phenomena, problems pertaining to the earth as a whole were classed with the former.

[237] So Usener (1887) xxxviii.
[238] Sedley (1998a) 122-123 with note 76.
[239] Sedley (1998a) 119-122.

Lucretius *De rerum natura* VI

In book VI of the *DRN* Lucretius discusses a number of atmospherical and terrestrial phenomena roughly coinciding with the subjects of Aristotle's *Meteorology*, and other works of this genre. More precisely, the following subjects are dealt with (or, in the case of snow, wind, hail, hoar-frost and ice, simply enumerated and then passed over):

96-159	Thunder
160-218	Lightning
219-422	Thunderbolts
423-450	Whirlwinds (*prēstēres*)
451-494	Clouds
495-523	Rain
524-526	Rainbow
527-534	Snow, wind, hail, hoar-frost, ice
535-607	Earthquakes
608-638	Why the sea does not grow bigger
639-702	Etna
703-711	The principle of multiple explanations
712-737	The summer flooding of the Nile
738-839	Avernian places
840-847	Water in wells colder in summer
848-878	The spring of Hammon
879-905	A cold spring which kindles tow
906-1089	The magnet
1090-1286	Diseases

Lucretius does not, in this context, deal with comets and shooting stars, nor does he discuss them in the astronomical passage in book V 509-770. Shooting stars ('noctivagaeque faces caeli flammaeque volantes') are mentioned in an overview of astronomical and meteorological phenomena in V 1189-93, but in such a way that it cannot be made out in which of the two groups Lucretius would have classed them. Yet, the evidence seems to be slightly in favour of Lucretius' assigning comets and shooting stars to astronomy. The overview of atmospherical phenomena in book VI is quite exhaustive and even those subjects, like snow, wind, hail, hoar-frost and ice, which he chooses not to discuss, he still feels obliged to mention. Had he felt that comets and shooting stars belong to this class too, he would probably have mentioned them too. The account of astronomical phenomena in book V, on the other hand, is rather selective. Here Lucretius could have omitted comets and shooting stars without explicitly saying so.

Problems pertaining to the earth *as a whole* are not discussed in the meteorological passage either. Lucretius does, however, discuss one such

problem – the stability of the earth – in book V (534-563), right in the middle of his astronomical section, which suggests that he might have considered other problems concerning the earth as a whole as belonging in that class as well.

Book VI falls apart into two main divisions, the first dealing with atmospherical, and the second with terrestrial phenomena. There is some incertainty about the exact place of the cut, especially with respect to the section on earthquakes (535-607). In lines 527-534 (i.e. just before the account of earthquakes) Lucretius invites the reader to find out for himself the causes of "the other things that grow above and are produced above" (527, tr. Rouse-Smith), such as snow, wind, hail, hoar-frost and ice. This seems to imply that the account of these "things that grow *above* and are produced *above*" is hereby concluded, and that all subsequent subjects, beginning with earthquakes, belong to another class of phenomena.[240] It is also possible, however, to place the dividing line *after* the subject of earthquakes. The next subject, the constant size of the sea, starts with the following words (608-9):

Principio mare mirantur non reddere maius naturam, ...	In the first place people wonder why nature doesn't make the sea bigger, ..

The word 'principio' ('in the first place') seems to suggest that Lucretius is now passing on to something new, viz. phenomena that inspire wonder –, of which the constant size of the sea presents the first instance.[241] Below we shall further explore this group of problems, both in relation to the preceding section in Lucretius, and to more or less corresponding sections in other meteorological works (see §2.3 on p.99ff below).

Comparison with other meteorological accounts may tell us, among other things, how each of the two proposed divisions relates to the traditional divisions of the subject, and to what extent Lucretius fits in this tradition.

2.2.3 The table

Table 2-1 on the following page provides a synopsis of the subjects that are dealt with in each of the nine 'meteorologies'. Subjects that are *explicitly* excluded from meteorology by the respective authors have been shaded grey. Also indicated are the major subdivisions of the subject matter as applied in

[240] Bailey (1947), 1567 and 1632, classifies all phenomena up to and including snow, wind, hail, hoar-frost and ice (i.e. lines 96-534) with 'atmospheric phenomena' and the rest (i.e. lines 535-1137), *including earthquakes*, with 'terrestrial phenomena. Cf. Giussani (1896-8), ad *DRN* VI 535-607.

[241] So Giussani (1896-8), ad *DRN* VI 608-638, and Bailey (1947), 1646-7.

each of the nine texts. The order in which the texts and the subjects are presented is my own and is not here at stake.[242]

For the sake of brevity, passages of Pseudo-Aristotle's *De mundo* 4 are indicated by the last digit of the Bekker page only, the first two digits of the relevant pages being always 39. In Diogenes Laërtius' account of Stoic meteorology I have applied my own numbering according to the order in which the subjects are presented by Diogenes. Epicurus' *Letter to Pythocles* is structured according to the chapter numbers of the edition of Bollack & Laks (1978), to which I have made the minor adjustment of dividing chapters 17 and 27 each into an A and a B part.

[242] The *order* of subjects in a number of texts *is* dealt with in §2.4 on p.115 below.

Table 2-1: Range of subjects and subdivisions in various ancient accounts of meteorology

Work / Subject	Aristotle *Meteorology* I-III	[Aristotle] *De Mundo* 4 (394a19 - 6a27)	Aëtius *Placita* III (+ IV 1)	Pliny *NH* II 89-248	Seneca *NQ*	Stoics ap. Diog. Laërt. VII 151-4	*Syriac meteorology*	Epicurus *Pyth.* 16-36	Lucretius *DRN* VI 96-end
		ἀέρια	**τὰ μετάρσια**	**sidera**	**sublimia**	**τὰ ἐν ἀέρι γιν.**			
Milky way	I 8		1						
Comets	I 6-7	(5a32) & 5b8-9	2	89-94	VII	4		31	
Shooting stars	I 4	(5a32)	2	96a	I 1 & 14-15	5		35	
Other luminary phenomena	I 5	5b3-17	2	96b-101	?				
Rods and mock suns	III 6	5a35-36	6	99a	I 9-13				
Halo	III 2-3	5a36 - b3	18	98a	I 2		14a	30	
				aër					
Rainbow	III 2 & 4-5	5a32-35	5	150b-151	I 3-8	3		29	524-526
Thunder	II 9	5a11-14	3	112-3	II	11	1	18	96-159
Lightning	II 9	5a14-21	3	112-3	II	10	2-5	19-20	160-203
Thunderbolts	III 1	5a21-23	3	112-3 & 135-46	II	12	6	21	204-422
Whirlwinds (*prēstēres* etc.)	III 1	5a23-24	3	131-4	V 13	13	13	22	423-450
Mist	I 9	4a19-23		152					
Clouds	I 9	4a26-27	4	111 & 152			7	17A	451-494
Rain	I 9	4a27-32	4	111		6	8	17B	495-523
Snow	I 11	4a32 - b1	4	152	IVb	9	9	26	(527-534)
Hail	I 12	4b1-5	4	152	IVb	8	10	25	(527-534)
Dew	I 10	4a23-24		152			11	27A	
Hoar-frost	I 10	4a25-26		152		7	12	27B	(527-534)
Ice		4a25						28	(527-534)
Winds	I 13 & II 4-6	4b7 - 5a10	7	111 & 114-130	V	2	13	24 (?)	(527-534)
Seasons			8			1			
Weathersigns								16 & 36	
		γῆ	**τὰ πρόσγεια**	**terra**					
Earthquakes	II 7-8	5b30 - 6a16	15	191-200	VI	14	15	23	535-607
					terrena				
PROBLEMS PERTAINING TO THE EARTH AS A WHOLE			9-14	154-190 & 242-248					
Volcanoes (Etna)	(II 8, 367a1-11)	5b19-23		207 & 236-8	(VI 4.1, etc.)				639-702
Poisonous exhalations		5b26-30		207-8	VI 28 & III 21				738-839
Springs and rivers	I 13	5b19 & 23-26	*(Stob. 39 ?)*	233-234a	III				840-847
Miraculous waters	(II 3, 359a18-b22)			224b-232	III 20 & 25-26				848-905
Summer flooding of the Nile			IV 1		IVa				712-737
		θάλασσα							
Constant size of the sea	II 2, 355b20-32			166.9-11	III 4-5				608-638
Coastal change	I 14	6a18-21		201-206a					
Origin & salinity of the sea	II 1-3		16	222b					
Tides		6a25-27	17	212-220					
Minerals and metals	III 6			207					
Magnets									906-1089
Diseases									1090-1286

2.2.4 Some observations

Fiery phenomena of the upper atmosphere

In *Meteor*. I 4-8 Aristotle sets one group of phenomena apart as belonging to the fiery upper part of the atmosphere. To this group he assigns comets, shooting stars, and the Milky Way. These three phenomena are variously treated in subsequent works on meteorology. The Milky Way seems to have been excluded from this group quite early in the tradition.[243] Except for Aëtius, all subsequent 'meteorologists' have omitted the subject. There seems to have been some doubt about the assignation of comets to this group as well, a doubt reported and shared by Seneca.[244] Most meteorologists, however, were happy to follow Aristotle's lead, discussing both shooting stars and comets under the general heading of atmospherical or lofty phenomena. The only explicit exception is Pliny, who classes comets and shooting stars together with some other luminary phenomena among astronomical matters.

The positions of the Syriac meteorologist, Epicurus and Lucretius are harder to ascertain. Comets and shooting stars are not discussed in the *Syriac meteorology* and Lucretius book VI, which suggests that they fell outside the scope of these works. It must be noted, however, that both subjects are also absent from Lucretius' astronomical passage in book V.

Epicurus does not formally distinguish between astronomical and atmospherical phenomena, both of which he calls 'lofty matters' (μετέωρα). Yet, the structure of his *Letter to Pythocles*, at least up to chapter 29, indicates that he accepted at least a practical division between the two groups of phenomena. Unfortunately, the confused order at the end of the letter, where comets and shooting stars are discussed together with a number of unmistakably astronomical phenomena makes it hard to decide to which group Epicurus would have assigned comets and shooting stars, although the placement of the chapters on these subjects suggests that Epicurus associated both phenomena with astronomy (see p.87 above).

Non-substantial luminary phenomena

Another sub-class of atmospherical phenomena distinguished by Aristotle is that of the non-substantial luminary phenomena.[245] The most notable of these are rainbows, 'rods', mock suns and haloes. Most subsequent meteorologists follow Aristotle and assign these to atmospherical or lofty

[243] See note 197 above.
[244] See note 229 above.
[245] On the ultimate Aristotelian origin of the distinction between substantial and non-substantial phenomena see Mansfeld (2005).

phenomena. Again, Pliny is the only explicit exception. He splits up the group, assigning mock suns (§99) and haloes (§98) to astronomy, and leaving only the rainbow (§§150-151) among atmospherical phenomena. In this case the *Syriac meteorology* seems to follow the majority view: among the otherwise meteorological phenomena it also includes the halo. It is strange, however, that the rainbow, which is the best known of this class of phenomena, should not have been included. In this respect the *Syriac meteorology* differs from all the other meteorologies. Lucretius' account in book VI only mentions the rainbow, but omits the halo. Epicurus, in the *Letter to Pythocles*, discusses both the rainbow and the halo. The fact that he discusses them in consecutive chapters suggests that he too, like most other meteorologists, considered these two phenomena to be related and hence to belong to the same class of phenomena, i.e. atmospherical phenomena.

Problems pertaining to the earth as a whole

Aëtius' section on τὰ πρόσγεια contains a number of chapters relating to the earth as a whole: (9) on the earth {being unique and limited}, (10) on the earth's shape, (11) on the earth's position, (12) on the earth's inclination, (13) on the earth's motion {or immobility}, and (14) on the earth's division {into five zones}.[246] The only other work to deal with such subjects within the scope of meteorological phenomena, is Pliny's *Naturalis Historia*. These subjects are absent from all the other works in the table and we have explicit information that most of their authors considered such subjects cosmological and astronomical rather than meteorological: Aristotle discusses the shape, position and stability of the earth in his cosmological and astronomical work *De caelo* (II 13-14), and the same subjects, as well as the earth's size and division into zones, are dealt with in the cosmological and astronomical treatise of the Stoic Cleomedes (I 1 & 5-8); Lucretius discusses the stability and location of the earth in the astronomical section of *DRN* book V (534-563), and Epicurus dealt with the same subject in book XI of his magnum opus *On nature* (fr.42 Arr.), amidst a number of cosmological and astronomical problems.[247] Seneca too, in the introduction to book II of the *Naturales Quaestiones*, tells us that certain problems concerning the earth, like its position, belong not to the *terrena* or *sublimia* but to the *caelestia*.[248] It would appear therefore that the inclusion of such problems among otherwise meteorological phenomena is an innovation by Aëtius and Pliny, probably inspired by their wish for a rigorous top-down presentation of natural

[246] The words between {…} are not part of the Aëtian chapter titles, but have been added by myself to better specify the precise subject of each chapter.
[247] See Sedley (1998a) 119-21.
[248] See n.231 above.

phenomena.[249] In general, then, such problems do not belong to meteorology.[250]

Earthquakes

In the table, earthquakes are variously placed among *terrestrial* or *atmospherical* phenomena. In the *De mundo* 4, in Aëtius III and in Pliny II, earthquakes are dealt with under the general heading of *terrestrial* phenomena. The reason for this seems to be that in all three works precedence is given to the *location* of the phenomenon. Seneca and the Stoics, on the other hand, agree in classing earthquakes with *lofty* or *atmospherical* phenomena. Seneca provides us with the reason for this – perhaps – surprising move (*NQ* II 1, 3):

"Quomodo," inquis, "de terrarum motu quaestionem eo posuisti loco quo de tonitribus fulguribusque dicturus es?"

Quia, cum motus spiritu fiat, spiritus autem aer sit agitatus, etiamsi subit terras, non ibi spectandus est; cogitetur in ea sede in qua illum natura disposuit.

"Why," you ask, "have you put the study of earthquakes in the section where you will talk about thunder and lightning?"

Because, since an earthquake is caused by a blast, and a blast is air in motion, therefore, even if air goes down into the earth, it is not to be studied there; let it be considered in the region where nature has placed it'.[251]

According to Seneca, who may be supposed here to speak on behalf of all Stoics, earthquakes, being caused by *air*, should be dealt with in connection with other phenomena of the *air*. In this respect the Stoics follow closely in Aristotle's footsteps. Although Aristotle does not yet apply the neat bipartion of meteorological phenomena into those of the *earth* and those of the *air* (or 'lofty': μετάρσια / sublimia), such as we find with many of his successors, he does explicitly link the subject of earthquakes with that of winds (*Mete.* II 7, 365a14-15):

Περὶ δὲ σεισμοῦ καὶ κινήσεως γῆς μετὰ ταῦτα λεκτέον· ἡ γὰρ αἰτία τοῦ πάθους ἐχομένη τούτου τοῦ γένους ἐστίν.

After the previous subject (i.e. wind) we must speak about earthquakes and earth tremors: for the cause of this phenomenon is akin to that of wind.

[249] On this top-down presentation of cosmological problems in Aëtius and other writers, and its consequences for the location of the sections dealing with the earth as a whole, see Mansfeld & Runia (2009a) 40-1 with n.71, and 133-4. On the order of Pliny's cosmology see Kroll (1930) p.2, and Hübner (2002).

[250] Similar observations and conclusions in Mansfeld (1992b) n.124 and Mansfeld & Runia (2009a) 119-22.

[251] Transl. Corcoran (1971/2), slightly modified.

For the *Syriac meteorology*, and the accounts of Epicurus and Lucretius the story is a bit different. In all three works earthquakes are accounted for by a number of alternative explanations, not just wind, which makes their link to atmospherical phenomena less obvious. Yet, it can hardly be a coincidence that just as in the account of Stoic meteorology, so too in the *Syriac meteorology* and in the *Letter to Pythocles*, earthquakes are the only 'terrestrial' phenomenon to be discussed among a number of otherwise atmospherical phenomena. It would appear that even though the Syriac meteorologist and Epicurus do not share the Stoics' and Aristotle's assumptions, they do follow the tradition that incorporates earthquakes among atmospherical phenomena. It seems reasonable to suppose that Lucretius, being a follower of Epicurus, whose meteorological account, moreover, closely matches the *Syriac meteorology*, belongs to this same tradition.

Terrestrial phenomena (other than earthquakes)

In most of the meteorological accounts a number of terrestrial phenomena (other than earthquakes) are included. Lucretius, too, discusses a number of terrestrial phenomena. It is remarkable that the two closest parallels to Lucretius, viz. the *Syriac meteorology* and Epicurus' *Letter to Pythocles*, do not deal with this class of phenomena. It could be and has been argued, in view of the close similarity between Lucretius' book VI and the *Syriac meteorology*, that the latter must originally have dealt with such subjects too.[252] There is no reason to assume that the *Letter to Pythocles* is incomplete, but Epicurus might have dealt with terrestrial phenomena somewhere else, perhaps in his *On nature*. Yet, there is no direct evidence for this claim, and the only terrestrial phenomena that we know for certain to have been discussed by Epicurus are magnets and diseases.[253] It might therefore be claimed just as well that the section on 'terrestrial phenomena' in *DRN* VI was Lucretius' own invention. In §2.3 below I will investigate how Lucretius' account of terrestrial phenomena in the second half of book VI relates to his account of atmospherical phenomena in the first half, and also how it relates to the discussion of similar matters in other meteorological works and summaries.

2.2.5 Some conclusions

The *Syriac meteorology*

The range of phenomena covered in the *Syriac meteorology* is smaller than in any of the other meteorologies. For this reason it has often been argued that the treatise must be an extract from a larger work in which more subjects were

[252] Steinmetz (1964) 216 with n.3; Mansfeld (1992a) 315-7.
[253] See p.98 with n.258 below.

dealt with. Steinmetz, for instance, suggests that the original work would have included chapters on the rainbow, mock suns, dew and volcanoes.[254] Many of the arguments for its completeness or incompleteness are based on its identification with Theophrastus' lost 2-volume *Metarsiologika*. Mansfeld, for instance, following a suggestion made by Daiber, believes that the chapter on earthquakes may originally have been the first chapter of Theophrastus' second book, which, in addition to this chapter, 'may have included treatment of other so-called terrestrial phenomena, e.g. "the advances and regressions of the sea and the extensions of the land" '.[255]

Now let us for a moment forget the ascription to Theophrastus and compare the work as we have it with other meteorologies. As we saw above (p.94), the *Syriac meteorology*, just like D.L.'s account of Stoic meteorology and Epicurus' *Letter to Pythocles*, includes earthquakes but excludes other terrestrial phenomena. Now, the reason for this practice in Stoic meteorology is clear: its subject matter is confined to 'things happening in the air' (τὰ ἐν ἀέρι γινόμενα); earthquakes are caused by moving air, and therefore must be classed with phenomena in the air. This motive, however, is not valid for Epicurus, for whom subterranean winds are only one of several explanations. The inclusion of earthquakes (*Pyth*. 23 [105-106]) among Epicurus' μετέωρα (lofty things) can therefore only be explained by his willy-nilly adherence to a tradition, whose principles he no longer ascribes to. The same explanation can be applied to the *Syriac meteorology*. The inclusion of earthquakes (ch.15) in no way entails the inclusion of other terrestrial phenomena.

Another group of subjects that appears to be missing is that to which comets and shooting stars belong. From Aristotle onwards these two subjects appear to have been standard ingredients of meteorological treatises. We find them included under atmospherical / lofty phenomena in the *De mundo* 4, in Aëtius book III, and in the account of Stoic meteorology in Diogenes Laërtius. As we have seen above,[256] Seneca prefers to see comets as astronomical rather than meteorological phenomena, but in doing so he also testifies that comets were a traditional part of meteorology. Pliny is the only author who explicitly classes both comets and shooting stars under the general heading of astronomy. We do not know why the Syriac meteorologist omits both subjects, but he is not alone in doing so: they are also missing in Lucretius' meteorological survey in book VI of the *DRN*. It is possible that both authors, like Pliny, considered these subjects astronomical rather than meteorological,

[254] Steinmetz (1964) 216 with n.3.
[255] Mansfeld (1992a) 315-7.
[256] See note 229 above and text thereto.

but this cannot be proved, as comets and shooting stars are equally absent from the astronomical section in *DRN* V. Both subjects *are* discussed in Epicurus' *Letter to Pythocles*. However, the fact that they are discussed there in close association with a group of undeniably astronomical subjects may suggest that Epicurus thought them astronomical rather than meteorological (see p.87 above). However this may be, the absence of comets and shooting stars from a meteorological treatise is not unparallelled, and there is no need to suppose that the Greek original of the *Syriac meteorology did* discuss these subjects.

This leaves us with only one more omission: the rainbow. The *Syriac meteorology* is the only meteorology which does not include the rainbow.[257] This is the more striking as the treatise *does* discuss the halo, with which the rainbow is traditionally associated. If, for the sake of brevity, one of the two is omitted it is usually the halo: this is the case in Diogenes' account of Stoic meteorology, and Lucretius book VI. In the meteorological section of Epicurus' *Letter to Pythocles*, whose range of subjects is otherwise very close to that of the *Syriac meteorology*, both the rainbow and the halo are discussed. There seems to be some reason, then, to suppose that the *Syriac meteorology*, or its Greek source, may have contained a chapter on the rainbow, which was lost in the course of the transmission of the text.

It appears to me, therefore, that, as far the range of subjects is concerned, except perhaps for its omission of the rainbow, the *Syriac meteorology* may well be complete.

What does all this mean for the treatise's attribution to Theophrastus? Very little, I am afraid. As the table shows, in its range of subjects it most closely resembles Diogenes Laërtius' Stoics, the latter part of Epicurus *Letter to Pythocles* and the first half of the sixth book of Lucretius' *DRN*. The omission of comets and shooting stars is parallelled in Lucretius VI, and perhaps also Epicurus' *Letter*, if comets and shooting stars are taken to be astronomical (see p.87 above). The most telling argument in favour of a Peripatetic origin is its inclusion of earthquakes within a range of otherwise atmospherical phenomena. This fact suggests a dependence on a tradition in which the explanation of earthquakes was closely linked to that of wind. This tradition is most clearly exemplified by Seneca and the Stoics, and can be traced back to Aristotle. In this respect, however, the *Syriac meteorology* does not differ from Epicurus' *Letter to Pythocles*; both works stand in the same relationship to the (Aristotelian) tradition, and there is no reason why one should be closer to the origin of the tradition than the other.

[257] See Mansfeld (1992a) 315-16.

Epicurus' *Letter to Pythocles*

Most that can be said about the *Letter* has been said already: it does not explicitly differentiate between astronomical and meteorological phenomena, yet in the organization of the *Letter* some kind of a division appears to be present. At the end of the *Letter* the order of subjects is a bit confused, and due to this confusion it is not entirely clear whether Epicurus considered comets and shooting stars astronomical or rather atmospherical. The evidence seems slightly in favour of the first option (see p.87 above), and if this is true the range of truly atmospherical phenomena in the *Letter* would correspond almost exactly to that of the *Syriac meteorology* (except for the rainbow which is absent from the Syriac as we have it).

Lucretius' *DRN* book VI

Lucretius' meteorological account differs from Epicurus' in two important respects. Firstly, whereas Epicurus does his best to obscure the difference between astronomical and meteorological phenomena by discussing them under the single heading of μετέωρα, Lucretius deals with both fields separately. The astronomical passage in book V 509-770 is firmly separated from the discussion of meteorological phenomena in book VI by the intervention of a very long section on the origins of life and civilisation, which occupies the second half of book V (771-1457). Secondly, the range of meteorological subjects discussed by Lucretius is considerably longer than that of either Epicurus' *Letter to Pythocles*, or the *Syriac meteorology*, which in many other respects appears the closest parallel to Lucretius' book VI. Whereas the *Letter to Pythocles* and the *Syriac meteorology* confine themselves to atmospherical phenomena and earthquakes, Lucretius proceeds to deal (608-1286) with a range of (other) terrestrial phenomena, such as the sea, the Etna, the Nile, poisonous exhalations, springs and wells, magnets and diseases, which are not represented in the *Letter to Pythocles* or in the *Syriac meteorology*.

It cannot be excluded, of course, that Epicurus dealt with such matters elsewhere: Galen credits him with an elaborate theory of magnetism,[258] and Diogenes Laërtius ascribes to him a work titled Περὶ νόσων δόξαι πρὸς Μίθρην, *Opinions on diseases, to Mithres*,[259] which may or may not have dealt with the physical side of diseases. However, there is no evidence that he discussed any of the other subjects which Lucretius covers in *DRN* VI 608ff. It is possible, therefore, that Epicurus was not Lucretius' main source for this

[258] Galen, *On Natural Faculties*, I 14 [vol. II p. 45 Kühn] (= Epic. fr.293 Us.).
[259] Diog. Laërtius X 28.

passage. In the next section the character of Lucretius' passage and its possible relations to meteorological and other literature will be examined.

2.3 Terrestrial phenomena other than earthquakes

2.3.1 Lucretius

On p.89 above it was suggested that Lucretius' section on the constant size of the sea was the first of a new class of problems, different in character from the preceding phenomena, both atmospherical and earthquakes. The clue as to what this difference might be is given right at the beginning of this new division (lines 608/9): 'Principio mare *mirantur* non reddere maius / naturam, ...' – 'In the first place people *wonder* why nature doesn't make the sea bigger, ..' As Giussani and Bailey point out, this sense of *wonder* also characterises many of the problems that follow (explicitly so in 608 *mirantur*, 654-55 *mirari* & *miratur*, 850 *admirantur*, 910 *mirantur*, 1056 *mirari*). In this sense, then, these problems differ from the preceding ones, which may incite awe and fear, but are not said to cause wonder.[260]

Although Lucretius does not tell us explicitly in what way the second group of phenomena should inspire this sense of wonder, which the preceding do not, it is not hard to see that there *is* a difference in character between the phenomena in the first group and *most* of the second group. While the phenomena in the first group (including earthquakes) are all capable of occurring just about anywhere, the majority of the subjects discussed in the second part are concerned with *exceptional* and *local* phenomena, the kind of phenomena the ancients referred to as παράδοξα, θαυμάσια or θαύματα and *mirabilia* or *miracula*,[261] i.e. 'marvels' or 'miracles'.[262] Such are the Etna, the river Nile (explicitly said to be 'unique' - 713 *unicus*), the 'Avernian' places (one near Cumae, one in Athens and one in Syria), and the spring near the shrine of Hammon (in the Siwa-oasis in Egypt). Also local is the cold spring which kindles tow (lines 879-905), whose location Lucretius does not reveal, but which may be identified with either the spring of Jupiter in Dodona or the

[260] This is not entirely true: in the introduction to book VI Lucretius speaks of people wondering (59 mirantur) about things that take place above our heads in the 'ethereal' regions (61 quae supera caput aetheriis cernuntur in oris), i.e. astronomical and atmospherical phenomena. Yet, in the body of the text the use of this verb is restricted to certain terrestrial phenomena only.

[261] For ancient names for such phenomena see Ziegler (1949) cols. 1137-38; Schepens & Delcroix (1996) 380-2; Wenskus (2000) col. 309.

[262] Lists of such phenomena are found throughout Pliny's *Naturalis Historia*, where they are referred to as *miracula* and *mirabilia*.

spring of the nymphs in Athamania,[263] about which similar stories were told. The magnet, too, may be counted among local phenomena, as it is found specifically – so Lucretius tells us – in the land of the Magnetes (in Lydia, Asia Minor). I have summarized all this in the following table (for the sake of completeness I have also included 703-711 which do not deal with a specific phenomenon, but with the method of multiple explanations in general):

Table 2-2: Lucretius' account of terrestrial phenomena

lines	subject		exceptional	local
608-638	Why the sea does not grow bigger		608 mirantur	
639-702	Etna		654 mirari	639 Aetna
703-711	Multiple explanations			
712-737	The summer flooding of the Nile		713 *unicus*	712 Nilus
738-839	Avernian places	Lacus Avernus (745-47)		747 Cumas apud
		Acropolis (748-55)		749 Athenaeis in moenibus
		Syria (756-59)		756 in Syria
840-847	Water in wells colder in summer			
848-878	The spring at the shrine of Hammon		850 admirantur	848 apud Hammonis fanum
879-905	A cold spring which kindles tow			(Dodona / Athamania)
906-1089	The magnet		910 mirantur 1056 mirari	909 Magnetum in finibus
1090-1286	Diseases			1115 Aegypto 1116 Achaeis finibus 1117 Atthide

Three phenomena stand out in the above list: the constant size of the sea, wells being colder in summer, and diseases. The sea, which occupies such a large portion of the earth,[264] can hardly be called a *local* phenomenon. It is clear that the sense of wonder it it said to inspire is of a different kind from that inspired by, for instance, the Nile or the spring of Hammon. Thematically it seems to be more closely related to the atmospherical phenomena of the preceding section: one of the explanations offered (627-630) – viz. that a considerable portion of water is drawn up by the clouds – is the exact counterpart (as Lucretius himself points out in 627) of one of the causes of cloud formation (470-475) and of rain production (503-505).[265]

[263] See Ernout-Robin (1925-28) *ad loc*. The spring of Jupiter in Dodona is described by Pliny *NH* 2.228.1-3 and Mela 2.43 and the spring of the nymphs in Athamania by Antigonus 148, the Doxographus Florentinus 11 and Ovid *Met.* 15.311-12.

[264] Cf. Lucr. *DRN* V 203.

[265] For this reason Robin (Ernout-Robin *ad loc*.), ignoring Lucretius' own textual clues, prefers to include this passage with the atmospherical phenomena that precede it.

The account of why water in wells is colder in summer than in winter is also different. Whereas most phenomena in this section are somehow exceptional among their kind – the Etna among mountains, the Nile among rivers, the spring of Hammon among springs and the magnet among stones –, this passage is about something generally attributed to all of its kind: all wells were believed to be colder in summer and warmer in winter.[266] Yet it is not hard to imagine why Lucretius included it in this section: the annual temperature fluctuation of wells is somewhat similar to the daily temperature fluctuation of the spring of Hammon.

This brings us to the last subject, not just of the 'terrestrial phenomena' but of the entire book: diseases. The language with which Lucretius introduces the subject does not suggest any major break with the preceding subjects. Soon, however, it appears that they are somewhat different. Diseases, according to Lucretius, are produced in two different ways (1098-1102):

Atque ea vis omnis morborum pestilitasque aut extrinsecus, ut nubes nebulaeque, superne per caelum veniunt, aut ipsa saepe coorta de terra surgunt, ubi putorem umida nactast intempestivis pluviisque et solibus icta.	And all this might of diseases and this pestilence either comes from without, like clouds and mists, from above through the sky, or often, having gathered, they rise from the earth itself, when this, being moist, has come to rot, having been hit by out-of-season rains and suns.

Diseases either come from without through the sky,[267] like clouds and mist, or they arise locally from the earth itself. These two kinds seem to correspond to what ancient as well as modern medicine refers to as *epidemic* and *endemic* diseases.[268] In the following lines (1103-1118) Lucretius first deals with the second kind of diseases: those that are peculiar to certain regions and peoples, depending on the local climate, and which may also affect those who travel

[266] Cic. *N.D.* II 25.7 - 26.1; Sen. *NQ* VI 13.3-4; Plin. *NH* II 233.1-2.

[267] This theory is anticipated in line 956 ('morbida visque simul, cum extrinsecus insinuatur') in the account of the magnet, and seems to look back to 483ff where the possibility of an extra-cosmic origin of clouds is suggested. Line 956, which explicitly refers to disease, seems to ascribe an extra-cosmic origin to diseases as well, but only if it is connected with the preceding line from which it is separated by a lacuna of unknown length (see the commentaries). In the present passage, however, apart from the reference to clouds, there is nothing to suggest that diseases might come from without the cosmos. The point rather seems to be that diseases are either innate to a certain region, or come from elsewhere. See Kany-Turpin (1997).

[268] Bailey does observe the distinction but makes nothing of it. He calls all the diseases in this passage 'epidemic' and also 'marvel'. For the distinction between epidemic and endemic diseases, see Galen *In Hippocratis de victu acutorum commentaria iv*, Kühn 15.429-430; id. *In Hippocratis librum primum epidemiarum commentarii iii*, Kühn 17a.13; Ps.-Galen *Definitiones medicae*, Kühn 19.391. See also the admirably concise accounts in Karl-Heinz Leven (ed.) *Antike Medizin. Ein Lexikon*, Munich 2005, lemmata 'Endemie' and 'Epidemie'.

there. Lucretius ends this brief account with three examples that would not be out of place in our list of local marvels: elephantiasis which is unique to Egypt, a foot-disease peculiar to Attica and an eye-disease typical of Achaea. Then (1119-1132) Lucretius goes on to discuss the other kind of diseases: those that travel with the air like clouds and mist and thus come upon us. Before coming to the 'finale', Lucretius recapitulates the major point of his account (1133-1137): it makes no difference whether we travel to an unwholesome place (*endemic* disease) or whether nature brings the unwholesomeness to us (*epidemic* disease). Lucretius ends the account, and the entire work, with a long description of an outbreak of the second type (*haec* ratio morborum), the famous plague of Athens.[269] In sum, Lucretius' account of diseases does not entirely blend in with the preceding accounts of mostly local marvels. While *endemic* diseases bear a certain resemblance to local marvels such as the Nile, the spring of Hammon and especially Avernian places, which are accounted for in a similar manner,[270] *epidemic* diseases have more in common with the non-local atmospherical phenomena of the first half of book VI; they are repeatedly likened to clouds and mist.

Beside these three problems – the constant size of the sea, the paradoxical annual temperature fluctuation in wells, and diseases – all the other subjects discussed in the second half of book VI are concerned with exceptional local phenomena.

2.3.2 Local marvels in meteorology and paradoxography

Although some of the local marvels discussed by Lucretius, as well as similar ones, are also mentioned in various other meteorologies, phenomena of this kind are more typically found in an another genre of writings, generally known as paradoxography.[271]

Paradoxography is the activity and the written result of collecting accounts of natural marvels. Such 'marvels' comprise 'unexpected features of the natural world (animals, plants, rivers and springs), but also the world of man, human physiology, unusual social customs, and even curious historical facts (...)',[272] which are drawn from all kinds of earlier writings, often with explicit

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[269] In ancient medical literature (e.g. Galen *In Hippocratis de victu acutorum commentaria iv*, Kühn 15.429) a *plague* (Greek λοιμός) is defined as a *deadly epidemic* (ἐπιδημία ὀλέθριος). See also Karl-Heinz Leven, op. cit., lemma 'Pest'.

[270] See esp. lines 769-780 on the earth containing both beneficial and harmful elements; and lines 781-817 listing a number of harmful substances and places.

[271] On paradoxography in general see e.g. Ziegler (1949); Schepens & Delcroix (1996).

[272] Schepens & Delcroix (1996) 381.

acknowledgement of the source.[273] Paradoxographies do not usually express doubt about the veracity of the marvellous stories they report, nor do they provide physical explanations for them; they restrict themselves to simply reporting them. In this respect paradoxography differs from the scientific writings from which many of the marvellous stories were culled. Discarding the *On marvellous things heard*, which is generally believed to be the work, not of Aristotle, but of a number of subsequent authors working between the 3rd cent. BC and 2nd cent. AD,[274] the oldest reported writer of paradoxography is Callimachus of Cyrene (ca. 310-240 BC), part of whose work is reproduced in Antigonus' *Historiarum mirabilium collectio*.[275]

The place of natural marvels in ancient scientific literature – and especially meteorology – and the relationship between science and paradoxography are complex subjects. Although paradoxography as a separate genre seems to have originated only in the Hellenistic age, scientific works like Aristotle's not only provided it with many individual marvel stories, but actually set the example of producing *lists* of particular local phenomena. Aristotle's *Meteorology*, for instance, contains two lists of particular waters: at 350b36 - 351a18 of partially underground rivers, and at 359a18-b22 of salty and other-tasting waters, many particular instances of which are also reported in paradoxographical literature. In its turn scientific literature of later ages reappropriated a lot from paradoxography. In book II of Pliny's *Naturalis historia*, for instance, (as in the rest of his work) several long lists of 'miracula' (so Pliny calls them) are produced, which are almost indistinguishable in character from the accounts found in purely paradoxographical works, from which they seem to have been borrowed.[276]

Both the attitude towards, and the space devoted to, particular local phenomena in ancient meteorologies changes in the course of time. Aristotle's attitude towards such phenomena is ambiguous. Although, as we have just seen, the *Meteorology* includes several lists of such particular problems, these are never the actual *objects* of inquiry. The list of underground rivers at 350b36 - 351a18 only serves to illustrate why some people might – incorrectly – think that the sea itself is replenished from underground reservoirs, and the list of salty waters at 359a18-b22 serves to lend plausibility to the belief that the salty taste of sea-water too is due to admixture. In later meteorologies the amount of paradoxographical passages increases dramatically. In the *De mundo* the entire section on terrestrial phenomena, save for a long account of

[273] Schepens & Delcroix (1996) 383-6.
[274] Ziegler (1949) cols. 1150-51; Schepens & Delcroix (1996) 427; Vanotti (2007) 46-53.
[275] Antigonus *Hist. mir.* 129ff.
[276] On Pliny's paradoxographical passages see e.g. Ziegler (1949) cols. 1165-66; Schepens & Delcroix (1996) 433-9; Naas (2002), ch.5.

earthquakes, is a mere enumeration of local marvels. In Seneca's *Naturales Quaestiones* a large portion of book III 'On waters' is filled with lists of peculiar waters. Pliny's *Naturalis Historia* caps them all: book II contains extensive lists of earth miracles (206b-211), water miracles (224b-234) and fire miracles (235-238), often, as in paradoxography proper, with explicit reference to the source of each story. As a rule, in paradoxography as well as meteorology, such peculiar local phenomena are not explained, or only in the most general terms.

A curious exception to this rule is the summer flooding of the Nile. True to his own precept, in *Metaph*. VI 3, 1027a20-26,[277] that science should not be concerned with particular, but only general problems,[278] Aristotle does not even mention the Nile flood in his *Meteorology*, where we only find the general and unqualified observation (I 13, 349b8) that *all* rivers flow higher in winter than in summer.[279] Interestingly, among the works ascribed to Aristotle there is a treatise, only preserved in a 13th century Latin translation, titled *Liber de inundacione Nili* ('Book on the flooding of the Nile'), which is entirely devoted to the question of why the Nile, in contrast to all other rivers, overflows in summer.[280] Although the work's authorship is still a matter of dispute, most scholars agree that it should at least be assigned to Aristotle's school.[281] Apparently then, even in Aristotle's school such a particular problem could be worthy of scientific investigation after all. It need not surprise us, therefore, that in some subsequent meteorological accounts the problem of the Nile flood was simply included within the scope of their subject matter. This is the case with Aëtius and Seneca, who devote a whole chapter (IV 1) and a whole book (IVa) to it, respectively. It is interesting to note that precisely this problem, perhaps the most famous of all local marvels,

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[277] Cf. *An. post.* I 8, 75b21-36.

[278] See Taub (2003) 83.

[279] Arist. *Mete.* I 13,349b8: Διὸ καὶ μείζους {sc. τοὺς ποταμοὺς} τοῦ χειμῶνος ῥεῖν ἢ τοῦ θέρους ... – 'Therefore also (they suppose that) rivers flow higher in winter than in summer …'.

[280] Arist. (?) *Liber de Nilo* 2-4: 'Propter quid aliis fluminibus in hyeme quidem augmentatis, in estate autem multo factis minoribus, {sc. Nilus} solus eorum, qui in mare fluunt, multum estate excedit ... ?' – 'For what reason, while other rivers rise in winter, and become much smaller in summer, does the Nile, alone of those that flow into sea, rise strongly in summer ... ?'

[281] The work is variously attributed to Aristotle and Theophrastus. An influential case for Aristotle's authorship has been made by J. Partsch (1909); and for Theophrastus' by P. Steinmetz (1964) 278-96. Both views have had their adherents until quite recently; for an overview see Sharples (1998) 197 with notes. Partsch's view is also accepted by R. Jakobi & W. Luppe (2000).

does not feature in any of the surviving paradoxographies. Perhaps the very fact that so many had studied it, and provided explanations for it, disqualified it as a 'mirabile'.

In what follows I would like to view Lucretius' account of – mostly local and particular – terrestrial phenomena against the background of the treatment of such phenomena in other meteorological as well as paradoxographical works. As some of the 'meteorologies' we have hitherto referred to do not discuss terrestrial phenomena (except for earthquakes) at all, I will here limit myself to those that do, viz. Aristotle's *Meteorology*, Pseudo-Aristotle's *De mundo* 4, Aëtius' *Placita* III, Seneca's *Naturales Quaestiones* and Pliny's *Naturalis historia* II. From among the many paradoxographical works dealing with terrestrial phenomena, I have chosen to include in the table only Antigonus' *Historiarum mirabilium collectio* and Pseudo-Aristotle's *De mirabilibus auscultationes*, which are the most extensive ones and present most parallels. In the accompanying text occasional references shall be made to other paradoxographies as well, such as Apollonius' *Historiae Mirabiles*, Claudius Aelianus' *De natura animalium* and the so-called 'Paradoxographus Vaticanus' and 'Paradoxographus Florentinus'. In the table below I have included all terrestrial phenomena discussed by Lucretius in *DRN* VI 608ff, to which I have added the sweet spring in the sea off Aradus, which Lucretius mentions (890-894) as a partial parallel to the spring that kindles tow (879-905), and which may well derive from the same stock. I have also added two more general categories, volcanoes and marvellous waters, of which Lucretius offers only some specimina. In the table a reference in bold characters indicates that the phenomenon in question is not merely mentioned but also physically accounted for. Brackets indicate that the phenomenon is not mentioned in its own right but only to serve as a parallel to, or an example of, some other phenomenon. A wavy line (~) indicates an almost identical phenomenon at a different geographical location. References to the *De mundo* 4 are indicated by the last digit of the Bekker page only, the first two digits of the relevant pages being always 39.

Table 2-3: The subjects of *DRN* VI 608ff with parallels in meteorology and paradoxography.

Work / Subject	Lucretius *DRN* VI	Arist. *Meteor.* I-III	Aët. *Plac.* III	[Arist.] *De mundo* 4	Seneca *NQ*	Pliny *NH* II	Antigon.	[Arist.] *Mir.Ausc.*
Constant size of the sea	**608-638**	**355b20-32**			**III 4-8**	166.9-11		
Volcanoes		(367a1-11)		5b19-23	(V 14.4 etc.)	236-238	166-167	34-40
- Etna	**639-702**			5b21		236.1-3		38b & 40
The Nile flood	**712-737**		**IV 1**		**IV a**			
Poisonous exhalations	**738-839**			5b26-30	(III 21) & (VI 28)	207.9-208.10	121-123, 152a-b	
a. Lacus Avernus	746-748						152b	102
b. Acropolis	749-755						12	
c. Syria / Phrygia (*)	756-759			5b30		208.4-5	123	
Temperature in wells	**840-847**				**(VI 13.3-4) & (IV a 26-27)**	233.1-2		
Marvellous waters		(350b36 ff) (359a18 ff)			III 20 & 25-26	224b-232	129-165	53-57 etc.
- Spring of Hammon	**848-878**					228.6-10	144	
- Spring which kindles tow	**879-905**					228.1-6	148	
- *Sweet spring off Aradus*	(890-894)	(~351a14-16)				227.4-5	~129.2	
Magnets	**906-1089**							
Diseases	**1090-1286**				(VI 27-28)			

(* On the identity of these two places see text on p.107 below)

Below I will briefly discuss each subject (or group of subjects), point out the parallels in meteorological and paradoxographical literature, and indicate to what extent Lucretius' treatment corresponds to, and differs from, these.

Constant size of the sea

This problem is not, as we have seen, a 'mirabile' in the technical sense, and accordingly not found in any ancient paradoxography. Thematically the problem is closely related to atmospherical phenomena and was probably discussed in this context long before Aristotle's *Meteorology*: in Aristophanes' *Clouds* (produced ca. 420 BC), in a parody of contemporary physical theory,[282] the constant size of the sea is one of several problems to be discussed (1278-1295), the others being the origin of rain (369-371), the causes of thunder (375-394), and the causes of the thunderbolt (395-407). Later the same problem is discussed in a meteorological context in Aristotle's *Meteorology* and Seneca's *Naturales Quaestiones*, and briefly touched upon in Pliny's *Naturalis Historia* II. Lucretius' discussion of this subject is entirely in line with this.

[282] For the date see Dover (1968), pp.lxxx-xcviii. For the parody of contemporary physics see Dover's and other commentaries ad locc.

Volcanoes

Although earthquakes appear to have been a standard ingredient in ancient meteorologies, volcanoes were not.[283] Aristotle only briefly refers to them, as possible side-effects of earthquakes, not phenomena to be studied in their own right, and he does not even mention the most formidable of them all, the Etna. Seneca's attitude is similar. After some brief references to volcanic phenomena in book II (at 10.4; 26.4-6 and 30.1), in book V (14.4) he promisses to discuss the subject more fully in connection with earthquakes. Book VI on earthquakes, however, contains only one, disappointingly brief, reference to volcanoes, in a catalogue of possible side-effects of earthquakes (VI 4.1). Aëtius omits the subject alltogether. Things are different in the *De mundo* and in Pliny's *Naturalis Historia*. In both works volcanoes are clearly set appart from earthquakes, and both works mention a number of volcanoes by name, including the Etna. Neither work, however, makes any attempt at explaining volcanism. In this respect they resemble the paradoxographical accounts in Antigonus (166-167) and the Pseudo-Aristotelian *De mirabilibus auscultationes* (34-40), only the latter of which includes the Etna itself. Lucretius' approach is entirely different: he not only mentions the Etna as a phenomenon to be studied in its own right, but he actually explains its working.

The Nile flood

From very early on the summer flooding of the Nile had aroused the interest of the Greeks. Whereas, in their experience, all other rivers rose in winter, the Nile alone did so in summer. This called for an explanation and many different theories were devised to account for this curious behaviour.[284] Aristotle does not deal with the subject in his *Meteorology*, but it is discussed at length in Seneca's *Naturales Quaestiones* and in the meteorological section of Aëtius' *Placita*. It would seem therefore that Lucretius, by including this local phenomenon, is perfectly in line with the meteorological tradition.

Poisonous exhalations

Lucretius next discusses what he calls 'Avernian places' (738 *loca Averna*), places where poisonous exhalations rise from the ground.[285] Many

[283] Hine (2002) 58-60.

[284] Different theories concerning the summer flooding of the Nile are listed by Herodotus *Hist.* II 19-27, [Arist.] *Liber de Nilo*, Seneca *NQ* IVa, Aëtius IV 1, and several others. For a conspectus see Diels (1879), 228.

[285] Others referred to such places as 'Charonia' (Plin. *NH* 2.208; Strabo 12.8.17; Antigonus 123; Stoics *SVF* III 642 apud D.L. VII 123; etc.) or 'Plutonia' (Cic. *Div.* 1.79; Strabo *Geogr.* 5.4.5; etc.): cf. Lucr. VI 762 'ianua Orci'. There are no ancient parallels for Lucretius' generic use of the word 'Avernus', unless perhaps, knowing that lake

instances of such phenomena are mentioned in paradoxography, and the subject also turns up in some of our 'meteorologies', such as the *De mundo* 4, Pliny's *Naturalis Historia* II and Seneca's *Naturales Quaestiones*. Seneca discusses the subject twice (at III 21 and VI 28) but gives no specific examples, and makes no real effort at explaining the phenomenon. The *De mundo* (395b26-30) offers a few examples, but no explanations. Pliny's account (207.9-208.10) is by far the longest, and yet the least scientific. It consists of a long list of instances, which is itself part of an even longer list of phenomena which Pliny describes as 'earth's wonders' (206.5 *terrae miracula*). Far from physically explaining these phenomena Pliny ends his account by simply attributing them to the 'divine power of nature' (208.9-10 *numen naturae*). Lucretius' attitude is entirely different from Pliny's: for Lucretius these phenomena, like any other, must and can be explained physically.

Lucretius offers three examples. The first example is the Lacus Avernus, where overflying birds are said to fall dead from the sky. Although the case was well known in antiquity, and is reported in several paradoxographies (Antigonus 152b, *Mir. ausc.* 102, Paradox. Vat. 13), it is not mentioned in any of our 'meteorologies'.[286] Lucretius' second example is the Athenian Acropolis which crows are said to avoid. This story, too, is not mentioned in any of our 'meteorologies',[287] but it is found in several paradoxographies: Antigonus 12, Apollonius 9, and Claudius Aelianus' *Natura animalium* V 8. None of these, however, relate this phenomenon to poisonous exhalations. The only ancient text, beside Lucretius', that makes the connection is Philostratus' *Life of Apollonius of Tyana* (II 10), where the absence of crows on the Acropolis is compared to the absence of birds on mount Aornus on the fringes of India, and to similar phenomena in Lydia and Phrygia.

Lucretius' third example, a place in *Syria* where four-footed animals collapse and die, is not known from any other ancient text. Lucretius' description is, however, very similar to the stories told about a place near

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Avernus was called Aornos (bird-less) in Greek, Lucretius felt he could render other instances of the word 'Aornos' as 'Avernus' as well. Other places of a similar nature bearing the name 'Aornos' or 'Aornon' were reported to exist near Thymbria in Caria (Strabo, 14.1.11) and in Thesprotis in northern Greece (Pausanias, 9.11.6). Philostratus (*Life of Apollonius of Tyana* II 10) attributes a similar character to Mount Aornos in India.

[286] Pliny knows the story (*NH* XXXI xviii 21), but does not mention it in his list of places with poisonous exhalation in *NH* II.

[287] Pliny knows the story (*NH* X xiv 30), but does not mention it in his list of places with poisonous exhalation in *NH* II.

Hierapolis in *Phrygia*,[288] and Robin (Ernout-Robin ad VI 749ff) even actually quotes Lucretius with 'Phrygia' instead of 'Syria', without commenting on the change. It is possible that Lucretius' story is simply a garbled version of the reports about the site in Phrygia, transferred somehow to Syria, perhaps through confusion between the Phrygian Hierapolis and its Syrian namesake.[289]

Temperature in wells

Lucretius next discusses the temperature variation in wells, which were commonly believed to be warm in winter, and cold in summer.[290] This problem is not a 'mirabile' in the technical sense of the word, as it is not confined to one or a few specific places, but common to all of its kind. Accordingly it does not normally feature in paradoxographical works, although in Pliny's *NH* II it is mentioned (233.1-2) as part of a long section on 'water miracles' (224b-234), consisting for the most part of true 'mirabilia'. The problem is not generally discussed in meteorology either. Beside Lucretius and Pliny, the only 'meteorological author' who mentions the phenomenon is Seneca, who refers to it twice: in book IVa in the context of Oenopides' account of the Nile flood,[291] and in book VI in the context of Strato's explanation of earthquakes. Curiously Seneca's attitude varies: in book VI he accepts the observation as well as Strato's explanation of it, but in book IVa he rejects not just Oenopides' theory, but the observation itself: wells and other underground recesses only seem warm in winter and cold in summer, because they are protected from external temperature fluctuations. It is possible, as Robin observes,[292] that the present subject's connection with the Nile flood (as testified by Seneca and others) is what persuaded Lucretius to include it in his account of terrestrial phenomena.

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[288] Pliny *NH* II 208.4-5; Apuleius *De mundo* 17.17ff; Paradoxogr. Vaticanus 36, etc. Esp. this last account is very close to Lucretius': Ἐν Ἱεραπόλει τόπος ἐστὶ Χαρώνιος λεγόμενος, ἐν ᾧ οὐδὲν ζῷον δῆτα βαῖνει· πίπτει γὰρ παραυτίκα. 'In Hierapolis there is a so-called 'Charonian' place, in which no animal goes: for it falls immediately.' Note that in this account 'Hierapolis' is not further specified, so that someone unfamiliar with the story might easily connect it to the wrong city.

[289] The Syrian Hierapolis, a.k.a. Bambyce, is mentioned by Plut. *Ant.* 37 & *Crass.* 17; Strabo 16.1.27; Pliny *NH* V 81; Ael. *De nat. an.* 12.2; and Pseudo-Lucian *De dea Syria* (passim).

[290] See n.266 above

[291] See also Diodorus Siculus I 41.

[292] Ernout-Robin ad *DRN* VI 840-847.

Marvellous waters

Lists of marvellous or peculiar waters were a standard ingredient of ancient paradoxography. Such lists are found for instance in Antigonus (129-165: 'borrowed', as Antigonus himself claims, from Callimachus), in the *De mirabilibus auscultationes* (53-57 et passim), and in the Paradoxographus Florentinus. Similar lists, of various lengths and serving various purposes, are also found in some of our meteorologies. In Aristotle's *Meteorology* two such lists occur: in I 13, 350b36-351a18, Aristotle mentions a number of rivers that flow underground before emerging again, and in II 3, 359a18-b22 a number of salty and other-tasting waters; yet neither group is presented as something to be studied in its own right: the first group serves merely as a concession to those who believe that all rivers are fed from one or several underground reservoirs, a point of view rejected by Aristotle, and the second group serves to illustrate Aristotle's theory that the salty taste of sea water is due to the admixture of something. Longer lists are found in book III of Seneca's *Naturales Quaestiones* 20 & 25-26. Formally the purpose of Seneca's lists is to illustrate that tastes and other peculiar properties of local waters are acquired through contact with some other substance, but the second list ends in a mere enumeration of marvel stories. Finally, Pliny, who offers the longest list (cvi 224b-234), does not even pretend that these are anything other than marvels: in his own table of contents this section is described as 'Mirabilia fontium et fluminum' (Marvels of sources and rivers), and similar terms recur throughout the passage.[293]

Lucretius' approach is very different. Instead of producing a long list of marvellous waters, he singles out just two instances for further discussion: the spring of Hammon, and a spring (not otherwise identified) which kindles tow. A third spring, the spring of sweet water in the sea off Aradus, is not discussed but only described to serve as a partial analogy for the spring which kindles tow. Yet, as we shall see, it is likely that all three water marvels stem from the same source text.

The first marvellous water described by Lucretius is the spring of Hammon whose waters are cold in the day-time and hot at night. This story, first reported by Herodotus and repeated by many historians and other authors since, is also found in Pliny's section on marvellous waters in *NH* II (228.6-10), but not in any of the other meteorologies. A variant account, according to which the spring's waters are hot at midnight *and midday*, but cold at

[293] Pliny *NH* II 224 'mirabilius', 'miraculis', 227 'natura mira', 232 'mira oracula', 233 'permira naturae opera'.

daybreak and sunset, is only found in the paradoxographical works of Antigonus (144) and the Paradoxographus Florentinus (19).

Lucretius next gives an account of a cold spring which kindles tow that is held above. He does not identify the spring but his account is very similar to the stories told of the spring of Jupiter at Dodona, reported in Pliny's section on marvellous waters (228.1-6) and in Pomponius Mela 2.37, and the spring at the shrine of the nymphs in Athamania, reported by Antigonus (148) and the Paradoxographus Florentinus (11).

In the course of this account Lucretius also mentions the spring of sweet water in the sea near the island of Aradus off the coast of Phoenicia, a spring which – among the ancients – is only mentioned by Strabo (16.2.13) and in Pliny's section on marvellous waters (227.4-5). In Pliny's account it is connected to a similar spring near the Chelidonian islands off the coast of Lycia in Asia Minor. Of these two springs Antigonus only mentions the latter (129.2). Other springs of this nature are reported to exist in the eastern part of the Black Sea in Aristotle's list of underground waters (*Mete.* I, 13.351a14-16).

Magnets

This is the first among the 'terrestrial phenomena' that we know was discussed by Epicurus too.[294] Before him the subject had been discussed by Thales, Empedocles and Democritus.[295] Unfortunately we do not know the context of these discussions. The subject of magnets is not found in any of our 'meteorologies'. The only link that I can see is with the subject of stones in general, which is briefly touched upon in Aristotle's *Meteorology* III 6, and even more briefly in book II of Pliny's *NH* 207 (see Table 2-1 on p.91 above). Surprisingly, the subject does not occur in any of the surviving paradoxographies either, although it would not have been out of place there. The closest parallel in paradoxography is the strange claim in Apollonius *Hist. Mir.* 23 that magnets attract iron *only during the day-time*. Perhaps, as with the Nile-flood, the fact that so many had already investigated and explained the phenomenon banned it from inclusion in paradoxographies.

Diseases

This is another subject that we know to have been discussed by Epicurus himself.[296] There is no evidence, however, that Epicurus had somehow linked the subject to meteorology, as Lucretius does.

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[294] See note 258 above.

[295] Thales A22 D-K (Arist. *De an.* A2, 405a19ff), Empedocles A89 D-K (Alex. Aphr. *Quaest.* II 23), Democritus A165 D-K (Alex. Aphr. *Quaest.* II 23).

[296] See p.98 above.

Above (on p.101) we have seen that Lucretius distinguishes two kinds of diseases: *epidemic* diseases, which come upon a place and after a while abate again, and *endemic* diseases which are peculiar to a certain place and never wholly disappear. Lucretius gives us three examples of *endemic* diseases (1115-7): elephantiasis in Egypt, a particular foot-disease in Attica and an eye-disease in Achaea. Although these and similar cases would not seem out of place in paradoxography, in fact they do not feature in any surviving work of that genre.

Nor are diseases generally discussed in meteorological works. The only meteorologist, beside Lucretius, who has something to say about diseases is Seneca. In *NQ* VI 27-28, remarking upon certain peculiar phenomena that accompanied the Campanian earthquake of 62 AD, Seneca also comments on the ensuing death of hundreds of sheep, which he attributes to a plague. It is said, he claims, that plagues often occur after great earthquakes. This he accounts for on the assumption that the earth contains many harmful and lethal seeds, which may be released by the force of the earthquake. That the earth should contain such pestilential seeds can be inferred also, writes Seneca, from the existence of certain places that emit poisonous exhalations all the time (VI 28.1). So, according to Seneca, plagues are related in their origin to poisonous places, and may occur as a symptom of earthquakes. One might be tempted to see the account in Seneca's *NQ* as an example of the kind of treatment that might have induced Lucretius to include diseases in a discussion of mostly meteorological phenomena. Yet, it seems more likely that the relationship went the other way: Seneca's description of diseases and poisionous exhalations appears to owe a lot to Lucretius, who may well have been Seneca's source of inspiration.[297]

But if Lucretius' inclusion of diseases with meteorological phenomena was inspired by neither meteorology nor paradoxography, perhaps the link must be looked for outside these genres. An interesting parallel for the inclusion of diseases among a number of mostly meteorological occurrences is provided by Cicero. In *ND* II 13-15 (= *SVF* I 528), Cicero relates the four causes which, according to Cleanthes, are responsible for forming the notion of gods in the minds of men. The third cause (*ND* II 14) is described as follows:

[297] Piergiorgio Parroni (2002), for instance, refers to Lucr. VI 1093-6 and VI 740-6 as possible sources of inspiration for Sen. *NQ* VI 27-28.

Tertiam quae terreret animos fulminibus tempestatibus nimbis nivibus grandinibus vastitate *pestilentia* terrae motibus et saepe fremitibus lapideisque imbribus et guttis imbrium quasi cruentis, tum labibus aut repentinis terrarum hiatibus tum praeter naturam hominum pecudumque portentis, tum facibus visis caelestibus tum stellis is quas Graeci κομήτας nostri cincinnatas vocant ..., tum sole geminato, quod ut e patre audivi Tuditano et Aquilio consulibus evenerat ..., quibus exterriti homines vim quandam esse caelestem et divinam suspicati sunt.

As a third cause (Cleanthes posited that) which might frighten the minds on account of thunderbolts, storms, clouds, snow, hail, devastation, *pestilence*, earthquakes and frequent rumblings (of the earth), showers of stones, blood-like drops of rain, then landslides or sudden chasms in the earth, then preternatural portents of man and beast, then the sight of celestial torches, then those stars which the Greeks call κομῆται (comets) and we long-haired stars ..., then the doubling of the sun ..., the fear of which has brought people to suspect that some celestial and divine power exists.

This cause together with the fourth – the orderly motion of the heavens and heavenly bodies (*N.D.* II 15) – is very similar to what Lucretius himself cites as the cause of mankind's *mistaken* belief in intervening gods (V 1183-93). It is this *misconception* Lucretius sets out to dispel in book VI (as he promises in VI 48-90), pointing out that all these phenomena can be explained physically. Although diseases do not properly belong to meteorology, yet, just like meteorological phenomena, they frighten us, by our inability to understand their causes, into believing that they are brought about by the gods, and to eradicate this fear diseases need to be physically accounted for no less than meteorological phenomena and local marvels.[298]

2.3.3 Conclusion

The inclusion of local marvels in works of meteorology, especially in sections concerned with terrestrial phenomena, is not exceptional. Except for the summer flooding of the Nile, which is treated on a par with other meteorological phenomena, local marvels are dealt with in meteorology in much the same way as in paradoxographical literature, to which they properly belong and from which they are probably drawn: in most meteorological works such local marvels as are dealt with are simply enumerated in long lists, with no, or hardly any, effort to explain them individually. Lucretius' treatment of local marvels differs from that in other meteorologies in two important ways. In the first place, instead of the long lists found in some of the other meteorologies, Lucretius offers just a small selection. In the second place, each of the marvels he has selected is provided with an extensive explanation.

In addition to the virtual absence of such explanations in the extant meteorologies, there are several considerations to suggest that explaining local

[298] In his commentary on Cic. *ND* II 14 'pestilentia' Pease (1958) seems to view the inclusion of diseases in Lucr. *DRN* VI in the same light.

marvels was a relatively new affair. Firstly, excepting the problem of the Nile flood, local marvels are not dealt with in Aëtius' doxography, as they probably would have been if there had been a tradition of explaining them, resulting in divergent opinions. Secondly, in the case of local marvels Lucretius himself most often provides just one explanation, whereas problems of a more general nature, like thunderbolts and earthquakes, are accounted for with a number of alternative explanations,[299] which are most often drawn from earlier accounts (see §1.4 above); this suggests that in the case of local marvels not many explanations had been devised before, upon which Lucretius could have drawn.

It would be interesting to know whether this new approach to marvellous phenomena is due to Lucretius himself or perhaps to Epicurus or an intermediary writer. Again there are two considerations to suggest that the account of marvellous phenomena does not derive from Epicurus. In the first place, local marvels are not discussed in Epicurus' *Letter to Pythocles,* nor is there any fragment or testimony to suggest that he discussed such phenomena elsewhere, except for magnets and diseases.[300] In the second place, if – as I have suggested above – the passages on local marvels in Lucretius book VI are ultimately derived from paradoxographical works, and if – as is usually assumed – the paradoxographical genre was inaugurated by Callimachus (ca. 310-240),[301] then it is chronologically improbable (though not impossible) for Epicurus (341-270) to have written on these subjects. If this is true, the passage must have been conceived either by Lucretius himself or by another Epicurean from whom Lucretius subsequently borrowed it.[302] Lucretius or his source may have been inspired to do so by the fact that other meteorologies too incorporated them, yet without explanations. He may have felt himself entitled to do so by Epicurus' own occasional exhortations to the reader to find out certain things for himself (*Hdt*. 45, 68, 83; cf. Lucr. *DRN* I 402-409; 1114-17 and VI 527-534): a good Epicurean is expected to apply the principles of Epicurean physics to other, as yet unsolved problems. In this respect Lucretius' discussion of local marvels is the obverse of *DRN* VI 527-534. There Lucretius chooses *not* to discuss a number of phenomena which Epicurus *had* discussed (snow, wind, hail, hoar-frost and ice), instead inviting

[299] For an overview of the number of alternative explanations per problem in *DRN* V and VI see APPENDIX B on p.245 below.

[300] See p.98 above.

[301] On Callimachus as the founding father of paradoxography see Ziegler (1949) col. 1140; Schepens & Delcroix (1996) 383; Wenskus (2000) col. 311 with references.

[302] Robert D. Brown (1982), 349, thinks that Lucretius may have been inspired by Callimachus.

the reader to find out by himself; here he includes a number of phenomena which Epicurus had *not* discussed, using for himself Epicurus' explicit invitation to do so.

2.4 Order of subjects

2.4.1 Introduction

Above I have compared *DNR* VI with a number of other meteorologies regarding the *range* and *subdivision* of their subject matter. It is now time to have a look at some other aspects as well. It has often been observed that some of the afore-mentioned works exhibit an especially close correspondence in the *order* of their subjects. This is the case with Lucretius VI, Aëtius III, and the *Syriac meteorology*, and to a lesser degree Epicurus' *Letter to Pythocles* (from chapter 17 [99] onwards). Several scholars have produced useful synopses to bring out these similarities.[303] Yet, most of these synopses suffer from lack of perspicacity and detail, and from a certain bias in their presentation, exaggerating the similarities by omitting some of the evidence, rather than letting the evidence speak for itself. Most of them also fail to include Epicurus' *Letter to Pythocles*, which one would expect to be very close to Lucretius VI as well. I will therefore repeat the exercise in some more detail, paying due attention to all the resemblances as well as differences in the order of presentation of each of the four works.

Incidentally, these same works also resemble each other in another respect. In all four of them, meteorological problems are generally accounted for by a number of different explanations. In Aëtius' *Placita* every single explanation is attributed by name to one or several earlier thinkers, while Lucretius, Epicurus and the *Syriac meteorology* instead present them, without reference to their original authors, as equally possible alternative explanations. The subject of multiple explanations has been explored in Chapter One of the present work. Yet, this further similarity enforces the impression that these four texts are somehow more closely related to each other than to other writings of this genre. In this section, however, the focus will be on the similarities in the order of subjects.

2.4.2 The table

In the table below the subjects of each of the four works are presented, in the order in which they occur, in four parallel columns. Subjects which are anomalously placed in comparison to the other works are printed in bold letters, while subjects that are merely appended to, or included in, another or a

[303] Reitzenstein (1924) 34-5; Runia (1997a) 97; Sedley (1998a) 158. See also the lists in Kidd (1992) 305-6.

more general subject are bracketed and italicized. The subjects of the *Letter to Pythocles* are indicated by the chapter numbers of the edition of Bollack and Laks, which I have occasionally subdivided into an A and a B part; the traditional numbering is added between square brackets.

Table 2-4. The order of subjects in Aëtius, the *Syriac meteorology*, Lucretius and Epicurus

Aëtius *Placita* **III + IV 1**	**The *Syriac meteorology***	**Lucretius** *DRN* **VI**	**Epicurus** *Letter to Pythocles* **17-31 + 35**
1. milky way			**17A [99]: clouds**
2. comets and shooting stars			**17B [99-100]: rain**
3. thunder, lightning, thunderbolts and whirl-winds (*typhōnes* and *prēstēres*)	1. thunder	96-159: thunder	18 [100]: thunder
	2. lightning	160-218: lightning	19 [101-2]: lightning
	3. thunder without lightning		
	4. lightning without thunder		
	5. why lightning precedes thunder	*(164-172: why lightning precedes thunder)*	20 [102-3]: why lightning precedes thunder
	6. thunderbolts	219-422: thunderbolts	21 [103-4]: thunderbolts
		(379-422: theological excursus)	
		423-450: whirlwinds (*prēstēres*)	22 [104-5]: whirlwinds (*prēstēres*)
4. clouds, rain, snow and hail	7. clouds	451-494: clouds	**23 [105-6]: earthquakes**
	8. rain	495-523: rain	**24 [106]: subterranean winds**
	9. snow		25 [106-7]: hail
	10. hail		26 [107-8]: snow
	11. dew		27A [108]: dew
	12. hoar-frost		27B [109]: hoar-frost
			28 [109]: ice
5. rainbow		524-526: rainbow	29 [109-10]: rainbow
			30 [110-1]: halo round the moon
6. rods and mock suns			
7. winds	13. wind		
	13.43-54: whirlwinds (*prēstēres*)		
8. winter and summer	**14.1-13: halo round the moon**	**527-534: snow, winds, hail, hoar-frost and ice**	**31 [111]: comets**
9-14. THE EARTH	**14.14-29: theological excursus**		**35 [114-5]: shooting stars**
15. earthquakes	15. earthquakes	535-607: earthquakes	
16. origin and bitterness of the sea		608-638: constant size of the sea	
17. ebb and flood			
18. halo		639-702: the Etna	
IV 1. the flooding of the Nile		712-737: the flooding of the Nile	
		738-839: poisonous exhalations	
Stob. 39 'On waters' (*)		840-905: wells and springs	
		906-1089: the magnet	
		1090-1286: diseases	

(* On the possibility that Stobaeus 39 goes back to a lost Aëtian chapter see the argument on p.80 above.)

2.4.3 Some observations

The order of subjects of each of the four works (including Epicurus' *Letter to Pythocles*) is so similar that one can hardly escape the impression that they must ultimately derive, *as far as this order is concerned*, from one and the same work. None of the four works, or so I believe, has entirely preserved this original order, but each one deviates from it as a result of conscious decisions made by their individual authors as well as unconsious mistakes made in the course of each text's transmission. Below I shall try to indicate which (conscious and accidental) moves may have produced the order of subjects now present in each work, and what the original order may have been.

Milky way, comets and shooting stars

Working his way down through the phenomena of the Aristotelian sublunary world, Aëtius starts his account of τὰ μετάρσια with the phenomena that Aristotle had assigned to the topmost part of the sublunary sphere just below the realm of the stars: the Milky Way and comets and shooting stars. All three subjects are absent from the *Syriac meteorology* and *DRN* VI. Two of them, shooting stars and comets, are discussed in Epicurus' *Letter to Pythocles*, but only at the end, where they straddle a number of undisputably astronomical subjects. This suggests that Epicurus may have assigned *comets* and *shooting stars* to astronomy rather than meteorology (see p.87 above), and the same consideration may explain why Lucretius and the *Syriac meteorology* do not include them.

Theological excursus

The final part of Lucretius' account of thunderbolts is an argument against the view that thunderbolts come from the gods. The argument consists of a series of rhetorical questions like: why do thunderbolts strike high mountains, why do they fall in uninhabited regions, why do they sometimes strike good, god-fearing people, and leave the evil-doers alone, etc.,[304] all leading up to the inevitable conclusion that the falling of thunderbolts cannot be attributed to the gods. A very similar argument is also found in the *Syriac meteorology*, in a passage generally referred to as the 'theological excursus'.[305] Here too the core of the argument is a series of rhetorical questions all concerned with *thunderbolts*, and in most cases closely matching the rhetorical questions and

[304] Mansfeld (1992a), 320, points out that the argument as such is an old one: see Aristoph. *Nubes* 398-402. See also n.282 on p.106 above, and text thereto.

[305] See Daiber (1992) 280-1, Mansfeld (1992a), Van Raalte (2003) – who rejects the passage as a later interpolation.

their development in Lucretius. At the end of the excursus, however, the author rather oddly concludes that (14.25-6) "it is thus not right to say <about> *hurricanes*[306] [sic!] that they come from God", even though the entire argument is about *thunderbolts*, not *hurricanes*. Most likely, therefore, 'hurricanes' is just a mistake for 'thunderbolts'. Equally strange is the fact that the excursus does not, as in Lucretius, follow the exposition of *thunderbolts* (ch.6), but is appended to the chapter on *haloes* (ch.14), to which it does not apply at all. Daiber therefore suggests that the passage "actually [belongs] to the chapters on thunderbolts (ch.6) and on εὖρος and *prēstēr* (13.33-54)".[307] That it should belong to the chapter on thunderbolts seems obvious, but Daiber's reference to εὖρος and *prēstēr* was probably elicited by the mention of *hurricanes* in the conclusion of the excursus, which – I argued – is just a mistake for 'thunderbolts'. Mansfeld, ignoring Daiber's mention of εὖρος and *prēstēr*, interprets his words as implying that the excursus "should probably be reallocated to [...] the chapter on thunderbolts".

Mansfeld himself opts for a different solution. In the introduction to the excursus its subject is stated as (14.14) "the thunderbolt" and "anything that has been mentioned". This means that the excursus, given its present location after the discussion of the halo but before earthquakes, seems to apply to haloes (among other things), but not to earthquakes, which is strange because haloes are quite harmless and earthquakes are not. Mansfeld therefore conjectures that the excursus would originally have been the concluding chapter of the whole treatise, which would make the backward reference apply to earthquakes as well.[308]

Of these two proposals for reallocation of the excursus I prefer the first one. Mansfeld's proposal assumes that the excursus was meant to apply to earthquakes as well. Yet, the excursus does not say anything to this effect. Instead its entire argument is about thunderbolts, and therefore the excursus would have been most naturally placed directly following the physical account of thunderbolts, just as the corresponding passage in Lucretius. Another parallel for this position is provided by Seneca, who incorporates a similar passage (*NQ* II 42ff) in his overall account of thunder and lightning.

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[306] Arabic الزوابع *[az-zawābi'i]*, plural of الزوبعة *[az-zauba'a]*, 'storm', 'hurricane', the same word used in 13.45, 47 and 51 as an alternate name for the *prēstēr*.

[307] Daiber (1992) 280.

[308] Mansfeld (1992a) 316 & 318.

Whirlwinds (*prēstēres*)

The *Syriac meteorology* differs from the other three works in its placement of the discussion of the *prēstēr*.[309] Whereas in the accounts of Aëtius, Lucretius and Epicurus the *prēstēr* is attached to *thunder, lightning* and *thunderbolts*, in the *Syriac meteorology* it is appended to the discussion of *wind*.[310] In order to fully appreciate what is happening here it will be necessary to cast the net a bit wider, and include some other meteorological writings.

In Aristotle's *Meteorology*, and in most subsequent meteorologies, two types of whirlwind are distinguished: the *typhōn* and the *prēstēr*.[311] Both types are closely linked to the *thunderbolt*, so much so that all three are considered manifestations of the same phenomenon, differing only by degree, the thunderbolt being wholly fiery, the *prēstēr* half, and the *typhōn* not at all. Aëtius conforms entirely to this tradition, discussing under one single heading not just *thunder, lightning* and *thunderbolts,* but also *typhōnes* and *prēstēres*.[312] Theophrastus too can be placed in this tradition: in the *De igne* (1.8-9) *prēstēres* and *thunderbolts* are mentioned together, as examples of *fire* being produced through violent motion.[313] In other words, for Theophrastus, as for Aristotle, *prēstēres* are *fiery* and closely related to *thunderbolts*.[314]

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[309] The relevant section is not preserved in the Syriac, but Bar Kepha's Syriac paraphrase (194v a22, Daiber 188) has: ܚܢܗܠܗ *[prīsṭīs]*, an evident mistake, as Daiber notes, for ܚܢܗܠܢ *[prīsṭīr]*. The Arabic translations have: فريسطير *[frīsṭīr]* (Bar Bahlūl 13.19, Daiber 208) and: فرسطير *[frĭsṭīr]* (Ibn al-Khammār 13.43, Daiber 241). All these are obvious transliterations of the Greek πρηστήρ *[prēstēr]*, which in post-classical times was pronounced *[prīstīr]*.

[310] As observed by Kidd (1992) 303, and Sedley (1998a) 159 &182.

[311] Arist. *Mete.* III 1, 371a8-18; [Arist.] *De mundo* 4, 395a21-24; Arrian (fr.3. p.187.4-11 Roos-Wirth) apud Stob. *Ecl.* 29.2.4-7; Stoics apud Diog. Laërt. VII 154.4-6; Chrysippus *SVF* II 703 apud Aët. III 3.13; Seneca *NQ* V 13.1-3 (who calls the *typhōn* 'turbo', and defines the *prēstēr* as an 'igneus turbo', i.e. a fiery *typhōn*); Pliny *NH* II 133-134 (who mentions beside the *turbo/typhōn* and the *prēstēr* a number of other similar phenomena: *vertex, procella, columna, aulon*).

[312] Cf. also Hesiodus *Theog*. 844-6: καῦμα δ' ὑπ' ἀμφοτέρων κάτεχεν ἰοειδέα πόντον / βροντῆς τε στεροπῆς τε πυρός τ' ἀπὸ τοῖο πελώρου / πρηστήρων ἀνέμων τε κεραυνοῦ τε φλεγέθοντος. – 'And through the two of them {sc. Zeus and Typhoëus} heat took hold on the dark-blue sea, / through the *thunder* and *lightning*, and through the fire from the monster, / and the *prēstēr*-winds and blazing *thunderbolt*.' (tr. Hugh G. Evelyn-White, slightly modified).

[313] See however Theophrastus *De ventis* 53 where the *prēstēr*, without reference to its fiery nature, is said to be produced from the conflict of two opposed winds.

[314] As observed by Kidd (1992) 303.

At first sight Epicurus and Lucretius may seem to belong to the same tradition, for they too discuss the *prēstēr* immediately following the *thunderbolt*. However, their account of the *prēstēr* differs from more traditional accounts in three important respects: (1) there is no mention of its fiery nature, (2) there is no reference to the *typhōn* as its less fiery counterpart,[315] and (3) there is nothing in the text to suggest that the *prēstēr* and the *thunderbolt* (as well as the *typhōn*) are varieties of the same phenomenon. The same three observations also apply to the discussion in the *Syriac meteorology*, which closely matches the accounts of Epicurus and Lucretius. However, whereas Epicurus and Lucretius, while severing the traditional ties between the *prēstēr* and the *thunderbolt*, maintain the traditional order of subjects, the *Syriac meteorology* goes one step further and reassigns the *prēstēr* to the chapter on *wind*.[316] It seems reasonable to assume that in this case the *Syriac meteorology* has departed from the original order of subjects, which has been preserved by Aëtius, Epicurus and Lucretius.[317]

Rainbow, halo, rods and mock suns

As we observed above (see p.79), Aët. III 18 on the halo is out of place. In almost every other meteorology the halo is related to the rainbow and to rods and mock suns, wich in Aët. III make up chapters 5 and 6 respectively. It is likely, therefore, that Aëtius, too, discussed the halo contiguously to these two subjects. Jaap Mansfeld (2005) argues for the order rainbow – halo – rods & mock suns.[318] This sequence is partly preserved in Epicurus' *Letter to Pythocles* which discusses the rainbow and the halo in two subsequent chapters. In *DRN* VI and the *Syriac meteorology* only one of these phenomena is discussed: the rainbow (very briefly) in *DRN* VI, and the halo in the *Syriac meteorology*.

Winds & earthquakes

The subject of winds is differently placed in each of the four works. In Lucretius VI (527-534) wind is mentioned in an enumeration of subjects (snow, winds, hail, hoar-frost and ice) which the reader is invited to investigate for himself. This does not necessarily mean that Lucretius found all these subjects consecutively in whatever source he used; he has simply lumped them together at the end of his exposition of atmospherical

[315] Lucr. VI 438 uses 'turbo' simply as a synonym for '*prēstēr*'.

[316] Sen. *NQ* V 13.1-3 and Plin. *NH* II 133-134, too, deal with whirlwinds in the context of winds, yet, like Aristotle and several others, they use the word '*prēstēr*' in the limited sense of 'fiery whirlwind' (see n.311 above).

[317] My conclusion is basically that of Sedley (1998a) 159 and 182.

[318] See note 214 on p.79 above.

phenomena, because he has chosen not to discuss them. We should not, therefore, attach too much weight to the location of the subject of *wind* in Lucretius.

Another problem presents itself in Epicurus' *Letter to Pythocles*. Immediately following the chapter on *earthquakes*, Epicurus goes on to discuss *winds* (πνεύματα). There has been much debate about this chapter. Usener thinks it is a dislocated fragment of the account of *prēstēres*,[319] and Bailey that it is a relic of a chapter on *volcanoes* (matching Lucr. VI 639-702), most of which would have been lost in a lacuna.[320] Others prefer to see it as an explanation of the origin of *atmospherical winds*,[321] thus providing the counterpart of Aëtius III 7 and the *Syriac meteorology* ch.13. However, there is no textual evidence to suggest a lacuna, and if the chapter had been about *atmospherical winds*, one would have expected Epicurus to use the normal Greek word for *wind*, ἄνεμος, instead of πνεῦμα, which may refer to any gust of air.[322] The use of a definite article and a connecting particle at the beginning of the chapter (τὰ δὲ πνεύματα ...) in fact suggests that Epicurus, far from starting something new, is expanding on something he mentioned just before, viz. the *subterranean wind* (πνεύματος ἐν τῇ γῇ) of the previous chapter, which he holds responsible for the production of *earthquakes*.[323] Epicurus' chapter 24, therefore, is probably *not* about *atmospherical winds* at all, and does *not* constitute a counterpart to Aët. III 7 and Syr. 13. The only drawback of this conclusion is that it robs the *Letter to Pythocles* of its chapter on atmospherical winds, which otherwise seems to have been a standard subject in ancient meteorology (see Table 2-1 on p.91 above).

This leaves us with only two texts out of four, from which we might hope to learn something about the original position of the chapter on winds. Unfortunately the two texts diverge on this point: in the *Syriac meteorology* the halo is discussed *after* winds, but in Aëtius III the halo was probably discussed in connection with the rainbow and rods and mock suns *before*

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[319] Usener (1887) p.48 in apparatu critico *ad loc.*: "nam haec adduntur superiori de turbinibus loco"

[320] Bailey (1926) 310; *id.* (1947) 1655.

[321] Arrighetti (1973) 533.

[322] In Aristotle's *Meteorology* (I 13 & II 4-6) and the *De mundo* (IV 394b7-395a10) the word ἄνεμος is used specifically to refer to atmospherical wind (cf. *De mundo* 4, 394b13: τὰ δὲ ἐν ἀέρι πνέοντα πνεύματα καλοῦμεν ἀνέμους ...), while πνεῦμα may refer to any (supposed) gust of air, including e.g. thunder, lightning, thunderbolts and whirlwinds (*Mete.* II 9 – III 1; *De mundo* 4, 395a11-24). Aëtius' chapter on atmospherical winds (III 7) is called Περὶ ἀνέμων, as is Theophrastus' treatise on winds.

[323] Bollack & Laks (1978) 240-1.

winds (see previous heading). It is therefore impossible to say with certainty which order was original, but I will give it a try.

Above (on p.94) we saw that Seneca and his fellow Stoics include earthquakes with atmospherical, rather than terrestrial, phenomena. The reason for this, Seneca states, is that earthquakes, being caused by *air*, should be dealt with in connection with other phenomena of the *air*. In this respect he closely follows Aristotle who attributes earthquakes to subterranean winds and discusses them immediately after atmospherical winds. It is probably because of this close connection that Diogenes Laërtius' overview of Stoic meteorology, which is otherwise limited to atmospherical phenomena, also includes earthquakes. I also argued that the inclusion of earthquakes among 'lofty' phenomena in the *Syriac meteorology* and Epicurus' *Letter to Pythocles* must be due to these works going back to this same tradition, even though they no longer endorse its underlying assumption that earthquakes are uniquely caused by winds. However, if both works include earthquakes with atmospherical phenomena because earthquakes were traditionally connected with winds, it seems likely that in the original order of subjects the section on earthquakes would also have *immediately followed* the chapter on winds (as in Aristotle's *Meteorology*). If this is true the most likely original sequence of subjects would have been: *rainbow – halo – rods & mock suns – winds – earthquakes*, which is precisely the sequence we find in Aëtius III (accepting the reallocation of the chapter on the halo as proposed above). There is only one problem: in Aëtius III the chapters on winds (7) and on earthquakes (15) are assigned to different classes of phenomena, viz. μετάρσια and πρόσγεια, and separated from each other by no less than seven intervening chapters, most of which concern the earth as a whole. By including these subjects in his meteorology Aëtius III deviates, not just from the three works mentioned above, but from almost every other work on meteorology (see p.93 above). Therefore the inclusion of these chapters by Aëtius most likely reflects a deliberate departure from his sources. Giving priority to the earthquakes' location (earth) rather than their cause (wind/air), he chose to place the dividing line between atmospherical and terrestrial phenomena right between winds and earthquakes. Similar considerations may also have led him to move a number of subjects concerned with the earth *as a whole* from cosmology and astronomy – to which most cosmologists assign them – to the beginning of the terrestrial section. Another chapter, on the alternation of the seasons, he then placed at the end of the section on atmospherical phenomena, i.e. after the chapter on winds. If this reconstruction is correct, the rainbow will originally have been dealt with (as it still is in Aëtius III and Ep. *Pyth.*) right after the section on clouds, rain, snow, hail, etc., of which the rainbow is a possible

symptom. In the *Syriac meteorology*, on the other hand, the rainbow is omitted and the account of the halo moved to a position after the chapter on wind.[324]

Terrestrial subject other than earthquakes

While in the *Syriac meteorology* and Epicurus' *Letter to Pythocles* earthquakes are the only 'terrestrial' phenomena to be dealt with, Aëtius and Lucretius discuss several more:

Table 2-5. Terrestrial subjects other than earthquakes in Aëtius and Lucretius

Aëtius *Placita* III 16 – IV 1	**Lucretius *DRN* VI 608-1286**
16. origin and bitterness of the sea	608-638: constant size of the sea
17. ebb and flood	
	639-702: the Etna
IV 1. the flooding of the Nile	712-737: the flooding of the Nile
-	738-839: poisonous exhalations
(Stobaeus 39 'On waters'?)	840-905: wells and springs
-	906-1089: the magnet
-	1090-1286: diseases

At first sight the correspondence between the two works, as far as the terrestrial phenomena are concerned, seems minimal: only one subject, the summer flooding of the Nile, is identical. If we stand back a bit, however, two further similarities become visible: in both works the account of the Nile flood is preceded by a section or sections dealing with the sea (even though the precise subjects are not the same), and – if we accept the ultimate Aëtian origin of the subject of Stobaeus *Ecl. Phys.* 39 'On waters' (see p.80 above) – both works have a section or sections dealing with 'waters' (even though the precise subjects are not the same). If we take into account the large degree of correspondence in the order of subjects in the atmospherical sections of both works, the correspondence in the terrestrial section can hardly be a matter of coincidence.

2.4.4 The original order of subjects

The table below presents a reconstruction of the original order of subjects that underlies both Aëtius III, the *Syriac meteorology*, Epicurus' *Letter to Pythocles* 17ff and Lucretius *DRN* VI. Subjects whose inclusion in the original

[324] Sedley (1998a), 159, also believes the *Syriac meteorology*'s chapter on the halo to be misplaced, on the grounds that in its present location it spoils the top-down sequence of phenomena.

work is uncertain have been bracketed; three dots indicate that other subjects may have been dealt with in between; subjects that are subordinate to others are indented, and subjects that seem to be misplaced in each of the four works are printed in bold. It must be born in mind that subjects which are represented by only one or two of the four extant texts may be later additions and not belong to the original sequence of subjects.

Table 2-6. Proposed original order of subjects

	Aet. III	**Syr. met.**	**Ep. *Pyth.***	**Lucr. VI**
ATMOSPHERICAL PHENOMENA				
Milky way	1			
Comets	2		**31**	
Shooting stars	2		**35**	
Thunder	3	1	18	96-159
Lightning	3	2	19	160-218
(Thunder without lightning)		3		
(Lightning without thunder)		4		
(Why lightning precedes thunder)		5	20	164-172
Thunderbolts	3	6	21	219-422
(Theological excursus)		**14.14-29**		379-422
Whirlwinds (*prēstēres*)	3	**13.43-54**	22	423-450
Clouds	4	7	**17A**	451-494
Rain	4	8	**17B**	495-523
Snow	4	9	26	***527-534***
Hail	4	10	25	***527-534***
Dew		11	27A	
Hoar-frost		12	27B	***527-534***
(Ice)			28	***527-534***
Rainbow	5		29	524-526
Halo round the moon	**18**	**14.1-13**	30	
Rods and mock suns	6			
Winds	7	13		*527-534*
Earthquakes	15	15	**23-24**	535-607
TERRESTRIAL PHENOMENA				
…				
Subjects pertaining to the sea	16-17			608-638
…				
The flooding of the Nile	IV 1			712-737
…				
(Other terrestrial waters)	(Stob. 39)			840-905
…				

2.4.5 Deviations from the original order

Each of the four works deviates from the conjectured original order of subjects in its own way. Below I will briefly discuss the most important

omissions, additions and transpositions each of the four works may have undergone.

Aëtius III: The original order of subjects seems best preserved by Aëtius. The only discrepancy is the chapter on haloes, which is illogically placed in the section on terrestrial phenomena, probably due to a scribal error. Aëtius' account further differs from the other works by transferring the chapter on earthquakes from atmospherical to terrestrial phenomena and inserting a number of other chapters before, viz. one on the alternation of the seasons, and several dealing with the earth *as a whole*, subjects that were usually discussed in the context of cosmology and astronomy. Both additions should probably be ascribed to Aëtius' wish to organize his subject matter strictly according to each phenomenon's location.

Syriac meteorology: The milky way, comets & shooting stars are not discussed in the *Syriac meteorology*. Their absence may indicate that the author did not consider these phenomena atmospherical, as Aristotle had done, but astronomical. Also absent is the rainbow, which is a standard ingredient in every other ancient meteorology. Its absence is even more conspicuous because the less well known halo, which is traditionally related to the rainbow, *is* dealt with. I cannot imagine any reason why the rainbow should be omitted, except for an accident in the text's transmission. Three passages, moreover, seem to have been moved to a different position. The section on whirlwinds (*prēstēres*) has been transplanted from its traditional place next to thunderbolts to a new position at the end of the chapter on winds. This move may have been prompted by the author's, the translator's or a scribe's realisation that whirlwinds are in fact winds and should be discussed in connection with these (see p.120 above). Two other moves are harder to account for. The halo, which, as we have seen, was originally dealt with in connection with the rainbow, has probably been moved from a position before, to a position after winds. Moreover, a theological excursus, in which the divine provenance of thunderbolts is refuted, has been separated from the physical account of thunderbolts, to which it obviously belongs, and been appended to the chapter on the halo, with which it has nothing to do. Perhaps these two apparently irrational transpositions and the omission of the rainbow can be accounted for on the assumption that a scribe first omitted to copy these passages, and later, when realising the omissions, inserted two of the missing passages (the halo and the theological excursus) at the point which he had reached by then, unfortunately still forgetting to include the rainbow.[325]

[325] The dislocation of Aët. III 18 on the halo is explained similarly in Mansfeld (1995) 27 and Mansfeld & Runia (2009a) 44.

Lucretius *DRN* VI: Like the *Syriac meteorology* and possibly for the same reason (see above) Lucretius omits the Milky Way, comets and shooting stars. He further skips snow, hail, dew, hoar-frost and ice – perhaps so as not to bore his readers with accounts that would for the most part be only variations of what was already said about clouds and rain. He goes on to discuss the rainbow very briefly (524-526), but omits the halo and winds. Before moving on from lofty to earthly phenomena, he first sums up most of the phenomena he earlier omitted (527-534) – snow, winds, hail, hoar-frost and ice – inviting the reader to examine the possible explanations for himself.

Epicurus *Letter to Pythocles*: The order of subjects in the *Letter to Pythocles* is so strange and irregular that the correspondence with the other three works is easily overlooked.[326] The strangest feature is the return, after a long intermezzo on atmospherical phenomena, to astronomy. This unexpected return also makes it hard to know for certain whether Epicurus meant comets and shooting stars to go with astronomy or meteorology, although the evidence seems slightly in favour of the first option (see p.87 above). As for the truly meteorological part of the *Letter*, i.e. chs.17-30, although the order of its subject-matter may seem very different from the order found in the other three works, on closer inspection the differences amount to just two major transpositions. First, for some unknown reason clouds and rain have been detached from the other types of precipitation and placed before the account of thunder, lightning, thunderbolts and the *prēstēr*. Secondly, earthquakes and subterranean winds have been moved from their original place at the end of the passage, after the rainbow and the halo, to a position immediately following the account of the *prēstēr*, perhaps because of their equally destructive effects.[327] Only after the chapters on earthquakes and subterranean winds does Epicurus return to the other kinds of precipitation. Atmospherical winds are omitted altogether. Although these transpositions have much disturbed the *Letter*'s order of subjects, two long sequences out of the original order remain virtually intact: *thunder – lightning – thunderbolts – prēstēr;* and (with the minor transposition of snow and hail): *hail – snow – dew – hoar-frost – ice – rainbow – halo*. Especially significant is the fact that in the first sequence the *prēstēr* has retained its traditional position after the thunderbolt, even though – as we have seen – in Epicurus' view the two phenomena are not related (see p.120 above).

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[326] Runia (1997a) 97, comparing Lucr. VI and Aët. III, and Sedley (1998a) 157-8, comparing Lucr. VI, Aët. III and the *Syriac meteorology*, both ignore the order of subjects of the *Letter to Pythocles*.

[327] Note that the overview of Stoic meteorology in Diog. Laërt. VII 151-154, whose order of subjects is even more garbled than Epicurus', also jumps from *prēstēres* to *earthquakes*.

It appears to be possible to reconstruct an original order of subjects from which all four works derive, each of them deviating from it in its own special way. It would be interesting to know what work this order of subjects originally came from and in what way our four texts relate to this original and to each other. In order to come closer to answering these questions it will be useful to have a closer look at the structure of our four texts on the level of individual chapters and sections.

2.4.6 The internal structure of chapters and sections

Although the order in which the different subjects are presented in each of the four works is very similar, the internal structure of chapters and sections is not always the same. A first point of difference can be gleaned from Table 2-4, on p.117 above. While Epicurus, Lucretius and the *Syriac meteorology* all tend to deal with each phenomenon in isolation, Aëtius sometimes collects a number of related subjects into one chapter. Chapter 3, for instance, deals with thunder, lightning, thunderbolts, *prēstēres* and *typhōnes*, which are accounted for by a number of integrated theories, and chapter 4 deals with clouds, rain, snow and hail in the same way.

Of the three remaining works Epicurus' exhibits the simplest structure. The account of almost every phenomenon is reduced to the question of its causation, which is accounted for with a list of alternative theories, sometimes followed by a brief methodological remark. In a few cases other aspects of the phenomenon under investigation are dealt with separately: in this way the account of lightning in general (ch.19) is followed by an account of why lightning precedes thunder (ch.20); the account of earthquakes (ch.23) by an account of the subterranean winds responsible for earthquakes; the account of hail (ch.25) by an account of the round shape of hailstones (ch.25a), the account of the rainbow (ch.29) by an account of its round shape (ch.29a); and the account of the halo (ch.30) by an account of the circumstances that may lead to a halo (ch.30b).

A more complex structure is found in the *Syriac meteorology* (see APPENDIX C on p.246 below). Although some of its chapters are limited, as in Epicurus' *Letter to Pythocles*, to listing a number of alternative explanations for a certain phenomenon's occurrence, most of them deal with several related questions and aspects as well. The most outspoken examples are chapter 6 on thunderbolts, and chapter 13 on winds. A very similar structure, though less explicit (as there are no chapters), underlies Lucretius' meteorology, which in its more complex sections deals with many of the same questions, and in a

somewhat similar order, as the *Syriac meteorology*. In the table below I have printed in parallel columns the contents of the Syriac's and Lucretius' sections on thunderbolts. Items that have no match in the other text are italicized.

Table 2-7. *Syriac meteorology* chapter 6 and Lucretius VI 219-422 on thunderbolts

***Syriac meteorology* chapter 6**	**Lucretius *DRN* VI 219-422**
2-9: The nature of thunderbolts	219-224: The nature of thunderbolts
10-16: Their subtlety and penetration *and speed*	225-238: Their subtlety and penetration
-	*239-245: Introduction to the causes of thunderbolts*
16-21: Causes of thunderbolts	246-268: Necessary conditions
21-28: Necessary conditions	269-280: Causes of thunderbolts
28-36: Their escape from the cloud	281-294: Their escape from the cloud
-	*295-322: More causes of thunderbolts*
36-67: Reasons for their downward movement	*323-347: Reasons for their speed*
67-74: Why they are more frequent in spring	348-356: Their effects
74-85: Why they are more frequent in high places	-
85-91: Their effects	357-378: Why they are more frequent in *autumn and* spring
(discussed in 14.14-29)	379-422: Thunderbolts not the work of the gods

Although the corresponding sections of the *Syriac meteorology* and *DRN* VI are structured very similarly, neither text can be reduced to the other: amidst matching items each text also includes items that have no counterpart in the other one.

Similar observations can be made on the level of the individual items of each section. For instance, the last item of Lucretius' section on thunderbolts, which deals with the question whether thunderbolts are instruments of the gods, offers virtually the same arguments as the corresponding section of the *Syriac meteorology* (14.14-29), but in a different order.[328] Also the lists of alternative explanations correspond to a large degree – sometimes even including the analogies used to illustrate each explanation –,[329] although the order in which they are presented often differs. As an example, I have printed below in two parallel columns the alternative explanations of thunder as offered in the *Syriac meteorology* and by Lucretius, with the corresponding illustrative analogies in square brackets:

[328] Mansfeld (1992a) 326-7.

[329] The degree of corresponce in the illustrative analogies is variously assessed: Kidd (1992) 301 sees 'close parallels including the illustrative analogies' between Lucretius and the Syriac meteorolgy, while Garani (2007) 97 observes a 'remarkable lack of correspondence between Theophrastean [i.e. in the *Syriac meteorology*] and Lucretian analogies.'

Table 2-8. The alternative explanations of thunder in the *Syriac meteorology* and Lucretius VI

***Syriac meteorology* ch.1**	**Lucretius *DRN* VI 96-159**
2-5: (1) collision of concave clouds [clapping hands]	96-115: (1) collision of clouds [flapping and tearing of a canvas awning]
6-8: (2) wind whirling in hollow cloud [wind in caves and large jars]	116-120: (2) friction of clouds [-]
9-11: (3) thunderbolt quenched in a moist cloud [white-hot iron quenched in cold water]	121-131: (3) exploding cloud [explosion of inflated bladder]
12-14: (4) wind hitting and breaking an icy cloud [flapping paper]	132-136: (4) wind blowing through ragged clouds [wind blowing through trees]
15-17: (5) wind blowing through crooked cloud [butchers blowing into guts]	137-141: (5) wind rending cloud [wind uprooting trees]
18-20: (6) exploding cloud [explosion of inflated bladder]	142-144: (6) waves breaking in the clouds [waves breaking in rivers and the sea]
21-23: (7) friction of clouds [millstones being rubbed together]	145-149: (7) thunderbolt quenched in a moist cloud [white-hot iron quenched in cold water]
	150-155: (8) cloud burnt by thunderbolt [forest fire]
	156-159: (9) frozen cloud breaking up [-]

Four explanations appear to be common to the *Syriac meteorology* and Lucretius, two of which are even illustrated by the same analogy (the exploding bladder and red-hot iron being quenched in water). Yet, the order in which these four explanations occur is entirely different for the two works. Comparison of other lists of alternative explanations will yield similar results, revealing a significant correspondence, which, however, rarely extends to the order of presentation.

In sum: a comparison of the internal structure of the corresponding chapters and sections of our four meteorologies shows different degrees of similarity. While the Syriac and Lucretius' meteorologies appear to be very similar, and hence probably closely related, Epicurus' *Letter to Pythocles* is structured in a much simpler way, confining itself to the investigation of the causes of each phenomenon, which possibly testifies to the *Letter*'s summary nature. The chapters of Aëtius' account, by contrast, are organized according to a different rationale, which may suggest that Aëtius' book III is only distantly related to the other works.

2.5 Relations between the four texts

Four meteorological texts, viz. Aëtius' *Placita* III, Epicurus' *Letter to Pythocles* (ch.17ff), the *Syriac meteorology* and Lucretius' *DRN* VI, resemble each other closely in the order of their subjects, while the latter two show a large degree of correspondence in the structure of individual chapters and

sections as well. Although it is likely that these four texts are somehow related, it appears to be impossible to simply reduce them to each other. It is unlikely, therefore, that they are directly related, but the similarities in order and structure must have been transmitted by still other texts, which are no longer extant. In this section I will try to specify these missing links as best as the evidence allows. In order to do this it will also be necessary to deal with the identity of the *Syriac meteorology*, whose equation with (a part or a summary of) Theophrastus' *Metarsiology* has hitherto been accepted too readily.

2.5.1 Epicurus' Letter to Pythocles and his "other meteorology"

In the *Letter to Pythocles* Epicurus claims to be merely summarizing what he wrote elsewhere (ἐν ἄλλοις; see also p.85ff above).[330] As far as the cosmology and astronomy are concerned, these "other places" have been identified as (parts of) books XI and XII of the *On nature*. As for the meteorological portion of the *Letter* these "other places" have not yet been identified, but we can be certain that there existed some other, more elaborate, account of meteorology, whether this was part of book XII or XIII of the *On nature*, as Sedley suggests, or of some other of Epicurus' numerous works. This "other meteorology", as I shall call it, may well be the source of the reports on Epicurus' seismology in Seneca's *NQ* VI 20 and Aët. III 15.11, and on Epicurus' views on rain and hail in Aët. III 4.5, which provide details not present in Epicurus' *Letter to Pythocles*. In this "other meteorology" Epicurus will have discussed at least those subjects that are also dealt with in the meteorological section of the *Letter* (i.e. chs. 16-30, and perhaps also 31 and 35 on shooting stars and comets), and perhaps more (e.g. such subjects as are dealt with in the terrestrial parts of Aëtius III and Lucretius' VI).

Since the *Letter to Pythocles* is only a summary of Epicurus' "other meteorology", it is likely that the traces of the original order (see p.124ff. above) it still preserves were transmitted to it from this more extensive work.

2.5.2 Lucretius DRN VI and Epicurus' "other meteorology"

There has been much scholarly debate about Lucretius' sources. Any investigation into these sources must begin with Lucretius' own statement on the matter: in the whole body of the *DRN* Lucretius acknowledges only one source: the writings of Epicurus.[331] I do not think this necessarily means that

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[330] Jaap Mansfeld points out to me, as he once did to David Sedley, that the plural ἐν ἄλλοις was sometimes used to refer to a single passage: see Sedley (1998a) 120 n.68.

[331] *DRN* III 9-12: "... tuisque ex, inclute, chartis / floriferis ut apes in saltibus omnia libant / omnia nos itidem depascimur aurea dicta ..." – "… and from your pages, illustrious man,

Epicurus' writings were Lucretius' only source, but this is where any investigation should start.[332] As for the sources of Lucretius' meteorology in book VI the first work that comes to mind is, of course, Epicurus' *Letter to Pythocles*, which deals with many of the same subjects. However, even a superficial comparison will show that the succint treatment in the *Letter to Pythocles* cannot have been the main source for Lucretius' much richer account. Yet, as I have argued above, the *Letter* itself only summarizes what Epicurus had written on these matters elsewhere. Although this other, more detailed, account of meteorology is no longer extant, it is reasonable to assume that this was Lucretius' main source, at least for the subjects up to and including earthquakes. Moreover, if both the meteorological part of Epicurus' *Letter to Pythocles* and book VI of Lucretius' *DRN* derive from Epicurus' "other meteorology", and if both works have each in their own way adapted the 'original order of subjects' established above, it seems likely that such traces of the original order as each of the two works preserves have come to them through Epicurus' "other meteorology". If so, Epicurus' "other meteorology" must have been closer to the original order of subjects than either of the two works derived from it.

2.5.3 Authorship and identity of the *Syriac meteorology*

It is now time to address a question I have been postponing for some time: is the *Syriac meteorology*, as it claims to be, a work by Theophrastus? The majority view nowadays seems to be that it is, that it is in fact a translation (of either the whole, or possibly a part) of Theophrastus' *Metarsiology*,[333] a work in two books of which otherwise only the title,[334] a 'table of contents' (possibly incomplete),[335] and a few paraphrasing fragments survive.[336]

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just as bees in the flowery woods sip everything, we likewise feed on all your golden words ...".

[332] So already Reitzenstein (1924) 37.

[333] See n.166 on p.64 above.

[334] Diog. Laërt. 5.44: Μεταρσιολογικῶν α′ β′.

[335] Proclus *In Platonis Ti.* 35A (II 121.3 Diehl = Theophr. fr.159 FHS&G): ... ζητοῦντος, πόθεν μὲν αἱ βρονταί, πόθεν δὲ ἄνεμοι, ποῖαι δὲ αἰτίαι κεραυνῶν, ἀστραπῶν, πρηστήρων, ὑετῶν, χιόνος, χαλάζης, ἃ δὴ καλῶς ποιῶν ἐν τῇ τῶν μετεώρων αἰτιολογίᾳ (so Steinmetz (1964), 216-7, ms.: ἀπολογίᾳ) τῆς πρεπούσης εἰκοτολογίας καὶ αὐτὸς ἠξίωσεν ... – "... by investigating whence come thunders, whence winds, what are the causes of thunderbolts, lightnings, *prēstēres*, rains, snow, hail, which he too in his discussion of meteorological phenomena quite properly thought deserving of a fitting conjectural account ...".

Another option, that the work goes back to Epicurus, was suggested and then swiftly rejected by Bergsträßer, the first editor of the first text found, and this procedure was repeated by several other early commentators.[337] The most recent editor of all three versions, Hans Daiber, makes no reference to this option but confidently claims that the work is an unabridged translation of Theophrastus' *Metarsiology*.[338]

I think there is still some reason for doubt. Above (§1.5.5 on p.64) I have already indicated that the systematic application of multiple explanations, such as we find in the *Syriac meteorology*, is very different from Theophrastus' practice in other, undisputed, works. The best that recent commentators have been able to come up with is the observation that Theophrastus *occasionally* offers multiple explanations. Yet, as I have also shown, even in those cases Theophrastus usually offers far less explanations than the *Syriac meteorology* does, and generally does not support each alternative explanation with analogies from everyday experience, or derive his alternative explanations from the views of earlier thinkers. In all these respects the *Syriac meteorology* is closer to Epicurus' *Letter to Pythocles* and the astronomical and meteorological passages of Lucretius *DRN* (V 509-770 and VI respectively), than to any undisputed work by Theophrastus. Significantly, Theophrastus was never in ancient literature cited as a champion of multiple explanations, as Epicurus was. On the contrary, one ancient witness, Seneca, explicitly claims that regarding the causes of earthquakes Theophrastus held the same, single, view as Aristotle,[339] while citing Democritus and Epicurus for having offered multiple alternative explanations.[340]

The *Syriac meteorology* also differs from Theophrastus' undisputed works in another respect. As we have seen above (p.120), the way *prēstēres* are viewed in the *Syriac meteorology* is very different from what we find in Theophrastus' *De igne*, yet very similar to the corresponding passages in the works of Epicurus and Lucretius. In *De igne* 1.8-9 Theophrastus views the *prēstēr*, like Aristotle before him, as a fiery whirlwind, closely related to the thunderbolt. In the *Syriac meteorology*, on the other hand, *prēstēr* seems to be the generic word for whirlwind, which is nowhere said to be fiery or to be somehow related to the thunderbolt. The *Syriac meteorology* even goes one step further than Epicurus and Lucretius, by relocating the discussion of the

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[336] Theophrastus' meteorological fragments have been collected in FHS&G (1992) 356-365 as frgs. 186A – 194. Of these only 186B and 192 are explicitly attributed to Theophrastus' *Metarsiology*.

[337] See n.172 and text thereto on p.65 above.

[338] Daiber (1992) 285-6, 287.

[339] Sen. *NQ* 6.13.1: "In hac sententia licet ponas Aristotelem et discipulum eius Theophrastum." (= Theophrastus fr.195 FHS&G).

[340] Sen. *NQ* 6.20 (= Democritus fr.A98 D-K / Epicurus fr.351 Us.)

prēstēr, from its traditional position after the thunderbolt, to the end of the section on winds. It might of course be argued that Theophrastus changed his view of *prēstēres* after writing his *De igne* and before composing his *Metarsiology*. That Theophrastus did in fact change his position might seem to be confirmed by a passage in his *De ventis*, which is supposed to have been written after the *Metarsiology*.[341] Here, in ch.53, the origin of *prēstēres* is attributed, without any reference to their fiery nature or their connection with *typhōnes* and thunderbolts, to the conflict of contrary winds. However, the brief mention of *prēstēres* and thunderbolts in the *De igne* explicitly refers the reader to an earlier exposition of these phenomena, which is interpreted as a reference to the *Metarsiology*.[342] Yet, if this is true, the *Metarsiology* must have presented the more traditional view of the *prēstēr* as a fiery whirlwind related to the thunderbolt, and not the innovative concept of a *prēstēr* as a special (and fireless) type of wind, as advanced by Epicurus, Lucretius and the *Syriac meteorology*, and perhaps also Theophrastus' *De ventis*.

These, to my view, are the most important objections against the identification of the *Syriac meteorology* with Theophrastus' *Metarsiology*. None of them seems absolutely fatal: Theophrastus could have dealt with meteorological matters differently from other subjects (it will not do, however, to state that using multiple explanations was characteristic of him), Seneca could have been misinformed about Theophrastus' account of earthquakes, and Theophrastus could have changed his view of *prēstēres* between writing his *De igne* and his *Metarsiology* (in which case the *De igne* must have been written earlier, and the supposed backward reference to the *Metarsiology* be explained in some other way). Yet, the effect of all these objections is cumulative, and shows that the alternative hypothesis of an Epicurean origin should at least have been taken more seriously.

Yet, the assumption of an Epicurean origin is not without its difficulties either. Below I will discuss four passages that seem to testify to a Theophrastean (or at least Peripatetic) rather than an Epicurean origin.

(1st) Chapter 6 of the *Syriac meteorology*, on thunderbolts, contains a section (36-67) concerning the downward motion of thunderbolts, which has no counterpart in Lucretius' book VI. According to the *Syriac meteorology* (36-41), a thunderbolt reaches us (i.e. *moves downward*) either because winds beat the cloud on top, or because the cloud is split at the bottom. In both cases

[341] Steinmetz (1964) 9 n1, 56; Daiber (1992) 286
[342] Steinmetz (1964) 9 n2, 114; Daiber (1992) 273, 286.

the movement is the result of a force external to the thunderbolt.[343] The fact that the Syriac meteorologist finds it necessary to explain the thunderbolt's downward movement is significant. Although Lucretius does not deal with the subject in the corresponding portion of book VI, he refers to the question elsewhere. In *DRN* II 203-215 he warns his reader not to believe that things can move upward of their own accord. Everything material, including fire, has a natural tendency to move downward, a tendency which can only be checked or reversed by an external force. When, under normal circumstances, fire is seen to rise, this must be attributed to the surrounding air, which, by being heavier, squeezes the fire upwards. Therefore, when a thunderbolt (which is fiery) moves downward, this is due primarily to its own nature, and would seem to need no further explanation. However, it can be argued that even from an Epicurean perspective a further explanation may still be asked for. If, under normal circumstances, fire is seen to rise, even though this is not to be attributed to its own nature but to upward pressure from the surrounding air, one may reasonably ask why in the case of thunderbolts these normal circumstances do not apply. Therefore, an explanation of the downward movement of thunderbolts need not be un-Epicurean *per se*, even though it is absent from both Epicurus' *Letter to Pythocles* and Lucretius' book VI.

However, the continuation of the explanation in the *Syriac meteorology* (41-48) is distinctly un-Epicurean:

> The reason that the cloud is split from the bottom and not from (42) the top is as follows: Those <u>two vapors</u> which ascend from the earth are joined, (43) namely the thick vapor and the fine vapor. If they ascend, (44) then the fine one of both (kinds) moves quickly <u>upwards</u>, because it approaches its <u>natural place</u>. (45) And that is because each one of the bodies, when it is distant (46) from its (natural) place, has a weak and slow movement; but if it is near to its (natural) place, (47) (its movement) is quick and strong. Therefore, whenever the fine vapor (48) ascends, it has a *much quicker*[344] movement.
>
> (tr. Daiber (1992), modified)

Two elements in this passage bear witness to its Peripatetic origins: the theory of the two vapors and the notion of a natural place. The two vapors,

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[343] Cf. Arist. *Mete.* I 4, 342a13-27 on natural vs. forced motion of shooting stars (and thunderbolts), and II 9, 369a20-30 on the downward motion of thunderbolts, fallwinds (eknephiai) etc.

[344] Daiber (1992), following the Arabic version of (presumably) Ibn al-Khammār, has '*quick*', but Wagner, in Wagner & Steinmetz (1964), who follows the Syriac version, has '*much quicker*' ('viel schneller'). Unfortunately, the section in missing in the Arabic version of Bar Bahlūl.

which play a major part in Aristotle's *Meteorology*,[345] do not seem to be essentially incompatible with Epicurus' atomism, but in fact both Epicurus, in the *Letter to Pythocles*, and Lucretius, in *DRN* VI, refrain from using them.

The notion of a *natural place* is, however, typical of the Peripatos and entirely alien to Epicureanism. According to Aristotle, the sublunary sphere is subject to two opposing natural motions: heavy bodies move naturally downwards and light ones upwards; both natural motions have their end-point in a natural place: the downward motion ends in the absolute *down* which is the centre of the (finite) universe, and the upward motion ends in the absolute *up* which is the circumference of the sublunary sphere.[346] Both motions accelerate when the natural place is approached.[347] According to Epicurus, however, there is only one natural motion, viz. downward, to which there is no limit, as the universe itself is unlimited, and which is uniform (i.e. not accelerated).[348] The notion of a natural place is therefore entirely un-Epicurean. We may conclude therefore that the source of this passage, at least, cannot have been Epicurus.

Still, there is something strange about the passage. While here the formation of clouds is attributed to the interaction between the two vapors, the next chapter (ch.7), which deals specifically with cloud formation, says nothing about the two vapors or exhalations. Could it be that the present passage and the chapter on clouds have different origins?

(2nd) The two vapors, which we first encountered in ch.6 on thunderbolts, make a second appearence in ch.13 on winds. In fact the whole chapter, except for its final section on *prēstēres* (43-54), has a decidedly Peripatetic flavour. Unfortunately, we are not able to compare it with the Epicurean position, since both Epicurus and Lucretius fail to include a section on atmospherical winds in their meteorological overviews (see p.121 above).

(3rd) Although, as we just observed, ch.7 on clouds does not mention the Peripatetic theory of the two vapors, in another respect it is quite Theophrastean. It is worth quoting the relevant lines (2-9 & 27-29):

> (2) The clouds come into existence for two causes: because of the accumulation (3) and thickness of air and its transformation into *a watery*

[345] Arist. *Mete.* I 4, 341b6-13 et passim. Cf. also *Phys.* IV 1, 208b9-10 and 210a3-6; *Cael.* IV 3, 310a30-35.
[346] Arist. *Cael.* IV (esp. chs.3-5 = 302a-304b).
[347] Arist. *Cael.* I 8, 277a28-29 & b5-9; *ibid*. II 6, 288a17-22.
[348] Epic. *Hdt*. 60-1.

> *substance*[349] or because of much vapor (4) which ascends and with which the ascending vapors of the seas as well as the remaining (5) fluids become mixed.
>
> Air comes together and becomes thick for two reasons: (6) because of coldness or because of contrary winds which squeeze it and bring it together. (7) We can observe something similar amongst us: When ascending vapor in (8) the bath encounters the roof and cannot penetrate this because of its thickness, (9) it accumulates and becomes water.
>
> {....}
>
> The clouds (28) turn into water, when they become very thick; their thickness is (29) caused by the pressure of hard winds or by coldness. (tr. Daiber (1992), modified)

In this case we are in a position to compare this with the views elsewhere attributed to Theophrastus. In his commentary on Aristotle's *Meteorology* Olympiodorus writes [350]:

> One should know, that while Aristotle says that cooling is the only cause of clouds turning into water, Theophrastus says that cooling is not the only cause of the production of water, but also compression. Note, for instance, that in Aethiopia, where there is no cooling, rain still pours down because of compression: for he says that there are very high mountains over there, agains which the clouds collide, and that subsequently rain pours down, because of the resulting compression. But in cauldrons too, says he, moisture runs down again, and in the vaults of baths, where there is no cooling; this clearly coming about through compression.

The text of the *Syriac meteorology* agrees with this report in two ways: firstly they both name the same two causes of water-formation in clouds, viz. cooling and compression, and secondly, they have one example in common, viz. the example of water-formation against the roof of a bath-house.[351]

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[349] The Arabic version of (presumably) Ibn Al-Khammār has '*the nature of water*'. According to Daiber (p.219) this is probably a misinterpretation of the Syriac (352b29), '*a watery substance*'. Unfortunately, the section is missing in the Arabic version of Bar Bahlūl.

[350] Olympiodorus *In Arist. Mete.* I 9, 346b30 (p.80.30-81.1 Stüve) = fr.211B FHS&G (for the Greek text see p.63 above). See also Proclus *In Plat. Tim.* 22E (= Theophr. fr.211A FHS&G); Galen *In Hippocr. Aer.* 8.6 (= fr.211C *ibid.*), and Theophrastus *De ventis* 5.1-5.

[351] Based on these correspondences Drossaart Lulofs (1955), 442, and Steinmetz (1964), 55, identify the two passages and then use Olympiodorus' testimony as a proof of the incompleteness of the *Syriac meteorology*. Daiber (1992), 276 & 283-4, on the other hand, suggests that Olympiodorus may have added material from Theophrastus' Περὶ ὑδάτων.

Again, neither explanation – cooling or compression – seems to be essentially incompatible with Epicurus' atomism, but the fact is that for some reason both Epicurus and Lucretius, while including *compression* among a number of alternative causes,[352] entirely ignore *cooling*.[353] In this respect, then, the *Syriac meteorology* is closer to Theophrastus than to Epicurus and Lucretius.

(4th) The second half of ch.14 is devoted to a refutation of divine interference in the case of thunderbolts. As was first observed by Jaap Mansfeld, the passage is very close in content and structure to Lucretius VI 379-422.[354] Both passages offer a list of rhetorical questions (why do thunderbolts strike high mountains, why do they fall in uninhabited regions, why do they sometimes strike good, god-fearing people, and leave alone the evil-doers, etc.), all leading up to the conclusion that the falling of thunderbolts cannot be attributed to god or the gods. Lucretius leaves this conclusion pretty much unsaid, but in the *Syriac meteorology* the passage is introduced as follows:

> (14) Neither the thunderbolt (pl.) nor anything that has been mentioned has its origin in God. For it is (15) not correct (to say) that God should be the cause of disorder in the world; nay, (He is) the cause (16) of its arrangement and order. And that is why we ascribe its arrangement and order to God (17) [mighty and exalted is He!] and the disorder of the world to the nature of the world. (tr. Daiber (1992))

The first part of this remark is not unlike Epicurus. The sentence: "For it is not correct to say that God should be the cause of disorder in the world" is, as Mansfeld observes,[355] very close to what Epicurus says in his *Letter to Menoeceus*, 134: "for nothing is done by a god in a disorderly way" (οὐθὲν γὰρ ἀτάκτως θεῷ πράττεται). However, what the Syriac meteorologist goes on to say is very un-Epicurean. Whereas the Syriac leaves god in charge of everything orderly in the world, Epicurus explicitly denies the gods'

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[352] Epicurus on cloud formation (*Pyth*. 17A): Νέφη δύναται γίνεσθαι καὶ συνίστασθαι (1) καὶ παρὰ πιλήσεις ἀέρος πνευμάτων συνώσει ...., and on the production of rain (*Pyth*. 17B): Ἤδη δ' ἀπ' αὐτῶν (1) ᾗ μὲν θλιβομένων .... Lucretius on cloud formation (VI 463-64) 'venti / portantes cogunt ad summa cacumina montis', and on the production of rain (VI 510-512): 'nam vis venti contrudit et ipsa / copia nimborum turba maiore coacta / urget et e supero premit ac facit effluere imbris'.

[353] Also observed by Montserrat & Navarro (1991) 301 with n.78.

[354] Mansfeld (1992a), 326-7.

[355] Mansfeld (1992a), 325-6.

involvement in orderly and disorderly matters alike.[356] The *Syriac meteorology* repeats its un-Epicurean position in the concluding part of the excursus (25-29).

In sum, the following aspects of the *Syriac meteorology* seem to exclude an Epicurean origin of the text:

(i) Section 6.36-67 accounts for the downward motion of thunderbolts, which in Epicurean physics does not need to be accounted for.

(ii) Section 6.41-48 appeals to the Peripatetic theory of natural place which is incompatible with Epicurean physics.

(iii) Section 6.41-48 and chapter 13 appeal to the Peripatetic theory of the two vapors, which is never found in Epicurus and Lucretius. In the first of these two passages the two vapors are invoked to account for the coming-into-being of clouds. Surprisingly, in ch.7 which is entirely devoted to the subject of clouds the two vapors are not mentioned at all.

(iv) In chapter 7 (lines 6 and 29) the *Syriac meteorology* ascribes cloud formation and rain production to cooling and compression, just as Theophrastus does in fr.211B FHS&G. Yet, cooling does not feature among the several explanations offered by Epicurus and Lucretius.

(v) In the theological excursus (14.14-29) the Syriac meteorologist, like Epicurus and Lucretius, denies God's responsibility for disorder in the world, but, unlike Epicurus and Lucretius, leaves God in charge of everything orderly (lines 15-17 and 27-29).

Two of these objections (ii and v) are positively fatal to the assumption of an Epicurean origin of the *Syriac meteorology* (or at least the pertinent portions of it), a conclusion strengthened by the three remaining objections. An Epicurean origin of the entire document must therefore be rejected. It is still possible, however, that the *Syriac meteorology* is a compendium of some sort, derived for the most part from Epicurus' meteorology, but supplemented and 'corrected' on the basis of other, possibly Peripatetic or even specifically Theophrastean theories. This hypothesis would account for the overal Epicurean, rather than Theophrastean, character of the work, and also for the curious fact that those features which object most strongly to an Epicurean origin are concentrated in just a few passages.

It would seem, then, that we are left with two possible scenario's: either the *Syriac meteorology* is, as the *communis opinio* would have it, a version of Theophrastus' lost *Metarsiology* (allowance made for a certain amount of shortening, omissions, transpositions and perhaps also additions), or it is a

[356] Epic. *Hdt.* 76-77; Lucr. *DRN* II 1090-1104; *ibid.* V 1183-93; 1204-10; Cic. *ND* I 52.

compendium largely, but not solely, dependent on Epicurean meteorology, into which certain peripatetic elements have been incorporated. How such a compendium came to be transmitted under the name of Theophrastus I could not say, but there is certainly nothing exceptional about such false ascriptions.

2.5.4 Lucretius, Epicurus and the *Syriac meteorology*

As we have seen above, Lucretius *DRN* VI 96-607 and the *Syriac meteorology* resemble each other to such a degree, that it is hard to avoid the conclusion that they must be closely related. Yet, we have also seen that the relevant portion of *DRN* VI probably derives directly from a more extensive account of meteorology by Epicurus, which Epicurus himself later summarized in his *Letter to Pythocles*. If this is true, the relationship between Lucretius VI and the *Syriac meteorology* (whichever view we take of this work's identity) must run via Epicurus' more extensive meteorology.

In the previous section two hypotheses about the status of the *Syriac meteorology* have been proposed. If the *Syriac meteorology* is, as is commonly believed, a (possibly shortened and garbled) version of Theophrastus' *Metarsiology*, then this work of Theophrastus' is likely to have been the immediate source for Epicurus' more extensive meteorology,[357] and thus an indirect source for Lucretius *DRN* VI 96-607 and Epicurus' *Letter to Pythocles* 17-30.

If, on the other hand, the *Syriac meteorology* is a compendium largely based on Epicurean meteorology, its most likely source is Epicurus' more extensive account of meteorology, on which *DRN* VI 96-607 and Epicurus' *Letter to Pythocles* 17-30 depend as well. In this scenario Theophrastus' *Metarsiology*, which without the evidence of the *Syriac meteorology* we know nothing about, has no place.

The two possible scenarios for the relations between Epicurus, Lucretius and the *Syriac meteorology* are presented below. Texts that are no longer extant are bracketed; arrows indicate the influence these works may have exercised on each other *with respect to their structure and order of subjects* (they are not meant to exclude the possibility of other, external, sources for particular problems and theories).

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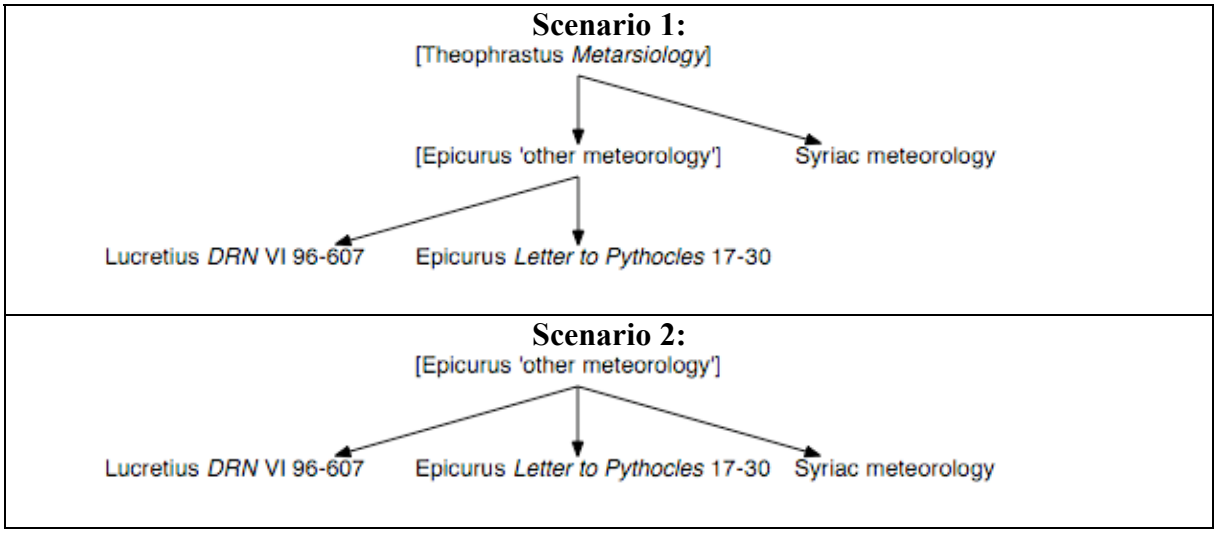
[357] Sedley (1998a), 182, while acknowledging the close similarity between Lucretius VI and the *Syriac meteorology*, which he believes to be Theophrastus' *Metarsiology*, strangely maintains that not this work but the corresponding section of Theophrastus' *Physical Opinions* was Epicurus' and therefore Lucretius' ultimate principal source.

Figure 2-1: Possible relations between Epicurus, Lucretius and the *Syriac meteorology*



2.5.5 Aëtius' *Placita* and Theophrastus' *Physical Opinions*

This leaves us with only one more work whose relation to the rest needs to established. Above we have seen that the original sequence of subjects which seems to underly both Aëtius III and the three works mentioned above, is best preserved by Aëtius. He alone, like Aristotle before him, includes the Milky way, comets and shooting stars among atmospherical phenomena, and he alone preserves the original, Aristotelian, sequence *wind - earthquakes* (even though several chapters on the earth as a whole have been interposed). Yet, it is also clear, and not just for chronological reasons, that Aëtius III could not have been the original source from which the other three works derive their order and structure. It is more probable that it derives its order from the same original source as the other three works, but independently.

An attractive candidate for this common origin would be Theophrastus' *Physical opinions*,[358] a doxographical work from which Aëtius' *Placita* is commonly believed to be ultimately derived,[359] and from which Epicurus is often assumed to have culled most of his alternative explanations in astronomy and meteorology (see §1.4 on p.53ff above).[360]

[358] On Theophrastus' work being called Φυσικαὶ δόξαι (*Physical opinions*) rather than Φυσικῶν δόξαι (*Opinions of the physicists*) see Mansfeld (1990) 3057-8 n.1and *id.* (1992b) 64-5.

[359] Diels (1879) 102ff. For an overview of Diels' views on the matter see e.g. Burnet (1892) 33-6; Regenbogen (1940) cols. 1535-9; Mansfeld & Runia (1997) 78-9.

[360] For Epicurus' dependence on Theophrastus' *Physical opinions* see Usener (1887) xl-xli. Cf. also Sedley (1998a) 166-85.

It should be noted, however, that the evidence for Theophrastus' *Physical opinions* is slight. Only a handful of fragments remain,[361] which do not permit any conclusion about the work's structure and order of subjects. If the *Syriac meteorology* really is, as is commonly believed, a version of Theophrastus' *Metarsiology*, then we can safely assume that the corresponding portion of the *Physical opinions,* by the same author, had roughly the same order of subjects, which, therefore, it could have transmitted to Aëtius III. Yet, the attribution of the *Syriac meteorology* to Theophrastus is, as I have shown, by no means certain, and neither, therefore, is the structure and order of subjects of Theophrastus' *Physical opinions*. Its relation to Aëtius' *Placita* and Epicurus' meteorological works is, therefore, at best conjectural,[362] but it is the best hypothesis we have.

2.5.6 Summary

Above we have explored the possible relationships between Epicurus' *Letter to Pythocles* (17-30), Lucretius' *DRN* VI (96-607) and the *Syriac meteorology* as regards their scope and order of subjects. We have also, tentatively, indicated how Aëtius III may relate to the other three works. It is now time to bring together the main threads of the argument and summarize our findings:

1. Both Lucretius' *DRN* VI 96-607 and Epicurus' *Letter to Pythocles* 17-30 derive their scope and order of subjects from a more extensive account of meteorological phenomena by Epicurus, now lost, that may have been part of book XII or XIII of his *On nature*.

2. The *Syriac meteorology* is either (scenario 1) a – possibly shortened and garbled –version of Theophrastus' *Metarsiology*, which Epicurus all but reproduced as his own in his more extensive meteorological account, and from which he adopted the use of multiple explanations, which he subsequently extended to astronomical phenomena as well; or (scenario 2) it is a compendium largely based on Epicurus' more extensive meteorological account, in which case the use of multiple explanations may well have been Epicurus' own invention, and another source for the order of subjects and the individual explanations in his work must be assumed.

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[361] The collections of fragments made by Usener (1858); and Diels (1879) 473-95 are too inclusive: see e.g. Regenbogen (1940) 1536.68-1537.14; Steinmetz (1964) 334-351; Runia (1992) 116-7.

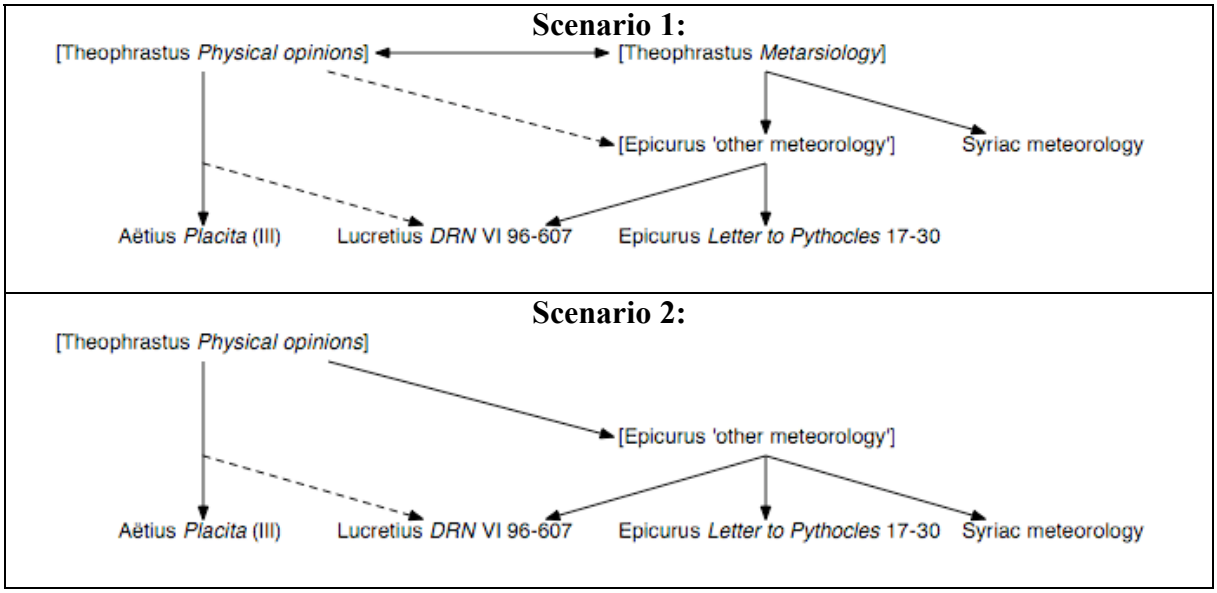
[362] For a more cautious view concerning the relation between Aëtius' *Placita* and Theophrastus' *Physical opinions* see e.g. Mansfeld (1989) esp. 338-42; *id*. (1992b); *id*. (2005).

3. In scenario 1, Theophrastus' *Metarsiology* is the most likely direct source of Epicurus' more extensive meteorology, with Theophrastus' *Physical opinions* as a possible secondary source.[363] In scenario 2, there is no reason to assign any role to Theophrastus' *Metarsiology* (which in this case we know nothing about) and Theophrastus' *Physical opinions* may well have been Epicurus' primary source.

4. In both scenarios, Theophrastus' *Physical opinions*, from which Aëtius' work is believed to be derived, is the most likely link between Aëtius on the one hand and Epicurus, Lucretius and the *Syriac meteorology* on the other.

The two scenarios are illustrated below. Texts that are no longer extant are bracketed; arrows indicate the influence these works may have exercised on each other *with respect to their structure and order of subjects*, and dashed arrows indicate a possible alternative or additional influence.

Figure 2-2: Possible relations between Aëtius, Epicurus, Lucretius and the *Syriac meteorology*



With respect to the two scenarios presented above a number of remarks and reservations need to be made:

1. It must be borne in mind that the two schemas only indicate the major influences the works involved may have exercised on each other *with respect to the scope and order of subjecs*, and must not be read so as to exclude other, possibly external, sources for particular problems and theories.

2. There is one aspect which both of the above scenarios fail to explain. Whereas the *Syriac meteorology* and Epicurus' *Letter to Pythocles* 17-30 restrict themselves to the explanation of atmospherical phenomena (and

[363] See n.357 above.

earthquakes), Aëtius III and Lucretius' *DRN* VI both continue their accounts with a number of terrestrial problems, one of which is common to both works, viz. the summer flooding of the Nile, while two other accounts, viz. those on the sea and on waters are at least thematically related (see Table 2-5 on p.124 above). This is sometimes taken as an indication that Lucretius drew directly upon the doxographical tradition as well (hence the dashed arrows in the illustrations above).[364] This assumption, however, leaves the majority of the – mostly exceptional and local – phenomena in the latter part of Lucretius' book VI unaccounted for. Their inclusion may have been, as I suggested above (§2.3 on p.99ff), a personal innovation by Lucretius in answer to the increasing popularity of such marvel stories in the paradoxographical as well as meteorological literature of his time.

3. It may be argued that the two scenarios are overly simplistic, and in a way they are: for as soon as we admit other sources for particular problems and theories beside the ones proposed above (see points 1 and 2), we must also admit the possibility that these other sources influenced the scope and order of subjects as well. On the other hand, although this possibility cannot be absolutely ruled out, it must also be observed that no other sources, beside the ones suggested above, are needed to account for the similarities in the scope and order of subjects of the four works involved.

2.6 Conclusions

In this chapter I have compared Epicurus' *Letter to Pythocles* and Lucretius' *DRN* VI with a number of meteorological works both as to the range and subdivision of subjects included (§2.2) and to the order in which these subjects are dealt with (§2.4). The inclusion in the later part of *DRN* VI of a large number of local marvels also led me to make a comparison with the genre of paradoxography (§2.3), while the comparison of the order of subjects provided the occasion to examine the possible relations between the *Letter to Pythocles* and *DRN* VI and other meteorological texts, and to reexamine the claims about the authorship of the *Syriac meteorology* (§2.5). The most important findings of this chapter are the following.

In §2.2: The range of subjects covered by the *Syriac meteorology*, which is the closest parallel to *DRN* VI, seems to be complete (except for the omission of the rainbow). Contrary to the majority of ancient meteorological texts, Lucr. *DRN* VI, Epic. *Pyth.* and the *Syriac meteorology* probably considered comets and shooting stars astronomical rather than meteorological

[364] Cf. Runia (1997a), esp. pp.98-99.

phenomena. Along with the majority of ancient meteorological texts, Lucr. *DRN* VI, Epic. *Pyth.* and the *Syriac meteorology* assigned earthquakes to atmospherical rather than terrestrial phenomena.

In §2.3: The later part of *DRN* VI differs from the earlier part as well as from corresponding sections of other meteorological works in predominantly discussing particular local phenomena (marvels). Although other meteorologies too refer to such phenomena, as a rule these are not themselves the objects of inquiry but only serve to convey some general point. The only notable exception is the summer flooding of the Nile which had since long been the object of physical speculation, and was sometimes included in a discussion of meteorological phenomena. However, particular local phenomena are more typically found in works of the literary genre known as paradoxography, which is not about physical inquiry at all, but simply contents itself with recounting marvellous stories. In *DRN* VI Lucretius deals with such phenomena in a way that is different from the approach in other meteorological as well as paradoxographical works, by making them the principal objects of inquiry rather than simply listing them. For chronological reasons it is unlikely that Lucretius' treatment of these phenomena derives from Epicurus. It seems more likely that the passage on marvellous phenomena is an expansion by Lucretius himself.

In §2.4: Four texts in particular, viz. Lucretius *DRN* VI, Epicurus' *Letter to Pythocles* (17-30), the *Syriac meteorology*, and book III of Aëtius' *Placita*, exhibit a remarkable similarity in the order of their subjects. It is possible to derive an original order, from which the order of each of these four texts is somehow derived.

In §2.5: The many similarities in the range, subdivision and order of subjects in these four works suggest that they are somehow related. It is highly likely that the meteorological portions of Epicurus' *Letter to Pythocles* and Lucretius' *DRN* VI both go back to a more extensive account of meteorology by Epicurus, probably part of his magnum opus *On nature*. The relation this work bears to the *Syriac meteorology* depends on our views on its identity. If we accept its commonly accepted identification with Theophrastus' *Metarsiology*, it is likely that this work was the main source for Epicurus' meteorological writings. If, on the other hand, we take the – arguable – view that the *Syriac meteorology* is a compendium of mainly Epicurean meteorology, it will not tell us anything about Epicurus' source, which instead we might identify with Theophrastus' *Physical opinions*. The latter work, from which Aëtius doxographical work is supposed to be ultimately derived, may also provide the missing link between Aëtius and the three other works.

"Nous sommes en 50 avant Jésus-Christ. Toute la Gaule est occupée par les Romains... Toute? Non! Un village peuplé d'irréductibles Gaulois résiste encore et toujours à l'envahisseur."

- René Goscinny & Albert Uderzo, from the opening page of every consecutive album of *Asterix* (1961-present)

3 THE SHAPE OF THE EARTH

3.1 Introduction

In Plato's *Phaedo* (97d), which claims to report the conversations held by Socrates on the last day of his life in 399 BC, Socrates first tells us how, as a young man, about to start reading Anaxagoras, he expected to be told, among other things, whether the earth is flat or round. Later in the same dialogue (108e, 110b) Socrates states his present conviction that the earth is shaped like a sphere. While we cannot be certain that Socrates really thought any of these things, it is clear that Plato himself at least was convinced of the earth's sphericity, as were most of his Greek contemporaries and those who came after; the last Greek philosopher reported to have advocated a flat earth is Democritus, who died around 370 BC. From this date onwards the earth's sphericity, supported by an ever increasing amount of evidence, was accepted by all.

Well, perhaps not all. It is often claimed that, in spite of all the evidence, Epicurus (341-270 BC) and his Roman follower Lucretius (99-55 BC) rejected the earth's sphericity and stubbornly clung to the antiquated concept of a flat earth,[365] a view that has elicited such qualifications as "singularly behind the

[365] The Epicureans' rejection of the earth's sphericity or, conversely, their advocacy of a flat earth is stated for a fact by, for instance, Dreyer (1906) 171-2; Thomson (1948) 167-68; Rist (1972) 47; Sedley (1976) 49; Schmidt (1990) 33, 215; Furley (1996) 119; Sedley (1998b) 346; Furley (1999) 420-1, 429; Milton (2002) 184; Chalmers (2009) 52; Sedley (2008) 'Lucretius' in *The Stanford Encyclopedia of Philosophy* (Fall 2008 Edition), http://plato.stanford.edu/archives/fall2008/entries/lucretius/ [accessed 20 June 2010]; Konstan (2009) 'Epicurus' in *The Stanford Encyclopedia of Philosophy* (Spring 2009 Edition), http://plato.stanford.edu/archives/spr2009/entries/epicurus/ [accessed 24 August 2010]; and the article 'Flat Earth' in *Wikipedia, The Free Encyclopedia* (12 June 2010, 15:38 UTC), http://en.wikipedia.org/w/index.php?title=Flat_Earth&oldid=367617347 [accessed 20 June 2010].

time",[366] "alarmingly retrograde",[367] "queerly indifferent to scientific truth",[368] "scarcely [deserving] to be mentioned in the history of science",[366] "ludicrous" (a pun on the name 'Lucretius'),[369] and "sadly un-Greek".[368] By contrast, I know of only one serious attempt to defend the Epicureans.[370] In a brief paper, published in 1996,[371] David Furley sets out to answer three questions:

1. Why did the Epicureans hold on to the claim that the earth is flat?
2. Were they familiar with contemporary astronomy?
3. Did they know of its arguments and put up a reasoned defence of their own position?

In answer to the first question Furley points out, firstly, that a flat earth follows inevitably from the Epicurean theory of atomic motion, and, secondly, that this shape also naturally commended itself to the Epicureans, who set such a high value on perception: the earth looks flat, and therefore we must start from the assumption that it is flat. With respect to the second question Furley refers to the fragments of Epicurus' *On nature*, where Epicurus engages critically with the methods and pretentions of contemporary astronomy. In answer to the third question Furley argues that another controversional Epicurean theory, about the sun and the other heavenly bodies being as small as they appear to us, may have been devised in part in order to reconcile the Epicureans' flat-earth cosmology with Aristotle's observation that the aspect of the sky changes with latitude.

Although this attempt to defend or at least to better understand Epicurus' views must be applauded, Furley, like so many other scholars, omits to mention one important point: nowhere in Epicurus' remaining works and fragments and nowhere in Lucretius' *De rerum natura* do we find any explicit statement about the shape of the earth.[372] What evidence there is, is at best circumstantial and not without some ambiguity. Even Epicurus' ancient

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[366] Dreyer (1906), loc. cit.

[367] *Thriceholy*, 'Flat Earth and the Ptolemaeic System', http://thriceholy.net/desert.html#Flat%20Earth [accessed 25 June 2010].

[368] Thomson (1948), loc. cit.

[369] Ethical Atheist, *The Flat Earth*, 'Chapter 5: Analysis of 7000 Years of Thinking Regarding Earth's Shape', http://atlantisonline.smfforfree2.com/index.php?topic=1792.0 [posted 26 June 2007, accessed 25 June 2010].

[370] Only recently I learned of the existence of an unpublished PhD thesis by Donald Paul Conroy (1976), which seems to cover much of the same ground as Furley's article and the present chapter. Although I managed to get hold of a copy, it came to late for me to incorporate any of its findings.

[371] Furley (1996). See also Furley (1999) 420-1, 429.

[372] As is rightly observed by Munro (1864) vol. 2, p.341 ad *DRN* V 534; Woltjer (1877) p.123 ad *DRN* V 534ff; Ernout-Robin (1925-28) vol. 3, p.72 ad *DRN* V 534-536; Bailey (1947), vol. 3, p.1403 ad *DRN* V 534ff. Taub (2009) 114-5 (referring to Conroy (1976) 110: see n.370 above).

critics, who were always ready to make fun of him – e.g. for his claim that the sun is as big as it seems, or for seriously considering the possibility that the sun might be extinguished at night –, remain silent on this point. A more thorough investigation of Epicurus' views concerning the shape of the earth should therefore start with a survey of the evidence for attributing a flat-earth cosmology to the Epicureans. In the commentaries this attribution is usually inferred from such passages as Epicurus *Hdt*. 60, Lucretius' *DRN* I 1052ff and V 534-563, in which a parallel natural motion is argued for, or implied. Although it is hard to see how a parallel motion could be combined with anything other than a flat earth, it is methodologically wiser to distinguish such passages from those where the shape of the earth can be directly inferred from astronomical observations or theories. Another limitation of Furley's paper is that it focuses exclusively on one piece of astronomical evidence, viz. the changing aspect of the sky when one moves to the north or to the south, while in fact several such proofs were known in antiquity. One wonders how Epicurus and Lucretius would or could have dealt with those.

In this chapter I propose to conduct a thorough investigation into the views of the Epicureans concerning the shape of the earth, their motivation for these views and their attitude towards the relevant astronomical theories and proofs. Based on a large number of passages from Epicurus, Lucretius and other Epicureans, I will try to answer the following questions:

1. What natural motion did the Epicureans assign to the atoms and bodies in general?
2. Does this natural motion imply a flat earth?
3. Do the Epicurean views on astronomy presuppose a flat earth?
4. Why (if they did) did the Epicureans hold on to the claim that the earth is flat?
5. Were they familiar with contemporary astronomy?
6. Did they know of its arguments for the earth's sphericity and put up a reasoned defence of their own position?

I will go about this investigation as follows: first, in §3.2, I will deal with some preliminary issues that may serve as a background to the investigation. Then, in §3.3, I will discuss a number of passages from Epicurus, Lucretius and other Epicureans that are (or may seem to be) relevant to one or more of our questions. I will take my lead from Lucretius, for two reasons. In the first place Lucretius provides most of the evidence, while such evidence as is furnished by other sources is mostly parallel to what we find in Lucretius (and will be so presented). Secondly, following Lucretius allows us to read most of the relevant passages as part of one continuous account, which may provide additional clues as to the underlying argument. Finally, in section 3.4, I will

summarize and combine my findings and try to present a balanced answer to the questions formulated above.

3.2 Some preliminaries

Before I go on to deal with the views of Epicurus and Lucretius themselves some preliminary information may be useful or enlightening. I will start, in §3.2.1, by giving a brief historical overview of ancient views concerning the shape of the earth. Then, in §3.2.2, I will briefly discuss the most important ancient proofs that were brought forward in favour of a spherical earth, and indicate whether they were, or might have been, known to Epicurus and Lucretius. In the following subsection, §3.2.3, I will briefly deal with Epicurus' ancient critics and what they might tell us about Epicurus' views concerning the shape of the earth. Finally, in §3.2.4, I will discuss how the shape of the earth relates to the direction of natural motion or 'gravity'.

3.2.1 The shape of the earth in antiquity: a historical overview

The world picture that arises from the earliest works of Greek literature, the epics of Homer and Hesiod, is fairly simple.[373] The earth is a flat disk, encircled by the waters of Ocean, with the heavens as an inverted bowl above, and the Tartarus in a corresponding position below.[374] The views of Thales of Miletus (624-547), the first philosopher, do not seem to have been all that different. According to Thales, the earth is a disk floating like a log or a vessel on a primordial sea.[375] If our reports are true, the first important step towards a radically different world view was made by Thales' younger compatriot Anaximander (610-546). While sticking to the image of a flat earth (a column drum or a cylinder),[376] he dispensed with the need for an underprop, such as Thales' water. Instead he claimed that the earth, being equably related to every portion of the surrounding heavenly sphere, has no reason to move in any direction, and therefore does not fall down.[377] If this account of

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[373] On the history of ancient astronomy in general, see e.g. Heath (1913) 7-129; *id.* (1932) xi-lv; Dicks (1970), Evans (1998). On the shape of the earth in particular, see e.g. Thomson (1948) 94-122; Evans (1998) 47-53.

[374] Dicks (1970) 29-30; Heath (1913) 7; *id.* (1932) xi; Furley (1989a) 14. Cf. also Geminus *Isagoge* 16, 28.

[375] Arist. *Cael.* II 13, 294a28-32 [fr.A14 D-K] and Sen. *NQ* III 14 [fr.A15 D-K]. The ascription to Thales of a spherical earth in Aët. III 10, 1 cannot be correct, because (1) it is incompatible with its floating, (2) it is anachronistic with respect to his successors' views, and (3) it is contradicted by the explicit claims that either Pythagoras or Parmenides was the first to make the earth spherical (see note 380 below).

[376] Hippol. *Ref.* I 6.3 [fr.A11 D-K]; Aët. III 10, 2 [fr.B5 D-K]; Ps.-Plut. *Strom.* 2 [fr.A10 D-K].

[377] Arist. *Cael.* II 13, 295b 10-16 [fr.A26 D-K]; Hippol. *Ref.* I 6, 3 [fr.A11 D-K].

Anaximander's views is correct,[378] he certainly did not convince his successor Anaximenes (584-526), who returned to the old view of an earth in need of support: according to Anaximenes, the earth is flat like a table, and rides upon the air on account of its flatness.[379]

It was at the other end of the Greek world, in southern Italy, that the idea first arose that the earth might be a sphere, an idea proposed by either Pythagoras (ca. 580-500) or Parmenides (ca. 500) – on this the sources are divided.[380] We are not told what brought them to this idea, but they may have been inspired by Anaximander's equilibrium theory, which, according to our reports, was also accepted by Parmenides.[381] Perhaps they thought that if the earth was equably related to every portion of the surrounding heavenly sphere, the earth's shape too should be so related, i.e. spherical. The idea of a spherical earth remained current in subsequent centuries among Pythagoras' followers,[382] and it is quite likely that the sphericity of the earth was also accepted by Empedocles (ca. 490-430), who is said to have been a follower of both Pythagoras and Parmenides,[383] and who in one of his fragments testifies to a *centrifocal* conception of up and down (see §3.2.4 below).[384]

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[378] Furley (1989a), 17-22, is inclined to think that the ascription of this theory to Anaximander is anachronistic.

[379] Arist. *Cael.* II 13, 294b 13-30 [fr.A20 D-K]; Hippol. *Ref.* I 7, 4 [fr.A7 D-K]; Ps.-Plut. *Strom*. 3 [fr.A6 D-K]; Aët. III 10.3 [fr.A20 D-K]; Aët. III 15.8 [fr.A20 D-K].

[380] Diog. Laërt. VIII 48 [Parmenides A44 D-K]. Cf. Diog. Laërt. VIII 25 [Pythagoristae A1a D-K], and IX 21 [Parmenides A1 D-K].

[381] Aët. III 15.7 [fr.A44 D-K].

[382] Arist. *Cael.* II 2, 285b22-27 ascribes to the Pythagoreans the view that the north pole and the inhabitants of the northern hemisphere are above, whereas the south pole and the inhabitants of the southern hemisphere are below, and Arist. *Cael.* II 13, 293b25-30 describes how the Pythagoreans defend their claim that the earth is not at the centre by pointing out that even on the supposition of a centrally placed earth, its inhabitants are not at the centre but half the diameter away from it, which nevertheless doesn't seem to affect our observations of the heavens. Both these theories presuppose a spherical earth. See also Dicks (1970) 72-73.

[383] Diog. Laërt. VIII 54-56.

[384] Fragment B35 D-K, lines 3-4: [...] ἐπεὶ Νεῖκος μὲν ἐνέρτατον ἵκετο βένθος / δίνης, ἐν δὲ μέσῃ Φιλότης στροφάλιγγι γένηται, [...] = 'when Strife reached the *lowest depth* / of the vortex, and Love came to be in the *middle* of the whirl ...' ('the lowest depth' and 'the middle' seem to indicate the same place), and lines 9-10: ὅσσ' ἔτι Νεῖκος ἔρυκε μετάρσιον· οὐ γὰρ ἀμεμφέως / τῶν πᾶν ἐξέστηκεν ἐπ' ἔσχατα τέρματα κύκλου = 'all the things which Strife retained *up high*: 'for it had not (yet) altogether retreated perfectly from them to the *outermost boundaries of the circle*.' ('up high' and 'the outermost boundaries of the circle' seem to indicate the same thing). On the other hand, in Aëtius II 8 concerning the inclination of the cosmic axis with respect to the flat earth,

In the meantime the eastern Greeks still adhered to the traditional view. The historian Herodotus (484-425) probably believed the earth to be flat,[385] and Anaxagoras of Clazomenae (500-428) and Diogenes of Apollonia (ca. 460) both adopted Anaximenes' view of a flat earth floating on air.[386] They were followed in this respect by the atomists from Abdera, Leucippus (early 5th century) and Democritus (ca. 460-370).[387] By this time, however, word of the new theory had reached Athens, where for a time both theories existed side by side. In Plato's *Phaedo* (97d) we hear that young Socrates (470-399), upon taking in hand a volume of Anaxagoras', expected to be told, among other things, whether the earth is flat or round.

In the end the second view won the day. In the same dialogue (108e - 109a) Plato (427-347) has Socrates, much older now, explain that he has been convinced by someone that the earth is a sphere and remains where it is, because, being placed equably in the centre of heaven, it has no reason to move in this direction rather than that – the same combination of theories that we saw attributed to Parmenides. From then on the idea of a spherical earth spread rapidly. In fact, there is no explicit information of anyone later than Democritus propounding a flat-earth cosmology.[388] Even within the circle of his followers, there seems to have been some dissent. If we may believe the scanty information provided by Diogenes Laërtius,[389] a certain Bion (early fourth century BC?), who 'was a follower of Democritus and a mathematician, from Abdera, {...} was the first to say that there are regions where the night lasts six months and the day six months.' The only regions for which this statement applies are the north and south poles, and Bion could only have

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Empedocles is mentioned alongside the flat-earthers Anaxagoras and Diogenes of Apollonia (see p.225 with n.565 below).

[385] Furley (1989a) points to Herodotus' report in III 104 that in India the hottest time of the day is in the morning, and that from then on the temperature steadily drops until at sunset it is extremely cold. This, according to Furley, indicates a flat earth, where in the east the sun arrives vertically overhead very soon after sunrise. Another proof may be found in IV 42 where Herodotus, reporting on the circumnavigation of Africa, expresses disbelief at the sailors' claim that during their westward passage around the southern portion of the continent they had the sun on their right, i.e. to the north. With the image of a spherical earth before him, Herodotus would have had no reason for doubting the sailors' statement.

[386] On Anaxagoras see Arist. *Cael.* II 13, 294b 13-30; Hippol. *Ref.* I 8, 3 [fr.A42 D-K]; Diog. Laërt. II 8 [fr.A1 D-K]; Exc. astron. cod. Vatic. 381 (ed. Maass *Aratea* p. 143) [fr.A87 D-K]. On Diogenes see *Schol. in Basil. Marc.* 58 [fr.A16c D-K] and Aët. II 8.1.

[387] On Leucippus see Aët. III 10.4 [fr.A26 D-K]; Diog. Laërt. IX 30 [fr.A1 D-K]. On Democritus see Arist. *Cael.* II 13, 294b 13-30; Aët. III 10.5 [fr.A94 D-K].

[388] That is, until around 300 AD, when the Christian writer Lactantius (*Div. Inst.* III 24) rejected the spherical earth on account of its incompatibility with the Holy Scripture.

[389] Diog. Laërt. IV 58.4-6. See Hultsch (1897) 485–487; Abel (1974) 1014.

arrived at such a claim on the basis of a firm understanding of all the implications of a spherical earth.[390] Also Eudoxus (408-355), the leading mathematical astronomer of his day, probably accepted the earth's sphericity. This much at least can be inferred from his theory about the Nile flood (which he generously attributed to the priests of Heliopolis), viz. that the Nile had its sources in the southern hemisphere where it is winter when we have summer,[391] a theory that presupposes a spherical earth. Moreover, his famous theory of concentric *spheres* on which the fixed stars and planets move also seems to require a *spherical* earth at the centre of the cosmos.

To Aristotle (384-322) we owe the first thorough argument concering the earth's shape.[392] Aristotle accounts for the earth's sphericity and its stable position in the centre of the cosmos on the assumption of a general centripetal tendency of all heavy matter. He also offers two astronomical proofs for the earth's sphericity – the circular shape of the earth's shadow during a lunar eclipse, and the changes in the sky's aspect when one moves to the north or the south –, and he informs us that mathematicians had calculated the earth's circumference, arriving at a number of 400.000 stades (≈ 72.000 km). Not much later the voyages of Pytheas of Marseille (ca. 325 BC) in the northern Atlantic, and Alexander's conquests of Egypt, Persia and parts of India (334-323) provided the geographers and astronomers with a large body of new observations on which to base their theories and calculations. Especially Pytheas is important in this respect: he is the first person on record to have used the length of the shadow of the gnomon to determine latitude,[393] and also the first to record the maximum daylength for a number of different latitudes (up to 24 hours in Thule on the arctic circle).[394] This, then, was the state of

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[390] For the theoretical background of Bion's claim see e.g. Achilles 35.23-38; Cleom. I 4, 219-231; Ptol. *Alm.* II 6, 116.21-117.9; Plin. *NH* II, 186-187.

[391] Aët. IV 1.7 (Eudoxus fr.288 Lasserre).

[392] Arist. *Cael.* II 14, 297a8 – 298b20; cf. also *Mete.* I 3, 340b35-36.

[393] Strabo I 4, 4: '... for as to the ratio of the gnomon to its shadow, which Pytheas has given for Massilia, this same ratio Hipparchus says he observed at Byzantium, at the same time of the year as that mentioned by Pytheas.' [transl. Horace Leonard Jones (1917), modified] & Strabo II 5, 8: 'But if the parallel through Byzantium passes approximately through Massilia, as Hipparchus says on the testimony of Pytheas (Hipparchus says, namely, that in Byzantium the ratio of the gnomon to its shadow is the same as that which Pytheas gave for Massilia), ...' [transl. Horace Leonard Jones, modified].

[394] Gem. *Is.* VI 9 states that Pytheas reported on places where the night was extremely short, only 2 or 3 hours; Plin. *NH* II 186-7 ascribes to Pytheas the incorrect view that in Thule (six days sayling north of Britain) the day and the night each last 6 months (this is in fact only true of the geographical north and south poles), but at *NH* IV 104,

affairs when, around 300 BC, Epicurus (341-270) devised his (presumably) flat-earth philosophy.

But the story does not end here. At around the same time Zeno of Citium (333-264), whose followers – the Stoics – were to become the Epicureans' most fervent adversaries, decided for a spherical earth.[395] Not much later Eratosthenes of Cyrene (276-194) made his famous and remarkably accurate calculation of the earth's circumference.[396] Then, around 150 BC the Stoic scholar Crates of Mallos constructed the first terrestrial globe,[397] while Hipparchus (ca. 190-129) prescribed using simultaneously observed eclipses to establish differences in longitude.[398] Finally, during Lucretius' own life-time (ca. 95-55), Posidonius (135-51), another Stoic scholar, made a new, very influential, estimate of the earth's circumference.[399] Nor was familiarity with the sphericity of the earth restricted to the Greeks: among the Romans too the theory had found currency. Among Lucretius' contemporaries both Varro (116-27) and Cicero (106-43) accepted the earth's sphericity.[400]

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apparently referring back to the previous passage but not mentioning Pytheas, he corrects his report, saying that in Thule *at the summer solstice* there is no night at all. Strabo II 5, 8 may be referring to the same observation when he states that according to Pytheas in Thule the arctic circle (i.e. the circle that comprises the ever visible stars) coincides with the summer tropic, a view that is astronomically equivalent to what Plin. *NH* IV 104 says.

[395] Aët. III 10.1 [*SVF* II 648]; Diog. Laërt. VII 145.6-7 [*SVF* II 650]; Achilles *Isagoge* 4 [*SVF* II 555]; Cic. *N.D.* II 98.5-6 [not in *SVF*]. Cf. Diog. Laërt. VIII 48.10-12 [*SVF* I, 276] where Zeno claims Hesiod's authority for his own theory.

[396] Cleomedes I 7, 49-110. For other ancient reports as well as modern literature on this measurement see Bowen-Todd (2004) *ad loc*.

[397] Strabo II 5, 10.3-5.

[398] Strabo I 1, 12: 'In like manner, we cannot accurately fix points that lie at varying distances from us, whether to the east or the west, except by a comparison of the eclipses of the sun and the moon. That, then, is what Hipparchus says on the subject.' [transl. Horace Leonard Jones]

[399] Cleomedes I 7, 7-48. For other ancient reports as well as modern literature on this measurement see Bowen-Todd (2004) *ad loc*.

[400] Varro *Men*. fr.516 Bücheler, apud Non. 333, 25 'in terrae pila'; Cic. *Rep.* VI 15 = *Somn. Scip.* 3, 7. Cf. Cic. *Tusc*. I 68.12 and *ND* II 98.5-6.

Figure 3-1: Time-line of ancient theories on the shape of the earth

Flat earth		Spherical earth
Homer Hesiod	800 BC	
	700 BC	
Thales Anaximander Anaximenes	600 BC	 Pythagoras ? Parmenides
Anaxagoras Herodotus Leucippus Democritus	500 BC	Empedocles ? Pythagoreans
	400 BC	Bion of Abdera ? Plato Eudoxus Aristotle
Epicurus ?	300 BC	Pytheas Zeno of Citium Eratosthenes
	200 BC	 Crates of Mallos Hipparchus
Lucretius ?	100 BC	Posidonius Cicero Varro

3.2.2 Ancient proofs of the earth's sphericity

In his *De caelo* II 14, 297b24-298a10, Aristotle provides two astronomical proofs of the earth's sphericity. In subsequent centuries many more proofs were devised. Other lists of proofs are provided by the Roman poet Manilius (before 14 AD), the Roman encyclopedist Pliny the elder (23-79 AD), the Greek philosopher Theon of Smyrna (ca. 70-135 AD), the Greek astronomer Ptolemy (ca. 85-165 AD) and the Greek philosopher Cleomedes (ca. 200 AD). One proof is also reported by the Greek geographer Strabo (64 BC - 24

AD).[401] The longest lists are those of Cleomedes (five proofs) and Pliny (six proofs).

Below I will discuss each of the ancient proofs, briefly explaining how they work, who reported them, when they may have been devised, and how – if at all – they might have been refuted by someone wishing to uphold the assumption of a flat earth:

1. According to Aristotle, the convex shape of the earth's shadow as it passes over the moon during a lunar eclipse proves that the earth must be spherical. In fact, however, such a shadow could be produced by many different forms, even by a flat, disk-shaped earth, as Furley observes.[402] For this reason, perhaps, this 'proof' was not repeated by subsequent authors. The argument depends, of course, on the assumption that the moon receives its light from the sun, and is sometimes robbed of this light by the interposition of the earth. Another possible way to escape the consequences of this argument would therefore be to deny that lunar eclipses are produced in this way.

2. Another proof, mentioned by Strabo, Pliny, Theon, Ptolemy and Cleomedes, is based on observations of, and from, approaching and departing ships. If a ship approaches land, then from the ship the mountain-peaks are seen first, and then gradually the lower-lying portions of the land seem to rise from the water. In the same way, from the land the top of the mast is seen first, and then gradually the rest of the ship appears to rise from the water. And when the ship departs then conversely the land and the ship are seen to sink under water. These effects can only be explained on the assumption that the surface of the water is curved. The oldest known report of this proof is provided by Strabo, who postdates both Epicurus and Lucretius. It is possible, therefore, that Epicurus and Lucretius were not familiar with this proof. If they had been familiar with it, and had wished to refute it, they might have dismissed such observations as mirages of the kind that is often observed above water.

3. As Aristotle observed,[403] and many others repeated afterwards, the position of the stars changes according to the observer's *latitude*. Some stars that are seen in the south are invisible in more northerly countries, and some stars that are continuously visible in the north, are seen to set and rise in the south. Such observations are commonly explained on the assumption that the

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[401] The relevant texts and passages are given in Table 3-1 below.

[402] Furley (1999) 421.

[403] Furley (1996), 121 (referring to Dicks (1970) pp.87-8, who does not say so, and Vlastos (1975) pp.38-40), claims that there is some evidence that this proof may have been known to Euctemon in the last half of the fifth century. Dicks (1970) n.380 (referring to Eudoxus frs.75a+b Lasserre) suggests that Eudoxus may have been Aristotle's source for this proof. For our purposes it is enough to know that it would have been available to Epicurus.

earth's surface is curved from north to south. David Furley (1996) suggests that observations of this kind can be reconciled with a flat earth, if the heavenly bodies are assumed to be relatively close by. He compares this to the effect of someone walking in a big room under a painted ceiling: as he walks he will observe the same paintings from different angles. In fact, however, this model only explains part of Aristotle's observation: while it may account for the fact that observers at different latitudes see the same stars at different heights, it fails to explain how certain stars can pass out of sight altogether.

4. A special case of the previous proof, briefly mentioned by Pliny and discussed more fully by Cleomedes, concerns the height of the celestial north pole. Cleomedes observes that in northern countries, such as Britain, the celestial north pole is seen high above the northern horizon, but in southern regions, such as southern Egypt and Aethiopia,[404] appears low in the sky. These observations, he claims, can only be accounted for on the assumption that the earth's surface is curved from north to south. Although the use of such observations as proof of the earth's sphericity cannot be dated to anyone before the time of Pliny the elder, the essential ingredients were known to Hipparchus (ca. 190-120 BC),[405] and may well go back even further. Chronologically, therefore, there is no reason why Lucretius could not have known of the observations relating to this proof. The consequences of this proof are, however, easily dissipated on the assumption that the heavenly bodies, including the celestial north pole, are relatively close by, as Furley suggests.

5. Not just the position of the celestial north pole, but also the position of the sun at noon on a given day of the year varies with latitude. In our part of the world, the midday sun stands generally higher in southern countries, and lower in northern countries, and accordingly shadows are longer in the north and shorter in the south. This observation, which is another special case of proof 3, is presented as a further proof of the earth's sphericity by Pliny the elder. The relevant observations are much older, however. Pytheas of Marseille (ca. 325 BC) already used the length of the shadow of the gnomon to determine latitude.[406] Consequently, Epicurus and Lucretius could have known of these observations. However, just as with the previous proof, these

[404] Text and translation are quoted on p.226 and p.229 below.

[405] In his *In Arati et Eudoxi Phaen.* I 3, 6-7, Hipparchus provides the average values for Greece of: (a) the ratio of the gnomon to its shadow at noon during the equinox (cf. proof 5), (b) the maximum day-length (cf. proof 6), and (c) the polar height (τὸ ἔξαρμα τοῦ πόλου) (cf. proof 4), indicating that these three values are different at other latitudes.

[406] See note 393 above.

observations can be reconciled with a flat earth on the assumption that the heavenly bodies are relatively close by.

6. Another proof of the earth's sphericity is based on the observation that the maximum daylength increases with increasing latitude. Although Pliny is the only author to present this observation as a formal proof of the earth's sphericity, the facts were widely known.[407] The first person on record to measure latitude by the maximum daylength was, again, Pytheas of Marseille.[408] Chronologically, therefore, Epicurus and Lucretius could have known the facts which underly this proof. In this case, however, there is no easy way to escape its consequences. As Cleomedes already observed, on a flat earth sunrise and sunset would be the same for everyone, and accordingly there would be no latitudinal variation of daylength.[409]

7. The last proof I wish to address concerns the time difference between places lying at different longitudes. Pliny reports that on several occasions when warning-fires were alighted successively from west to east, the last one was observed to be alighted at a much later (local) hour than the first. (Pliny's argument would have been more convincing if the fires had been alighted from east to west, and the last one been observed to be alighted at an earlier local time than the first.) However, a much more secure way to establish time-differences between places consisted in simultaneous observations of lunar eclipses. Hipparchus had already prescribed this procedure as a means to accurately measure differences in longitude,[410] and the same procedure was cited as a proof of the earth's sphericity by Manilius, Pliny, Theon, Ptolemy and Cleomedes. Concrete examples are offered by Pliny and Ptolemy, who both refer to the lunar eclipse of September 20, 331 BC, which was observed at a certain hour near Arbela in Mesopotamia, several days before the famous battle, and at a much earlier hour in Carthage (so Ptolemy) and Sicily (so Pliny).[411] Although the argument cannot be dated with certainty till before the time of Hipparchus, Pliny's and Ptolemy's reference to the eclipse of 331 BC suggests that the argument may have been known much earlier. Lucretius could have known it, and it could have been known to Epicurus himself. As with the previous proof it is hard if not impossible to avoid its consequences. The only way out, it would seem, is to contest the observations themselves. One might point to the fact that lunar eclipses are extremely rare, that

[407] See e.g. Strabo II 5.38-42; Geminus *Isag*. VI 7-8, Cleom. II 1, 438-451; Ptol. *Alm.* II 6, Mart. Cap. VIII 877.
[408] See note 394 above.
[409] Concerning this proof see also subsection 3.2.3 below.
[410] See note 398 above.
[411] Pliny, loc. cit.; Ptol., *Geogr.* I 4, 2.

simultaneous observations from different locations are even rarer, and that the historical records (such as Pliny's and Ptolemy's) are often conflicting.

The following table provides a summary of the ancient proofs of the earth's sphericity, with reference to the authors, texts and passages reporting them, and their earliest datable occurrence:

Table 3-1: Ancient proofs of the earth's sphericity

	Aristotle 384-322 BC *Cael.* II, 14	Manilius before 14 AD *Astron.* I	Strabo 64 BC - 24 AD *Geogr.* I, 1	Pliny 23-79 AD *N.H.* II	Theon Smyrn. ca. 70-135 *Expos.* III	Ptolemy ca. 85-165 *Alm.* I, 4	Cleomedes ca. 200 ? *Cael.* I, 5	Earliest datable occurrence
1. Convexity of the earth's shadow during a lunar eclipse	297b24-31							Aristotle 384-322 BC
2. Observations of, and from, departing and approaching ships			20.18-27	164.1-5	3.1-14	16.13-18	114-125	Strabo 64 BC - 24 AD
3. Aspect of the sky varying with latitude	297b31 - 298a10	215-220		177.8 - 179.4	2.10-26	15.23 - 16.13	49-54	Aristotle 384-322 BC
4. Elevation of the pole varying with latitude				179.4-11			44-49	Hipparchus ca. 190-120 BC
5. Length of shadows varying with latitude				182-185				Pytheas ca. 325 BC
6. Max. day-length varying with latitude				186-187			54-56	Pytheas ca. 325 BC
7. Longitudinal time difference established by eclipses		221-235		180-181	2.1-10	14.19 - 15.23	30-44	Hipparchus ca. 190-120 BC

Of the proofs mentioned above, the 1st, 3rd, 5th and 6th could chronologically have been known to Epicurus, while Lucretius could have known the 4th and 7th as well. If, as Furley suggests, the Epicureans did try to put up a reasoned defense of their own flat-earth cosmology against contemporary astronomy, one would expect them to betray a knowledge of, and engage with, the proofs the astronomers offered for the sphericity of the earth. In our survey of Epicurean passages in section 3.3 below, we will therefore also look for clues that might tell us whether Lucretius, Epicurus or other Epicureans were aware of these observations, and whether or how they managed to reconcile them with their own views concerning the shape of the earth.

3.2.3 Epicurus' ancient critics

In antiquity, Epicurus was criticized and even ridiculed for many of his doctrines. He was attacked, for instance, for assigning upward and downward

directions to the infinite universe,[412] for assigning a random and uncaused motion, the παρέγκλισις or 'swerve', to the atom,[413] for holding that the sun is the size it appears to be,[414] and for contemplating the possibility that the sun might be extinguished at sunset and rekindled at dawn.[415] If Epicurus had also claimed, in contrast to everybody else, that the earth is flat, would his critics not have seized the opportunity to attack him for yet another 'stupidity'? Yet, no such criticism has come down to us.

One of Epicurus' most fervent critics was Cleomedes, who in the second book of his astronomical treatise attacks Epicurus by name for two of his theories.[416] Yet, in the first book, in a section where the theory that the earth might be flat is explicitly refuted, Cleomedes fails to name Epicurus. If he had known Epicurus to be a flat-earther, would he not have named him?

And yet Cleomedes comes very close to actually identifying Epicurus here: in I 5.11-13 those who believe the earth to be flat are said to be 'following only the sense presentation based on sight', which is exactly how the Epicureans are characterized in II 1.2-5.[417] What is more, one of Cleomedes' actual arguments against the earth being flat might as well be aimed directly at the Epicureans. In I 5.30-37 Cleomedes argues that those who believe the earth to be flat must also believe that the sun rises and sets for everyone at the same time, which is observably wrong. However, in II 1.426-451 he ridicules Epicurus for believing that the sun may be extinguished at sunset and rekindled at sunrise, pointing out that on a spherical earth sunset and sunrise occur at different times in different regions. Cleomedes might at this point have concluded that Epicurus must be thinking of a flat earth, but he does not. Instead he opts for a *reductio ad absurdum*, suggesting that according to Epicurus' theory the sun must be at the same time extinguished for some observers and rekindled for others – and this incalculably many times. Again one wonders why Cleomedes does not simply accuse Epicurus of claiming the earth to be flat.

The answer must be that Cleomedes (or his source) could not find any explicit statement to this effect in Epicurus' works. All the other criticisms,

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[412] Chrysippus (*SVF* II 539) apud Plutarch *De Stoic. repugn*. 44, 1054b. See also on p.195 below.

[413] Cicero *De fin*. I 18-20 (Epic. 281a Us.); id. *De fato* 46 (Epic. 281c Us.). See also on p.194 below.

[414] Cleomedes II 1.1-413; Cicero, *De fin*. I 20; *Acad*. II 82. See also on p.213 below.

[415] Cleomedes II 1.426-466; Servius *in Verg. Georg*. I 247 (Epic. 346a Us.), id. *in Verg. Aen.* IV 584 (Epic. 346b Us.). See also on p.218 below.

[416] Cleomedes II 1.1-413 on the size of the sun; II 1.426-466 on the sun's daily extinction and rekindling.

[417] Cleom. I 5.11: ... αὐτῇ τῇ κατὰ τὴν ὄψιν φαντασίᾳ κατακολουθήσαντες ... and Cleom. II 1.2-5: ... αὐτῇ τῇ διὰ τὴς ὄψεως φαντασίᾳ κατακολουθήσαντες ...

those of Cleomedes as well as other critics, were aimed at theories that could be explicitly ascribed to Epicurus. The view that the earth is flat, on the other hand, could not. Thus the critics' failure to adress this subject is another indication, in addition to Lucretius' silence on the matter, that Epicurus never explicitly opted for a flat earth.

What we will be looking for, then, in our survey of relevant Epicurean passages, is circumstantial evidence, consisting in passages which either entail or presuppose a flat earth.

3.2.4 The direction of natural motion and the shape of the earth

In his article 'The Dynamics of the Earth', David Furley distinguishes two fundamentally different ancient theories of natural motion.

In one of these, which he calls *linear* or *parallel*, natural motion takes place along parallel lines. *Up* and *down* are defined in accordance with this *parallel* motion of fall, and the cosmos can be divided into an *upper* and a *lower* hemisphere. The tendency of heavy objects to fall down also applies to the earth as a whole, which, in order not to fall, must be supported by something underneath, be it water (Thales), or air (Anaximenes, Anaxagoras and Democritus), or the earth itself, extending downwards to infinity (Xenophanes).[418]

In the other theory, which Furley calls *centrifocal*, all natural motion is defined by the *centre*: *down* is motion towards the centre, *up* motion away from the centre, and the circular motions of the heavenly bodies are motions around the centre. The earth itself, being heavy, is also prone to move towards the centre, but being already agglomerated around the centre, it will not move; therefore there is no need for external support. This downward tendency applies to animals and human beings as well, allowing them to stand on every side of the earth, with their feet pointing towards the centre. People living diametrically opposite us are called *antipodes*, i.e. 'having their *feet* pressed *against* ours'.[419] Furley's prototype of a centrifocal cosmology is the one propounded by Aristotle, who assigned three different natural motions to the elements: earth and water moving *towards the centre*, air and fire moving *away from the centre*, and aether or the first element (or the fifth as it is

[418] Arist. *Cael.* II 13, 294b 13-30. See also Arist. *Mete.* II 7, 365a20-37, where the parallel cosmology of Anaxagoras is explicitly opposed to Aristotle's own centrifocal system.

[419] Cf. Cic. *Luc*. 123, 7: "Vos etiam dicitis esse e regione nobis, e contraria parte terrae qui adversis vestigiis stent contra nostra vestigia, quos *antipodas* vocatis." See also Kaufmann (1894).

commonly called) moving in circles *around the centre*. Other centrifocal cosmologies are those of Plato, Strato and the Stoics. Strato, for instance, although he seems to have dispensed with Aristotle's first element and assigned a natural downward motion to all four sublunary elements (attributing the apparent upward tendency of air and fire to extrusion by the heavier elements), still defined this natural downward motion as motion towards the centre.[420]

Plato's cosmology differs from Aristotle's in one important respect. In the *Timaeus*, 62c-63a, Plato observes that everyone speaks of 'up' and 'down' with respect to themselves, and that accordingly for someone standing on the other side of the earth 'up' and 'down' are exactly reversed. For this reason he rejects the use of these terms in a cosmological context altogether. In the *De caelo*, IV 1, 308a14-24, Aristotle critizises this view and attempts to save the terms 'up' and 'down' in an absolute sense by redefining them as 'away from the centre' and 'towards the centre' respectively. After Aristotle these definitions of 'up' and 'down' were accepted by most *centrifocalists*.[421] This does not mean, however, that all *parallel-linear* terminology was banned from these centrifocal systems. When speaking of a star's *setting* (δύσις / δυσμαί) and *rising* (ἀνατολή), or its *height* (ὕψος) or *elevation* (ἔξαρμα), they were in fact, as we still are, using a parallel-linear spatial reference system, where 'height' is used to denote the (angular) distance from the plane of the horizon, and not the distance from the centre of the earth.

Each of the two cosmological systems is also associated with one particular shape of the earth: in *parallel* cosmologies the earth is usually considered *flat*, while *centrifocal* theories are thought to imply a *spherical* earth. In the *De caelo*, Aristotle offers two arguments to demonstrate the truth of this implication. In the first place the all-sided centripetal pressure exerted by many individual chunks of earth, all seeking the centre of the universe, would naturally result in a spherical shape. Aristotle illustrates this by demonstrating that this shape would also have resulted if the earth had been generated at some time in the past (which he does not believe) (*Cael*. II 14, 297a12-b18). A similar argument was later put forward by the Stoics (Cic. *ND* II 116). In the second place a spherical shape logically follows from the observation that all heavy bodies fall at right angles to the surface of the earth, which in a centrifocal universe is only possible if the earth is spherical (*Cael*. II 14,

[420] For the evidence on Strato see n.494 on p.188 below.

[421] For the Stoics, see e.g. Ar. Did. fr.31, apud Stob. *Ecl.* I, p. 184, 8 W. (= *SVF* II 527): τὸ μέσον σημεῖον τοῦ κόσμου {...}, ὃ δὴ τοῦ παντός ἐστι κάτω, ἄνω δὲ τὸ ἀπ' αὐτοῦ εἰς τὸ κύκλῳ πάντῃ, Cic. *ND* II 84: 'in medium locum mundi, qui est infimus', *ibid*. 116: 'id autem medium infimum in sphaera est', and esp. Cleomedes, I 1,158-192 (partly quoted as *SVF* II 557).

297b18-24). For the link between parallel natural motion and a flat earth no such arguments have come down to us, unless we count the view of Anaximenes, Anaxagoras and Democritus, who claimed that in order to be able to float on air the earth had to be flat and broad. However, a very plausible argument is provided by Furley, who points out that, as long as we accept the observed fact that heavy objects everywhere fall at right angles to the earth's surface (cf. Aristotle's second argument above), a parallel motion of fall requires a flat earth.[422]

The two cosmological systems with their implied shapes of the earth are illustrated below:

Figure 3-2: *Linear* or *parallel* cosmology

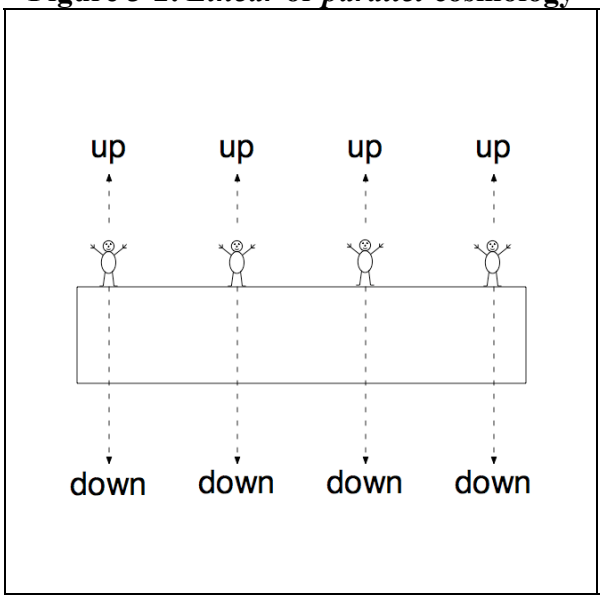
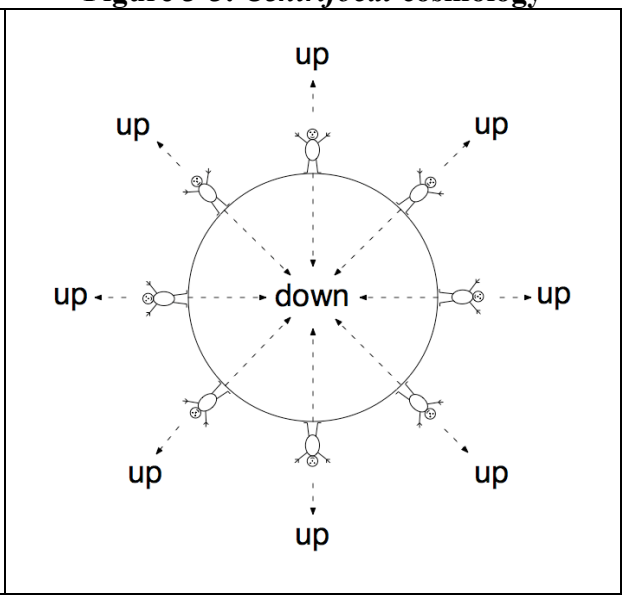


Figure 3-3: *Centrifocal* cosmology



I have dealt with these two cosmological systems at some length because, as we shall see, the case for imputing a flat earth on the Epicureans largely depends on the assumed logical connection between the direction of natural motion and the shape of the earth. A clear understanding of the the two theories of natural motion and their assumed implications for the shape of the earth will be a useful tool in our survey of Epicurean passages.

3.3 Discussion of relevant passages

After these preliminaries I will now turn to the promissed discussion of relevant Epicurean passages. In my search for such passages I have scanned through the whole of Lucretius' *DRN*, Epicurus' *Letters to Herodotus* and *Pythocles*, the fragments of book XI of Epicurus' *On nature*, and the cosmo-

[422] Furley (1976) 90; (1981) 10, 12; (1983) 91-2, 99; (1999) 42.

logical and astronomical fragments of Diogenes of Oenoanda's inscription, as well as the commentaries thereto, looking for signs that might be, or have been, interpreted as somehow implying, or otherwise relating to, a specific shape of the earth.

Lucretius appears to be the richest source of such passages, and for this reason I have chosen to take my lead from him. Such passages as can be found in the works and fragments of Epicurus and Diogenes are mostly parallel or supplementary to these, and will therefore be discussed in connection with them. In my discussion of these passages I will basically follow Lucretius' order, which may help us to understand how the different passages hang together. I have also stumbled upon an interesting fragment of Philodemus which seems relevant to my purpose and has no exact parallel with Lucretius or other Epicureans. A discussion of this fragment will be appended to the list. The following passages will be dealt with:

Table 3-2: Passages to be discussed

Lucretius	Parallel passages	Subject	Discussed in:
I 1052-93	-	*Rejection of centrifocal natural motion*	3.3.1 (p.163)
II 62-250	Epic. *Hdt*. 60 + fr.281 Us.	*Parallel downward motion*	3.3.2 (p.190)
IV 404-413	-	*Apparent proximity of the sun*	3.3.3 (p.198)
V 204-205	Cic. *ND* I, 24; Philod. Π. θεῶν III 70	*Climatic zones?*	3.3.4 (p.199)
V 449-508	(Aëtius I 4)	*Centrifocal cosmogony*	3.3.5 (p.202)
V 534-563	Epic. *Nat*. XI fr.42 Arr.	*Stability of the earth*	3.3.6 (p.213)
V 564-591	Epic. *Pyth*. 6 [91]	*Size of the sun*	3.3.7 (p.213)
V 621-636	Diog. Oen. fr.13 I.11-13	*Centrifocal terminology*	3.3.8 (p.217)
V 650-704	Epic. *Pyth*. 7 [92] + 15 [98]	*Sunrise and sunset*	3.3.9 (p.218)
V 762-770	Epic. *Pyth*. 13 [96] + scholion	*The conical shadow of the earth*	3.3.10 (p.219)
VI 1107	-	*The limp of the cosmic axis*	3.3.11 (p.222)
-	Philod. *Sign*. xxx 20-27	*The varying length of shadows*	3.3.12 (p.230)

3.3.1 The rejection of centrifocal natural motion (*DRN* I 1052ff)

3.3.1.1 Introduction

The first passage that seems to be relevant to our subject, and one that is often cited in support of the claim that the Epicureans held the earth to be flat, is found at the end of the first book of *DRN* (1052ff). Here Lucretius rejects a theory of *centrifocal* natural motion, which, as we have seen, is generally assumed to imply a spherical earth (see p.160ff above). On the following pages I will analyse this passage, paying due attention to its context, to the intended target, to Lucretius' refutation of the theory, and to the positive conclusions regarding Lucretius' own views that may be drawn from the passage.

3.3.1.2 Context of the passage

The passage itself begins in line 1052, but in order to fully understand it we must first deal with the preceding passage. In line 951 Lucretius had broached a new subject: the infinity of the universe and of its two constituent parts: matter and empty space. As such Lucretius' argument is an extended version of the more condensed argument in Epicurus' *Letter to Herodotus*, 41-2:

(i) Ἀλλὰ μὴν καὶ τὸ πᾶν ἄπειρόν ἐστι· τὸ γὰρ πεπερασμένον ἄκρον ἔχει, τὸ δὲ ἄκρον παρ' ἕτερόν τι θεωρεῖται· ⟨ἀλλὰ μὴν τὸ πᾶν οὐ παρ' ἕτερόν τι θεωρεῖται·⟩[423] ὥστε οὐκ ἔχον ἄκρον πέρας οὐκ ἔχει· πέρας δὲ οὐκ ἔχον ἄπειρον ἂν εἴη καὶ οὐ πεπερασμένον.
Καὶ μὴν καὶ τῷ πλήθει τῶν σωμάτων ἄπειρόν ἐστι τὸ πᾶν καὶ τῷ μεγέθει τοῦ κενοῦ·

(ii) εἴτε γὰρ ἦν τὸ κενὸν ἄπειρον, τὰ δὲ σώματα ὡρισμένα, οὐθαμοῦ ἂν ἔμενε τὰ σώματα, ἀλλ' ἐφέρετο κατὰ τὸ ἄπειρον κενὸν διεσπαρμένα, οὐκ ἔχοντα τὰ ὑπερείδοντα καὶ στέλλοντα κατὰ τὰς ἀνακοπάς·

(iii) εἴτε τὸ κενὸν ἦν ὡρισμένον, οὐκ ἂν εἶχε τὰ ἄπειρα σώματα ὅπου ἐνέστη.

(i) Moreover, the sum of things is infinite. For that which is bounded has an extremity, and the extremity is seen against something else: ⟨but the sum of things is not seen against something else:⟩[423] therefore, since it has no extremity, it has no boundary; and, since it has no boundary, it must be infinite and not bounded.
Moreover, the sum of things is infinite both in the multitude of the bodies and the magnitude of the void.

(ii) For if the void were infinite and the bodies limited in number, the bodies would have no place to stay, but would be carried down and scattered through the infinite void, having no other bodies to support and check them by means of collisions.

(iii) And if the void were limited, the infinite bodies would have no space to be.

Instead of Epicurus' single argument for the infinity of the universe (i), Lucretius offers no less than four arguments (I follow Bailey's analysis of the passage[424]):

1. (958-967): What is finite, must have a boundary, but for it to have a boundary there must be something outside to bound it. Yet, (by definition) there is nothing outside the universe. Therefore, the universe cannot be finite.

2. (968-983): If there were a boundary, what would happen if someone standing close to the boundary were to throw a spear towards it? If it stops, there must be matter outside to stop it, but if it proceeds there must be space outside for it to move in. In either case there turns out to be something outside, to the effect that the assumed boundary cannot be the ultimate boundary of the

[423] Addition proposed by Usener (1887), xviii, based on Cicero's rendering of the same argument in *Div.* II 103 (Epic. fr.297 Us.): 'Quod finitum est, habet extremum; quod autem habet extremum, id cernitur ex alio extrinsecus; *at quod omne est, id non cernitur ex alio extrinsecus*; nihil igitur cum habeat extremum, infinitum sit necesse est.' See commentaries *ad loc*.

[424] Bailey (1947) pp.763-4.

universe. And this procedure can be repeated wherever you assume the boundary to be. Therefore the universe can have no boundary and cannot be finite.

3. (984-997): If *space* were finite, all matter would since long by force of its weight have been heaped up at the bottom, and nothing would ever happen below the vault of heaven, nor would there even be a heaven or a sun. Yet, in fact the atoms are forever in constant motion. Therefore, *space* cannot be finite.

4. (998-1001): In our everyday experience everything is always bounded by something else, but with the universe (by definition) there can be nothing else to bound it. Therefore, the universe cannot be finite.

Of these four arguments for the infinity of the universe, the first is identical to the one provided by Epicurus. The earliest report of this argument is found in Aristotle, who rejects it.[425]

The second argument is a famous thought-experiment, ultimately deriving from the Pythagorean Archytas.[426] An essentially identical argument was also used by the Stoics.[427]

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[425] Arist. *Phys*. III 4, 203b20-22: ἔτι τῷ τὸ πεπερασμένον ἀεὶ πρός τι περαίνειν, ὥστε ἀνάγκη μηδὲν εἶναι πέρας, εἰ ἀεὶ περαίνειν ἀνάγκη ἕτερον πρὸς ἕτερον.

[426] Archytas, fr.A24 D-K (Simplicius *in Aristot. Phys.* 467.26-35 Diels): Ἀρχύτας δέ, ὥς φησιν Εὔδημος, οὕτως ἠρώτα τὸν λόγον· ὠὲν τῷ ἐσχάτῳ οἷον τῷ ἀπλανεῖ οὐρανῷ γενόμενος, πότερον ἐκτείναιμι ἂν τὴν χεῖρα ἢ τὴν ῥάβδον εἰς τὸ ἔξω, ἢ οὔ; καὶ τὸ μὲν οὖν μὴ ἐκτείνειν ἄτοπον· εἰ δὲ ἐκτείνω, ἤτοι σῶμα ἢ τόπος τὸ ἐκτὸς ἔσται. διοίσει δὲ οὐδὲν, ὡς μαθησόμεθα.ὠ ἀεὶ οὖν βαδιεῖται τὸν αὐτὸν τρόπον ἐπὶ τὸ ἀεὶ λαμβανόμενον πέρας, καὶ ταὐτὸν ἐρωτήσει, καὶ εἰ ἀεὶ ἕτερον ἔσται ἐφ' ὃ ἡ ῥάβδος, δῆλον ὅτι καὶ ἄπειρον. – 'Archytas, as Eudemus reports [fr.65 Wehrli], approached the argument as follows: "having reached, for instance, the edge of the fixed heaven, could I stretch my hand or staff outward, or not? Not being able to stretch it out would be absurd, but if I stretch it out, the outside will be either body or place. It will not make a difference, as we shall learn." He {i.e. Archytas} will then always in the same manner proceed towards the assumed boundary and ask the same question, and if there will always turn out be another thing towards which the staff is stretched out, it will be clear that the universe is infinite.' On this argument and its Stoic and Epicurean, see Sorabji (1988) 125-6.

[427] *SVF* II 535a (Simpl. *in Aristot. De caelo* 284.28-285.2 Heiberg): Οἱ δὲ ἀπὸ τῆς Στοᾶς ἔξω τοῦ οὐρανοῦ κενὸν εἶναι βουλόμενοι διὰ τοιαύτης αὐτὸ κατασκευάζουσιν ὑποθέσεως. ἔστω, φασίν, ἐν τῷ ἐσχάτῳ τῆς ἀπλανοῦς ἑστῶτά τινα ἐκτείνειν πρὸς τὸ ἄνω τὴν χεῖρα· καὶ εἰ μὲν ἐκτείνει, λαμβάνουσιν, ὅτι ἔστι τι ἐκτὸς τοῦ οὐρανοῦ, εἰς ὃ ἐξέτεινεν, εἰ δὲ μὴ δύναιτο ἐκτεῖναι, ἔσται τι καὶ οὕτως ἐκτὸς τὸ κωλῦσαν τὴν τῆς χειρὸς ἔκτασιν. κἂν πρὸς τῷ πέρατι πάλιν ἐκείνου στὰς ἐκτείνῃ, ὁμοία ἡ ἐρώτησις· εἶναι γὰρ δειχθήσεται κἀκείνου τι ἐκτὸς ὄν. – 'Those of the Stoa want there to be a void outside the heavens and prove it through the following assumption: let someone stand, they say, at the edge of the fixed heavenly sphere and stretch out his hand upwards {i.e. away from the centre = outwards}. If he does stretch it out, they take it that there is something outside the heavens into which he has stretched it, and if he

The third argument is exceptional from several points of view. In the first place it seems to be concerned with the infinity of *space* rather than the *universe*. This has led several editors to apply all kinds of transposition to the text in order to 'restore' the logical sequence of the argumentation.[428] However, Bailey has quite rightly demonstrated that the argument is precisely where it should be. Since the universe is composed of matter and space, the infinity of either part – in this case *space* – automatically implies the infinity of the whole, i.e. the *universe*. The argument may therefore serve as an argument for the infinity of the universe. In the second place, however, by using this argument at this point Lucretius is willfully anticipating something he has not yet proved, the proof of which partly depends on the outcome of the present passage. The argument assumes the laws of atomic motion, which Lucretius does not discuss until II 62ff – and especially the atoms' natural *downward* motion, which is not discussed until II 184ff. However, (and this is something the commentators, including Bailey, do not seem to have appreciated) the acceptance of these laws of atomic motion – and again especially the atoms' natural *downward* motion – depends implicitly upon the rejection of the alternative theory of natural motion put forward in I 1052ff (to be discussed presently), a passage which in turn depends on the *infinity of space*, which is precisely the subject of the present argument. In sum, Lucretius' third argument is *circular* to a certain extent. Fortunately, it is only one of several arguments, and we do not therefore depend on it for the conclusion that space and the universe are infinite.

The fourth argument is basically a restatement of the first. A very similar argument is also brought forward by the Stoic Cleomedes.[429]

After these four arguments, in lines 1002-7 Lucretius sums up his conclusion. One would have expected this conclusion to be that the *universe* is infinite, but instead Lucretius seems to say that *space* is infinite. However, the continuation suggests that this is something Lucretius does not yet consider to be quite established. We may perhaps solve the problem if we interpret 'space' here as the 'spatial extent of the universe', i.e. space, both empty and filled with matter.[430]

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cannot stretch it out, there will still be something outside which prevents his hand from being stretched out. And if he should next stand at the limit of this and stretch out his hand, the question is similar: for it will be demonstrated that there is something outside of that point too.'

[428] See Bailey's commentary for an overview.

[429] Cleomedes I 1, 112-122.

[430] See Bailey *ad loc*.

After this conclusion the argument moves on (1008-1013): given the infinity of the universe two theoretical options present themselves: (a) its two constituents, matter and space, are *both* infinite, or else (b) *either one* of these two is infinite.

At this point, to all likelyhood, the text presents a lacuna. Option b seems to imply two further options: (b1) either matter is infinite and empty space is not, or (b2) empty space is infinite, while matter is not. Both these options are in fact explicitly discussed and refuted by Epicurus, in the passage quoted above (sections iii and ii respectively), but in Lucretius' text, as we have it, both seem to have been lost in the lacuna. Right after the lacuna we find ourselves in the middle of a discussion of what would happen if space were infinite, but matter not, i.e. the elaboration of option b2, corresponding to part ii of Epicurus' account. This means that the lacuna must have contained both the statement and refutation of b1, as well as the statement of b2. The text of the lacuna must have run something like this (using Bailey's words): "< But (b1) if space were limited, it could not contain the infinite bodies of matter; and (b2) if matter were limited > ....". There follows the account of lines 1014ff.

Before we go on to discuss this passage, it may be a good idea for us to pause briefly and take our bearings. When we arrive at line 1014, just after the lacuna, the infinity of the *universe* has been firmly established, but also, and more importantly, the infinity of *space*. It may be interesting to note that up to this point the position of the Epicureans is in no way different from that of their most ardent rivals, the Stoics: see e.g. Cleomedes I 1.39-149.[431] As we have seen, even some of Lucretius' arguments for the infinity of the universe are identical to Stoic ones: his second argument corresponds to the Stoic argument reported by Simplicius (*SVF* II 535a),[432] and his fourth to Cleomedes I 1.112-122.

Lucretius has only to fulfill one more promise, and this is where the Epicureans and Stoics part company: *to prove the infinity of matter,* given the infinity of space. To this task he devotes the rest of book I. The argument in lines 1014-51 consists of two stages. First, in lines 1014-20, Lucretius argues that without an infinite amount of matter the world would not be able to survive and would not even have been created, because all the atoms would be scattered through infinite space. This stage corresponds to Epicurus' argument in section ii of the text quoted above.[433] Then, in lines 1021-51, Lucretius goes

[431] On the Stoic conception of extra-cosmic void see Algra (1993) and id. (1995) 261-336.

[432] See note 427 above.

[433] Cf. also Diog. Oen. fr.67: Πεπερασμέ[ναι] τοιγ[α]ροῦν ἡμεῖν [ὑπ]οκείμεναι κατὰ τὸ [π]λῆθος αἱ ἄτομοι φύ[σεις κ]αὶ δι' ἃς εἰρήκαμεν [α]ἰ[τ]ίας ἀσυνέλευστοι τυνχάνουσαι (μετὰ γὰρ αὐτὰς ἄλλαι φύσεις οὐκέτ' εἰσίν, αἳ περιλαβοῦσαι τὸ

on to explain how the world *is* actually created and preserved. According to Lucretius, everything we see around us is created through chance meetings of atoms, which being (infinitely) many and having tried every kind of motion and combination during infinite time, finally happened to combine into such a structure as is our world. Yet, even now our world is still being preserved through the agency of atoms from outside, which either replace the atoms that are constantly being lost, or prevent them from escaping by battering them back into line. In order to accomplish this an infinite amount of matter is required.

May we take it then that the infinity of matter has now been proved? Not quite. In the following section Lucretius is forced to retrace his steps and to suspend his desired conclusion about the infinity of matter, because an alternative theory must be removed first.

3.3.1.3 The rival theory

In lines 1052ff Lucretius describes and refutes a rival theory which would account for the cosmos staying together without the need for extra-cosmic matter. Because the passage involves the rejection of centrifocal cosmology, it is important to study it from every possible angle. I will therefore print the text in full, with a translation and a select commentary of my own, followed by a schematic presentation of the structure of the passage. Except for some minor changes, which – if relevant – will be indicated in the commentary, the text is as printed by Bailey (1947).

Text		Translation
Illud in his rebus longe fuge credere, Memmi,		In these matters, Memmius, flee far from believing this,
in medium summae quod dicunt omnia niti,		what they say: that all things tend to the centre of the universe,
atque ideo mundi naturam stare sine ullis		and that therefore the cosmos stays together without
ictibus externis neque quoquam posse resolvi,	1055	any external blows, and cannot be dissolved in any direction,
summa atque ima quod in medium sint omnia nixa		because the upper and the lower parts all tend to the centre
(ipsum si quicquam posse in se sistere credis),		(if you believe that anything can stand on itself),
et quae pondera sunt sub terris omnia sursum		and that, what weights there are below the earth, these all tend
nitier in terraque retro requiescere posta,		upwards, and rest inversely placed against the earth,
ut per aquas quae nunc rerum simulacra videmus.	1060	like images of things we now see in the water.

πλῆθος αὐτῶν κάτωθέν τε ὑπερείσουσι καὶ ἐκ τῶν πλαγίων συνάξουσιν αὐτὰς), πῶς ἀπογεννήσωσι τὰ πράγματα χωρὶς ἀλλήλων; ὥστ᾽ οὐκ ἂν ἦν οὐδ᾽ ὅδε ὁ κόσμος. εἰ γὰρ ἦσαν πεπερασμένοι, συνελθεῖν οὐκ ἠ[δύναντ᾽ ἄν]. – Therefore if the atoms are assumed by us to be finite in number and for the [reasons] we have stated are incapable of coming together (for there are no longer other atoms behind them to surround their number and support them from below and bring them together from the sides), how are they to engender things, when they are isolated from one another? The consequence is that not even this cosmos would exist. For if the number of atoms were finite, they [would] not [be able] to come together. (tr. Smith, slightly modified)

Et simili ratione animalia suppa vagari
contendunt neque posse e terris in loca caeli
reccidere inferiora magis quam corpora nostra
sponte sua possint in caeli templa volare;
illi cum videant solem, nos sidera noctis
cernere, et alternis nobiscum tempora caeli
dividere et noctes parilis agitare diebus.

Sed vanus stolidis haec * * *
amplexi quod habent perv * * *
nam medium nihil esse potest * * *
infinita; neque omnino, si iam <medium sit>,
possit ibi quicquam consistere * * *
quam quavis alia longe ratione * * *
omnis enim locus ac spatium, quod in<ane vocamus>,
per medium, per non medium, concedere <debet>
aeque ponderibus, motus quacumque feruntur.
nec quisquam locus est, quo corpora cum venere,
ponderis amissa vi possint stare in inani;
nec quod inane autem est ulli subsistere debet,
quin, sua quod natura petit, concedere pergat.
haud igitur possunt tali ratione teneri
res in concilium medii cuppedine victae.
Praeterea quoniam non omnia corpora fingunt
in medium niti, sed terrarum atque liquoris
– umorem ponti magnasque e montibus undas,
et quasi terreno quae corpore contineantur –,
at contra tenuis exponunt aëris auras
et calidos simul a medio differrier ignis,
atque ideo totum circum tremere aethera signis
et solis flammam per caeli caerula pasci,
quod calor a medio fugiens se ibi conligat omnis,
nec prorsum arboribus summos frondescere ramos
posse, nisi a terris paulatim cuique cibatum
* * * * * * * * * * * *

And they claim that in the same way animals wander
upside down, and cannot fall back from the earth into the lower
regions of the heavens, any more than these our bodies
can of their own accord fly into the temples of heaven;
and that when they see the sun, we see the stars of the night
and that they divide their heavenly seasons alternate with ours
and have their nights equal to our days.

But idle <belief suggested> these things to the idiots,
because they have embraced them with perv<erse reasoning>,
for there can be no centre <since the universe is>
infinite, nor – even if <there were a centre> –
could anything at all stand still there, <rather>
than in a far different manner <be driven away>;
for every place and space, which we <call void>
– whether or not the centre –, <must> yield
equally to weights, wherever their movements tend.
nor is there any place, where bodies upon arriving
lose the force of weight and stand still in the void;
nor, on the other hand, must that which is void, resist to
anything, but, as its nature demands, must yield.
Therefore, not in such a way can things be held
in union, overcome by longing for the centre.
Besides, since they suppose that not all bodies
tend towards the centre, but (only) those of earth and water
– the moisture of the sea and mighty waves from the mountains,
and such things as are contained as it were in earthly body –,
while on the other hand they expound that the thin breezes of air
and hot fires are at the same time borne away from the centre,
and that therefore the whole aether twinkles all around with stars
and the flame of the sun grazes through the blue of the sky,
all heat fleeing from the centre gathers itself there,
and that the topmost branches of the trees would not at all be
able to sprout leaves, if not slowly from the earth to each food
<were distributed> * * * * * * * * * * * *

Commentary

1053 quod dicunt: There is some disagreement about the right construction of 'quod dicunt'. According to some commentators,[434] it depends on 'in medium summae': 'the centre of the universe, *as they call it*', which would be an anticipation of Lucretius' criticism in lines 1070-1 that the universe, being infinite, cannot have a centre. This would make the whole train of *AcI* ('Accusativus cum Infinitivo') constructions up to line 1060 (except 1057) appositional to 'illud' and therefore dependent on 'fuge credere'. According to others,[435] 'quod dicunt' goes directly with 'illud': 'this, *what they say*, viz. that ...', making all the *AcI's* effectively dependent on 'dicunt'. Although both options are syntactically viable, there is good reason to prefer the second one, since all the *AcI's* in the

[434] Giussani (1896-8), Ernout-Robin (1925-8), Furley (1966) 187-8, Brown (1984). Examples of 'illud' explained by an *AcI*-construction are found at II 184ff, 216ff, 581ff, 891ff, 934ff, III 319ff, V 146ff.

[435] Bailey (1947). For an example of 'illud' with a relative clause Bailey refers to I 370ff. A better example is III 370-3 ('Illud in his rebus nequaquam sumere possis, / Democriti quod sancta viri sententia ponit, / corporis atque animi primordia singula privis / adposita alternis variare, ac nectere membra.'), where 'illud' governs not just a relative clause, but an *AcI* as well. A third option, proposed by Munro (1864), explaining 'quod dicunt' as parenthetical to the whole *AcI*-construction ('*id* quod dicunt'), corresponds to Bailey's interpretation in so far as it makes the *AcI's* effectively dependent on 'dicunt'.

rest of the passage depend on *verba declarandi* as well: 1061-7 on 1062 'contendunt', 1083-6 on 1083 'fingunt', and 1087-93 on 1087 'exponunt'. This has serious consequences for the interpretation of the passage: if all the *AcI's* in lines 1053-60 depend on 'dicunt', they must all be interpreted as part of what the unnamed rivals say: Lucretius wants us to be believe that the theory he describes and later rejects was not merely invented by him for the sake of argument, but was actually brought forward by the unnamed rivals themselves.

1054 mundi naturam: periphrastic for 'mundum'. It should be noted that here, as elsewhere in Lucretius, 'mundus' stands for the Greek κόσμος (cosmos), i.e. the structured whole consisting of heaven and earth and everything in between.[436] Cf. Lewis & Short 'mundus' II B, with refs. to Cic. *Tim*. 10.9-11 and Pliny *NH* II 8.

1054 stare: There is some ambiguity about the word 'stare', which, applied to the cosmos, could either refer to its 'staying together' or to its 'staying in one place'.[437] It is clear however that Lucretius is mainly thinking of the first possibility: compare lines 1081-82, where the same thought is expressed as 'teneri in concilium' = 'to be held in union'.

1054-5 sine ullis / ictibus externis: This is best understood as a parenthetical remark of Lucretius' own, and need not imply that the unnamed rivals actually formulated their theory in opposition to Epicurus.

1056 summa atque ima: The comma could be placed either after or before 'summa atque ima'.[438] If after, 'summa atque ima' go with the preceding line, providing a new subject for 'resolvi'. If before, 'summa atque ima' will be the subject of 'sint nixa' in the same line, making 'omnia' an apposition. I slightly prefer the second option because in that way the words 'summa atque ima' prepare the way for Lucretius' parenthetical remark in the next line. The meaning of the lines is not, however, essentially effected either way.

1065-7: As Brown (1984) observes, these lines do not imply the rejection of the astronomy involved. In V 650-704 Lucretius explicitly admits the possibility that the sun passes below the earth each night. What he *does* object to is the belief that there are people down there (*illi*) to observe (*videant*) the sun and its effects.

1068-75 & 1094-1101: The text of the passage as it has come down to us is damaged. Part of a leaf of the archetype must have been torn off, partly destroying lines 1068-75, and completely destroying lines 1094-1101, which would have been on the verso. Of the extant manuscripts, only the Oblongus has preserved whatever remained of lines 1068-75. Fortunately, this is enough to gather the general sense. The second section, however, is lost beyond repair. As a result we do not know the precise relationship between what came before and what came after this lacuna.

3.3.1.4 Structure of the passage

The passage consists of two main parts: a description of the rival theory (1053-67) and a refutation of this theory (1068-93ff), containing at least three

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[436] See also Furley (1981) 4: "*Mundus* in Latin and *kosmos* in Greek meant a limited, organized system, bounded by the stars."

[437] The same ambiguity also attaches to the Greek verb μένειν and its cognate noun μονή, which are used in statements of the corresponding Stoic theory. The relevant texts are Ar. Did. fr.23, quoted on p.172 below, and those quoted in n.445 on p.173 below.

[438] Furley (1966) 188.

objections (more may have been lost in the lacuna). In the course of the argument Lucretius presents eight propositions allegedly brought forward by the unnamed rivals: five as part of his description of the theory, and three more as part of his third objection. The structure of the passage can be set out as follows:

A. Description of the rival theory (1053-67):
  1. Everything tends towards the centre of the universe (1053)
  2. In this way the coherence of the cosmos is explained – without external blows (1054-57)
  3. Weights below the Earth press upward and stand upside down against the Earth (1058-60)
  4. Animals living on the other side of the Earth walk upside down and do not fall down into the lower regions of the heavens (1061-64)
  5. People living on the other side of the Earth have day and night, and summer and winter reversed (1065-67)
B. Refutation of the rival theory (1068-93ff):
  i. There is no centre in the infinite universe (1070-71)
  ii. Nothing would stop at this 'centre', because a mere point in space cannot offer resistance (1071-82)
  iii. The anonymous rivals also claim (1083-93ff) that:
    6. *not* everything tends towards the centre, but only earth and water, whereas air and fire move away from it (1083-88)
    7. this is the reason why "the whole aether twinkles all around with stars, and the flame of the sun grazes through the blue of the sky" (1089-90)
    8. and this is also why plants grow upwards (1091-93)
    ..... (1094ff)

The eight propositions do not all enjoy the same status, but they serve different purposes in Lucretius' argument. Proposition 1 is the really important one. It is this view that makes the rival theory qualify as an alternative to Lucretius' own theory of external blows. Proposition 2 is important too, because it tells us explicitly what proposition 1 was meant to explain: viz. the coherence of the cosmos. Propositions 3-5 are merely corollaries of proposition 1. They are not important in themselves, nor are they objects of Lucretius' criticism, but they are used to ridicule the rivals' theory, and so prepare the reader's mind for the real criticism in part B of the passage. A similar point can be made with respect to propositions 6-8. Here too the first one, proposition 6, is the really important one. According to most commentators, Lucretius' third objection must have focused on this proposition, perhaps pointing out its inconsistency with proposition 1, or the disastrous consequences of proposition 6 alone: viz. the escape of air and fire into infinite space. By contrast, propositions 7 and 8 are relatively unimportant. Their only function is to tell us why the unnamed rivals felt the need to accept proposition 6 in the first place: viz. to account for the fact that the stars and the sun remain poised in the sky, and that plants grow upwards. Note that the facts contained in these two propositions are not themselves being disputed.

3.3.1.5 Identification of the unnamed opponents

It has long been debated who the unnamed opponents were. Most scholars believe that Lucretius is specifically targetting the Stoics, although a few dissenters vehemently deny this, pointing instead towards Aristotle or Plato.

The identification of the unnamed opponents seems to depend largely on the view one takes of Lucretius as a philosopher. At one end of the spectrum are those who see Lucretius as an Epicurean 'fundamentalist', whose work is mainly a Latin versification of the works of Epicurus himself. At the other end are those who wish to see Lucretius right in the middle of the philosophical debates of his time, when the Stoics had become the Epicureans' main antagonists.[439] In the first case, our passage must go back to Epicurus himself, who – it is believed – can only have had the Peripatetics or the dogmatic Academics for a target, since the Stoic school had only just come into existence.[440] In the second case, however, our passage may well represent the debates of Lucretius' own time in which the Stoics figured prominently.

In this subsection I will try to steer clear from both preconceived positions, and instead focus as much as possible on Lucretius' description of, and arguments against, the rival theory, in order to identify it. It may be thought that for the present purpose, i.e. the reconnaissance of Lucretius' own cosmological views, the identification of the anonymous rivals is not really necessary, but I will try to demonstrate that knowing them and their actual theories will enable us to better understand Lucretius himself.

As I said, the majority of commentators interpret the present passage as an attack on the Stoics.[441] In support of their identification they quote Arius Didymus fr.23 on Zeno[442]:

Ζήνωνος· τῶν δ' ἐν τῷ κόσμῳ πάντων τῶν κατ' ἰδίαν ἕξιν συνεστώτων τὰ μέρη τὴν φορὰν ἔχειν εἰς τὸ τοῦ ὅλου μέσον, ὁμοίως δὲ καὶ αὐτοῦ τοῦ κόσμου· διόπερ ὀρθῶς λέγεσθαι πάντα τὰ μέρη τοῦ κόσμου ἐπὶ τὸ μέσον τοῦ κόσμου τὴν φορὰν ἔχειν,	Zeno's {tenet}: Of all the things in the cosmos which are constituted with their own *hexis* the parts have their motion towards the middle of the whole, and the same applies also to the parts of the cosmos itself: therefore it is correct to say that all the parts of the cosmos have their motion towards the middle of

[439] For a summary of the debate see Warren (2007) 22-4. Notable representatives of the first view are Furley (1966); *id.* (1978) 206-8 and Sedley (1998a), esp. 62-93, where Lucretius is called a 'fundamentalist'. The second view is championed by e.g. Schrijvers (1999) and Schmidt (1990).

[440] I will return to this point at the end of this subsection, on p.182 below.

[441] See Munro, Giussani, Ernout-Robin, Bailey *ad loc*.

[442] Ar. Did. fr.23 Diels, apud Stob. *Ecl.* I 19,4 p.166, 4 W. (= *SVF* I 99). On the validity of the ascription to Zeno, see Algra (2003) 15-19 = Algra (2002) 163-7.

μάλιστα δὲ τὰ βάρος ἔχοντα. ταὐτὸν δ' αἴτιον εἶναι καὶ τῆς τοῦ κόσμου μονῆς ἐν ἀπείρῳ κενῷ καὶ τῆς γῆς παραπλησίως ἐν τῷ κόσμῳ, περὶ τὸ τούτου κέντρον καθιδρυμένης ἰσοκρατῶς. οὐ πάντως δὲ σῶμα βάρος ἔχειν, ἀλλ' ἀβαρῆ εἶναι ἀέρα καὶ πῦρ· τείνεσθαι δὲ καὶ ταῦτά πως ἐπὶ τὸ τῆς ὅλης σφαίρας τοῦ κόσμου μέσον, τὴν δὲ σύστασιν πρὸς τὴν περιφέρειαν αὐτοῦ ποιεῖσθαι· φύσει γὰρ ἀνώφοιτα ταῦτ' εἶναι διὰ τὸ μηδενὸς μετέχειν βάρους.

the cosmos, especially those parts which have weight. The same fact explains both the immobility of the cosmos in infinite empty space and similarly of the earth in the cosmos, the earth being equably settled around its centre. Not in every respect, however, does body have weight, but air and fire are weightless: yet they too somehow tend towards the middle of the whole sphere of the cosmos, and they gather towards its periphery, for they are naturally *upward-moving* {i.e. *centrifugal*}[443] because they have no share in weight.[444]

The quotation seems highly apposite. All the major propositions of Lucretius' anonymous opponents are here: (1) the centripetal tendency of *all* matter (*πάντα* τὰ μέρη τοῦ κόσμου ἐπὶ τὸ μέσον τοῦ κόσμου τὴν φορὰν ἔχειν), (2) the explicit use of this theory to account for the coherence and immobility of the cosmos (ταὐτὸν δ' αἴτιον εἶναι καὶ τῆς τοῦ κόσμου μονῆς ἐν ἀπείρῳ κενῷ),[445] and (6) the paradoxical claim that air and fire, while tending towards the centre, are also naturally centrifugal (οὐ πάντως δὲ σῶμα βάρος ἔχειν, ἀλλ' ἀβαρῆ εἶναι ἀέρα καὶ πῦρ· {...} φύσει γὰρ ἀνώφοιτα ταῦτ' εἶναι διὰ τὸ μηδενὸς μετέχειν βάρους),[446] – and there are many other testimonies to confirm the Stoics' commitment to these views.[447]

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[443] 'Upward' in Stoic cosmology equals 'away from the centre of the cosmos': see note 421 above.

[444] On the interpretation of this text and its parallels, see Sambursky (1959) 111-3, Furley (1966) 191-3, Hahm (1977) 107-126, Algra (1988) and Wolff (1989) 499-533 and 539-542.

[445] Cf. Achilles *Isagoge* 9 (*SVF* II 554): Φασὶ μὲν οὖν μένειν τὸν κόσμον ἐν ἀπείρῳ κενῷ διὰ τὴν ἐπὶ τὸ μέσον φοράν, ἐπεὶ *πάντα* αὐτοῦ *τὰ μέρη* ἐπὶ τὸ μέσον νένευκε. Μέρη δέ ἐστιν αὐτοῦ γῆ ὕδωρ ἀὴρ πῦρ, ἃ πάντα νεύει ἐπὶ τὸ μέσον. Διὰ τοῦτο οὖν οὐδαμοῦ ῥέπει ὁ κόσμος. Cic. *ND* II 115 (*SVF* II 549): '... ita stabilis est mundus atque ita cohaeret, ad permanendum ut nihil ne excogitari quidem possit aptius. *Omnes* enim *partes* eius undique medium locum capessentes nituntur aequaliter'. Cleomedes I 1.91-2: Φήσομεν δὲ ὅτι ἀδύνατον αὐτῷ {sc. τῷ κόσμῳ} φέρεσθαι διὰ τοῦ κενοῦ· νένευκε γὰρ ἐπὶ τὸ ἑαυτοῦ μέσον καὶ τοῦτο ἔχει κάτω, ὅπου νένευκεν. Chrysippus apud Plut. *De Stoic. repugn*. 44, 1055a (*SVF* II 550): πιθανὸν *πᾶσι τοῖς σώμασιν* εἶναι τὴν πρώτην κατὰ φύσιν κίνησιν πρὸς τὸ τοῦ κόσμου μέσον.

[446] Cf. Aët. I 12.4 (= *SVF* II 571): Οἱ Στωικοὶ δύο μὲν ἐκ τῶν τεσσάρων στοιχείων κοῦφα, πῦρ καὶ ἀέρα· δύο δὲ βαρέα, ὕδωρ καὶ γῆν. κοῦφον γὰρ ὑπάρχει φύσει ὃ νεύει ἀπὸ τοῦ ἰδίου μέσου, βαρὺ δὲ τὸ εἰς μέσον. *Schol. Hes. Theog.* 134 Gaisf. *Gr. Poet. Min*. II 482 (= *SVF* I 100): φύσιν ἔχει πάντα τὰ κοῦφα ἀφιέμενα πίπτειν ἄνω. Cic. *ND* II 117: 'aer natura fertur ad caelum'. Plut. *De Stoic. repugn*. 42, 1053e (= *SVF* II 434): τὸ πῦρ, ἀβαρὲς ὄν, ἀνωφερὲς εἶναι, καὶ τούτῳ παραπλησίως τὸν ἀέρα. Achilles *Isagoge* 4 (= *SVF* II 555b): τεσσάρων οὖν ὄντων τῶν στοιχείων, συμβέβηκε τὸ πῦρ καὶ τὸν ἀέρα, κουφότατα ὄντα, ἐπὶ τὴν ἄνω φορὰν ἔχειν τὴν ὁρμήν, {...} ὅτι δὲ ἡ γῆ καὶ τὸ ὕδωρ

The other propositions can be linked to the Stoics too. The theory of the antipodes (3-5), for instance, though not exclusively Stoic, seems to have been especially dear to them. It is given extensive treatment by the Stoic astronomer Cleomedes,[448] and they are mocked for holding such views by Plutarch.[449] Also (7) the theory that the sun and the stars require some kind of nourishment is well attested for the Stoics.[450] Even proposition 8, which probably stated that the upward growth of plants is somehow caused by the centrifugal tendency of air or fire, can be related to the Stoic tenet that attributes the growth of plants to the presence of an internal fire.[451]

Yet, the identification of the unnamed opponents with the Stoics is not universally agreed upon. In an article, published in 1966, David Furley critically reviews a number of passages in the *DRN* that had until then been interpreted as attacks on the Stoics. One of these passages is the one we are presently investigating.[452] Furley argues that this passage cannot have been aimed at the Stoics, but should be read as an attack on Aristotle instead. Furley's views were in turn forcefully contested by Jürgen Schmidt in 1990,[453]

βαρέα καὶ κατωφερῆ, οὐ δεῖ λόγου, τῆς πείρας διδασκούσης. Cf. also Seneca *N.Q.* II 13.1-14.1; II 24.1; II 58.2; VII 23.1.

[447] See notes 445 and 446 above.

[448] Cleomedes I 1.258-261: Πρὸς δὲ τοὺς ἀντίποδας οὐδὲν ἡμῖν κοινόν ἐστιν, ἀλλὰ πάντα ἀντέστραπται. Καὶ γὰρ τὰ ὑπὸ γῆν ἀλλήλων ἔχομεν κλίματα, καὶ τὰ κατὰ τὰς ὥρας ἡμῖν ἔμπαλιν ἔχει, καὶ τὰ κατὰ τὰς ἡμέρας καὶ νύκτας καὶ τὰ κατὰ τὰς αὐξήσεις τῶν ἡμερῶν καὶ μειώσεις. – "With the antipodeans we have nothing in common, but everything is reversed. For we occupy the regions that are 'down under' with respect to eachother, and everything relating to the times is contrary between us, both with respect to days and nights and with respect to the lengthening and shortening of the days." (cp.with Lucr. I 1065-7).

[449] Plut. *De facie* 7, 924a4-6: οὐκ ἀντίποδας οἰκεῖν ὥσπερ θρῖπας ἢ γαλεώτας τραπέντα ἄνω τὰ κάτω τῇ γῇ προσισχομένους; – "Do you not say that people are living opposite us, who cling to the earth like wood-worms or geckos turned upside-down?" (cp. with Lucr. I 1058-64).

[450] See e.g. Cic. *ND* II 40 (= *SVF* I 504); 43; 83; 118 (= *SVF* II 593); III 37 (= *SVF* I 501b / II 421); Aët. II 17a.1 (*SVF* II 690); Aët. II 23.7 (*SVF* I 501d / II 658); Diog. Laërt. VII 145 (*SVF* II 650); Cleomedes I 8.79-82 (*SVF* II 572); Plut. *De Iside* 41, 367e (*SVF* II 663); Plut. *De facie* 25, 940c (*SVF* II 677).

[451] See Ar. Did. fr.33 Diels, apud Stob. *Ecl*. I 25, 5 (*SVF* I 120): {πῦρ} τεχνικόν, αὐξητικόν τε καὶ τηρητικόν, οἷον ἐν τοῖς φυτοῖς ἐστι καὶ ζῴοις, ὃ δὴ φύσις ἐστὶ καὶ ψυχή, and Cic. *ND* II 41 (*SVF* I 504): 'ille {sc. ignis} corporeus vitalis et salutaris omnia conservat alit auget sustinet sensuque adficit.'

[452] Furley (1966) 187-195.

[453] Schmidt (1990) 212-22.

who tries to restore the Stoics as the prime targets of Lucretius' criticism. Unfortunately, Schmidt's work seems to have gone largely unnoticed, to the effect that in the 1992 Loeb-edition of Lucretius we can still read, without any qualification, that Lucretius' argument was probably aimed at Aristotle.[454] In 1998, the case has been reopened by David Sedley.[455] All too readily dismissing Schmidt's refutation, Sedley endorses Furley's arguments against the Stoics and even adds one of his own. He does not, however, accept Furley's view that the intended target is Aristotle, but instead points to dogmatic Platonists under the leadership of Polemo.

Although I am not convinced by Schmidt's additional conclusion that Lucretius must have been influenced by Academic scepticism and therefore must have been working from neo-epicurean sources, I think that Schmidt has clearly demonstrated the inadequacy of Furley's argument. However, in view of Sedley's recent resumption of the case, with an additional argument, and his introduction of a new possible target for Lucretius' criticism, I think that a new defence of the traditional interpretation of the passage is in order. On the following pages I intend to show that the Stoics are not only the most likely, but in fact the only possible targets of Lucretius' criticism in the present passage.

It is true that some of the unnamed rivals' views can be identified with Aristotelian and Platonic tenets as well. For instance, both Plato and Aristotle believed that earth and water have a natural tendency towards, and air and fire away from, the centre of the cosmos (proposition 6).[456] Both also had some conception of antipodeans, people living on the other side of the earth with their feet pressing towards ours (propositions 3-5).[457] Things become much harder, however, if we want to reduce proposition 7, about the sun feeding itself, or 8, about plants growing due to the upward tendency of air and fire, to Platonic and Aristotelian views.[458] However, the most important and, to my mind, fatal objection against identifying the unnamed opponents' with Plato or Aristotle, is the absence in their works of any version of propositions 1 and 2. Proposition 1 is the claim that *all* things tend towards the centre of the

[454] Rouse-Smith (1992) 86-87, note b.
[455] Sedley (1998a), 78-82.
[456] Plato *Ti.* 62c-63e (speaking of fire and earth); Arist. *Cael.* I 2, 269a18-19 and esp. *Cael.* IV.
[457] Plato *Ti.* 63a (Cf. also Cic. *Luc*. 123, 7 against the adherents of Antiochus' Old Academy: "Vos etiam dicitis esse e regione nobis, e contraria parte terrae qui adversis vestigiis stent contra nostra vestigia, quos *antipodas* vocatis.") Arist. *Cael.* IV 1, 308a20.
[458] Both theories are refuted by Aristotle, in *Mete.* II 2, 354b34 – 355a32 and *De an*. II 4, 415b28 – 416a9 respectively. His pupil Theophrastus, on the other hand, seems to acknowledge some relation between plant growth and the motion of fire, in *De igne* 56.

universe. The closest match is Plato's and Aristotle's view that all *heavy* things (i.e. earth and water) tend towards the centre, but it is entirely unclear how such a view could explain the integrity of the *whole* cosmos (i.e. including the *light* elements, air and fire), as the unnamed opponents say it does (prop. 2). It is true that Aristotle uses the centripetal tendency of *earth* to explain the immobility of the *earth*,[459] but this is not at stake here. If Lucretius' had wished to criticise *this* theory, he would have done so in book V, in connection with his own theory about the earth's stability (V 534-563). In the present passage, however, we are dealing with the integrity of the whole *cosmos*. Moreover, Furley and Sedley seem to ignore the fact that Lucretius' unnamed opponents *themselves* used the centripetal tendency of all matter to explain how 'the cosmos stays together' and 'cannot be dissolved in any direction' (prop. 2).[460] This implies that the unnamed rivals *themselves* assumed the existence of an external void into which the cosmos might otherwise be dissolved. Aristotle, on the other hand, explicitly denied the existence of an extracosmic void,[461] and Plato is generally believed to have held the same view.[462] Neither of them, therefore, had any need to explain the integrity of the cosmos as a whole. It is therefore extremely unlikely that Lucretius' criticism would have had either of them for a target.

This does not prove, of course, that the target must be Stoic. In fact, several arguments against the Stoics being Lucretius' main target can be conceived. Two powerful arguments have been brought forward by Furley, and a third has been devised by Sedley. Before we can conclude that the target is Stoic after all, these three arguments will have to be dealt with.

Furley's first argument turns on the apparent inconsistency between propositions 1 and 6. First, in line 1053, Lucretius has the unnamed opponents say that *all* things tend towards the centre, and then, in lines 1083-88, that *not* all things tend towards the centre, but only earth and water, whereas air and fire move away from it. The inconsistency leaps to the eye, and most commentators think that this was precisely what Lucretius wished to point out. However, Furley claims that no such inconsistency is implied: in line 1053

[459] Arist. *Cael.* II 14, 296b28 – 297a2.

[460] If, as I argued on p.169 above, the *AcI's* in this passage are all dependent on 'dicunt' in line 1053, then it is clear that the opinion expressed in the present lines must also be attributed to the unnamed opponents themselves.

[461] Arist. *Cael*. I 9, 279a12-17. Cf. *Phys.* IV 8-9, 214b12 – 217b28, where Aristotle rejects the existence of any kind of void.

[462] See e.g. Aët. II 9.4: Πλάτων Ἀριστοτέλης μήτ' ἐκτὸς τοῦ κόσμου μήτ' ἐντὸς μηδὲν εἶναι κενόν.

Lucretius would have been thinking of *heavy* things *only*, and then, in lines 1083-88, he would have made explicit the earlier, implicit, qualification. According to Furley, then, the unnamed opponents simply said that earth and water are centripetal, and air and fire centrifugal, and nothing more. This interpretation effectively paves the way for Furley's own identification of the unnamed opponents with Aristotle, and Sedley's with Polemo's Platonists. Furley does not explain why the obvious interpretation, which is accepted by every other commentator, should be rejected. It is clear to me, therefore, that line 1053 must be taken literally: according to Lucretius the unnamed opponents really said that *all* things (*both heavy and light*) converge to the centre. Only in this way the rival theory can provide a reasonable alternative to his own theory of *external blows*.

This brings us back to where we were: the unnamed opponents hold two inconsistent views: *all* things move towards the centre, and *not all* things move to the centre. As we saw above, both these views are in fact attested for the Stoics, and for no other school but the Stoics. According to Furley, however, 'the evidence for this Stoic theory is […] confused'.[463] What the Stoics actually meant, he says, following Sambursky's interpretation,[464] is that air and fire 'are only *relatively* centrifugal', i.e. 'only *in the presence of earth and water*' [my italics]. I do not believe this interpretation can be right. Arius Didymus fr.23 (see p.172 above) informs us explicitly (as do several other reports) that according to the Stoics air and fire are naturally centrifugal (φύσει ἀνώφοιτα),[465] which suggests something much stronger and more basic than a mere *relative* lightness. It will not do to simply dismiss the evidence as being 'confused'. Besides, Sambursky and Furley seem to attribute to the Stoics a theory that begins to sound very much like the one held by Democritus, Strato, Epicurus and Lucretius himself,[466] all of whom claimed that *all* things are heavy and move downwards *by nature*, while the lighter bodies are pressed upwards *against their nature* by the heavier ones. In the existing ancient reports, however, the Stoics are never included among those who held this theory. That the Stoics in fact felt themselves much more at home with the opposite view (that air and fire are *positively light*) can also be observed through a comparison between Seneca *N.Q.* II 13 & 24 and Lucretius *DRN* II 203-215. Lucretius views the downward movement of thunderbolts and shooting stars as manifestations of the true, natural tendency

[463] Furley is here referring to Ar. Did. fr.23 quoted on p.172 above, and the texts quoted in notes 445 and 446 above.
[464] Sambursky (1959) 111.
[465] See note 446 above, where all explicit references to 'nature' and 'naturally' have been underlined.
[466] For the evidence see p.191ff below.

of fire, whereas the upward movement of flames is attributed to pressure from the heavier elements. For the *Stoic* Seneca it is the other way round: the natural movement of fire is upward, whereas the descent of thunderbolts and shooting stars is an exception brought about by pressure from above.[467] However, for the purpose of identifying Lucretius' unnamed opponents, it does not really matter how the Stoic theory is interpreted. It is enough that Lucretius' description of the rival theory closely resembles the existing reports on the Stoics. If all these reports are confused, as Furley maintains, Lucretius can hardly be blamed for entertaining the same confusion in his depiction of the same theory. From this point of view, then, there is no reason why Lucretius' unnamed opponents should not be identified with the Stoics, and there is every reason for not identifying them with Aristotle or with Platonists under the leadership of Polemo.

Furley's second argument concerns the expression 'in medium *summae*' in Lucretius I, 1053. In Bailey's commentary on I, 235 a useful list is given of the many different meanings which the word *summa* (lit. 'sum', 'sum total', 'totality') may have in the *DRN*, either by itself or in combination with other words. Three uses deserve our consideration in the present context:

(1) the totality of matter *in this world alone*,

(2) the totality of matter *everywhere*, and

(3) the totality of matter *and void*, usually translated as 'the universe'.

The first option can be easily discarded, even though 'summa' happens to be used in precisely this sense only eight lines earlier (1045). According to Lucretius (as well as most other philosophers), our world is *finite* and therefore the matter contained in it too. Yet, in lines 1070-1 Lucretius critises his opponents, because what is *infinite* cannot have a centre. In the present context, therefore, *summa* (whatever it is) must be something *infinite*, which the matter *in this world* is not. The second option is problematic too. According to Lucretius, the totality of matter is infinite, as he has stated just before (line 1051). In the present passage, however, Lucretius is examining a theory, which, if accepted, would cancel this provisional conclusion, because it would allow for the cosmos to remain intact without the need for an infinite amount of extra-cosmic matter. As a consequence Lucretius cannot here use

[467] Seneca is here following the argument of Arist. *Mete.* I 4, 342a13-27 and II 9, 369a20-30: see n.343 above

the infinity of matter without committing a serious *petitio principii*.[468] That leaves us only the third option: *summa* is the totality of matter *and void*. For this to be infinite it suffices that only one of its two constituents be infinite. Although the infinity of *matter* has not yet been fully established, the infinity of the *void* has been proved, and therefore the infinity of their sum too. Consequently, for Lucretius' argument to be valid, *summa* must be read as the *totality of matter and void*, i.e. *the universe*. According to Lucretius, then, the unnamed opponents said that all things move towards the centre of *the universe*.

This is not, however, what the Stoics said, as Furley rightly points out. Arius Didymus fr.23 (see p.172 above) and other sources clearly state that according to the Stoics all things move towards the centre of *the cosmos*,[469] which is finite and *can* have a centre. Furley concludes therefore that the Stoics cannot have been Lucretius' intended targets. This conclusion, however, seems to me to be too strong. As Schmidt observes,[470] Lucretius (or his source) may simply have misunderstood or misrepresented the Stoic position on this point – something not uncommon in ancient polemics. However, the Stoic position may not have been as clear-cut as Furley thinks. As Plutarch testifies in ch.44 of his *On Stoic self-contradictions*, Chrysippus had explained the indestructability of the cosmos as a whole by its occupying 'the centre'. If we may trust Plutarch, Chrysippus actually said: "to the virtual indestructability of the cosmos a good deal is contributed even by the position that it has occupied in space, that is to say through its being in the centre, since, if it should be imagined to be elsewhere, destruction would most certainly attach to it" (transl. Cherniss, slightly modified).[471] Whatever 'centre' Chrysippus had in mind here, it cannot be the centre of the *cosmos*, for how could the cosmos occupy its own centre? Not unreasonably therefore Plutarch identifies this 'centre' with the centre of *space*, and accuses Chrysippus of inconsistency, because, as Chrysippus says elsewhere, space, being infinite, cannot have a centre.[472] If Plutarch could bring this criticism against the Stoics, why not Lucretius?

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[468] Schmidt (1990), 217, does accept this solution with all the circularity it involves, making 'summa' Lucretius' latinization of Stoic 'τὸ ὅλον', the (finite) sum total of matter.

[469] See note 445 above, where I have underlined the explicit references to 'the centre of the cosmos'.

[470] Schmidt (1990) 217; cf. Brown (1984) *ad loc*.

[471] Chrysippus apud Plut. *De Stoic. repugn*. 44, 1054c7-10 (*SVF* II 551): Εἰς τὴν οἱονεὶ ἀφθαρσίαν πολύ τι αὐτῷ συνεργεῖ καὶ ἡ τῆς χώρας κατάληψις, οἷον διὰ τὸ ἐν μέσῳ εἶναι· ἐπεὶ εἰ ἀλλαχῇ νοηθείη ὤν, καὶ παντελῶς ἂν αὐτῷ συνάπτοι ἡ φθορά.

[472] On the interpretation of Plutarch *De Stoic. repugn*. 44, 1054b-1055a see Algra (1995) 282-307.

At any rate, even if it is found that on this point Lucretius' criticism does not really apply to the Stoics, it is far less appropriate against Furley's preferred candidate, Aristotle, who denied the infinity of the universe altogether.[473] For him the universe coincides with the cosmos, which is finite and therefore *can* have a centre. As a result, Aristotle is even more invulnerable to Lucretius' criticism than the Stoics. The same appears to hold for Plato. It is true that in his own works Plato neither explicitly denies nor acknowledges the existence of extra-cosmic void. Yet, tradition associates him with Aristotle in denying the existence of empty space both inside and outside the cosmos.[474] By contrast, the evidence with which Sedley supports his view that Plato may at one time have been interpreted as admitting extra-cosmic void is highly circumstantial and not very convincing.[475] Therefore, although Furley certainly has a point here, his conclusion that Lucretius' target cannot be Stoic does not obtain.

A third argument against identifying the unnamed opponents with the Stoics is brought forward by David Sedley. His argument concerns lines 1089-91, which he paraphrases as: 'the upward motion of fire from the earth feeds the heavenly bodies, which are themselves fiery'. Apparently then, Lucetius' unnamed opponents said that the heavenly bodies are nourished by *fire* rising from the earth. Sedley observes that this is very different from what the Stoics said, who held that the heavenly bodies were sustained by *moisture* evaporating from terrestrial waters.[476] Sedley's argument can be countered in two ways. In the first place, Lucretius does not actually say that the heavenly bodies are nourished by *fire*. His words are:

atque ideo totum circum tremere aethera signis		and that therefore the whole aether twinkles all around with stars
et solis flammam per caeli caerula pasci,	1090	and the flame of the sun grazes through the blue of the sky,
quod calor a medio fugiens se ibi conligat omnis,		because all heat fleeing from the centre gathers itself there,

What Lucretius says here is that the sun, being fiery, is grazing through the sky, because heat (i.e. fire) gathers itself there. When we are told that a certain animal always feeds in a certain place, this can mean two things: it feeds there because it is the natural place for its food to be, or because it is the natural place for the animal itself to be. So too in the case of the sun: the sun feeds in the sky either because that is the natural place for *its food*, or because it is the

[473] Arist. *Cael.* I 9, 279a7-17.
[474] See note 462 above.
[475] Sedley (1998a), 80-81.
[476] See note 450 above.

natural place for *the sun itself*. Sedley plunges for the first option, but in fact Lucretius' language rather suggests the second, for, while saying nothing about the nature of the sun's food, he explicitly mentions the fiery nature of the sun itself ('solis *flammam*'). So, I would say, the *sun* is up in the sky, because the *sun is fiery* and it is natural for *fire* to collect in the sky. That the sun spends its time there *grazing* is simply a picturesque detail, with no bearing on the argument, just like the *twinkling* of the stars in the preceding line is not an object of Lucretius' criticism. The image of grazing heavenly bodies is used by Lucretius on two other occasions (I 231 & V 525), and appears to derive from Epicurus himself.[477]

If this is not enough, it may be noted that the Stoic theory *does* actually lend itself to the interpretation that the heavenly bodies are nourished by *fire*. According to the Stoics, the process of exhalation is nothing but the transformation of moisture into air,[478] and subsequently into fire.[479] By the time the exhalation reaches the heavenly bodies it *is* fire, so that the stars can be said to be nourished by fire. Therefore, Sedley's conclusion that the unnamed opponents cannot have been the Stoics is not compelling.

Anyway, it requires a lot more work to connect the theory of the sun's nourishment with Sedley's and Furley's preferred candidates: the Platonists and Aristotle. *Pace* Sedley, there is nothing resembling this theory in Plato's *Timaeus*,[480] and we know next to nothing of Polemo's exposition of this work. That Aristotle should be Lucretius' intended target is even more unlikely, as we find him explicitly denying both that the heavenly bodies are fiery[481] and that they need nourishment.[482] As a result Furley is forced to the dubious

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[477] Cf. Epic. *Pyth*. 8 [93], writing about the motions of the heavenly bodies: ... κατά τινα *ἐπινέμησιν* τοῦ πυρὸς ἀεὶ ἐπὶ τοὺς ἐξῆς τόπους ἰόντος – "... due to a certain *grazing* of the fire which always moves towards the adjacent places." On the different translations proposed for the word ἐπινέμησις in this passage, see Mansfeld (1994), n.35.

[478] Plut. *De aud. poët.* 11, 31d (*SVF* I 535): τὸν ἐκ τῆς γῆς ἀναθυμιώμενον ἀέρα – "the *air* which is being exhaled from the earth."

[479] Plut. *De Stoic. repugn*. 41, 1053a (*SVF* II 579.1-3): ἔμψυχον ἡγεῖται τὸν ἥλιον, πύρινον ὄντα καὶ γεγενημένον ἐκ τῆς ἀναθυμιάσεως εἰς πῦρ μεταβαλούσης. – "He (Chrysippus) believes the sun to be ensouled, being fiery and having been created from *the exhalation which has transformed itself into fire*." Plut. *De comm. not.* cp. 46 p. 1084e (*SVF* II 806d): γεγονέναι δὲ καὶ τὸν ἥλιον ἔμψυχον λέγουσι, τοῦ ὑγροῦ μεταβάλλοντος εἰς πῦρ νοερόν. – "They say that the sun too is created an ensouled being, *the moisture transforming itself into intelligent fire*."

[480] Sedley (1998a), p.79 n.85, quotes *Ti.* 63b2-4, but this is only about fire collecting in the heavens, not about the sun *feeding on fire*.

[481] Arist. *Cael.* II 7, 289a11-35; *Mete.* I 3, 339b16 - 340a18.

[482] See n.458 above.

assumption that Aristotle in his younger years would have embraced theories which he later strongly rejected.[483]

In sum, allowing for a certain degree of misrepresentation on Lucretius' part, the unnamed opponents can only be plausibly identified with the Stoics. Only they, of all imaginable candidates, believe in the existence of an extra-cosmic void, only they envisage the possibility that the matter which constitutes our cosmos could be dispersed into the surrounding void, and only they counter this fear by positing a centripetal tendency of all matter.

Some details of the rival theory may also be found in Plato and Aristotle, but the crucial items, viz. the existence of extra-cosmic void and the universal centripetal motion of all matter, can only be found in Stoicism. Therefore there can be no doubt that Lucretius' criticism is directed primarily against the Stoics.

By way of an epilogue to this section I would like to return briefly to the subject of Lucretius' source or sources (see the beginning of this subsection on p.172). It is something of a dogma among historians of ancient philosophy that Epicurus did not engage with the newly founded school of the Stoics.[484] To those who, like Furley and Sedley, believe that Epicurus was Lucretius' sole philosophical source, any reference to, or criticism of, the Stoics in Lucretius' work is therefore bound to be embarrassing. For this reason both Furley and Sedley have done their best to track down and demolish any such alleged Stoic and other post-epicurean influences in *DRN*, and in most cases very convincingly.[485] In the present case however, the Stoics are the only possible targets for Lucretius' criticism. However, recognition of this fact need not be all that damaging to Furley's and Sedley's main thesis after all. The assumption that Epicurus ignored the Stoics is not founded on any positive evidence and may well be wrong. We know for a fact that Epicurus was aware of the existence of Stoicism, for he is cited twice by Diogenes Laërtius (VII 5, 11 & 9, 8) as a source of information on the Stoics' early history, and there is no reason why he couldn't have been equally aware of their doctrines. It is not

[483] Schmidt (1990) 219-20.

[484] So Furley (1978) 3; *id.* (1966) 184, or, more cautiously, Sedley (1998a) 73: "Epicurus' own targets in his philosophical critiques had been above all the Presocratics {...} and Plato. The contemporary Stoic school had apparently achieved prominence too late to feature as a further target."

[485] Furley (1966); Sedley (1998a) 62-93.

impossible therefore, that Lucretius' criticism of the Stoics in the present passage derives from Epicurus himself.

3.3.1.6 Lucretius' avoidance of centrifocal terminology

Before offering his formal arguments against the rival theory, Lucretius tries to set his reader's mind against it. This he does by carefully misrepresenting some of the theory's corollaries.

The rival theory is, as we have seen above, a *centrifocal* theory: all motions are described as being directed towards, or away from, the centre. As a rule, such theories employ a *centrifocal spatial reference system*, defining 'downwards' as 'towards the centre', and 'upwards' as 'away from the centre'. This applies to the Stoics as well as to Aristotle. We can see this for instance in Arius Didymus fr.23 quoted above (p.172), where 'being upward-moving' (εἶναι ἀνώφοιτα) is contrasted with 'moving towards the centre' (τείνεσθαι ἐπὶ τὸ μέσον),[486] as if they were logical opposites. As a consequence centrifocalists are able to say, just like parallelists, that everywhere heavy things tend downwards, and light things upwards.

In Lucretius' account of the rival theory we find nothing of the sort. Instead he consistently uses 'up' and 'down' and 'above' and 'below' and similar expressions in a *parallel* sense. As a consequence Lucretius is able to saddle his rivals with the parodoxical view (1058-60) that on the other side of the earth weights 'tend *upwards* and rest *inversely* placed against the earth, like images of things we now see in the water', and (1061-64) that 'animals wander *upside down*, and cannot fall back from the earth into the *lower* regions of the heavens', nothing of which the Stoics would have actually said, because in a centrifocal spatial reference system weights fall *down* on whatever side of the earth they happen to be.

3.3.1.7 The lacuna and the status of lines 1102-13

Before we go on to discuss Lucretius' formal argument against the rival theory, I want to briefly move forward, to the text following the eight-line lacuna, in order to decide whether or not it is part of the refutation of the rival theory. The text runs as follows:

[486] See also n.421 above.

* * * * * * * * * * * *
ne volucri ritu flammarum moenia mundi
diffugiant subito magnum per inane soluta,
et ne cetera consimili ratione sequantur,
neve ruant caeli tonitralia templa superne,
terraque se pedibus raptim subducat et omnis
inter permixtas rerum caelique ruinas
corpora solventes abeat per inane profundum,
temporis ut puncto nil extet reliquiarum
desertum praeter spatium et primordia caeca.
nam quacumque prius de parti corpora desse
constitues, haec rebus erit pars ianua leti,
hac se turba foras dabit omnis materiai.

* * * * * * * * * * * * <... there is a danger>
lest, after the flying fashion of flames, the walls of the cosmos
suddenly flee apart, being dissolved through the great void,
and lest the other parts in like manner follow,
and lest the thundering quarters of the sky crash in from above,
and the earth swiftly withdraw itself from under our feet, and as
a whole amidst the mingled ruin of things and heaven,
dissolving their bodies, depart through the profound void,
so that in a moment of time nothing rests of the remains
but deserted space and invisible atoms.
For from whichever part you first assume the atoms
to leave, this part will be the door of death to things,
through this the whole mass of matter will remove itself abroad.

A lot has been written about the function of these lines and their connection with the preceding passage. Since Bailey (1947) it is generally assumed that it is a warning against the disastrous consequences that would ensue if one were to apply the rival theory of centrifugal air and fire to the cosmos as we know it. Yet, in fact only the first two lines (1102-3) can be plausibly read in this manner: if fire is taken to be *centrifugal*, then the walls of the cosmos, being fiery,[487] might well be expected to flee apart and be dissolved into the great surrounding void. From line 1104 onwards, however, the disaster scenario becomes purely Epicurean (as even Bailey and his followers admit): there is no reason why, on the assumption of *centrifugal* air and fire, the other elements should follow (1104), there is no reason why the sky should fall down (1105),[488] or why the earth should be withdrawn from under our feet (1106). These events can only be understood as ingredients of an Epicurean disaster scenario.[489] But if this is so, if so many details of the description point to a purely Epicurean account, why not try to interpret the

[487] Cf. *DRN* I 73: 'flammantia moenia mundi'.

[488] Bailey translates line 1105 as: 'lest the thundering quarters of the sky *rush upwards*' (rejecting Munro's '*tumble in from above*'), apparently understanding 'upwards' in the Stoic sense, as a synonym for 'away from the centre' (see note 421 above). Yet, this will not do at all. Firstly, as Brown (1984) aptly points out, because the Latin will not allow it: *caelum ruere* was proverbial for the sky *falling down*, and *superne* in Lucretius' days always meant 'from above' or 'above', but never 'upwards'. Secondly, it would be against Lucretius' consistent practice, if, having managed throughout the passage to remain faithful to Epicurus' *parallel* conception of 'up' and 'down', he now suddenly were to conform to the *centrifocal* language of his rivals and use the word 'upwards' in the Stoic sense of 'away from the centre'. Besides, if 'superne' is to be understood in a *centrifocal* sense, so is 'se subducat' in the next line, but this is impossible, because in a centrifocal cosmology there is no lower place toward which the earth might withdraw.

[489] Cf. *DRN* VI 605-7: ne pedibus raptim tellus subtracta feratur / in barathrum, rerumque sequatur prodita summa / funditus, et fiat mundi confusa ruina. – '{fear} that the earth may be withdrawn from under our feet and fall into the great abyss, and that the sum of things, now compromised, may follow, and a confused ruin of the world come about.'

first two lines accordingly as well? In other words, would it be consistent with the Epicurean theory of atomic motion, if, on the assumption of an infinite extra-cosmic void, the walls of the world were to fly off in *every* direction? I believe it would. In *DRN* II 1133-5, for example, Lucretius describes how every compound thing, including the cosmos itself, having reached the limits of its growth, and the greater its extention, will scatter and emit *in all directions* (in cunctas undique partis) more atoms than is due.[490] Apparently then, even with infinite matter all around, a cosmos loses atoms *on all sides*, and it will do so even more when there is only empty space around: there is no reason at all why the first two lines of the present passage could not have been framed from a purely Epicurean point of view. Therefore I propose to reject Bailey's interpretation and to return to the one proposed by Munro, who thought that in the lacuna Lucretius would first have formally concluded his criticism of the anonymous opponents, and then reasserted his *own* position, viz. that for our finite cosmos to remain stable in infinite space, an infinite supply of extra-cosmic matter is needed. The twelve lines following the lacuna would then be a description, on purely Epicurean lines, of what might happen to the cosmos in the absence of this extra-cosmic matter. These lines, therefore, are not part of the anti-Stoic passage, which would have ended somewhere in the lacuna.

3.3.1.8 Lucretius' criticism of the rival position

It is now time to have a closer look at Lucretius' criticism of the rival theory and see what this may tell us about Lucretius' and Epicurus' own position. I will therefore review the three points of Lucretius' criticism, and see how valid and cogent they are, first, against Lucretius' most likely targets, i.e. the Stoics, and, second, against any form of centrifocal theory, and also whether Lucretius was justified in rejecting the theory.

As we saw above (§3.3.1.4 on p.170), Lucretius' criticism of the rival position consists of (at least) three points:

i. There is no centre in the infinite universe (1070-71)
ii. Nothing would stop at this 'centre', because a mere point in space cannot offer resistance (1071-82)
iii. The anonymous rivals also claim (1083-93ff) that:
    6. *not* everything tends towards the centre, but only earth and water, whereas air and fire move away from it (1083-88)
    7. this is the reason why "the whole aether twinkles all around with stars, and the flame of the sun grazes through the blue of the sky" (1089-90)
    8. and this is also why plants grow upwards (1091-93ff)

[490] *DRN* II 1133-5: quippe etenim quanto est res amplior, augmine adempto, / et quo latior est, *in cunctas undique partis* / plura modo dispargit et a se corpora mittit.

(i.) The first point of Lucretius' criticism is aimed at the unnamed opponents' claim that all things tend towards the centre of the *universe*. According to Lucretius, this is an impossible notion, because the *universe*, being *infinite*, cannot have a centre. As Furley points out, however, this criticism does *not* seem to apply to the Stoics, who are reported to have said that all things tend towards the centre of the *cosmos*, which is *finite*. Either Lucretius does not have the Stoics in mind after all (so Furley), or, if he does, he is misunderstanding or misrepresenting their position (so Schmidt and Brown).

If Lucretius had been aware of the actual Stoic position, could he have accepted it? Probably not. If every part of the cosmos moves towards the centre of the cosmos *qua whole*, as the Stoics say, this means that the motion of each part is determined by the whole, and hence by every other part of this whole, whether adjoining or not. Yet, in Epicurean physics objects can only influence each other by physical contact.[491] Therefore, if there is to be a focus of universal attraction in the cosmos, the location of this focus should be independent of the location of each of the attracted bodies, but the only thing in Epicurean physics that exists independent of all bodies, is *space*. Accordingly, if there is to be a focus, it can only be defined with respect to space, which brings us back to Lucretius' criticism that space, being infinite, can have no centre. One wonders, however, what would happen if Lucretius' adversaries would simply concede the point and say: "All right, let's not call it 'centre', then; it is simply a point in space."

(ii.) The second point of Lucretius' criticism concerns the incorporeal nature of space. This thing which the opponents call the 'centre' (whether of space or of the cosmos), being spatially defined, must be a spatial and therefore incorporeal point. However, as Lucretius has stated before, space can offer no resistance but must by its very nature yield to any movement.[492]

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[491] Furley (1981) 8, 12; *id.* (1999) 420.

[492] *DRN* I 437-9: 'sine intactile erit, nulla de parte quod ullam / rem prohibere queat per se transire meantem, / scilicet hoc id erit, vacuum quod inane vocamus'; and. See II 235-7: 'at contra nulli de nulla parte neque ullo / tempore inane potest vacuum subsistere rei, / quin, sua quod natura petit, concedere pergat'. This was sound Epicurean doctrine: see esp. Sextus Emp. *Adv. Math.* X 221-2: ἀχώριστα μὲν οὖν ἐστι τῶν οἷς συμβέβηκεν ὥσπερ ἡ ἀντιτυπία μὲν τοῦ σώματος, εἶξις δὲ τοῦ κενοῦ· οὔτε γὰρ σῶμα δυνατόν ἐστί ποτε νοῆσαι χωρὶς τῆς ἀντιτυπίας οὔτε τὸ κενὸν χωρὶς εἴξεως, ἀλλ' ἀίδιον ἑκατέρου συμβεβηκός, τοῦ μὲν τὸ ἀντιτυπεῖν, τοῦ δὲ τὸ εἴκειν. – 'unalienable from the things of which they are properties, are, for instance, resistance from body and yielding from void: for it is neither possible to imagine body without resistance, nor void

There is no reason, therefore, why anything should stop at this 'centre', rather than continue to move in whatever direction it was moving.[493]

Here Lucretius seems to make a mistake: if, as the unnamed opponents say, all things have a natural tendency to move towards the 'centre' (and no further), it is not the object stopping at the 'centre' that needs explaining, but rather its continued motion beyond the 'centre'. If the object stops this is simply the fulfillment of this natural tendency, not the result of some kind of resistance. The origin of Lucretius' mistake seems to lie in his incapability or unwillingness to set aside for the moment his own (not yet proved!) Epicurean conception that all things fall down to infinity, a tendency which can only be resisted by force. However, behind the mistake lies a valid observation: the rival theory seems to posit an *anomaly*: one point in space that behaves differently from any other point in infinite space. And apparently the Epicureans found such an anomaly hard to swallow. In fact, however, the anomaly is only apparent: if every atom is thought of as having an *in-built* centripetal tendency, then this tendency would be a property of matter, not of space.

(iii.) We do not know how Lucretius' third argument continued, since its final part has been lost in the eight-line lacuna following on line 1093. Bailey suggests that Lucretius may first have pointed out the inconsistency of centrifugal air and fire with the earlier claim that *all* things move towards the centre, and then argued that this theory could not be true anyway, because, if fire and air are centrifugal, there is nothing to stop them from continuing their centrifugal motion *ad infinitum* and being dispersed and lost in the infinite void.

Several sources comfirm that the Stoics did in fact make these two (seemingly) inconsistent claims, and so the Stoics seem to be the perfect targets for Lucretius' criticism. According to Furley, however, the Stoics *meant* to say that the *primary* movement of *all* bodies is towards the centre,

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without yielding, but they are the eternal property of each, resisting of the one, and yielding of the other.' Cf. also the scholium ad Epic. *Herod.* 43: ... τοῦ κενοῦ τὴν εἶξιν ὁμοίαν παρεχομένου καὶ τῇ κουφοτάτῃ καὶ τῇ βαρυτάτῃ – '... the void providing equal yielding to the lightest and the heaviest of atoms'.

[493] A very similar criticism against the Stoic position is brought forward by Plutarch, in his *On the face in the moon*. Having earlier (7, 924b5-6) reminded the reader that the Stoics considered such things as a 'centre' *incorporeal*, he later states that "there is no body that is 'down' towards which the heavy bodies are in motion and it is neither likely nor in accordance with the intention of these men {i.e. the Stoics} that the incorporeal should have so much influence as to attract all these objects and keep them together around itself" (11, 926b4-7, transl. Cherniss, slightly modified). See also Cherniss' useful remarks on p.65, note d.

and that air and fire are only *relatively* centrifugal, in so far as they are squeezed upwards by the heavier elements earth and water. If this interpretation were right (which I do not believe) the Stoic position would in fact answer both parts of Lucretius' criticism. In the first place the observed inconsistency would turn out to be only apparent, and in the second place the danger of air and fire escaping into infinite space would be removed, as their centrifugal tendency would automatically stop as soon as they had risen above the heavier elements, whereupon their natural centripetal tendency would prevail. Such a theory, then, would be invulnerable to this part of Lucretius' criticism, and if he had really wanted to exclude every kind of centrifocal theory, he should have considered it. It is not as if he could not have imagined such a theory: in II 184ff he himself argues for a single downward tendency of all matter ('downward' in this case, of course, in a *parallel* sense). Moreover, we know of at least one person who combined a single downward tendency of all matter with a *centrifocal* conception of 'up' and 'down': Strato, Aristotle's second successor as head of the Lyceum.[494]

If Lucretius had been aware of the possibility of such a theory, how would he have responded? There is a passage in his work that might suggest that he would still have rejected it. In *DRN* I 984-997, Lucretius offers (*inter alia*) the following argument for the infinity of space (my paraphrase)[495]: 'If space were finite, all matter would since long by force of its weight have been heaped up at the bottom, and nothing would ever be done below the vault of heaven, nor would there even be a heaven or a sun. Yet, in fact the atoms are forever in constant motion. Therefore, space cannot be finite.' Lucretius seems to think that the existence of an absolute *bottom* in the universe would cause all matter to be packed together into an inert mass. In the theory we are presently investigating the 'centre' provides just such a 'bottom' towards which all matter converges, so that the likely result in this case would also be an inert mass, quite unlike the world we actually see around us. So, even a general centripetal tendency of all matter, as maintained by Strato, would probably have been unacceptable to an Epicurean.

I will not leave it at this, however. Even though the parallel suggests that Lucretius would probably have rejected a general centripetal tendency of all matter, I do not think he would have been entirely justified in doing so.

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[494] Aët. I 12.7 (Strato fr.51 Wehrli); Simplic. *In De cael.* 267.30-34 Heiberg (fr.52) [quoted on p.192 below]; *ibid*. 269.4-6 (fr.50) [quoted on p.191 n.498 below]. It must be noted, however, that Strato followed Aristotle in denying the existence of extra-cosmic void: Aët. I 18.4 (fr.55 Wehrli); Theodoret. *Graec. affect. cur.* IV 15.2-3 (fr.54).

[495] On this argument see p.165 above.

According to Epicurus, all atoms are forever moving; when their motion is checked in one direction they rebound, and continue moving in another direction.[496] This, I think, would be enough to prevent matter from being packed together into an inert mass, even when its natural motion would be impeded by an absolute 'bottom' or 'centre'.

It is now time to sum up my conclusions. In lines 1070-1093ff Lucretius rejects the centrifocal theory of the Stoics. His reason for doing so at this point is that their theory is the only remaining obstacle to his own Epicurean view that the infinite universe contains an infinite amount of matter. Other existing centrifocal theories, like Plato's, Aristotle's and Strato's, would not qualify at this point as they all assume the universe to be finite, a view which Lucretius has rejected earlier (before line 1014). The Stoic theory, then, was the only *existing* centrifocal theory that still needed to be refuted. But what about non-existing but possible and imaginable theories? In order to establish his own theory once and for all, Lucretius should have dealt with those too. Above I have tried to show that he would probably have rejected such theories as well, but I have also tried to show that he would perhaps not have been entirely justified in doing so.

3.3.1.9 Conclusion

Although Lucretius presents his rejection of centrifocal cosmology as the inevitable outcome of a logical argument, on closer scrutiny his arguments do not seem to be as strong as they appear. It is quite possible that Lucretius had other motives for rejecting centrifocal cosmology. The rejection of centrifocal cosmology allows Lucretius to finally conclude (as he will probably have done explicitly in the lacuna after line 1093) that *infinite space* contains an *infinite amount of matter*. In the following books of the *DRN* the infinity of matter is simply taken for granted. It plays an especially important role in II 1023-1147, where the infinity of matter leads Lucretius to assume the existence of an infinite number of worlds, and this in turn provides the basis for the *principle of plenitude* upon which the simultaneous truth of all alternative explanation in astronomy and meteorology rests (V 526-33: see §1.3.2 on p.12ff above). If on the other hand Lucretius had accepted some kind of centrifocal system this would not just leave the infinity of matter unproved, since it would remove the need for 'external blows' to keep the world together, but it would actually rule out the very existence of extra-cosmic matter (let alone an *infinite* amount of it), because this external matter, being subject to the same centripetal tendency as internal matter, would either have to be considered part of the cosmos already, and therefore not be

[496] Epic. *Hdt.* 43; Lucr. *DRN* II 62-111.

'external' to it, or else to be forever added to it, producing a forever increasing cosmos, which seems to be contradicted by the senses. Accepting a centrifocal cosmology would therefore exclude the infinity of matter, the infinite number of worlds, and the simultaneous truth of all alternative explanations.

Justifiably or not, Lucretius rejects centrifocal cosmology. Whether or not this rejection automatically entails the acceptance of a parallel-linear cosmology will be investigated in the next section.

3.3.2 Downward motion (*DRN* II 62-250)

3.3.2.1 Introduction

In the previous section we saw Lucretius rejecting a theory in which everything moves naturally towards the centre of the universe. We also saw – although Lucretius tries to obscure this by imposing his own parallel linear terminology – that the most likely proponents of this theory, the Stoics, identified this universal centripetal tendency with the downward motion that seems to be characteristic of heavy bodies. Theoretically, Lucretius' rejection of this theory can mean one of two things: either the downward motion of heavy bodies is *not natural*, or, if it is, it is *not centripetal*.

A version of the first option is often ascribed to Democritus, who is supposed to have claimed that heavy objects only acquire their downward tendency when caught in a cosmic whirl or vortex. If this ascription is correct, it is remarkable that Epicurus and Lucretius, who in many respects may be considered Democritus' philosophical heirs, entirely ignore this option. Like most ancient philosophers they did not hesitate to make the downward tendency of heavy bodies a natural and unalienable property of the primary constituents of matter.

However, in contrast to most other philosophers of their time, Epicurus and Lucretius reject the notion of *centripetal* downward motion. Instead, as we shall see, they assume that all heavy bodies move downward along *parallel* trajectories.

Another point of contention concerns the status of upward motion. While it was generally agreed that downward motion was a fundamental property of the first elements, it was not so obvious whether upward motion was so too. Whereas Plato and Aristotle, and to a certain extent the Stoics as well,[497] attributed both tendencies to the elements – downward to the heavy elements earth and water, and upward to the light elements air and fire –, the Epicureans maintained that in reality only heavyness and natural downward motion

[497] *Pace* Sambursky (1959), 111, and Furley (1966), 191-3: see p.176f. above.

existed, while the upward tendency of lighter bodies was explained as expulsion and displacement by heavier ones.

Below I want to examine the Epicurean stance on each of these three questions, viz. whether downward motion is natural or forced, whether it is centripetal or parallel, and how it relates to upward motion. To facilitate the flow of my argument I will discuss them in reverse order.

3.3.2.2 Upward versus downward motion

In *DRN* II 184-215 Lucretius argues that nothing moves upwards of its own accord, but only downwards, and that those things which are observed to move upwards do so only because of the outward pressure exerted by the surrounding medium. Just as a plank of wood, when forcibly held under water and then released, is ejected violently by the surrounding water, so a flame must be thought to be forced upwards (204 *expressa*) by the surrounding air.

Epicurus' words on this subject have not been preserved, but his views are reported by Simplicius in three passages which Hermann Usener included as fragment 276 of his *Epicurea*. The relevant parts of the first two passages are quoted below; the third one provides no additional information.[498]

(1) Simplic. *In Arist. De caelo* III 1, 299a25 = 569.5-9 Heiberg[499]:

Οἱ γὰρ περὶ Δημόκριτον καὶ ὕστερον Ἐπίκουρος τὰς ἀτόμους πάσας ὁμοφυεῖς οὔσας βάρος ἔχειν φασί, τῷ δὲ εἶναί τινα βαρύτερα ἐξωθούμενα τὰ κουφότερα ὑπ' αὐτῶν ὑφιζανόντων ἐπὶ τὸ ἄνω φέρεται, καὶ οὕτω λέγουσιν οὗτοι δοκεῖν τὰ μὲν κοῦφα εἶναι τὰ δὲ βαρέα.

The followers of Democritus and later Epicurus say that the atoms, being all of the same nature, have weight, but that due to the fact that some things are heavier, the lighter ones are expelled by the heavier ones, when these settle down, and so move upwards, and in this way, they say, some bodies seem light and others heavy.

[498] The third reference is in Simplic. *In Arist. De caelo* I 8, 277a33, 269.4-6 Heiberg (*Epicurea* 276 (3) / Strato 50 Wehrli): ἰστέον δέ, ὅτι οὐ Στράτων μόνος οὐδὲ Ἐπίκουρος πάντα ἔλεγον εἶναι τὰ σώματα βαρέα καὶ φύσει μὲν ἐπὶ τὸ κάτω φερόμενα, παρὰ φύσιν δὲ ἐπὶ τὸ ἄνω ...

[499] Also included among the fragments of Democritus as A61a D-K.

(2) Simplic. *In Arist. De caelo* I 8, 277b1 = 267.30-268.4 Heiberg[500]:

Ταύτης δὲ γεγόνασι τῆς δόξης μετ' αὐτὸν Στράτων τε καὶ Ἐπίκουρος πᾶν σῶμα βαρύτητα ἔχειν νομίζοντες καὶ πρὸς τὸ μέσον φέρεσθαι, τῷ δὲ τὰ βαρύτερα ὑφιζάνειν τὰ ἧττον βαρέα ὑπ' ἐκείνων ἐκθλίβεσθαι βίᾳ πρὸς τὸ ἄνω, ὥστε, εἴ τις ὑφεῖλε τὴν γῆν, ἐλθεῖν ἂν τὸ ὕδωρ εἰς τὸ κέντρον, καὶ εἴ τις τὸ ὕδωρ, τὸν ἀέρα, καὶ εἰ τὸν ἀέρα, τὸ πῦρ.	This opinion was later adopted by Strato and Epicurus, who assumed that every body has weight and moves towards the centre, but that, due to the fact that the heavier ones settle down, the less heavy are extruded upwards by force, so that, if one were to remove the earth from below, the water would reach to the centre, and if one removed the water, the air would, and if one removed the air, the fire.

These two reports confirm and supplement Lucretius' account in several respects:

(a) We now learn that the same theory had been held by Democritus before (see below),[501] and by Strato afterwards. Yet, the passage in which the theory is claimed for Strato is also somewhat misleading. It says that according to Strato and Epicurus every body has weight and moves *towards the centre*. This was certainly not Epicurus' view, as we have seen above and shall further explore below. The centrifocal language of Simplicius' report is probably due to a conflation of Epicurus' views with those of Strato, who *did* equate 'downwards' with 'towards the centre'.

(b) We also learn that weight and lightness of *(compound) bodies* are somehow linked to the weight of the composing *atoms*. The details of this relation are provided by Lucretius in *DRN* I 358-69, where the relative weight and lightness of bodies are attributed to the admixture of smaller and greater quantities of void.

(c) Just as in Lucretius' account, the upward motion of lighter bodies is said to be caused by their being *expelled* (ἐξωθούμενα) or *extruded* (ἐκθλίβεσθαι; cf. Lucr. 204 *expressa*) upwards by the surrounding heavier bodies.

(d) However, not only the *upward* motion of *lighter* bodies is affected by the surrounding medium, but also the *downward* motion of *heavier* bodies. As we saw above, Lucretius likens the *upward* motion of fire through the surrounding air to the upward thrust of a plank of wood submerged in water. In the two accounts of Simplicius the *downward* motion of *heavier* bodies is

[500] Also included among the fragments of Strato as fr.52 Wehrli

[501] Cf. Simplic. *In Arist. De caelo* IV 4 311b13, 712.27-29 Heiberg (Democrit. A61b D-K): οἱ περὶ Δημόκριτον οἴονται πάντα μὲν ἔχειν βάρος, τῷ δὲ ἔλαττον ἔχειν βάρος τὸ πῦρ ἐκθλιβόμενον ὑπὸ τῶν προλαμβανόντων ἄνω φέρεσθαι καὶ διὰ τοῦτο κοῦφον δοκεῖν.

also compared to motion through water: the verb ὑφιζάνειν (*sinking* or *settling down*) is typically used to denote the retarded downward motion of heavier bodies through a somewhat lighter, liquid, medium, e.g. of earth and mud through water, and dregs through wine or olive-oil.[502]

Why did Epicurus posit only one natural elementary motion, viz. *downwards*, instead of two, viz. *upwards* and *downwards*? Although the sources are not explicit about it, the reason is not hard to find. If both heavyness and lightness are supposed to be fundamental properties of certain elements, then the transformation of something heavy (a log, for instance) into something light (fire and smoke, for instance) would require for the composing elements to be transformed themselves. Yet, as Lucretius says again and again, elements, if they are to be real elements, cannot change.[503] Therefore, all the elements must have the same fundamental properties, and be all 'of the same nature' (ὁμοφυεῖς).

But why should this primary property be heavyness, and not lightness? On this point neither Epicurus nor Lucretius express themselves clearly, but the following argument might have been acceptable to them. In our experience heavier objects are generally more densely packed, and better able to offer resistance than lighter bodies.[504] Therefore, if weight and downward motion are considered fundamental, it is not hard to imagine how the heavier bodies (e.g. earth, stone, water) would be able to press the lighter ones (e.g. air, fire, smoke) upwards. If, on the other hand, lightness and upward motion are taken as fundamental, it is very difficult to conceive how the lighter bodies (air, fire, smoke), being rarified and volatile, would be able to press downwards the heavier ones (earth, stone, water). For this reason weight and downward motion seem the better candidates for primacy.

3.3.2.3 Downward motion and the atomic swerve

Above we have seen that Lucretius rejected the anonymous rivals' assumption of a centripetal tendency of all matter. We have also seen that in describing their *centrifocal* theory he consistently uses *parallel-linear*

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[502] See e.g. Nemesius *De nat. hom*. 5.151-153 (Einarson) (ἐὰν γὰρ εἰς ὕδωρ γῆν ὀλίγην βαλὼν ταράξῃς διαλύεται εἰς ὕδωρ ἡ γῆ· ἐὰν δὲ παύσῃ ταράττων στάσιν λαβόντος τοῦ ὕδατος ὑφιζάνει); Philoponus *In Arist. Mete.* 33.38 (Hayduck) (βαρυτέρα τοῦ ὕδατος οὖσα ἡ γῆ ὑποχωρεῖ τούτῳ καὶ ὑφιζάνει); Joh. Chrysostom. *Homiliae* 59.147.27-28 (MPG) (τῆς ἰλύος ὑφιζανούσης). Galen. *De methodo medendi* 10.973.13-14 (Kühn) (τῇ τοῖς οἴνοις ὑφιζανούσῃ τρυγί); id. *De simplicium medicamentorum temp.* 11.414.13-14 (Kühn) (ὁ δὴ καὶ ὑφιζάνει τῷ χρόνῳ, τρὺξ μὲν ἐπὶ τῶν οἴνων, ἀμόργη δ' ἐπ' ἐλαίου καλούμενον).

[503] See esp. *DRN* I 665-74 and 782-97.

[504] Cf. Arist. *Phys.* IV 9, 217b11-12: ἔστι δὲ τὸ μὲν πυκνὸν βαρύ, τὸ δὲ μανὸν κοῦφον. Cf. also Lucr. II 100-7.

terminology. Is this enough to conclude that Lucretius' own theory was parallel-linear? Perhaps. Nevertheless, it may be interesting to try and find some more positive proof for attributing a parallel-linear theory to the Epicureans.

In *DRN* II 83-85 two kinds of motion are ascribed to the atoms: they move either because of their own *weight* ('gravitate sua') or because of collisions with other atoms.[505] In II 190 and 205 we are told that *weights*, insofar as they are weights, all tend to move *downwards* ('deorsum').[506] Yet, this still does not tell us whether this downward motion is *parallel* or *centripetal*.

The clearest statement is found in the next section of Lucretius' account In II 216-250 Lucretius presents a third kind of atomic motion, the *swerve* or *declination* ('clinamen').[507] This swerve is introduced with the express purpose of allowing the atoms to meet and collide (221-224) [508]:

Quod nisi *declinare* solerent, omnia deorsum umbris uti guttae caderent per inane profundum, nec foret offensus natus nec plaga creata principiis: ita nil umquam natura creasset.	For if they were not used to *swerve*, all things would, like drops of rain, fall down through the profound void, and no collision would be born, nor blow created among the atoms: nature thus would never have created aught.

Without the swerve, i.e. if their motion were determined by weight alone, the atoms would never meet. This means that their downward trajectories do *not intersect* at any point; in other words: they are *parallel*. The same theory is also explicitly ascribed to Epicurus himself in a number of passages collected as fr.281 in Hermann Usener's *Epicurea*. The conclusion that downward motion must be parallel can also be inferred from a famous passage, §60, of Epicurus' *letter to Herodotus*:

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[505] Lucr. II 83-85: cuncta necessest / aut *gravitate sua* ferri primordia rerum / aut ictu forte alterius. Cf. Epic. *Hdt*. 61: οὔθ' ἡ ἄνω οὔθ' εἰς τὸ πλάγιον διὰ τῶν κρούσεων φορά, οὔθ' ἡ κάτω διὰ τῶν ἰδίων βαρῶν.

[506] Lucr. II 190: pondera quantum in se est cum deorsum cuncta ferantur; Lucr. II 205: pondera quantum in se est deorsum deducere pugnent.

[507] Cf. Cic. *De fato* 22 (Epic. fr.281b Us.): 'Itaque tertius quidam motus oritur extra *pondus* et *plagam*, cum *declinat* atomus intervallo minimo', Aët. I 12.5 (Epic. fr.280a Us.): κινεῖσθαι δὲ τὰ ἄτομα τότε μὲν κατὰ *στάθμην* τότε δὲ κατὰ *παρέγκλισιν*, τὰ δὲ ἄνω κινούμενα κατὰ *πληγὴν καὶ ἀποπαλμόν*.

[508] See also Cic. *De fin*. I 19 (Epic. fr.281a Us.): "... si omnia deorsus e regione ferrentur et, ut dixi, ad lineam, numquam fore ut atomus altera alteram posset attingere itaque attulit rem commenticiam: *declinare* dixit atomum perpaulum, quo nihil posset fieri minus."

Καὶ μὴν καὶ τοῦ ἀπείρου ὡς μὲν ἀνωτάτω καὶ κατωτάτω οὐ δεῖ κατηγορεῖν τὸ ἄνω ἢ κάτω. {...} Ὥστε ἔστι μίαν λαβεῖν φορὰν τὴν ἄνω νοουμένην εἰς ἄπειρον καὶ μίαν τὴν κάτω, {...}	Furthermore, of the infinite it is necessary that one not use the expressions "up" or "down" in the sense of "highest" and "lowest." {…} Therefore one may assume *one* upward course imagined to infinity and *one* downward, {…}[509]

There is no highest point from which the atoms all depart or a lowest point toward which they converge, nor do the directions we call 'upward' and 'downward' depend on the location of the observer, but all atoms move along parallel lines from infinity to infinity.

Neither Epicurus nor Lucretius offers any formal argument for this claim. To them parallel motion was the only conceivable alternative to the centripetal motion posited by their adversaries, and rejecting the latter therefore automatically implied the former. In addition they may have thought that they had the evidence of observation on their side: Lucretius compares the downward motion of the atoms to the fall of raindrops, which certainly looks parallel.

3.3.2.4 Downward motion: natural or forced?

For all their differences Lucretius and his centrifocalist opponents agreed on one thing: they all assumed that downward motion was something natural to the first elements. By contrast, Democritus is commonly claimed to have held that matter has *no* primary form of motion at all, but only acquires its (undeniable) upward and downward tendencies when caught in a *cosmic whirl*. This claim was first made by Adolf Brieger in 1884 and, independently, by Hugo Liepmann in 1885, and has been embraced by most subsequent scholars.[510]

The reason for ascribing such a view to Democritus is as follows. Aristotle repeatedly accuses Democritus of failing to assign a natural motion to the atoms. (Brieger mentions *Metaph.* XII 6, 1071b32; *Phys*. VIII 1, 252a34; *GA* II 6, 742b17 and *De caelo* III 2, 300b8.) This is often taken to mean that Democritus' atoms do *not have a natural downward tendency*. In addition it is stated by Aëtius (I, 3, 18 and I, 12, 6) that Democritus denied the atoms the property of *weight*. This claim is contradicted, however, by Aristotle (*GC* I, 8, 326a8) and Theophrastus (*De sens*. 61), who state that Democritus' atoms are *heavier* in proportion to their *size*.

This contradiction is resolved by most scholars in the following manner. Alone in the extra-cosmic void the atoms have no natural tendency to move in a particular direction. The *cosmic whirl*, however, has the effect of driving

[509] Text and translation (my emphasis): Konstan (1972), who also provides a thorough analysis of this passage.

[510] Furley (1976), 80 n.16, and (1983), 94, cites Dyroff (1899); Burnet (1892) 343-5; Kirk & Raven (1957) 415f; Guthrie (1965) 400-4; Alfieri (1953) 88ff; and O'Brien (1984).

larger and bulkier bodies towards the centre, and *this* is the downward tendency we generally associate with *weight*.

David Furley[511] strongly objects to this solution of the problem, because it does not take into account the dynamics of whirls, nor the views on weight that *can* be plausibly and positively attributed to the early atomists. Furley offers the following arguments:

1. In our every-day experience, the downward tendency of heavy objects is a necessary condition for the sorting effect of a whirl. Heavy objects sink down and because of the friction with the bottom they collect where the motion of the whirl is least: in the centre *of the bottom*. On the other hand, objects that are light enough to remain suspended or even to float to the surface are driven away from the centre. The upward and downward tendencies of heavy and light bodies must therefore precede, and exist independently from, the whirl.[512] I must admit that I do not entirely agree with this particular argument. I do not think that the early cosmologists were aware of the precise mechanics of a whirl. They do not seem to have realised, for instance, that *bottom friction* was a necessary factor, for, during the formation of the cosmos, when, according to their theories, the cosmic whirl was most active, nothing yet was formed that might serve as a 'bottom' to the whirl.

2. The cosmic whirl is in fact also used by certain early cosmologists to explain why some heavy bodies do **not** fall down.[513] Therefore, the general downward tendency of heavy bodies cannot be attributed to the whirl.[514]

3. According to the doxographical reports, the cosmic whirl causes heavy objects to move towards the centre. This sounds exactly like the behaviour attributed to heavy objects in *centrifocal* cosmologies like Aristotle's and the Stoics', where 'towards the centre' equals 'downward'. In reality, however, as Furley observes, whirls only draw heavy objects *horizontally* towards the central *axis* of their rotation. Yet, even if we admit – against Furley – that the cosmic whirl is somehow capable of drawing heavy objects *from all directions* towards its central *point*, as Aristotle's testimony suggests it does,[515] this is still far removed from the typical behaviour Democritus assigns to heavy objects. In Aristotle's *De caelo* II 13, 294b 13-30 Democritus is explicitly

[511] Furley (1976) and (1983).
[512] Furley (1983) 95-6.
[513] Anaxagoras frs. A12, A42, A71 D-K. That Democritus used the cosmic whirl in much the same way is suggested by the fact that he too, like Anaxagoras, believed the celestial bodies to be heavy and stone-like: cf. Democritus frs. A85, A87, A90, A39 D-K.
[514] Furley (1983) 96-7.
[515] Arist. *Cael.* II 14, 297a12-19.

numbered among those who believe that the earth is kept from falling down by the resistance of the air underneath. This means that for Democritus the centre, where the earth is, is not the focal point of gravity, and the downward motion of heavy objects is not *centrifocal* but *parallel*.[516]

To these three arguments I would like to add the following:

4. The early cosmologists attributed to the cosmic whirl the property of driving dense matter to the centre and tenuous substances to the periphery.[517] This means that neither tendency, the inward and the outward, is secondary to the other, but both are subordinate to the rotating movement of the whirl. Simplicius, however, ascribes to Democritus the view that *all* atoms are heavy and tend to move downwards, but that some lighter bodies are observed to move upwards, because they are *extruded* by the heavier bodies around them.[518] In other words: upward motion is secondary to downward motion. Therefore, if both reports are right, the downward and upward tendencies of heavy and light bodies cannot be identified with the inward and outward motions caused by the cosmic whirl.

Furley concludes (rightly, in my opinion) that the cosmic whirl cannot serve to account for the downward motion of heavy bodies, and was in fact never used so by Democritus (or anyone else, for that matter). Democritus, just as later Epicurus and Lucretius, considered *parallel* downward motion a *natural* and *fundamental* property of all the atoms.[519] Perhaps Aristotle, when he accused Democritus of *failing* to assign a natural motion to the atoms, was simply thinking of his own theory of natural motion as motion towards a natural place.[520] What is important to us is the realisation that probably no one in antiquity denied the fundamental character of downward motion, whether *parallel* or *centrifocal*, and that Lucretius was therefore justified in believing that by refuting *centrifocal* downward motion he had by the same token proved the only imaginable alternative, i.e. *parallel* downward motion.

3.3.2.5 Summary

At the beginning of this subsection I set out to answer three questions, viz. (1) whether the Epicureans considered downward motion natural or forced, (2) whether they conceived of downward motion as centripetal or parallel, and (3)

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[516] Furley (1983) 98-100; *id.* (1981) 11-2, and *id*. (1976) 80-1.

[517] Anaxagoras fr.B15, A42; Leucippus A1 (Diog. Laërt. IX 31-32).

[518] Simplic. *In Arist. De caelo* 569.5-9 Heiberg (Democr. fr.A61a D-K; text 1 on p.191 above) and *ibid*. 712.27-29 (Democr. fr.A61b; text in note 501 on p.192 above).

[519] This is, as Furley (1976), 81 n.20, (1983), 100, himself acknowledges, a return to the interpretation of Zeller (1879).

[520] See Furley (1976) and (1983).

how they explained upward motion in relation to downward motion. To these questions we have found the following answers:

Ad 1: Like almost every other philosophical school the Epicureans considered downward motion a natural concomitant of weight. If Democritus claimed otherwise (which is doubtful), the Epicureans appear to have been ignorant of the fact, and did not feel any need to justify their position.

Ad 2: As a consequence they could safely assume that by rejecting the centripetal model of their adversaries they had by the same token proved the only available alternative, viz. parallel downward motion.

Ad 3: In contrast to most other philosophers of their time the Epicureans rejected the concept of absolute lightness and natural upward motion, which they considered incompatible with the necessarily uniform nature of the primary elements.

For our investigation the second point is, of course, the most important, since parallel downward motion is generally assumed to imply a flat earth. The third point will be useful in our discussion of Lucretius' cosmogonical account on pp.202ff below.

3.3.3 The apparent proximity of the sun (*DRN* IV 404-13)

We have now established that Epicurus and Lucretius assumed a parallel downward motion. In §3.2.4 on pp.160ff above we have also seen that in such cosmologies the earth is most often and most conveniently considered *flat*. In the absence of more specific statements about the shape of the earth it would be interesting to have a passage that at least suggests a more specific shape. One such passage may be the following. In *DRN* IV 404-13 Lucretius describes the well-known illusion of the sun appearing to *touch* the mountains above which it is seen to rise, although in fact (IV 410-13) …

inter eos solemque iacent immania ponti	between the mountains and the sun lie vast plains
aequora substrata aetheriis ingentibus oris,	of sea spread below the great aetherial regions,
interiectaque sunt terrarum milia multa,	and thrown in between are many thousands of lands
quae variae retinent gentes et saecla ferarum.	which various peoples and breeds of wild beasts inhabit.

Although the purpose of these lines is to demonstrate the enormous distance that separates us from the sun,[521] Lucretius' way of expressing this distance also suggests that, on a cosmic scale, the sun is really *not so far away*,

[521] Cf. Cleomedes II 1.136-9: 'Again, often when setting or rising on a mountain peak, the Sun sends out to us the appearance of its touching the peak, although its distance from every part of the earth is as vast as is to be expected when the earth has the ratio of a point in relation to its height.' (transl. Bowen-Todd).

but lies closely to the edge of a *flat* earth. Only in this way would it be possible to measure the entire distance by lands and seas.

3.3.4 Climatic *zones*? (*DRN* V 204-5)

Another passage where the shape of the earth might seem to play a role is *DRN* V 204-5. Here, in the course of an argument against divine providence Lucretius writes:

Inde duas porro prope partis fervidus ardor adsiduusque geli casus mortalibus aufert.	Further, almost two thirds {of the earth} the boiling heat and continuous fall of frost take away from mortal men.

Most commentators see these lines as a reference to the theory of the five zones.[522] According to this theory the earth is divided into *five* climatic *zones* or *belts*, three of which are uninhabitable to man: the arctic and antarctic zones due to extreme cold, and the equatorial zone due to extreme heat, leaving only the two intervening temperate zones for human habitation. An interesting parallel to these lines is found in the speech of the Epicurean spokesman Velleius in Cicero's *De natura deorum* I, 24:

... terrae maxumas regiones inhabitabilis atque incultas videmus, quod pars earum adpulsu solis exarserit, pars obriguerit nive pruinaque longinquo solis abscessu.	... we observe that enormous regions of the earth are uninhabitable and uncultivated, because part of them is burned by the approach of the sun, and part is stiffened by snow and hoar-frost and the distant retreat of the sun.

Here too the commentaries refer us to the theory of the five zones.[523] An interesting detail, which most commentators fail to mention, is that this theory presupposes a *spherical earth*.[524] A third parallel, at least if we follow Diels'

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[522] Merrill (1907): "The ancients thought the torrid **zone** uninhabitable" with a ref. to Ov. *M*. I 49-50 '[**zonae**] quarum quae media est, non est habitabilis aestu; nix tegit alta duas'. Bailey (1947): "*duas partis*: {...} the 'two-thirds' are the tropic and arctic **zones**." Costa (1984): "*duas partis*: 'two-thirds': the equatorial and arctic **zones**. This refers to a belief that there were torrid, temperate and arctic belts or **zones** in the heavens which caused corresponding ones on the earth, only the temperate one [sic!] being habitable by man". Schmidt (1990) 197: "Kalte **Zone** [sic!] um die Pole, verbrannte **Zone** am Äquator, gemäßigte **Zonen** dazwischen." [my emphasis]. Similarly Abel (1974) 1036.50 -1037.59.

[523] See e.g. Goethe (1887) 37, and Pease (1955) vol.1, 202-3. Similarly Abel (1974) 1037.58-9.

[524] Schmidt (1990) 215, referring to the same passage, does mention the earth's sphericity: "Kennzeichnend für die Argumentation des Lukrez ist in diesem Zusammenhang, daß er ebenfalls an einer anderen Stelle, nämlich in V 204 f., die **Zonenlehre**, deren Kenntnis die **Kugelgeographie** voraussetzt, für einen Beweis heranzieht" [my emphasis]. Similarly Abel (1974) 1037.18-35.

extensive and, by his own admission, very tentative additions to the preserved text, is provided by Philodemus *Περὶ θεῶν* III, fr.70.4-5,[525] which would seem to be a reference to the unorthodox view that parts of the torrid region may be inhabitable after all:

... τὰ περὶ τὰ μ[εσημβρίν' ἐ]νο[ι]κ[ή]σιμα τῶν κατακ[α]ιομ[ένων τόπων] ...	… the theory concerning the southern inhabitable regions in the scorched places …

This passage too is sometimes cited as a reference to the theory of the five zones.[526] So, do these passages prove that the Epicureans did after all know and accept the earth's sphericity? Hardly. In none of the three passages the technical term 'zone' or any of its known translations is used, nor is the number *five* mentioned or implied. On the contrary: Lucretius and Velleius seem to be thinking of *three* rather than *five* 'parts'. If Lucretius had wished to refer specifically to the theory of the *five* zones, *three* of which are uninhabitable to man, he would not have spoken of *two-thirds* but of *three-fifths*, as the elder Pliny does, more than a century later (*NH* II 172): "... terrae tris partis abstulit caelum ...", "... three parts of the earth (out of five) the sky has taken away ..."

There is no reason, therefore, to suppose that Lucretius or Velleius was specifically thinking of the five-zone-*theory*. Instead, the two references apply just as well, if not better, to the ancient, and basically correct, *observation* that regions to the extreme north and south of our part of the earth were uninhabitable to man because of the freezing cold and the scorching heat respectively. Herodotus, for instance, writes that the country south of the Aethiopian 'deserters' is desolate (ἔρημος) because of the heat (*Hist*. II 31,1), and that because of the continuous winter the regions to the north of our continent are uninhabited (ἀνοίκητα) (*Hist*. IV 31,2). These observations were also accepted by flat-earth philosophers, and accommodated to their world view (see Figure 3-4 below).[527] See for instance the theory Aëtius II 8.1 attributes to Anaxagoras (fr.A67 D-K) and Diogenes of Apollonia (fr.A11 D-K):

[525] Diels (1916-7) 65 & 75.
[526] Schmidt (1990) 197.
[527] On the ancient three-part theory as opposed to the later five-zone theory see Abel (1974) 1012.55 – 1013.24.

Διογένης καὶ ᾽Αναξαγόρας ἔφησαν μετὰ τὸ συστῆναι τὸν κόσμον καὶ τὰ ζῷα ἐκ τῆς γῆς ἐξαγαγεῖν ἐγκλιθῆναί πως τὸν κόσμον ἐκ τοῦ αὐτομάτου εἰς τὸ μεσημβρινὸν αὐτοῦ μέρος, ἴσως ὑπὸ προνοίας, ἵνα ἃ μὲν ἀοίκητα γένηται ἃ δὲ οἰκητὰ μέρη τοῦ κόσμου κατὰ ψύξιν καὶ ἐκπύρωσιν καὶ εὐκρασίαν.	Diogenes (of Apollonia) and Anaxagoras said that after the formation of the cosmos and the creation of the animals out of the earth, the cosmos somehow spontaneously inclined towards its southern part, perhaps by providence, in order that some parts of the cosmos became uninhabitable, others inhabitable, according to freezing and scorching and temperation.

and the related theory Aëtius III 12.1 ascribes to Leucippus (fr.A27 D-K):

Λεύκιππος παρεκπεσεῖν τὴν γῆν εἰς τὰ μεσημβρινὰ μέρη διὰ τὴν ἐν τοῖς μεσημβρινοῖς ἀραιότητα, ἅτε δὴ πεπηγότων τῶν βορείων διὰ τὸ κατεψῦχθαι τοῖς κρυμοῖς, τῶν δ᾽ ἀντιθέτων πεπυρωμένων.	Leucippus said that the earth inclined toward its southern parts because of the drought in the southern parts, since the northern parts are rigid due to cooling-down by the frost, while the opposite parts are scorched.

In later times, the recognition of the earth's sphericity provided such observations with a new theoretical basis, transforming the three climatic divisions into *zones* encircling the earth: the frigid northern region was now defined by the arctic circle and became the *arctic zone*, and the torrid southern region was defined by the two tropic circles and became the *tropic or equatorial zone*, while the region in between became the *temperate zone*. Symmetry demanded the introduction of two further zones south of the winter tropic: a southern temperate zone, also known as the *counter-temperate* zone, and a southern frigid zone, also called the *counter-arctic* or *ant-arctic*. Thus the theory of the *five zones* was born.[528] The older theory of the three 'parts', and the newer theory of the five zones are illustrated below:

[528] On the five-zone theory in general see Abel (1974).

Figure 3-4: The three climatic regions

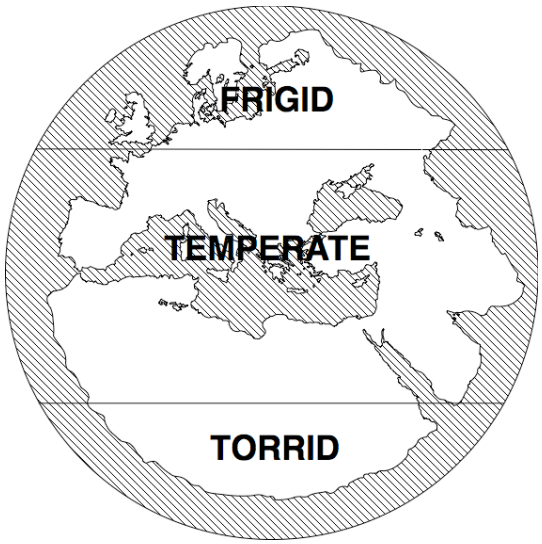
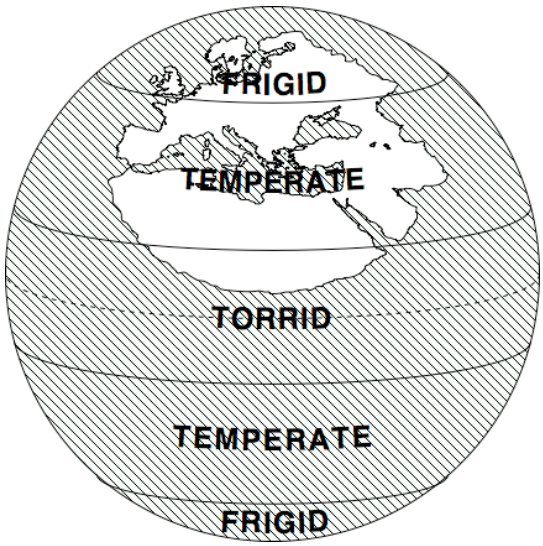


Figure 3-5: The five climatic zones



If we have to assign our three Epicurean passages to one of these two theories, it is clear that Lucretius and Velleius should be thought of as referring to the older theory, which presupposes a flat earth, while Philodemus' text is too unspecific to choose between the two theories. It may also be possible to interpret our passages as references to the un-theoretical observation underlying both theories, that there are three kinds of climate: temperate, frigid and torrid. Either way, there is no reason to see any of these passages as specific references to the five-zone theory.

3.3.5 Lucretius' cosmogony (*DRN* V 449-508)

3.3.5.1 Introduction

Until now the picture arising from our investigation seems unambiguous: Lucretius rejects centrifocal natural motion, which is commonly thought to imply a spherical earth, and instead, like Epicurus before him, assumes that natural motion is parallel, a notion which is thought to imply a flat earth. In addition we have found two passages that may not strictly exclude the earth's sphericity, but sit more easily with the notion of a flat earth.

The next passage I want to discuss, Lucretius' cosmogonical account in book V of the *DRN*, will – if my interpretation is correct – throw all this into confusion. The entire passage runs from line 416 to line 508, but the relevant portion for our purposes begins only at line 449. In these lines (449-508) Lucretius describes the formation of the major parts of the cosmos, resulting

in a four-layered structure with earth at the bottom, then water, then air and finally aether. The reason for including this passage in the present argument is that it can – as I will try to prove – only plausibly be understood in a *centrifocal* sense, which flatly contradicts Epicurus' and Lucretius' otherwise *parallel-linear* cosmology.

3.3.5.2 Origins and parallels

Although the extant works and fragments of Epicurus do contain some general remarks concerning cosmogony (see esp. the *Letter to Pythocles* 4 [89-90]), the relevant portion of Lucretius' account has no parallel in any work by any known Epicurean. The closest parallel is a curious chapter in Aëtius' *Placita*. A typical chapter in Aëtius' work reports by name the views of several philosophers concerning one or a number of related topics, which are presented in indirect speech (*AcI*-constructions). In chapter I 4, however, which deals with the coming-into-being of the cosmos, only one view is given, which is presented in direct speech and not attributed to anyone. The only certain clue to its provenance is the fact that it mentions atoms.[529] It is this account which furnishes the closest parallel to Lucretius' cosmogony, which it matches in all essential details (see below). For ease of reference the text and a litteral translation are printed below; the division into sections is my own.

	Πῶς συνέστηκεν ὁ κόσμος.	How the cosmos was constituted.
1	Ὁ τοίνυν κόσμος συνέστη περικεκλασμένῳ σχήματι ἐσχηματισμένος τὸν τρόπον τοῦτον.	The cosmos, then, was constituted and shaped with a bent shape in the following manner.
2	Τῶν ἀτόμων σωμάτων ἀπρονόητον καὶ τυχαίαν ἐχόντων τὴν κίνησιν συνεχῶς τε καὶ τάχιστα κινουμένην, εἰς τὸ αὐτὸ πολλὰ σώματα συνηθροίσθη, [καὶ] διὰ τοῦτο ποικιλίαν ἔχοντα καὶ σχημάτων καὶ μεγεθῶν.	As the atomic bodies have an unguided and haphazard motion and are constantly and most swiftly moving, many bodies were gathered together in the same place, and thereby had a variety of shapes and sizes.
3	Ἀθροιζομένων δ' ἐν ταὐτῷ τούτων, τὰ μὲν ὅσα μείζονα ἦν καὶ βαρύτατα, πάντως ὑπεκάθιζεν, ὅσα δὲ μικρὰ καὶ περιφερῆ καὶ λεῖα καὶ εὐόλισθα, ταῦτα καὶ ἐξεθλίβετο κατὰ τὴν σύνοδον τῶν σωμάτων εἴς τε τὸ μετέωρον ἀνεφέρετο.	As they gathered in the same place, those that were larger and heaviest settled down completely, while those that were small and round and smooth and slippery were extruded during the concourse of atoms and carried up into the upper region.

[529] For the various ascriptions of this account see e.g. Spoerri (1959) 7-8.

4 Ὡς δ' οὖν ἐξέλιπε μὲν ἡ πληκτικὴ δύναμις μετεωρίζουσα, οὐκέτι δ' ἦγεν ἡ πληγὴ πρὸς τὸ μετέωρον, ἐκωλύετο δὲ ταῦτα κάτω φέρεσθαι, ἐπιέζετο πρὸς τοὺς τόπους τοὺς δυναμένους δέξασθαι· οὗτοι δ' ἦσαν οἱ πέριξ, καὶ πρὸς τούτοις τὸ πλῆθος τῶν σωμάτων περιεκλᾶτο, περιπλεκόμενα δ' ἀλλήλοις κατὰ τὴν περίκλασιν τὸν οὐρανὸν ἐγέννησεν.

When the force of the blows stopped lifting them up, and the blows no longer drove them into the upper region, they were prevented from being carried down <and> were squeezed into those places that were able to receive them: these were the places all around, and to these the majority of the bodies were bent round, and as they became entangled with each other during the bending they generated the sky.

5 Τῆς δ' αὐτῆς ἐχόμεναι φύσεως αἱ ἄτομοι, ποικίλαι οὖσαι, καθὼς εἴρηται, πρὸς τὸ μετέωρον ἐξωθούμεναι τὴν τῶν ἀστέρων φύσιν ἀπετέλουν. Τὸ δὲ πλῆθος τῶν ἀναθυμιωμένων σωμάτων ἐπέπληττε τὸν ἀέρα καὶ τοῦτον ἐξέθλιβε· πνευματούμενος δ' οὗτος κατὰ τὴν κίνησιν καὶ συμπεριλαμβάνων τὰ ἄστρα συμπεριῆγεν αὐτὰ καὶ τὴν νῦν περιφορὰν αὐτῶν μετέωρον ἐφύλαττε.

Having the same nature and being varied, as was said, the atoms that were expelled to the upper region produced the nature of the heavenly bodies. The majority of the bodies that were being exhaled struck the air and extruded it: and the air, turned into wind during its movement and embracing the heavenly bodies, drove them round and preserved their present revolution in the upper region.

6 Κἄπειτα ἐκ μὲν τῶν ὑποκαθιζόντων ἐγεννήθη ἡ γῆ, ἐκ δὲ τῶν μετεωριζομένων οὐρανὸς πῦρ ἀήρ.

And then, from the bodies which settled down, the earth was generated, and, from the bodies which were lifted up, the sky, fire and air, were generated.

7 Πολλῆς δ' ὕλης ἔτι περιειλημμένης ἐν τῇ γῇ, πυκνουμένης τε ταύτης κατὰ τὰς ἀπὸ τῶν πνευμάτων πληγὰς καὶ τὰς ἀπο τῶν ἀστέρων αὔρας, προσεθλίβετο πᾶς ὁ μικρομερὴς σχηματισμὸς ταύτης καὶ τὴν ὑγρὰν φύσιν ἐγέννα· ῥευστικῶς δ' αὕτη διακειμένη κατεφέρετο πρὸς τοὺς κοίλους τόπους καὶ δυναμένους χωρῆσαί τε καὶ στέξαι, ἢ καθ' αὑτὸ τὸ ὕδωρ ὑποστὰν ἐκοίλανε τοὺς ὑποκειμένους τόπους.

Since a lot of matter was still contained in the earth and this was compressed by the blows of the winds and the breezes of the heavenly bodies, the earth's entire configuration, which was made up of small particles, was squeezed together and generated the moist nature: and since this nature was disposed to flow, it was carried down into the hollow places and those able to hold and contain it; or (else) the water by itself hollowed out the underlying places by settling there.

8 Τὰ μὲν οὖν κυριώτατα μέρη τοῦ κόσμου τὸν τρόπον τοῦτον ἐγεννήθη.

The most important parts of the cosmos, then, were generated in this way.

In the absence of explicit Epicurean parallels it is reasonable to wish to compare Lucretius' and Aëtius' cosmogonies on the one hand with those of Epicurus' philosophical ancestors, esp. Leucippus and Democritus, on the other hand. It turns out, however, that in spite of certain similarities, Lucretius' and Aëtius' cosmogonies are very different from these.[530] In Presocratic cosmogonies, including those of Leucippus and Democritus, the separation of the major cosmic parts is caused by the operation of a whirl or vortex (δίνη/δῖνος), which drives finer matter towards the periphery and coarser matter towards the centre, thus producing a spherical cosmos with the

[530] Similar observations in Spoerri (1959) 8-29.

earth at its centre. Paradoxically the whirl also causes certain heavy bodies *not* to move towards the centre but to remain poised at a certain distance, as is the case with the sun, the moon and the stars, which are composed of heavy (stony or earthlike) matter and yet do not fall down towards the earth.[531] In Lucretius' and Aëtius' cosmogonies, on the other hand, we find no trace of the whirl as the moving principle for the formation of the cosmos, but instead the major cosmic parts are separated as a result of their own upward and downward tendencies in proportion to their relative weights (this shall be further elaborated in §3.3.5.3 below). This applies to the sun and moon as well, which – according to Lucretius – occupy the region half way between earth and aether, because of their intermediate weight. In this respect Lucretius' and Aëtius' cosmogonies correspond to Epicurus'; in *Pyth.* 5 [90-91] Epicurus explicitly denies the δίνη such a crucial role, and also makes the sun, moon and stars consist of light substances like air and fire, rather than earth and stone.[532]

It is clear, therefore, that the type of cosmogony represented by Lucretius and Aëtius is essentially different from the one ascribed to Leucippus and Democritus, and therefore needs to be investigated and interpreted in its own right. Before we go on I will first try to establish more clearly that in the cosmogonical accounts of Lucretius and Aëtius the moving principle is weight, or rather weight-difference.

3.3.5.3 Weight as the moving principle of cosmogony

Neither Lucretius nor Aëtius is very explicit initially about the grounds for the upward and downward motions that cause the separation of the major cosmic parts. In Aëtius' account it is the 'larger and heaviest' (μείζονα καὶ

[531] Leucippus A1 D-K (Diog. Laërt. IX 31-32): the outer membrane which is at first moist and muddy, dries, catches fire, and forms the substance of the stars. Democritus A85 = Aët. II 13.5: Δημόκριτος {sc. τὰ ἄστρα εἶναι} πέτρους. ['Democritus says the stars are rocks'], Dem. A87 = Aëtius II 20.8: Δημόκριτος {sc. τὸν ἥλιον εἶναι} μύδρον ἢ πέτρον διάπυρον. ['Democritus says the sun is a fiery lump or rock'], Dem. A90 = Aëtius II 25.10: 'Αναξαγόρας καὶ Δημόκριτος {sc. τὴν σελήνην εἶναι} στερέωμα διάπυρον ἔχον ἐν ἑαυτῷ πεδία καὶ ὄρη καὶ φάραγγας. ['Anaxagoras and Democritus say the moon is a fiery solid mass, containing in itself plains and mountains and gullies'], Dem. A39 = Ps.-Plut. *Strom*. 7: ἡλίου δὲ καὶ σελήνης γένεσίν φησι κατ' ἰδίαν· φέρεσθαι ταῦτα μηδέπω τὸ παράπαν ἔχοντα θερμὴν φύσιν, μηδὲ μὴν καθόλου λαμπροτάτην, τοὐναντίον δὲ ἐξωμοιωμένην τῇ περὶ τὴν γῆν φύσει. ['He speaks about the special generation of sun and moon: they move, not at all yet having a warm nature, nor in general having brightness, but on the contrary (having a nature) entirely similar to the nature which is found close to earth.']

[532] But see Aëtius II 13.15 where Epicurus is said not to have committed himself to any particular substance of the stars, and II 20.14 where Epicurus is said to have called the sun an 'earthlike condensation'.

βαρύτατα) bodies that sank down, while the 'small, round, smooth, and slippery' ones moved upwards. According to Lucretius, the earthy particles sank down 'because they were heavy and entangled' (450: propterea quod erant gravia et perplexa), while those bodies whose particles were 'smoother', 'rounder' and 'smaller' moved upwards. Later on in Lucretius' account it becomes clear that from this array of material properties the real determining factor is *weight*. In lines 471-5, for instance, Lucretius explains that the first-beginnings of sun and moon took up a position half-way between earth and aether, 'because neither were they so *heavy* as to be pressed down and settle, / nor so *light* as to be able to glide throught the highest regions' (474-5). The predominant role of weight in cosmogony is confirmed in the concluding section of Lucretius' account (495-501), where Lucretius describes the resulting layered structure of the cosmos. Earth, which is *heaviest*, sank down; then came the sea, then air, then aether, each *lighter* than the one below, with aether, *lightest* of all, on top. It may be concluded, then, that the separation of the main cosmic masses comes about through their respective upward and downward tendencies, which in turn result from their different relative weights.

It is also interesting to see *how* these upward and downward tendencies depend on weight. In line 450 (already quoted above) we are told that first earthy particles sank down '*because* they were *heavy* and entangled'. Apparently being heavy (and entangled) is all that is needed to produce this downward motion. Then, as these earthy particles converged and became more and more entangled, they *squeezed out* (453: expressere; cf. Aët. I 4: ἐξεθλίβετο) and forced upwards every lighter substance. So, whereas downward motion is a *natural* and inevitable consequence of weight, upward motion is not, but rather comes about by *force*. This does not mean that downward motion is entirely free from external forces. Lucretius uses various expressions to describe this downward motion, the recurrent ones being *sedere* and *subsidere*, which are typically used to denote a retarded natural downward motion through a liquid medium, like mud in water or dregs in wine. This image is made explicit in lines 495-7, where Lucretius writes that 'the weight of the earth settled down, and being as it were the *mud* of all the world, {...} *sank deep down like dregs* (*subsedit funditus ut faex*)'. In the same sense Aëtius I 4 uses the rare compound ὑποκαθίζειν.[533]

[533] For other instances of this verb in this sense see: Galen, *Comp. med. sec. locos*, Kühn vol.13.285.2-4: ἅπαντα μίξαντες εἰς ἀγγεῖον κεραμοῦν, θερμαίνομεν ἐπ' ἀνθρακιᾶς, κινοῦντες ἐπιμελῶς, ἵνα μηδὲν *ὑποκαθίσῃ* τοῦ φαρμάκου. and id., *Comp. med. per*

The way in which downward and upward motion are spoken of here corresponds exactly to the Epicurean theory of weight and upward and downward motion as explained by Lucretius in *DRN* II 184-215, and by Epicurus himself in fr.276 Us. (see p.191ff above). There is only one difference: in those passages upward and downward motion were conceived of as *parallel*, the present context, however, requires them to be *centrifocal*.

3.3.5.4 Main clue for a centrifocal interpretation

The clearest indication that Lucretius' cosmogony must be interpreted centrifocally is found right at the beginning of the relevant section (V 449-51):

Quippe etenim primum terrai corpora quaeque, propterea quod erant gravia et perplexa, coibant in *medio* atque *imas* capiebant omnia sedes.	For, first of all, all bodies of earth, because they were heavy and entangled, came together in the *middle* and all took the *lowest* seats.

The most natural interpretation of these lines is to take 'came together in the middle' and 'took the lowest seats' as two equivalent statements, expressing one and the same process.[534] This would make the present lines just another of those many instances in the *DRN* where two statements are combined, using *et, ac, atque* or *-que*, to describe one and the same state of affairs.[535] If this is true, 'coming together in the middle' and 'taking the lowest seats' amount to the same thing: 'the lowest seats' *are* 'the middle'.

If the bottom of the cosmos is to be identified with its centre, so the periphery must be identical with the top. This too can be understood from Lucretius' text. In lines 457ff we are told that aether rose up ('se sustulit') in the same way as we see exhalations rising from the surface of lakes and rivers gather high above ('sursum in alto') as clouds. The concluding sentence runs as follows (467-470):

Sic igitur tum se levis ac diffusilis aether corpore concreto circumdatus undique <flexit> et late diffusus in omnis undique partis omnia sic avido complexu cetera saepsit.	Thus, then, at that time, the light & spreading aether, having placed itself, with compacted body, all around, <curved> in all directions, and spreading wide in all directions everywhere, thus fenced in all else with a greedy embrace.

The first word, 'sic' (thus), can only possibly refer to the process just described of aether *rising up*, like clouds gathering *high above*. But how can

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genera, Kühn vol.13.788.11-12: ἔψε δὲ ἐπὶ μαλακοῦ πυρός, κινῶν σπάθῃ δᾳδίνῃ ἀδιαλείπτως, ὥστε μὴ *ὑποκαθίσαι*, τάχιστα γὰρ κατακαίεται.

[534] Cf. Plin. *N.H.* 2.11.6 '*imam* atque *mediam* in toto esse terram'; Manil. *Astron.* 1.167 '*ima*que de cunctis {sc. tellus} *mediam* tenet undique sedem'; et *ibid*. 170 'ne caderet *medium* totius et *imum*'.

[535] See e.g. I 170: inde enascitur *atque* oras in luminis exit; or I 514: corpore inane suo celare *atque* intus habere. See Bailey (1947) Prolegomena VII. 14 (pp. 145-6) and Kenney (1971) nn. ad III 346.

rising up result in an embrace *all around?* The only possible way is if the upper region *is* all around, i.e. if 'up' equals 'towards the periphery' or 'away from the centre'.

This view is endorsed by Lück (1932) 30, who claims that in antiquity the terms 'above' and 'below' were *generally* used to denote the periphery and the centre of the cosmos. In applying this qualification to Lucretius he is, of course, mistaken: in the preceding sections we have clearly seen that the Epicureans did *not* normally conceive of 'up' and 'down' in this manner. A centrifocal interpretation of Lucretius' cosmogony is therefore strongly rejected by, among others, Giussani (1896-8), and Bailey (1947). Below I will first investigate their respective alternative interpretations and then return to the centrifocal interpretation they both reject.

3.3.5.5 Giussani's interpretation

Having rejected the centrifocal interpretation of Lucretius' cosmogony, Giussani (1896-8) opts for a purely parallel-linear view, where 'the earthy elements condense horizontally at the bottom, and the light and celestial elements extend more or less horizontally on high'.[536] Applying this interpretation to the final section of Lucretius' account (lines 495-508), as Giussani seems to want us to, we see before our eyes a structure consisting of four superimposed, horizontal layers, with earth at the bottom, then sea, then air, and on top of all the aether. This is a nice picture and one fully consistent with a parallel-linear interpretation of the passage.

There are several problems to this interpretation. In the first place, if nothing yet was formed, what was this 'bottom' on which the earthy particles came to rest? Secondly, we can be pretty sure that this is *not* what the cosmos looked like according to the Epicureans. Only a couple of lines below, in V 535ff, Lucretius clearly expresses the view that the earth is situated in the *centre*, not at the *bottom*, of the cosmos, and the same passage also tells us that air is found not only above, but also below the earth. Elsewhere (II 1066) we learn that aether 'holds [our cosmos] with a greedy embrace'.[537] Even within the cosmogonical passage itself Lucretius intimates as much, telling us (449-51) that particles of earth came together *in the middle*, and (467-70) that aether 'curved in all directions' and (echoing II 1066) 'thus fenced in all else with a greedy embrace.'

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[536] Giussani (1896-8), note ad V 449-494, 1st observation.

[537] Cp. also I, 1062-63 'loca caeli ... inferiora', which suggests that part of the heavens is below the earth.

Giussani recognises the problem, which he tries to solve by assuming a *second stage* to Lucretius' cosmogony.[538] The concluding section of Lucretius' account (495-508) does not – according to Giussani – describe the definitive position of the four elements, just their position at the end of the *first stage*. Not until the *second stage*, which – Giussani claims – is described in lines 467-70, does aether bend itself so as to *surround* the rest of the cosmos *from all sides*, and only then the earth acquires its final *central* position.

This interpretation will not work, however, for a number of reasons. In the first place, if the earth first settled at the lowest point, and only during the second stage took up its present central position, why does Lucretius in 449-451 mention these two motions in tandem and even in reversed chronological order? Secondly, if the earth's downward and centripetal motions are *not* identical, then the latter remains entirely unexplained. In lines 449-50 Lucretius told us that the particles of earth moved towards the centre and towards the lowest places, 'because they were heavy and entangled'. Now, nobody would object to heavyness causing downward motion, but why should heavyness also produce a centripetal tendency, unless 'towards the centre' and 'downwards' are the same thing? Thirdly, if Lucretius' cosmogony is assumed to consist of two stages, it is highly illogical that the second and final stage should be awarded just two casual remarks in the course of the account (449-51 and 467-70), while the conclusion (495-508) is reserved for a detailed description of what is only the outcome of the first stage. Such a conclusion would also make for a very clumsy transition to the next, astronomical, passage, which presupposes a fully, not a half, developed cosmos. Besides, if the state of affairs described in the conclusion does *not* represent the final and *present* situation, why is it written partly (501-5) in *present* tenses (influit, commiscet, sinit, fert)? Finally, as we have seen above, lines 467-70 clearly describe the *logical outcome* (cf. 467 'sic') of the process described in the preceding lines, not a subsequent development. Giussani's second cosmogonical stage is a fiction.

3.3.5.6 Bailey's interpretation

Giussani's interpretation is also rejected by Bailey, on the rather unspecific ground that he does 'not fully understand' it. Yet Bailey's own interpretation is hardly less problematic, as we shall see. Bailey starts, like Giussani, by emphatically rejecting a centrifocal reading of the passage. ''Top' and 'bottom'', Bailey says, 'are for him [i.e. Lucretius] absolute terms in relation to ourselves.' Lucretius' reference (V 449-51) to the particles of earth 'coming together in the centre and taking the lowest seats' Bailey tries to resolve on the

[538] Giussani (1896-8), note ad V 449-494, 1st observation; & note ad V 496.

assumption that Lucretius 'is thinking only of the parts visible from Earth and known to our sensation, the upper hemisphere, as one might call it.' 'To this', Bailey continues, 'the horizon forms the bottom, and the Earth is in the centre of it ...'

At first sight this might seem like a good solution to the problem, but on closer inspection it turns out to be rather trite: if the 'bottom' of the cosmos is defined by the horizon, which in turn depends on the earth's present position, and if the earth is said to have been formed at the 'bottom', then Lucretius is telling us nothing more than that the earth was formed where it is now (wherever this may be). It also seems rather odd that Lucretius should limit his account of the coming-into-being of the cosmos to its visible upper portion only, especially since elsewhere (e.g. V 534-536) he does not hesitate at all to think and speak of what is below the earth. More importantly, if the 'bottom' is defined in this way, there is no reason why the earthy particles should have stopped there instead of moving further downwards towards some other more secure and pre-existing 'bottom'. However all this may be, by defining 'bottom' and 'downward' in this manner Bailey is clearly advocating, like Giussani, a *parallel-linear* conception of the passage.

Immediately afterwards, however, he contradicts himself, when he allows that 'the light particles *rise up to the circumference*' [my Italics], for if upward motion is motion towards the circumference, downward motion – its natural opposite – must be motion towards the centre. Far from rejecting this conclusion, Bailey actually embraces it, approvingly quoting Lück who said 'that in antiquity 'below' in reference to the world means the middle and 'above' the periphery.' This is a purely *centrifocal* conception of the passage. Bailey ends up endorsing the very view he set out to reject! The interpretations offered by Costa (1984) and Gale (2009) are essentially the same.

3.3.5.7 A centrifocal interpretation of the passage

As two attempts to explain Lucretius' cosmogony in a parallel-linear sense have proved unsuccesful, it is now time to re-examine the alternative, a centrifocal interpretation of the account. I will do this in the form of a brief commentary, focussing on those passages and those aspects where the choice between the two alternatives is relevant for our understanding of these passages. Some of these have already been discussed above, but for the sake of completeness the relevant points will be repeated below.

449-451: The particles of earth came together in the centre and occupied the lowest seats. In a centrifocal model these are two different ways to express one and the same

motion. As there is only one motion, a single explanation suffices: the particles of earth moved towards the centre / the lowest seats, because they were heavy and entangled. Nobody will object to heavyness causing *downward* motion, which – in a *centrifocal* model – equals *centripetal* motion.

457-470: In these lines the formation of the 'fire-bearing aether' is described. In line **458** aether is said to have 'lifted itself' ('se sustulit'). In lines **460-466** aether's upward motion is compared to the way in which in the early morning mist is seen to rise from the waters and land, collecting up in the sky to form the texture of clouds. In line **467** Lucretius commences his conclusion with the words: '**sic** igitur' – '**in this way** then'. One would expect the conclusion to be that aether *rises up* in the same way as mists do. Instead Lucretius concludes (**467-470**) that in this way aether 'placed itself ... *all around* and *curved in all directions*, and spreading wide *in all directions everywhere*, thus *fenced in* all else with a greedy *embrace*.' This conclusion only follows if *upward* motion is identified with motion *away from the centre* and *towards the periphery*, i.e. if we explain the passage *centrifocally*.

471-472: 'These (earth and aether) were followed by the first-beginnings of sun and moon, whose globes revolve through the air between the two (= between earth and aether).' If we follow Giussani's parallel-linear interpretation, 'between the two' would have to mean: in a horizontal plane sandwiched between the (equally horizontal) planes of aether and earth. It would follow that the sun and the moon would never set. (It is interesting to note that this image comes actually very close to the view generally attributed to Xenophanes,[539] which is vehemently rejected by the Epicurean Diogenes of Oenoanda, fr.66). In a centrifocal system however, 'between the two' would mean: in a hollow sphere intermediate between the centre (the earth) and the periphery (the aether). This would at least allow for the sun and the moon to set and continue their courses below the plane of the horizon, as Lucretius does in fact allow them to (see *DRN* V 650-655).

495-508: In these lines Lucretius describes the layered structure of the cosmos that results at the end of the whole cosmogonical process, with earth at the bottom, above this the sea, above this the air, and on top of all fire-bearing aether. If we interpret the passage centrifocally, as I think we should, these layers must be conceived of as (hollow) *spheres* embracing one another. This would allow for the (*spherical*) earth to be at once at the bottom and in the centre (as was stated in 449-450; the earth's central position is stated again in line 534), for air to be not just on our side but also on the other side of the earth (where it may support the earth – see lines 534-563), and for aether to hold the rest of the cosmos 'with a greedy embrace' (as Lucretius said in 467-470, repeating what he wrote in II 1066).

In contrast to Giussani's and Bailey's *parallel* interpretation, a *centrifocal* reading of the passage turns out to produce an entirely logical and internally coherent account of the cosmogony.

3.3.5.8 Incompatibility of Lucretius' cosmogony with Epicurean physics

This conclusion, however, presents us with a serious problem. While two of the passages we investigated, viz. Lucretius' rejection of centrifocalism in I

[539] Xenophanes fr.A41a D-K = Aëtius II 24.9

1052-93 and the account of atomic motion in II 62-250, pointed clearly to a *parallel-linear* conception of downward motion, the present passage cannot be interpreted in any other way than *centrifocal*. Now, it may be observed that the passages which imply a parallel downward motion are concerned either with the behaviour of atoms in a pre- or extra-cosmic state (Lucr. II 216-250; Epic. fr.281 Us.) or with the behaviour of compound bodies inside our fully formed cosmos (Lucr. I 1052-93; *id*. II 184-215; Epic. fr.276 Us.), whereas the present passage deals exclusively with the behaviour of atoms and compound bodies *inside a cosmos that is being formed*. Someone might argue that there is no real contradiction if under special circumstances, such as the formation of a cosmos, atoms and compound bodies behave differently from the way they normally do. Such an objection might actually work if the motion of atoms and compound bodies during the formation of the cosmos had been described as forced motion, as it is in most presocratic cosmogonies, where heavy bodies are driven to the centre by the vortex. In Lucretius' cosmogony, however, the centripetal motion of heavy bodies is equated with downward motion which is the natural concomitant of weight. In other words, downward motion during cosmogony should be identical to downward motion outside the cosmos as well as inside a fully formed one, but it is not. Lucretius' cosmogony is incompatible with other parts of his and Epicurus' system.

Now, as we have seen, those passages which point to a *parallel* downward motion appear to be well integrated into the overall argument: Lucretius' rejection of *centrifocal* cosmology is presented as a logical consequence of the infinity of matter and space, and Lucretius' assumption of a *parallel* downward motion may be interpreted as a necessary implication of this rejection. In addition, this *parallel* downward motion is also implied by several passages in works and fragments of Epicurus himself. By contrast, Lucretius' *centrifocal* cosmogony is not. Although many details of this cosmogony correspond beautifully to other parts of Lucretius' and Epicurus' cosmology, the crucial detail that downward motion is *centrifocal* seems to be unique to this passage and not founded on anything that was stated before.

As a consequence, if the cosmogony cannot be reconciled with other passages, and seeing that those passages are firmly integrated into Epicurean physics, while the cosmogony is not, it is hard to avoid the conclusion that Lucretius' cosmogony is a *Fremdkörper*, that somehow found its place among the writings whose content Lucretius chose to work up into his poem. If so, what might be its origin and how did Lucretius end up including it? It is remarkable that, except for its being *centrifocal* rather than *parallel-linear*, it contains some unmistakable Epicurean echoes. Like the cosmogonies of Leucippus and Democritus it is atomistic (explicitly so in Aëtius' version) and

stresses the lack of design,[540] but unlike its Presocratic precursors, and in agreement with the few details provided by Epicurus himself (*Pyth*. 4-5 [89-91]), it makes do without a cosmic vortex and it creates the heavenly bodies out of light rather than heavy substances. So, even though it is incompatible with orthodox *parallel-linear* Epicureanism, it still seems to be rooted in Epicureanism somehow. For now, however, it suffices to say that Lucretius' cosmogony seems to be an anomaly that does not fit the general *parallel-linear* picture that arises from other passages. Before drawing any firmer conclusions we had better move on and see what other passages may tell us about the direction of downward motion and the shape of the earth.

3.3.6 Stability of the earth (*DRN* V 534-63)

In V 534-563 Lucretius explains how the earth is able to remain at rest in the middle of the cosmos by being supported by air. The same view is also expressed in a fragment of Epicurus' *On nature*,[541] and is explicitly attributed to Epicurus in a scholion to his *Letter to Herodotus* 73 (τὴν γῆν τῷ ἀέρι ἐποχεῖσθαι – 'that the earth rides on air'). This alone is enough to conclude that Epicurus' and Lucretius' cosmology is *parallel-linear*, for in a *centrifocal* cosmology the earth would need no underprop: see p.160ff and especially the pictures on p.162 above. It is remarkable that Lucretius should return to the a *parallel* cosmology so soon after his *centrifocal* cosmogony. This rather confirms our suspicion that the cosmogony is somehow anomalous among the rest of Lucretius' and Epicurus' views.

Lucretius' and Epicurus' theory about the stability of the earth is reminiscent of the view ascribed to Anaximenes, Anaxagoras and Democritus. These three, according to Aristotle, *Cael*. II 13, 294b14-23, thought that the earth could float on the air because of its *flatness*, which prevents the air from escaping. The explanation offered by Epicurus and Lucretius is somewhat different. In their version the air is said to be able to support the earth because together they form an organic unity, with the substance of the earth gradually blending into the air underneath. In this way, just like the neck does not feel the weight of the head, the air would not feel the weight of the earth. It is interesting to note that in contrast to its presocratic precursor this version of the theory does not specify the shape of the earth.

3.3.7 The size of the sun (*DRN* V 564-591)

In *DRN* V 564-591 Lucretius argues that the sun, like the other heavenly bodies, is more or less the size it appears to be. A shorter version of the

[540] Aëtius I 4: ... τῶν **ἀτόμων** σωμάτων **ἀπρονόητον** καὶ τυχαίαν ἐχόντων τὴν κίνησιν ... Cf. *DRN* V 419-420.

[541] Epicurus *On nature* XI, fr.42 Arr. See also frs.22 and 23 Arr.

argument, by Epicurus himself, is preserved in the *Letter to Pythocles* (6 [91]), where a scholion informs us that Epicurus had also discussed the matter in book XI of his *On nature*.

The argument in both passages may be summarized as follows (passing by some difficult details and minor differences): if a terrestrial fire is near enough for its light and heat (Lucretius 564-573), or its colour (Epicurus according to the scholion), or its outline (Lucretius 575-584), or its flicker and glow (Lucretius 585-591), to be observed, then its size does not diminish with increasing distance; but the sun's (and the moon's and the stars') light and heat (etc.) *are* observed: therefore the sun's (etc.) size does *not* diminish with increasing distance, and therefore the sun must be the size it appears to be. Ancient critics took this to mean that the sun according to Epicurus was actually very small, about the size of a human foot,[542] and this implication is accepted by most modern commentators.[543] It also receives some support from Lucretius who follows up the present passage with an account of how 'such a tiny sun' (tantulus ille sol) can shed so much light and warmth.

Several scholars have suspected a relation between this theory and Epicurus' views about the structure and size of the cosmos. Cyril Bailey,[544] for instance, connects the theory with Epicurus' (unreferenced) view that our 'world was comparitively small and the sun not very distant'. '[T]his', Bailey continues, 'would lead naturally to the belief that it [i.e. the sun] was not very large.' David Sedley,[545] too, suspects such a connection. He claims (without argument) that for Epicurus the earth was flat and that the sun set somewhere not too far past its westernmost edge (cf. my remarks on Lucr. IV 410-13 on p.198 above). As a result, Sedley argues, it would have caused Epicurus no small embarassment to discover that even in lands far to the west the sun, though much nearer, does not appear any bigger than at home. Orthodox astronomers could simply ascribe this to the negligible dimensions of the earth in comparison with the solar orbit, but for Epicurus this was not possible. Instead he explained the observed invariability of the sun's size on the assumption that the sun was somehow exempt from the laws of optics, an

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[542] See n.414 above.

[543] An alternative interpretation is offered by Keimpe Algra, in Algra (2001) and (forthcoming), who suggests that Epicurus and Lucretius are referring to the relative size of the sun, i.e. the portion of our field of view that is occupied by the sun, which is proportional to the ratio of the sun's size and its distance, or to its angular size. According to this interpretation, E. and L. did not commit themselves to a very small sun, but rather refrained from assigning a specific size.

[544] Bailey (1947) III 1408. See also Giussani (1896-8) ad vv. 564-611.

[545] Sedley (1976) 48-54.

exemption that seemed to be supported by the analogy of terrestrial fires seen from a distance. Whereas the image of other objects in our experience shrinks with increasing distance, the sun's – just like distant terrestrial fires – does not. It follows that the sun's image arrives at our eyes having more or less the same size it set out with, i.e. its actual size. Therefore the sun is about the same size it appears to be, which is approximately the size of a human foot. In this way Epicurus' theory about the size of the sun is linked to his (supposed) view that the sun is relatively close-by.

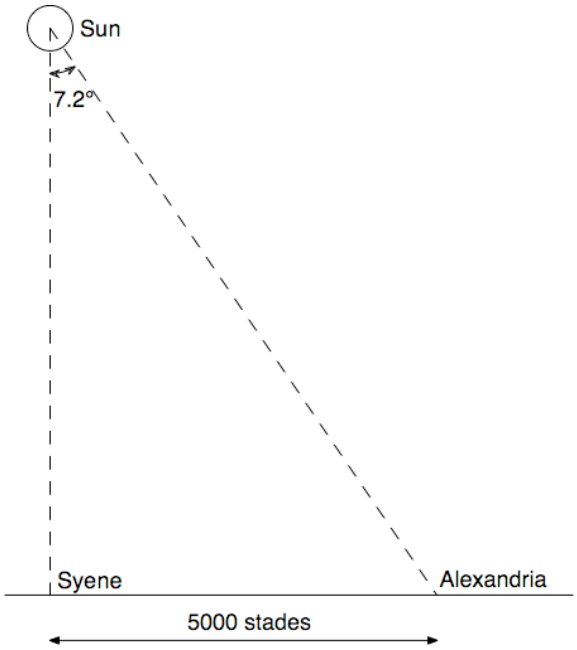
Neither Bailey nor Sedley explains why Epicurus and Lucretius wanted the sun to be so close to earth in the first place. In two recent publications David Furley attempts to supply the missing argument.[546] He suggests that Epicurus' commitment to a nearby, and hence very small, sun may have been partly motivated by his wish to account for certain astronomical observations in the light of his own flat-earth cosmology. Before Epicurus' time, Aristotle had already reported the observation that as we travel north or south the stars change their position, while some stars that never set in the north do so in the south, and others that are seen in the south are invisible in the north.[547] Aristotle and others explained these observations on the assumption that the earth is spherical. Furley points out that such observations could in fact be reconciled with a flat earth, if the heavenly bodies are assumed to be relatively close by: he compares this to the effect of walking under a painted dome. (In fact this model can only explain part of the reported observations: while it may account for the fact that observers at different latitudes see the same stars at different positions, it cannot explain how certain stars completely dissapear from sight.)

In order to give an indication of how close-by the heavenly bodies would have to be, Furley focuses on a special case of these observations. It was observed that the sun's position in the sky at noon on a certain day, for instance the day of the summer solstice, is not constant but depends on the observer's latitude, as could be demonstrated by the relative length of shadows.[548] Orthodox astronomers of course explained these observations with reference to the earth's curvature, but, as Furley demonstrates, the same facts might also be accomodated to a flat earth on the assumption that the sun is relatively near. A famous instance of these observations is ascribed to Eratosthenes, who noted that at noon during the summer solstice in Syene (modern Aswân in southern Egypt) the sun is vertically overhead, but in Alexandria, which is situated some 5000 stades or 788 km to the north,

[546] Furley (1996), *id.* (1999) 421, 428-9.
[547] Arist. *Cael.* II 14, 297b24 – 298a10. See also p.155 'third proof' above.
[548] See p.156 'fifth proof' above.

appears 7.2° out of plumb.[549] Eratosthenes used these data to calculate the circumference of the (spherical) earth, but Furley suggests that these same data might be used to calculate the sun's distance if the earth is assumed to be flat. He does not provide the actual calculation, only its outcome, but it is not hard to reconstruct. Assuming the earth to be flat, we can construct a right-angled triangle Sun-Syene-Alexandria, with a top angle of 7.2° and a base of 5000 stades (see the figure below). The distance between an observer in Syene and the sun is given as 5000/sin(7.2°), which yields 39,579 stades or 6,238 km. To an observer in Alexandria the sun is slightly further away.[550]

Figure 3-6: Furley's calculation of the sun's distance on the assumption of a flat earth



According to his argument, then, the earth's flatness requires the sun to be relatively close-by, which in turn implies that it cannot be very large. And this, according to Furley, may explain why Epicurus was so keen on proving its small size. In this way Epicurus' argument for the sun's size can be interpreted as a symptom of his commitment to a flat-earth theory, and his wish to uphold this theory against the pretensions of contemporary astronomy.

[549] See Cleomedes I 7.49-110.
[550] To be precise: 5000/tan(7.2°) = 39,894 stades or 6,287 km.

3.3.8 Centrifocal terminology (*DRN* V 621-36)

In *DRN* V 614-49, Lucretius discusses the turnings of the sun and the moon. In 621-36 Lucretius describes, as the first among a number of possible explanations, the theory, held by Democritus, that the turning speed of the heavenly bodies decreases with decreasing distance from the earth:

Nam fieri vel cum primis id posse videtur,		For, in the first place it seems that this may be the case,
Democriti quod sancta viri sententia ponit:		what the sacred opinion of the man Democritus states:
quanto quaeque magis sint terram sidera propter,		that in proportion as each heavenly body is nearer the earth,
tanto posse minus cum caeli turbine ferri;		so much the less can it be moved with the whirling of the sky,
evanescere enim rapidas illius et acris	625	since its swift and violent forces vanish
imminui supter viris, ideoque relinqui		and grow less below, and therefore the sun is slowly
paulatim solem cum posterioribu' signis,		left behind with the signs which come behind it,
inferior multo quod sit quam fervida signa.		because the sun is much lower than the burning signs.
Et magis hoc lunam: quanto demissior eius		And more so than the sun the moon: in proportion as its course is
cursus abest procul a caelo terrisque propinquat,	630	lower, being far from the sky, and approaches the earth,
tanto posse minus cum signis tendere cursum;		so much the less can it keep up its course with the signs;
flaccidiore etiam quanto iam turbine fertur		and in proportion as it is moved with an even fainter whirling,
inferior quam sol, tanto magis omnia signa		being lower than the sun, so much the more all signs
hanc adipiscuntur circum praeterque feruntur.		catch it up all around and move past it.
Propterea fit ut haec ad signum quodque reverti	635	Therefore it so happens that the moon appears to return to
mobilius videatur, ad hanc quia signa revisunt.		every sign more quickly, because the signs return to it.

The theory *as such* does not allow us to draw any conclusion about the shape of the earth or the direction of falling objects: there is no intrinsic reason why the heavenly bodies could not move in this special way in either kind of cosmology. The problem lies in the terminology employed. Throughout the passage Lucretius uses words like 'lower' and 'below' side by side with expressions like 'nearer the earth' and 'far from the sky', as if they were synonyms (instances of both kinds have been underlined in the text and translation above). This is *centrifocal* language, which has no place in a *parallel* cosmology.

Another instance of centrifocal terminology occurs in V 714, where the moon is said 'to keep the path of her course *below the sun*' ('cursusque viam *sub sole* tenere'), which can only mean that the moon is 'nearer the earth than the sun'.[551]

I have found no traces of centrifocal language in Epicurus' *Letters*, nor in the cosmological and astronomical fragments of book XI of his *On nature*. A clear instance, however, occurs in a fragment of the later Epicurean Diogenes of Oenoanda (fr.13 I.11-13):

Ἔτι δ' οἱ μὲν ὑψηλὴν ζώνην φέρονται, οἱ δ' αὖ ταπεινήν.	Moreover, some (of the heavenly bodies) move in a high orbit, others however in a low one. (tr. Smith)

[551] Bailey (1947) *ad loc.*

Here, as in the two passages of Lucretius, 'high' and 'low' must be understood as 'far from the earth' and 'near the earth' respectively.

The use of centrifocal terminology in these passages may call to mind Lucretius' cosmogonical account in V 449-508, which I argued can only be understood in a *centrifocal* sense (see p.202ff above), making it incompatible with Lucretius' and Epicurus' otherwise *parallel-linear* cosmology. However, the passages we are now investigating, may not warrant such a dramatic conclusion. In the cosmogony terms like 'up' and 'down' are explicitly linked to the natural motion of heavy bodies, so that the use of *centrifocal* terminology directly affects our conception of this motion. However, in the passages currently under investigation the natural motion of heavy bodies is not at stake. Save for the use of *centrifocal language* the theories that are being described do not necessarily exclude a *parallel-linear cosmology*. The use of centrifocal terminology in these passages, however ill-suited to Epicurean cosmology, may therefore be nothing but a slip into conformity with the accepted language of astronomy.

3.3.9 Sunrise and sunset (*DRN* V 650-79)

In V 650-79 Lucretius discusses the possible causes of sunset and sunrise. Two alternative theories are recognized: either the same sun passes unaltered below the earth and emerges again the next morning, or the sun is extinguished every night, to be rekindled the following day. The same theories of rising and setting are discussed by Epicurus in his *Letter to Pythocles* 7 [92], where they are applied to other heavenly bodies as well. The second of these two theories is the object of a fierce attack by the Stoic astronomer Cleomedes (II 1.426-66). Cleomedes points out that, since the earth is spherical, times of rising and setting differ with latitude as well as longitude. To illustrate the latitudinal variation he produces a list of actually *reported* minimum nighttimes for a number of places at different latitudes. This is an application of 'proof 6' of the earth's sphericity (see p.157 above). The longitudinal variation of the times of sunset and sunrise – 'proof 7' (see p.157 above) – Cleomedes had already discussed in his first book (I 5.30-44). Here he argued that the times of sunset and sunrise depend on longitude, and that this time-difference can be measured by simultaneous observations of eclipses at different longitudes. Since, then, the times of setting and rising are different for every place on earth it follows that the sun would have to be lit and extinguished at one and the same time incalculably many times. Cleomedes fails to draw the obvious conclusion that Epicurus did *not* believe the earth to be *spherical*, but such a conclusion would hardly have helped Epicurus.

Although the theory of the sun's daily extinction and rekindling would be perfectly consistent with a flat earth, it is incompatible with the observed facts, which can only be accounted for if the earth is spherical: daylength *does* vary with latitude, and local time *does* vary with longitude. Epicurus must have been either ignorant of these facts, or have willfully ignored them.

An interesting change of emphasis can be observed in the work of the 2nd century AD Epicurean Diogenes of Oenoanda (see p.35ff above). In fragment 13 of his Epicurean inscription, Diogenes promises to deal with the question of risings and settings. Before embarking on this subject he explains that with problems such as these one should not confine oneself to a single explanation when several options present themselves. Thus far he is speaking like a true Epicurean. Then he adds something that has no counterpart in any other Epicurean writing and seems to be against the spirit of Epicurean multiple explanations: "It is correct, however, to say that, while all explanations are possible, *this one is more plausible than that*." (tr. Smith, my emphasis). It seems that Diogenes reserves to himself the right to prefer certain explanations above others. Unfortunately his actual discussion of settings and risings has not been preserved. There is, however, another fragment, that touches upon the same problem. In fragment 66 he rebukes certain adversaries for "dismissing the unanimous opinion of all men, both laymen and philosophers, that the heavenly bodies pursue their courses round the earth both above *and below* ..." (tr. Smith, my emphasis). It is clear that Diogenes too subscribes to this 'unanimous opinion of all men', thus silently passing by Epicurus' alternative explanation that the heavenly bodies are extinguished at night. Diogenes may have justified his preference for the commonly accepted view with an appeal to plausibility, and he may well have done so in response to arguments such as those of Cleomedes.

3.3.10 The earth's conical shadow (*DRN* V 762-70)

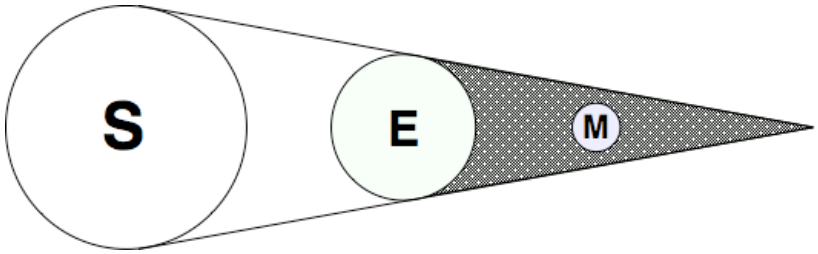
In *DRN* V 762-70 Lucretius discusses the subject of lunar eclipses. Among a number of alternative explanations he also mentions the theory of orthodox astronomy, that the moon, which on this theory receives its light from the sun, is eclipsed when it falls into the shadow of the earth (762-4):

Et cur terra queat lunam spoliare vicissim lumine et oppressum solem super ipsa tenere, menstrua dum rigidas coni perlabitur umbras, …?	And why should the earth in turn be able to rob the moon of light, and keep the sun oppressed, being herself above, while in its monthly course the moon glides through the rigid shadows of the cone, …?

The same theory was also mentioned, as a scholion informs us, in book XII of Epicurus' *On nature*,[552] and is alluded to in ch.13 [96] of Epicurus' *Letter to Pythocles*,[553] but only Lucretius provides the essential detail that the earth's shadow is shaped like a *cone*.

That the earth's shadow must of necessity have this shape was already known to Aristotle,[554] and is aptly demonstrated by Cleomedes and the elder Pliny.[555] Their argument runs as follows: supposing the sun and the earth to be spherical the earth's shadow will have one of three possible shapes: (1) if the sun is smaller than the earth it will produce a funnel-like shadow; (2) if the sun is equal to the earth a cilindrical shadow will result; and (3) if the sun is larger than the earth the shadow will be conical. Now, if the shadow were funnel-like it would extend over a large part of the night sky and obscure the moon almost continuously, which is not observed to happen. If, on the other hand, the shadow were cilindrical it would still be so large that the moon could not fail to be obscured every full moon, which goes against the evidence as well. Only a conical shadow is able to account for the observed fact, that the moon is eclipsed only during full moon and then only rarely and for a relatively short time. Therefore the earth's shadow must be conical, and the sun larger than the earth.

Figure 3-7: The moon in the conical shadow of the earth



There are two implications to this theory that need looking into: (a) it seems to presuppose a *spherical* earth, and (b) it requires for the sun to be *larger* than the earth. I will deal with each of these implications below.

Ad a: A perfect cone has a circular base and the only figure that will at all times present a circular outline to the sun is a sphere. A perfectly conical shadow therefore implies a spherical earth. Moreover, the conical shape of the

[552] Scholion ad Epic. *Pyth.* 13 [96]: σελήνην δὲ (ἐκλείπειν) τοῦ τῆς γῆς σκιάσματος (ἐπισκοτοῦντος) – 'the moon is eclipsed when the earth's shadow obscures it.'
[553] Epic. Pyth. 13 [96]: ἐπιπροσθέτησιν ... γῆς – 'interposition of the earth'.
[554] Arist. *Mete.* I 8, 345b1-9.
[555] Cleomedes II 2.19-30 & II 6.60-108; Pliny *N.H.* II 51.

earth's shadow also implies that, when during a lunar eclipse the moon crosses the earth's shadow, the obscured segment of the moon is always convex, as is in fact observed. In Aristotle's *De caelo* II 14, 297b24-31 this observation is presented as a proof of the earth's sphericity ('proof 1' on p.155 above). Therefore, by thus referring to the earth's conical shadow Lucretius might seem not only to presuppose a spherical earth, but even to acknowledge and accept Aristotle's proof of the earth's sphericity. However, I do not think this inference is necessary. In the first place a sphere is not the only shape that would produce a conical shadow (or a convex obscuration). A disk, for instance, will produce a perfectly conical shadow if the sun's rays hit it perpendicularly. And so will an ellipse when hit by the sun's rays at an appropriate angle. Moreover, the word 'cone' may be used here in a loose sense only, to describe any three-dimensional figure with a roughly circular base whose outline contracts with increasing distance. There is no real need therefore to suppose that the reference to a conical shadow implies a spherical earth.

Ad b: This brings us to the other implication: if the earth's shadow is shaped like a cone – and even if we interpret 'cone' in the loose sense indicated above –, the sun must be *larger* than the earth, which contradicts Epicurus' and Lucretius' supposed claim (see p.213 above) that the sun is very small. Three possible solutions present themselves: either that supposition was wrong and the Epicureans did not hold the sun to be very small,[556] or Epicurus and Lucretius failed to appreciate the geometrical implications of the present theory, or this is just another of those cases where, as Wasserstein observed,[557] the Epicureans failed to harmonize the explanation of one astronomical phenomenon with those of another. All three solutions are damaging to Furley's thesis that the small size of the sun was meant to reconcile certain astronomical observations with a flat earth. If the Epicureans did not believe the sun to very small after all, Furley's thesis must be rejected forthwith. If, on the other hand, the Epicureans were unable to grasp the geometrical implications of the present theory, they can hardly be expected to have understood the geometry involved in proving the relative proximity of the sun and hence its small size, in the way Furley suggests they did. Finally, if the Epicureans did not care to harmonize the explanations of different phenomena, why should they have cared to harmonize their flat-earth theory with one particular set of observations, as Furley suggests they did? In sum, the Epicureans' inclusion of the present theory among a number of possible alternatives throws serious doubt on Furley's thesis that their theory about the size of sun had anything to do with their supposed commitment to a flat earth.

[556] See n.543 on p.214 above.
[557] See p.31 above.

3.3.11 The 'limp' of the cosmic axis (*DRN* VI 1107)

There is an intriguing passage near the end of the *DRN*, where Lucretius discusses the relation between local climates, racial characteristics and endemic diseases.[558] Five examples are given (VI 1106-9):

Nam quid Brittannis caelum differre putamus, et quod in Aegypto est *qua mundi claudicat axis*, quidve quod in Ponto est differre, et Gadibus atque usque ad nigra virum percocto saecla colore?	For in what way do we suppose the climate of the Britons to differ, and that which is in Egypt, *where the cosmic axis limps*, or in what way that which is in Pontus to differ, and in Gades,[559] and all the way to the black tribes of men with their scorched colour?

It is the second of these lines I wish to focus on: "Egypt, where the cosmic axis limps." Many commentators have done their best to make some sense of these words, resulting in a great diversity of different interpretations. Some of these seem to attribute to Lucretius a specific view about the shape of the earth. It seems worthwile therefore to devote some time and space to a critical survey of the interpretations of this line.

Before I start I will first briefly discuss two of the terms involved:

mundi axis: According to most commentators (e.g. Bailey), *mundi axis* is the imaginary axis through the earth around which (the rest of the) cosmos was observed to revolve in just under 24 hours.[560] Some commentators (Robin, Leonard & Smith), speak, anachronistically, of the *earth's* axis, which is how the cosmic axis came to be known after Copernicus. Others (Lambinus, Munro, Merrill) take *mundi axis* as referring to the visible end-point of the cosmic axis, i.e. *the celestial north-pole*. This meaning is also suggested by the only other instance of the word 'axis' in the *DRN*, in VI 720: '{flabra} quae gelidis ab stellis *axis* aguntur' – '{winds} which are driven from the ice-cold stars of the *north-pole'*.

claudicat: The most puzzling word in Lucretius' line is *claudicat*. According to the dictionaries, *claudicare* can have two different meanings:

i. (literal:) to limp, to walk with a limp

ii. (metaphorical:) to be defective, to malfunction, to fail, to falter

The commentators, on the other hand, want *claudicat* to mean:

a. (Lambinus, Munro, Merrill, of the celestial north-pole:) *is depressed, lies low*

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[558] For a brief analysis of the context of this passage see p.101ff above.

[559] Modern Cádiz in Southern Spain.

[560] The same expression is attributed to Eudoxus in fr.124.84-5 Lasserre (= Simpl. *In Arist. de caelo* 495.22-3 Heiberg): σφαῖρα περὶ τὸν ἄξονα τοῦ κόσμου στρεφομένη.

b. (Robin, Bailey and most others, of the cosmic axis) *slants, slopes, tilts, inclines*

The problem is how to get from meaning i or ii to meaning a or b. Most commentators simply state that meaning i implies a or b. Sometimes they point out internal parallels in support of their view: III 453 '*claudicat* ingenium', IV 436-7 '*clauda* videntur / navigia', IV 515 'libella ... *claudicat*' (for some reason VI 834 '*claudicat* ... pinnarum nisus' is never mentioned), but they fail to explain how each parallel works, for this is hardly obvious: what have 'the mind' or 'a ship' (or 'the support of feathers') in common with the cosmic axis or the celestial north-pole? The only obvious parallel seems to be that of the level (libella) in IV 515, adduced by Bailey, where 'claudicat' seems to mean 'is inclined'. However, this parallel is misleading: *claudicat* here only **seems** to mean 'is inclined', because a properly functioning level should be horizontal, and therefore its 'malfunction' necessarily implies 'being inclined', but surely it is not the proper function of the cosmic axis to be horizontal. Munro's explanation of *claudicare* as 'leaning over like a limping man' does not convince either: the cosmic axis and the north pole do not seem to have much in common with a limping man, nor do limping men necessarily lean over. Although I am convinced that in the present context *claudicare* must mean something like (a) *to be inclined*, or (b) *to ly low*, a good explanation of how this meaning can be derived from the verb's original meanings has yet to be produced. For the moment I will, therefore, simply assume each of the two proposed interpretations and see where it leads us.

This having been said it is time to turn to the interpretation of the entire line. The problem, in my view, is a triple one:

I. what does it mean to say that the cosmic axis (or celestial north-pole) *limps*?

II. what is the *relevance* of this 'limp' in the present context?

III. why does it do so in *Egypt* of all places?

In the following discussion I will use these three questions to judge the validity of each explanation. The explanations that have been proposed can be reduced to three different interpretations:

1. the inclination of the cosmic (or terrestrial) axis with respect to the ecliptic or zodiac

2. the inclination of the cosmic axis with respect to the plane of the flat earth

3. the relatively small elevation of the celestial north-pole in Egypt

The fullest and yet most confused commentary is that of Robin, who touches upon all three interpretations with ample parallels, yet fails to observe

the fact that they are different and mutually exclusive. I will use his commentary as a guide to the three interpretations.

1. Robin sees in line 1107 an allusion to the *inclination of the earth's axis*, which he links to the *obliquity of the zodiac* (λόξωσις τοῦ ζῳδιακοῦ / *obliquitas (orbis/circuli) signiferi*). This latter term was used in ancient astronomy to denote the fact that the sun's *annual* path through the sky – often called *zodiac* after the belt of constellations by which it is marked – is inclined by about 23.5° with respect to the direction of the fixed stars' *daily* rotation. Because of this obliquity the sun does not stay on the equator, but wanders to and fro between the two tropics, and in doing so produces the four seasons. Both Epicurus and Lucretius were in fact familiar with this *obliquity of the zodiac*, which is mentioned by Epicurus among a number of possible explanations for the wanderings of the sun,[561] and by Lucretius as one possible way to account for the seasonal variation of day-lengths.[562] In modern, post-Copernican, astronomy the daily west-ward rotation of the fixed stars has been replaced by a daily east-ward rotation of the earth around its own axis, and the apparent yearly motion of the sun throught the signs of the zodiac is now attributed to a yearly rotation of the earth around the sun. The phenomenon which the ancients commonly referred to as the *obliquity of the zodiac* is now referred to as the *inclination of the earth's axis*. There is no indication, however, that anyone before the time of Copernicus ever referred to this phenomenon in terms of the terrestrial or celestial axis. Robin is mixing up ancient and modern terminology. Moreover, the *obliquity of the zodiac* is completely irrelevant to the subject of Lucretius' line: while it may explain the *annual* variation of the seasons, it has nothing to do with the *spatial* diversity of climates, which is what the present passage is about. Finally, there is no specific link between the *obliquity of the zodiac* and Egypt: it is a 'global' constant that is the same for Egypt and Britain and any other place on earth. In short, whatever Lucretius is saying in VI 1107, we can be confident that he is *not* referring to the *obliquity of the zodiac*.

2. Robin goes on to cite a number of Presocratic fragments dealing with the *inclination of the cosmos* (Anaxagoras, Diogenes of Apollonia, Empedocles) or, alternatively, *of the earth* (Leucippus and Democritus). He does not seem to view these as anything but illustrations of his own, erroneous, interpretation. In fact however, as Bailey has rightly observed, they provide

[561] Epic. *Pyth.* 9 [93].
[562] Lucr. *DRN* V 691-93.

the key to a different and far more promising interpretation. The most telling texts are Diog. Laërt. II 9.1-3 (Anaxag. fr.A1.31-32 D-K) (ignored by Bailey):

Τὰ δ' ἄστρα κατ' ἀρχὰς μὲν θολοειδῶς ἐνεχθῆναι, ὥστε κατὰ κορυφὴν τῆς γῆς τὸν ἀεὶ φαινόμενον εἶναι πόλον, ὕστερον δὲ τὴν ἔγκλισιν λαβεῖν.	The heavenly bodies were originally carried along like a dome, so that the ever visible pole was vertically above the earth, but later they (the stars / the pole?) acquired the inclination.

and Aëtius II 8.1 (Anaxag. fr.A67 D-K = Diog. Apoll. fr.A11 D-K):

Διογένης καὶ Ἀναξαγόρας ἔφησαν μετὰ τὸ συστῆναι τὸν κόσμον καὶ τὰ ζῷα ἐκ τῆς γῆς ἐξαγαγεῖν ἐγκλιθῆναί πως τὸν κόσμον ἐκ τοῦ αὐτομάτου εἰς τὸ μεσημβρινὸν αὐτοῦ μέρος, ἴσως ὑπὸ προνοίας, ἵνα ἃ μὲν ἀοίκητα γένηται ἃ δὲ οἰκητὰ μέρη τοῦ κόσμου κατὰ ψύξιν καὶ ἐκπύρωσιν καὶ εὐκρασίαν.	Diogenes (of Apollonia) and Anaxagoras said that after the formation of the cosmos and the creation of the animals out of the earth, the cosmos somehow spontaneously inclined towards its southern part, perhaps by providence, in order that some parts of the cosmos might become uninhabitable, others inhabitable, according to the freezing and scorching and temperation.

These texts are concerned with the problem of why the celestial north pole is not vertically above the plane of the (flat) earth, but appears at a certain angle above the northern horizon (38º to an observer in Athens). Anaxagoras and Diogenes assumed that after its coming-into-being the whole *cosmos*, including the fixed stars and the celestial north pole, had somehow tilted, causing the *celestial axis* to become *inclined* towards the south.[563] This *inclination* was also somehow responsible for the *latitudinal*[564] variation of climates. A similar view is attributed to Empedocles,[565] and a variant to Leucippus[566] and Democritus,[567] who suppose that not the cosmos, but the (flat) earth was inclined.

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[563] Verbs like (ἐγ-/ἐπι-)κλίνομαι (incline, slope) always indicate a deviation from the *horizontal* plane. The direction of the slope, i.e. the direction of its *descent*, is indicated by εἰς/πρὸς/ἐπί + acc.

[564] I use 'latitudinal' and 'latitude' here simply to refer to a place's position with respect to the north and the south, irrespective of the assumed shape of the earth.

[565] Aët. II 8.2 (Emp. A58 D-K): Ἐμπεδοκλῆς τοῦ ἀέρος εἴξαντος τῇ τοῦ ἡλίου ὁρμῇ, ἐγκλιθῆναι τὰς ἄρκτους, καὶ τὰ μὲν βόρεια ὑψωθῆναι τὰ δὲ νότια ταπεινωθῆναι, καθ' ὃ καὶ τὸν ὅλον κόσμον. "Empedocles says that when the air had yielded before the force of the sun, the Bears tilted, and the northern regions (of the earth/the kosmos?) were lifted, and the sourthern depressed, and accordingly the whole cosmos." Personally, I believe that the attribution of this view to Empedocles is wrong. While Anaxagoras, Leucippus and Democritus, and probably Diogenes too, were *flat*-earthers, Empedocles may well have believed the earth to be *spherical*; see p.150 with n.384 above.

[566] Aët. III 12.1 (Leuc. A27 D-K): quoted on p.201 above. See also Diog. Laërt. IX 33.6-8 (Leuc. A1.31-33 D-K): ... κεκλίσθαι τὴν γῆν πρὸς μεσημβρίαν· τὰ δὲ πρὸς ἄρκτῳ ἀεί τε νίφεσθαι καὶ κατάψυχρα εἶναι καὶ πήγνυσθαι.

It is to such views, according to Bailey, that Lucretius must be alluding in line 1107. For some reason, however, Bailey only gives Leucippus' and Democritus' version of the theory (which he wrongly ascribes to Anaxagoras and Diogenes too), making Lucretius say that "the *earth* was tilted upwards to the north and downwards to the south" [my italics]. It is hard to see, however, how '*mundi axis*' could be made to stand for '*the plane of the (flat) earth*'. It seems much more obvious to regard Lucretius' line as an allusion to the Anaxagorean view that (paraphrasing Bailey:) "the *cosmic axis* was tilted upwards to the north and downwards to the south".

Contrary to Robin's, this interpretation is very relevant to the context of the passage. Not only Anaxagoras and Diogenes, but also Leucippus and Democritus explicitly linked the *inclination* to the latitudinal variation of climates.

It is not clear, however, and Bailey fails to explain, how this inclination can be connected to *Egypt*. On a *flat* earth the *inclination of the cosmos* is a *constant*: the celestial axis is no more inclined in Egypt than among the Britons or in any other location. So, although this interpretation offers an interesting parallel with the theories of Lucretius' fellow flat-earthers Anaxagoras, Leucippus and Democritus, it may not be what Lucretius had in mind.

3. This brings us to the third and last interpretation, which is in fact the oldest: according to Lambinus (1564), quoted with approval by Merrill, Lucretius is alluding to the fact that for an observer in Egypt the celestial pole appears *low* in the sky ('polus arcticus ... illis est depressus'). Munro thinks along the same lines, and he aptly quotes Cleomedes I 5.47-8, who also contrasts Egypt and Britain in this respect:

... παρὰ μὲν Συηνίταις καὶ Αἰθίοψιν ἐλάχιστον φαίνεται τὸ τοῦ πόλου ὕψος, μέγιστον δὲ ἐν Βρεττανοῖς, ἐν δὲ τοῖς διὰ μέσου κλίμασιν ἀναλόγως.	... among the Syenites[568] and Aethiopians the elevation of the pole appears least, but among the Britons greatest, and proportionately at the intervening latitudes.

[567] Aët. III 12.2 (Democr. A96 D-K): Δημόκριτος διὰ τὸ ἀσθενέστερον εἶναι τὸ μεσημβρινὸν τοῦ περιέχοντος αὐξομένην τὴν γῆν κατὰ τοῦτο ἐγκλιθῆναι· τὰ γὰρ βόρεια ἄκρατα τὰ δὲ μεσημβρινὰ κέκραται· ὅθεν κατὰ τοῦτο βεβάρηται, ὅπου περισσή ἐστι τοῖς καρποῖς καὶ τῇ αὔξῃ.

[568] The inhabitants of Syene (modern Aswân), in southern Egypt, reputed to be exactly below the summer tropic circle (see p.230ff below). In reality Syene is situated about 0° 39', i.e. 72 km, north of the tropic.

Munro's quotation is repeated by Robin, who fails to observe its incompatibility with his own interpretation and with his other quotations. However, although the present interpretation is incompatible with the previous one, it is not unrelated. While Anaxagoras, Diogenes, Leucippus and Democritus had been content with the observation that the north pole is not vertically overhead, but appears at a certain angle above the northern horizon (38º in Athens), the progress of knowledge and the expansion of the greek 'horizon' made it clear that this angle is by no means fixed, but depends on the location, or more precisely the latitude, from which the observation is made (varying from about 24° in Syene to about 54° in Britain). Accordingly the elevation of the pole could be and was actually used as a measure for the geographical latitude of a place – as it still is. It had also been known for a long time that the temperature of a place somehow depends (among other things) on its latitude,[569] which could now be expressed in terms of the polar height. It would, therefore, make excellent sense for Lucretius, speaking of the variation of climates, to characterise Egypt by its relatively small polar elevation, which would then be a measure for its southern position and hence its hot climate.

At this point we encounter a problem: the small polar elevation in Egypt may be apt to distinguish it from Britain, or from 'the intervening latitudes' of Pontus and Gades, but what about 'the black tribes of men with their scorched colour', i.e. the Aethiopians,[570] who live even farther to the south, and for whom the north pole lies even lower? The key to this problem may be found in the next couple of verses (1110-13):

Quae cum *quattuor* inter se diversa videmus *quattuor* a ventis et caeli partibus esse, tum color et facies hominum distare videntur largiter et morbi generatim saecla tenere.	And as we see these *four* (regions) to be diverse among each other, according to the *four* winds and quarters of the sky, so the colour and aspect of men are seen to differ greatly, and diseases to possess the nations race by race.

Although in the previous lines Lucretius clearly mentioned *five* places or peoples, – the Britons, Egypt, Pontus, Gades, and the Aethiopians –, he now

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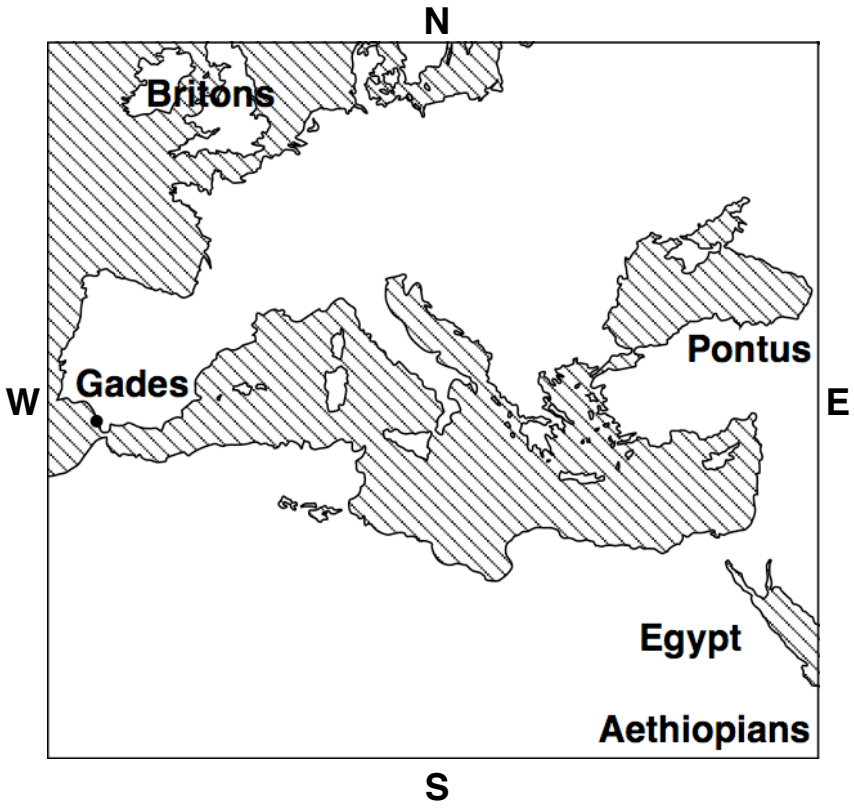
[569] See p.200ff and notes 566 and 567 with the text thereto above. Cf. also Arist. *Mete.* II, 5, 362b16-18: οὐ γὰρ ὑπερβάλλει τὰ καύματα καὶ τὸ ψῦχος κατὰ μῆκος, ἀλλ' ἐπὶ πλάτος – "for excesses of heat and cold take place, not according to longitude, but according to latitude."

[570] That the Aethiopians are meant is clear from the nearly identical line in VI 722, where these same 'black tribes of men' are situated in the hot country south of Egypt where the Nile originates. The theory that the Aethiopians were burnt black by the sun was first mentioned by Herodotus II 22 and later became commonplace: see e.g. [Arist.] *Probl.* X 66, 898b; Strabo XV 1, 24 (quoting the IV BC tragedian Theodectes); Ovid. *Met*. II 235-6; Manilius IV, 758-9; Sen. *NQ* IVa 2, 18.1-2; Lucan X 221-2; Pliny *NH* II 189, 2-3; Hyg. *Astron.* I 8, 3, 12; Ptol. *Tetr.* II 2, 56; *Etymologicum Magnum* s.v. Αἰθίοψ.

refers to them as if there were only *four* of them, which should roughly correspond to the *four* cardinal winds. The problem is illustrated in the map below:

Figure 3-8: Lucr. VI 1106-13: five places, four winds



The Britons obviously represent the north, and Egypt, where the celestial north pole lies low, the south. Pontus and Gades, which lie at roughly equal distances to the east and west of Rome, must represent these two directions. This leaves the Aethiopians, the southermost people known to the ancients: they too must represent the south, as they do in Cleomedes' work (see the quotation above) and in many other scientific writings.[571] It is clear then that Lucretius did not mean the Aethiopians and Egyptians to be contrasted: they both represent the south, where the north-pole lies low. Still, this double representation of the south, with Pontus and Gades squeezed in between, when, moreover, the subsequent reference to the four winds presupposes a single representative for each wind, suggests that Lucretius may have been planning to get rid of one of the two. As for Pontus and Gades: it is clear that

[571] See e.g. Strabo I 2, 24-28, Pliny *NH* II 189, 2-3; Ptol. *Tetr*. II 2, 56 and Asclepiades of Bithynia according to Aëtius V 30, 6.

these places were not chosen for their difference in *latitude* (which is minimal), but for their difference in *longitude* (which is considerable).[572] This means, however, that the supposed reference in line 1107 to the polar elevation does not apply to them. A strange discrepancy results: while in lines 1110-13 Lucretius suggests that climates vary with latitude *and longitude*, the theory he seems to allude to in line 1107 only accounts for the *latitudinal variation*.[573]

Of the three interpretations we have considered, only the third (Lambinus' and Munro's) answers all three questions we posed at the beginning: it explains the enigmatic words 'qua mundi claudicat axis' in a way that is both meaningful and relevant to the context and explains why this phenomenon is situated in Egypt of all places.

Now it is time to come to the crux of this section: the Cleomedes-quote, which Munro used to support his interpretation of line 1107, is part of an argument for the *sphericity* of the earth! *"If the earth's shape were plane and flat,"* says Cleomedes,[574] *"the pole would be seen by everyone at an equal distance from the horizon, and the arctic circle*[575] *would be the same. Yet, nothing like this is present in the phenomena, but instead, among the Syenites and Aethiopians the elevation of the pole appears least, but among the Britons greatest, and proportionately at the intervening latitudes."* The idea is that, due to the curvature of the earth, people at different latitudes observe the heavens at different angles, or – in other words – at different latitudes the cosmos is differently *inclined* with respect to the local horizon. This *inclination of the cosmos* (ἔγκλισις / ἔγκλιμα τοῦ κόσμου, *inclinatio mundi / caeli*) is usually expressed in terms of the angular *height of the celestial north pole*. (Cf. Geminus *Isagoge* 6.24.2-3: τὸ ἔξαρμα τοῦ πόλου, ὃ δὴ καλεῖται ἔγκλιμα τοῦ κόσμου). The whole theory is excellently explained by Cleomedes.[576] The main point for us is that not only in Cleomedes, but everywhere in ancient Greek and Roman astronomy, whenever the latitudinal variation of the polar elevation is mentioned, it is linked with, and used as

[572] In Cleomedes' work (I 5.37-44) the extreme west and east are represented by Iberia (Spain) and Persia respectively. Strabo and others prefer India to represent the east: see Bowen-Todd (2004) p.66, n.11. The only other work where Pontus is used to represent the east is Vitr. VI 1.1 (see next note).

[573] The same discrepancy can be seen in Vitruvius VI 1.1, where the assertion that climates vary with the inclination of the cosmos (i.e with latitude), is followed by a list of places that includes representatives of the east (Pontus) and the west (Spain); the south is represented by Egypt, and the centre by Rome, while the north is not represented.

[574] Cleomedes I 5.44-49.

[575] The circle that encompasses the ever-visible portion of the heavens.

[576] Cleomedes I 3.6-43.

evidence for, the *spherical* shape of the earth. If, as Lambinus and Munro believe, Lucretius VI 1107 refers to the varying polar height, doesn't this imply that Lucretius must have known and accepted the earth's *sphericity?*

3.3.12 Philodemus and the gnomon (Phil. *De sign*. xxx 20-27)

One may think that I have concluded too much from one enigmatic line in Lucretius. However, a somewhat similar instance is found in a fragment of his contemporary and fellow Epicurean Philodemus.

In the *De signis* xxx 20-27 Philodemus gives us three examples of inferences that go wrong, because they have been based on too limited a sample:

[Ἐάν γ]έ τις λέγηι [πάντας] ἀνθρώ[π]ους εἶναι λευ[κοὺς ἀ]πὸ τῶν παρ' ἡμῖν ὁρμώμε[νος ἢ] τοὐναντί[ο]ν ἀπὸ τῶν Αἰθιόπων, ἢ πανταχοῦ τοὺς ὀρθοὺς γν[ώ]μ[ο]νας περὶ μεσημβρίαν ἐν ταῖς θεριναῖς τροπαῖς [ἀνε]λεῖν σκιάν, ἆρ' οὐ μάταιος ἔ[σ]ται;	If a person says that *all* men are white, starting from those among us, or the opposite, starting from the Aethiopians, or that vertical gnomons *everywhere* wipe out their shadows around midday at the summer solstice, isn't he talking nonsense? (tr. De Lacy, modified)

In the first two examples the nature of the limitation is clearly stated: the investigation has been limited to 'those among us', or, alternatively, to the Aethiopians, resulting in the wrong conclusion that *all* men are white or that *all* men are black. In the third example the nature of the limitation is suppressed, but perhaps we are meant to supply it from the previous example: *if one were to limit one's investigation to the country of the Aethiopians*, one might come to the wrong conclusion that vertical gnomons *everywhere* are shadowless around midday at the summer solstice. In fact this was only observed to happen at the indicated time in Syene, an Egyptian town bordering on Aethiopia, and therefore sometimes considered Aethiopian: see e.g. Alexander *In Aristotelis Mete.* p.103.30-31 Hayduck:

Λέγονται μέντοι οἱ περὶ Συήνην οἰκοῦντες τῆς Αἰθιοπίας ἐν τῇ μεσημβρίᾳ ὄντος τοῦ ἡλίου κατὰ τὰς θερινὰς τροπὰς ἄσκιοι γίνεσθαι.	It is said that when the sun is at its midday culmination at the time of the summer solstice those living around Syene in Aethiopia become shadowless.

Philodemus does not explain where each of his three examples goes wrong, or what the true facts are in each case, but his argument requires that both he and his audience are aware of the true facts: not everywhere men are white but only among us, not everywhere men are black but only in Aethiopia, and not everywhere vertical gnomons are shadowless around midday at the summer

solstice but only in Syene. The true facts of this third case are excellently summarised by Cleomedes (I, 7.71-78):

Φησὶ τοίνυν, καὶ ἔχει οὕτως, τὴν Συήνην ὑπὸ τῷ θερινῷ τροπικῷ κεῖσθαι κύκλῳ. Ὁπόταν οὖν ἐν καρκίνῳ γενόμενος ὁ ἥλιος καὶ θερινὰς ποιῶν τροπὰς ἀκριβῶς μεσουρανήσῃ, ἄσκιοι γίνονται οἱ τῶν ὡρολογίων γνώμονες ἀναγκαίως, κατὰ κάθετον ἀκριβῆ τοῦ ἡλίου ὑπερκειμένου. {...} Ἐν Ἀλεξανδρείᾳ δὲ τῇ αὐτῇ ὥρᾳ ἀποβάλλουσιν οἱ τῶν ὡρολογίων γνώμονες σκιάν, ἅτε πρὸς ἄρκτῳ μᾶλλον τῆς Συήνης ταύτης τῆς πόλεως κειμένης.

Eratosthenes says, and it is the case, that Syene is located below the summer tropical circle. So when the sun, as it enters Cancer and produces the summer solstice, is precisely in mid-heaven, gnomons of sundials are necessarily shadowless, since the sun is located vertically above them. {...} But in Alexandria at the same hour gnomons of sundials do cast a shadow, since this city is located further north than Syene. (tr. Bowen-Todd, modified)

Philodemus' reference matches not just the content but even the exact vocabulary of this account, which indicates that Philodemus must have known and accepted these observations for a fact: he knew and accepted that the length of the shadow of a gnomon at noon at the summer solstice depends on the observer's latitude.

Now then, the quotation from Cleomedes is part of his account of Eratosthenes' famous calculation of the circumference of the earth, which was based on the assumption that *the earth is a sphere*. Moreover, the same and similar observations are also reported by the elder Pliny (*NH* II 183) as part of one of his formal proofs for the *sphericity of the earth* ('proof 5' on p.156ff above). Does this mean that by accepting these observations Philodemus also implicitly accepts the earth's sphericity?

3.4 Conclusions

Having completed our review of relevant passages we may now be in a position to answer the six questions formulated at the outset of this chapter:

1. Did the Epicureans posit a parallel downward motion of all bodies?

The ascription to the Epicureans of a flat-earth philosophy is usually supported with reference to their assumption of a parallel downward motion. The evidence for this assumption, however, now turns out to be more ambiguous than has hitherto been supposed. It is true that certain passages clearly imply a parallel downward motion: Lucretius' rejection of the centrifocal alternative in I 1053-93, his theory of the 'swerve' in II 216-50 and his view that the earth rests on air in V 534-63 all point to his acceptance of a parallel downward motion, while corresponding passages and fragments of Epicurus confirm that this was Epicurus' view as well. Other passages, however, contradict this conclusion: both Lucretius, in V 621-36 and 713-4, and Diogenes of Oenoanda, in fr.13 I.11-13, use centrifocal language, which

conflicts with their presumed parallel-linear cosmology, and Lucretius' cosmogonical account in V 449-508 requires the assumption of a centripetal downward motion of all bodies, which is absolutely incompatible with an otherwise parallel-linear system.

In view of this evidence it may seem that Epicurean cosmology, or at least Lucretius' version of it, is a hopeless mixture of two incompatible world views, but perhaps we need not be so pessimistic. All those passages in Lucretius which point to a parallel cosmology are firmly rooted in, and interconnected with, sound Epicurean doctrine: the rejection of centrifocalism follows only after a thorough criticism of that alternative, and allows Lucretius to finally conclude that the infinite universe contains an infinite amount of matter (cf. Epic. *Hdt.* 41-42), and consequently an infinite amount of worlds (Lucr. *DRN* II 1048-89, Epic. *Hdt*. 45); the acceptance of a parallel-linear cosmology, implied in II 184-250, appears to follow automatically from the rejection of the centrifocal alternative, and has a clear counterpart in Epicurus' own writings (e.g. Epic. *Hdt*. 60), while the passage about the earth being supported underneath (cf. Epic. *Phys*. XI fr.42 Arr. and *Hdt.* 73 scholion) in turn follows logically from the acceptance of parallel downward motion. Lucretius' centrifocal cosmogony, on the other hand, appears to be an isolated passage, unconnected (as far as its *centrifocal* character is concerned) with what comes before or after and unparalleled in the remaining works and fragments of any other Epicurean. Lucretius' use of centrifocal terminology in two astronomical passages does not constitute a real parallel, because – except for the terminology – the theories they expound in no way require or imply a centrifocal downward motion (as Lucretius' *cosmogony* does). The aberrant terminology in these passages must probably be attributed to the sources from which Epicurus and Lucretius borrowed these astronomical theories. We can safely assert, therefore, that Epicurus' and Lucretius' cosmology was parallel-linear. The only real obstacle to this view is Lucretius' cosmogony, which may represent a later development (within or outside the circle of Epicurus' followers) which somehow made its way into Lucretius' otherwise orthodox account of Epicurean physics.

2. Does parallel downward motion imply a flat earth?

Parallel downward motion seems to imply a flat earth, and centripetal motion a spherical one. Underlying both implications is the assumption that heavy objects everywhere fall at right angles to the earth's surface (see the illustrations on p.162 above). Although the assumption seems obvious there is no cogent logical reason for accepting it, and there is no evidence that the Epicureans felt bound by it, or else they would have simply concluded that the

earth is flat in the context of one of their passages dealing with the direction of downward motion. It cannot, therefore, be taken for granted that the Epicureans' commitment to parallel downward motion implies belief in a flat earth.

3. Do the Epicurean views on astronomy presuppose a flat earth?

If the Epicurean views on the shape of the earth cannot be simply inferred from their conception of downward motion, we shall have to look for other clues that are independent of this assumption. Several such clues can be found in passages dealing with astronomical matters. Here too, however, the evidence is ambiguous. The following passages seem to imply or presuppose a flat earth:

a) IV 404-413: the way the sun's distance is described in terms of intervening lands and seas suggests that Lucretius was thinking of a flat earth, with the sun rising not too far past its easternmost extremity. However, as independent evidence of the Epicureans' position this passage does not count for much: most likely it is simply the poet's picturesque way of conveying to the reader the enormous distance of the Sun, without implying any doctrinal stance concerning the shape of the earth.

b) V 204-5: Lucretius mention of three climatic regions must be considered either a reference to the antiquated theory that the earth's disk is divided into three climatic strips, or to the untheoretical observation which underlies both this old theory and the new five-zone theory. In the first case these lines would imply a belief in a flat earth, in the second case they are neutral with respect to the earth's shape. Accordingly the passage cannot be used as evidence for the Epicureans' commitment to either shape of the earth.

c) V 564-613 & Epic. *Pyth*. 6 [91]: according to Furley, the Epicureans' preoccupation with the (small) size of the sun and the other heavenly bodies was partly motivated by their wish to incorporate the observation that the aspect of the sky changes with the observer's latitude into their own flat-earth cosmology. Although Furley's suggestion is very attractive, I don't think it can be maintained. In the first place it is not certain that the Epicureans really claimed the sun and the other heavenly bodies to be very small,[577] secondly, if the sun's small size had been so important to the Epicureans one would have expected them to take heed of it in other contexts as well, which they did not (see below), and, thirdly, the small size of the sun and the other heavenly bodies only accounts for some aspects of the mentioned phenomena (notably those underlying 'proofs 4' and '5': see below), while ignoring the rest. However, with Furley's interpretation out of the way there is no further reason

[577] See n.543 on p.214 above.

to connect Epicurus' theory about the size of the heavenly bodies with his views concerning the shape of the earth.

d) V 650-704 & Epic. *Pyth.* 7 [92]: the theory that the sun is extinguished at sunset and rekindled at sunrise implies that sunset and sunrise are simultaneous for everyone on earth, which in turn implies that the earth is flat. This, then, is the first and only passage that clearly and unequivocally points to a flat earth. However, since this is only one of two possible explanations for sun's setting and rising, the only valid conclusion is that the earth *may* be flat, not that it definitely *is* flat.[578]

By contrast, the following passages seem to presuppose or imply a spherical earth:

e) V 762-70 (cf. Epic. *Pyth*. 13 [96-97]): the theory that the moon is eclipsed by falling into to the earth's *conical* shadow seems to imply both that the earth is spherical and that the sun is larger than the earth. As with the previous case it must be noted that this theory is only one of several possible explanations, and that therefore the only warranted conclusion is that the earth *may* be spherical and the sun *may* be larger than the earth, not that they definitely are. Yet, even if we assume this explanation of lunar eclipses to be correct, the earth's sphericity does not necessarily follow: a conical shadow can be produced by any shape that presents a circular outline to the sun, even a flat disk or oval, and the number of possible, non-spherical shapes increases dramatically if 'cone' is interpreted in a loose sense. The second implication, that the sun may be larger than the earth, concerns us only in so far as it contradicts the Epicureans' supposed claim that the sun is very small, and hence Furley's theory that the small size of the sun played a role in reconciling certain astronomical observations with their own flat earth cosmology (see item c above). In short, the present passage has no real implications for the shape of the earth as such, but it provides further confirmation that, whatever shape the Epicureans did ascribe to the earth, astronomical observations played no role (see also below).

f) VI 1107: this line may be an allusion to the fact that the celestial north pole stands lower in the sky for an observer in Egypt than for observers in more northerly countries, a fact that was used by others as a proof ('proof 4': see below) of the sphericity of the earth. It must be noted, however, that Lucretius himself does not draw this conclusion.

g) Philodemus *Sign*. xxx 20-27: this is an unmistakable reference to the observation that the length of shadows is not the same everywhere, but depends on the observer's latitude. This observation, too, was used by others

[578] I thank Keimpe Algra for this observation.

as a proof ('proof 5': see below) of the earth's sphericity. It most be noted, however, that Philodemus himself does not link this observation to the shape of the earth.

Once again the evidence appears to be hopelessly ambiguous: while one passage (d) clearly points to the possibility of a flat earth, two others (f and g) seem to imply a spherical one. These passages should not all be given the same weight, though. Whereas the first passage presents us with an explicit account of a possible theory in the context of Lucretius' explanation of astronomical problems, and is parallelled, moreover, by a similar account in Epicurus *Letter to Pythocles*, both other passages are mere allusions to astronomical observations – neither of them mentioned by Epicurus – in contexts where they are not themselves at issue. Besides, as Furley has shown, both observations could in fact be accommodated to a flat earth if the celestial north pole and the sun are assumed to be relatively close-by. All this leaves us with just one passage that clearly indicates the possibility of a flat earth: the theory that the sun is extinguished at sunset and rekindled at sunrise excludes any other shape. Yet, this one passage, which not even states but only implies that the earth may be flat, does not warrant the conclusion that the Epicureans were firmly committed of the earth's flatness.

4. Why did the Epicureans hold on to the claim that the earth is flat?

If neither their theories concerning the direction of downward motion nor their astronomical views allow us to ascribe to the Epicureans the firm conviction that the earth is flat, this question – at least in its present form – becomes meaningless. A better question would be: why did the Epicureans not reject the possibility that the earth is flat. This question I will try to answer in the final paragraph of this section.

5. Were they familiar with contemporary astronomy?

This question has been sufficiently answered by Furley,[579] who points to Epicurus' dealings with contemporary mathematical astronomers and their theories in book XI of his *On nature*. To this may be added the many unmistakable references to individual astronomical theories in Epicurus' *Letter to Pythocles* and book V of Lucretius' *DRN*.[580] It is clear, then, that the Epicureans were familiar, at least to a certain extent, with the theories of contemporary astronomy.

[579] Furley (1996) 120-1.
[580] See p.39ff above.

6. Did they know of the astronomical arguments for the earth's sphericity and put up a reasoned defence of their own position?

Whether or not the Epicureans were really convinced of the earth's flatness, it is still relevant to ask to what extent they were aware of, and dealt with, the astronomial proofs for the earth's sphericity. Below I will discuss one by one the seven proofs distinguished on p.154ff above:

1. The convexity of the earth's shadow during a lunar eclipse.

As Furley points out, this observation can be accounted for by many other shapes besides a sphere, including a flat disk. It is possible that the ancients realized this too, for after Aristotle no one else adduced this proof. Consequently, Epicurus and Lucretius cannot be blamed for ignoring it.

2. Observations of, and from, departing and approaching ships.

There are no records of this proof before the time of Strabo (64 BC - 24 AD), whose work postdates both Epicurus and Lucretius. Therefore, Epicurus and Lucretius cannot be blamed for ignoring it.

3. The aspect of the sky varying with latitude.

This proof was first reported by Aristotle and remained popular ever since. If Epicurus and Lucretius were serious about defending a specific view concerning the shape of the earth they could hardly afford to ignore this proof. Furley remarks that observations of this kind could in fact be reconciled with a flat earth if the heavenly bodies are assumed to be relatively close-by, like paintings on a ceiling, and he suggests that Epicurus' concern to prove that the sun and the other heavenly bodies are very small was partly motivated by his wish to uphold his own flat-earth theory in the face of such observations. However, while Furley's model can explain why from different latitudes heavenly bodies are observed at different angles, it fails to account for the fact that at certain latitudes certain stars are completely blocked from view. Moreover, Furley's theory is contradicted by the Epicureans' acceptance of the possibility that the moon is eclipsed by falling into the earth's conical shadow – a theory which presupposes that the sun is *larger* than the earth. Anyway, there is no independent evidence that Epicurus or Lucretius or any other Epicurean was aware of the observations underlying this proof (except for the special cases singled out as 'proof 4' and 'proof 5') and of their possible implications for the shape of the earth.

4. The elevation of the celestial north pole varying with latitude.

Although this proof cannot be dated with any certainty before the time of Hipparchus (ca. 190-120 BC), there is every chance that it is much older, being a special case of 'proof 3' and analogous in structure to 'proof 5'. The observations involved in this proof are probably alluded to by Lucretius in VI 1107, although there is no indication that he was aware of their possible

implications for the shape of the earth. In this case Furley's painted-ceiling model shows how such observations could be reconciled with a flat earth, but again there is no evidence that the Epicureans were committed to such a model in any way.

5. The length of shadows varying with latitude.

This proof can be dated to at least as early as Pytheas (ca. 325 BC). The observations involved in this proof are alluded to by the later Epicurean Philodemus (ca. 110 – ca. 40 BC), in a way that suggests that he as well as his audience were familiar with them, although he makes no reference to their possible implications for the shape of the earth. In this case, too, the observations could be made to agree with a flat earth using Furley's painted ceiling model.

6. The maximum day-length varying with latitude.

This proof, too, must have been known to Pytheas (ca. 325 BC), and so could have been known to Epicurus. If, therefore, Epicurus was at all serious about defending his own views concerning the shape of the earth, he should have taken note of this proof. Instead, however, by accepting the possibility that the sun is extinguished at sunset and rekindled at sunrise, Epicurus and Lucretius betray their ignorance of the observations underlying this proof.

7. Longitudinal time difference established by eclipses.

This proof cannot be dated with any certainty before the time of Hipparchus (ca. 190-120 BC), and so Epicurus may not have known it. Anyway, as with the previous proof, the theory of solar extinction and rekindling clearly shows that both Epicurus and Lucretius must have been ignorant of the observations relating to this proof.

In sum, there is no evidence that Epicurus was aware of any of the ancient proofs of the earth's sphericity, let alone that he did anything to invalidate them. On the contrary, we have positive evidence that he was either unaware of, or chose to ignore, the observations underlying one of these proofs: 'proof 6' (not counting 'proof 7', which may have been unknown at the time). Lucretius appears to have been vaguely aware of the observations underlying 'proof 4' and Philodemus was clearly familiar with those underlying 'proof 5', but neither of them mentions, let alone accepts or rejects, the implications of these observations for the shape of the earth.

This flat earth of the Epicureans turns out to be rather elusive. Epicurus and his followers never said that the earth is flat. Even their most ardent ancient critics never accused them of saying so. It is true that they assumed a parallel downward motion (with the curious exception of Lucretius' cosmogony, but this is another story), but they did not infer from this, as their predecessors had, that the earth is flat. Even their astronomical theories at best imply the

possibility that the earth is flat, but nothing more certain than that. It would seem then that the Epicureans had no firm conviction as to the shape of the earth: just like the cosmos the earth might have any shape.[581] Such a conclusion would also explain their indifferent attitude towards the astronomical proofs of the earth's sphericity: they might accept some of the observations underlying these proofs, but the 'proofs' themselves depend on preconceived models, which vainly pretend to capture the essence of the phenomenon they are meant to explain, when other explanations agree with the appearances just as well, and this – agreement with the appearances – is the Epicureans' sole test of truth in non-evident matters, such as the shape of the earth.[582]

[581] Cf. Woltjer (1877) 123, quoting Epic. *Hdt.* 74 with scholion: "Non perspicuum est quam formam terrae tribuerit poeta, quam Stoici sphaeram esse contendebant. Epicurus de mundorum forma dixit: ἔτι δὲ καὶ τοὺς κόσμους οὔτ' ἐξ ἀνάγκης δεῖ νομίζειν ἕνα σχηματισμὸν ἔχοντας, ἀλλὰ καὶ διαφόρους αὐτούς, οὓς μὲν σφαιροειδεῖς, οὓς δ' ᾠοειδεῖς καὶ ἀλλοσχήμονες ἄλλους· οὐ μέντοι πᾶν σχῆμα ἔχειν. Ergo *potest* terra sphaericam habere formam …"

[582] See Chapter 1, esp. p.13f, p.17f and p.51f.

GENERAL CONCLUSIONS

In this work I have conducted three more or less independent studies relating to Epicurean cosmology. Below I will briefly set out the main arguments and conclusions of each chapter.

In chapter one I have examined Epicurus' method of multiple explanations from several different perspectives. First I dealt with the view that Epicurus held every alternative explanation to be true at the same time. This view seems to follow from Epicurus' claim that non-contestation establishes truth and his use of non-contestation to support each one of his alternative explanations. However, although the inference seems to be sound, and Epicurus may have actually asserted the truth of alternative explanations, in fact this claim holds good only insofar as the phenomenon under consideration is viewed as an instance of a general type, and only insofar as the explanations are safe from being falsified by closer observation, and even then Epicurus does not seem to set much value on this *truth*, for when it comes to proving the fundamental physical theories only *singular truths* qualify. Then I argued that Diogenes of Oenoanda's claim that some explanations are more plausible than others is a departure from Epicurus and Lucretius for whom all alternative explanations have the same truth-value, and I suggested that Diogenes may have used this licence in order to be able to embrace the findings of contemporary astronomy without actually rejecting Epicurus' multiple explanations. In this connection I also examined Bailey's claim that in astronomy Lucretius usually presents the views of the mathematical astronomers first, and that in doing so he shows his preference for these explanations. It turns out that Bailey's observation is correct but not his interpretation of it. Instead, by presenting these explanations first Lucretius simply acknowledges the predominant position of these explanations among his audience, a predominance which he sets out to undermine by showing that other explanations are equally possible. Next, I pointed out the importance of doxography as a source for individual explanations. Finally, I argued that Aristotle's and Theophrastus' occasional use of multiple explanations and their epistemological justifications for this use are far removed in several respects from the method of multiple explanation as applied by Epicurus, but may have been its inspiration. In this context I also pointed out that the pervading use of multiple explanations in the *Syriac meteorology*, a meteorological treatise preserved in Syriac and Arabic and ascribed to Theophrastus, while closely resembling Epicurus' method, is very distant from the occasional use of multiple explanations in the uncontested works of Theophrastus.

In chapter two I compared Epicurus' *Letter to Pythocles* and Lucretius' *DRN* VI with a number of meteorological works as to the range and

subdivision of subjects included and as to the order in which these subjects are dealt with. This led me to conclude, among other things, that the range of subjects covered by the *Syriac meteorology* may well be complete (except for the omission of the rainbow), and that the meteorological accounts of Lucretius, Epicurus and the *Syriac meteorology* belong to a tradition, inaugurated by Aristotle, which connected earthquakes with atmospherical phenomena. Comparison of *DRN* VI with a number of meteorological and paradoxographical works showed that Lucretius' treatment of exceptional local phenomena is unique, and may well be his own invention, rather than being derived from Epicurus. Examining the often observed correspondence in the order of subjecs between the *Syriac meteorology*, book III of Aëtius' *Placita* and book VI of Lucretius' *De rerum natura*, I found that the second part of Epicurus' *Letter to Pythocles* should be taken into consideration as well, and that the order of all four works can be reduced to an original order, from which each of the four texts deviates in its own manner. This reconstructed 'original order' led me in turn to investigate the relations these four texts bear to each other and to this 'original', as far as the order of subjects is concerned. In this connection I also reexamined the *Syriac meteorology*, looking for clues that might link it more closely to either Theophrastus and the Peripatos in general, or Epicurus. It turned out that certain elements exclude an Epicurean origin, at least of the treatise as a whole. This might suggest that the treatise is Theophrastus' after all. It is remarkable, however, that these un-Epicurean elements are concentrated in just a few passages, some of which are of a markedly different character from the rest of the treatise. This, in turn, seems to suggest that the treatise has a mixed origin, mostly Epicurean but with an admixture of Peripatetic views. Based on these two hypotheses I sketched two different scenarios for the relations between the four treatises as regards the order of their subjects. First I argued that the meteorological portions of Epicurus' *Letter to Pythocles* and Lucretius' *DRN* VI both go back to a more extensive account of meteorology by Epicurus, probably part of his magnum opus *On nature*. The relation this work bears to the *Syriac meteorology* depends on our views regarding its identity. If we accept its commonly accepted identification with Theophrastus' *Metarsiology*, it is likely that this work was the main source for Epicurus' meteorological writings and for his use of multiple explanations. If, on the other hand, we take the view that the *Syriac meteorology* is a compendium of mainly Epicurean meteorology, it cannot no longer tell us anything about Epicurus' source, which we might identify with Theophrastus' *Physical opinions* instead. The latter work, from which Aëtius' doxographical work is

supposed to be ultimately derived, may also provide the missing link between Aëtius and the three other works.

In the final chapter I examined the claim, made by many modern scholars, that Epicurus and Lucretius believed the earth to be flat. After a thorough examination of every possibly relevant passage in their works I arrived at the following conclusions. Although the Epicureans assumed a parallel downward motion (with the exception of Lucretius' cosmogony, which may be a *corpus alienum*), they never concluded from this that the earth should be flat. The only theory of the Epicureans that is essentially inconsistent with a spherical earth is their alternative explanation of sunset and sunrise as extinction and rekindling of the sun, which seems to presuppose that sunset and sunrise occur at the same moment fore everyone on earth. Yet, this hardly amounts to a firm conviction that the earth is flat. The Epicureans' silence about the shape of the earth and their failure to deal with the available astronomical evidence for the earth's sphericity, should rather be interpreted as indifference. This is in line with the Epicureans' distrust of astronomical models, as repeatedly expressed in Epicurus' *Letter to Pythocles* and the fragments of book XI of his *On nature*.

Although the three studies that make up this dissertation are essentially independent, they are connected by several recurrent themes. One such theme, common to Chapters One and Two (pp.64ff and p.132ff respectively), is the authorship and identity of the *Syriac meteorology*. Another theme, also common to Chapters One and Two, is Lucretius' explanation of exceptional local phenomena, which stand out from ordinary meteorological occurrences in several respects: firstly by their uniqueness and – in some cases – their relative accessibility to sense-perception (see p.27f), and secondly because they do not feature in Epicurus' *Letter to Pythocles*, and whenever they are referred to in other meteorological or paradoxographical works, are generally left unexplained (see p.99ff). A third theme, common to Chapters One and Three, concerns the Epicureans' attitude to mathematical astronomy: their mistrust of physical and conceptual models as a means to arrive at the exclusive truth of hypotheses, and their persistent habit of considering every phenomenon in isolation, instead of combining their accounts into unified theories and so weed out impossible individual explanations. While in Chapter One this aspect of Epicurean explanations is addressed in general, Chapter Three provides a number of instances, e.g. the shape of the earth, the size of the sun, and the sun's nocturnal extinction, where a different attitude towards explaining might have produced quite different results. A fourth theme, common to all three chapters, though rarely stated explicitly, regards Lucretius' relation to Epicurus: is the *De rerum natura*, as far as its philosophical content is concerned, based solely on Epicurus' own writings, or

did Lucretius incorporate later intellectual developments as well? In the course of this dissertation three passage present themselves that have been, or could be, viewed as departures or developments from Epicurus. The first is Lucretius' rejection of centripetal downward motion in *DRN* I 1052-93, discussed on p.163ff above. Although its arguments and conclusion agree well with orthodox Epicureanism, it is commonly believed that Epicurus himself did not engage with Stoicism. Attempts to explain the passage as an attack on other philosophers, whom Epicurus could have criticized himself, fail to convince. So, unless we challenge the dogma that Epicurus ignored the Stoics, the passage must be considered post-Epicurean. The second passage is Lucretius' account of a number of exceptional local phenomena in *DRN* VI 608ff, discussed on p.27f and p.99ff above. Although the account is not incompatible with orthodox Epicurean doctrine, it is unlikely that Lucretius should have derived it from Epicurus. The third and final passage is Lucretius' cosmogonical account in *DRN* V 449-508, discussed on p.202ff above. Here at last we have a passage that is incompatible with Epicurean orthodoxy. However, before we start accusing Lucretius of heterodoxy, it must be noted that the passage is also incompatible with passages of Lucretius himself: the cosmogony appears to be a foreign body which Lucretius inadvertently incorporated in his otherwise orthodox account of Epicurean physics.

APPENDIX A: MULTIPLE EXPLANATIONS IN EPICURUS' *LETTER TO PYTHOCLES*

Ch.	Subject	Number of alternative explanations	Possibility	Grammatical conjunctions	Inexhaustivity of the list
1	Introduction	-			
2	Method	-			
3	Defintion of 'cosmos'	-			
3a	*motion of its boundary*	2	ἐνδέχεται	ἢ A ἢ B	-
3b	*shape of its boundary*	2+	ἐνδέχεται	ἢ A ἢ B	ἢ οἷαν δήποτε ...
4	Number and origin of cosmoi	1			
5	Formation of the heavenly bodies	1			
6	Size of the heavenly bodies	1			
7	Risings and settings	2	δύνασθαι	καὶ A ⟨καὶ⟩ B	-
8	Motions of the heavenly bodies	3	οὐκ ἀδύνατον	A ἢ B, εἶτα Γ	-
9	Turnings of the sun and moon	4(+)	ἐνδέχεται	A, ὁμοίως δὲ καὶ B ἢ καὶ Γ ἢ καὶ Δ	πάντα τὰ τοιαῦτα καὶ τὰ τούτοις συγγενῆ ...
10	Phases of the moon	3+	δύναιντ' ἂν	καὶ A καὶ B, ἔτι τε καὶ Γ	καὶ κατὰ πάντας τρόπους ...
11	Light of the moon	2	ἐνδέχεται	ἐνδέχεται ⟨μὲν⟩ A, ἐνδέχεται δὲ B	-
12	The face in the moon	2+	δύναται	καὶ A καὶ B	καὶ ὅσοι ποτ' ἂν τρόποι ...
13	Eclipses of sun and moon	2	δύναται	καὶ A καὶ B	-
14	The regularity of the periods	1			
15	Length of nights and days	2	-	καὶ A ⟨καὶ⟩ B	-
16	Weathersigns	2	δύνανται	καὶ A καὶ B	-
17A	Clouds	3+	δύναται	καὶ A καὶ B καὶ Γ	καὶ κατ' ἄλλους δὲ τρόπους πλείους ... οὐκ ἀδυνατοῦσι ...
17B	Rain	3	δύναται	ᾗ μὲν A, ᾗ δὲ B, ἔτι τε Γ	-
18	Thunder	5	ἐνδέχεται	καὶ A καὶ B καὶ Γ καὶ Δ καὶ E	-
19	Lightning	8+	-	καὶ A καὶ B καὶ Γ καὶ Δ ἢ E ἢ Z καὶ H καὶ Θ	καὶ κατ' ἄλλους δὲ πλείους τρόπους ...
20	Why lightning precedes thunder	2	-	καὶ A καὶ B	-
21	Thunderbolts	2+	ἐνδέχεται	καὶ A καὶ B	καὶ κατ' ἄλλους δὲ τρόπους πλείονας ἐνδέχεται...

Ch.	Subject	Number of alternative explanations	Possibility	Grammatical conjunctions	Inexhaustivity of the list
22	Whirlwinds	2	ἐνδέχεται	καὶ A καὶ B	-
23	Earthquakes	2+	ἐνδέχεται	καὶ A ⟨καὶ⟩ B	καὶ κατ' ἄλλους δὲ πλείους τρόπους ...
24	Subterranean winds	3	-	A καὶ B, τὸ δὲ λοιπὸν Γ	-
25(a)	Hail	2	-	καὶ A καὶ B	-
25(b)	Round shape of hailstones	2	οὐκ ἀδυνάτως εχει	A καὶ B	-
26	Snow	3+	ἐνδέχεται	καὶ A καὶ B καὶ Γ	καὶ κατ' ἄλλους δὲ τρόπους ἐνδέχεται ...
27A	Dew	2	-	καὶ A καὶ B	-
27B	Hoar-frost	1 (?)			
28	Ice	2	-	καὶ A καὶ B	-
29(a)	The rainbow	2	-	A ἢ B	-
29(b)	Round shape of the rainbow	2	-	A ἢ B	-
30(a)	The halo around the moon	3	-	[καὶ] A ἢ B ἢ καὶ Γ	-
30(b)	Circumstances leading to a halo	2	-	ἤτοι A ἢ B	-
31	Comets	3	-	ἤτοι A ἢ B ἢ Γ	-
32	Revolution of the stars	3+	-	οὐ μόνον A, ἀλλὰ καὶ B, ἢ καὶ Γ	καὶ κατ' ἄλλους δὲ πλείονας τρόπους τοῦτο δυνατὸν ...
33	Planets	2	ἐνδέχεται	ἐνδέχεται μὲν καὶ A, ἐνδέχεται δὲ καὶ B	-
34	Lagging behind of certain stars	3	-	καὶ A καὶ B καὶ Γ	-
35	Shooting stars	3+	δύνανται	καὶ A καὶ B καὶ Γ	καὶ ἄλλοι δὲ τρόποι ... εἰσιν.
36	Weathersigns from animals	1			
37	Conclusion				

APPENDIX B: MULTIPLE EXPLANATIONS IN LUCRETIUS' *DRN V* AND *VI*

Multiple explanations in *DRN* V 509-770 (on astronomy)		
Lines	**Subject**	**Number of explanations**
509-533	1. Motions of the stars	5
534-563	2. Immobility of the earth	1
564-591	3. Size of the sun, moon and stars	1
592-613	4. Source of the sun's light and heat	3
614-649	5. Turnings of the sun, moon and planets	2
650-655	6. Causes of nightfall	2
656-679	7. Causes of dawn	2
680-704	8. Varying lengths of day and night	3
705-750	9. Phases of the moon	4
751-761	10. Solar eclipses	3
762-770	11. Lunar eclipses	3

Multiple explanations in *DRN* VI (on meteorology)		
Lines	**Subject**	**Number of explanations**
96-159	Thunder	9
160-218	Lightning	4
219-422	Thunderbolts	5
423-450	Whirlwinds (*prēstēres*)	2
451-494	Clouds	5
495-523	Rain	3
524-526	Rainbow	-
527-534	Snow, wind, hail, hoar-frost, ice	-
535-607	Earthquakes	4
608-638	Constant size of the sea	5
639-702	Etna	1 (+ 1 subsidiary expl.)
712-737	The Nile flood	4
738-839	Poisonous exhalations	2
840-847	Temperature in wells	1
848-878	Spring of Hammon	1 (+ 1 subsidiary expl.)
879-905	Spring which kindles tow	1
906-1089	Magnets	1 (+ 2 subsidiary expl.)
1090-1286	Diseases	2

APPENDIX C: GENERAL STRUCTURE OF THE *SYRIAC METEOROLOGY*

Loc.	Subject	Number of explanations
1	Thunder	
1.2-23	*Causes of thunder*	7
1.24-38	*How clouds can produce noise*	1
2	Lightning	4
3	Thunder without lightning	3
4	Lightning without thunder	2
5	Why lightning precedes thunder	2
6	Thunderbolts	
6.2-9	*Their nature*	*1*
6.10-16	*Their fineness and penetration*	*1*
6.16-21	*Their causes*	*2*
6.21-28	*Necessary conditions*	*2*
6.28-36	*Their escape from the cloud*	*2*
6.36-41	*Reasons for their downward motion*	*2*
6.41-67	*Why clouds burst at the bottom*	*1 (+ 1 subsidiary expl.)*
6.67-74	*Why they are more frequent in spring*	*1*
6.74-85	*Why more frequent in high places*	*2*
6.85-91	*Their effects*	*1*
7	Clouds	
7.2-5	*Causes of clouds*	*2*
7.5-9	*Causes of air condensation*	*2*
7.9-27	*Reasons for the clouds floating on air*	*3*
7.27-29	*Causes of clouds turning into water*	*2*
8	Rain	
8.2	*Causes of heavy rain*	*1*
8.3-4	*Causes of continuous rain*	*1*
9	Snow	
9.2-8	*Causes of snow*	*2*
9.8-11	*Reasons for the whiteness of snow*	*1*
10	Hail	
10.2-3	*Causes of hail*	*1*
10.3-6	*Causes of the hailstone being round*	*3*
11	Dew	1
12	Hoar-frost	
12.2	*Causes of hoar-frost*	*1*
12.2-6	*Reasons for the whiteness of hoar-frost*	*1*

Loc.	Subject	Number of explanations
13	Winds	
13.2-3	*Their nature*	*1*
13.3-6	*Their origin (from above and below)*	*3*
13.7-18	*Wind from below*	*1*
13.18-21	*Wind from above*	*2*
13.21	*Wind moving sideways*	*1*
13.22	*Causes of strong winds*	*1*
13.23	*Causes of continuous winds*	*1*
13.24-27	*Causes of hot and cold winds*	*2*
13.27-32	*Winds arising from high and low places*	*1*
13.33-42	*The wind called 'WRS (Euros ?)*	*2*
13:43-54	*The prēstēr*	
(43-45)	Its nature	1
(45-47)	Its causes	2
(47-54)	Its effects on ships	2
14	Halo	
14.2-13	*Account of the halo*	*1*
14.14-29	*Thunderbolts not the work of God*	-
15	Earthquakes	
15.2-16	*Causes of earthquakes*	*4*
15.16-21	*Influence of wind*	*1*
15.22-25	*Why some places don't have earthquakes*	*3*
15.26-35	*Types of earthquakes*	*3*

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SAMENVATTING

Volgens de in de oudheid gangbare definities was de *kosmos* een geheel bestaande uit de hemel (een holle bol waarop de sterren zaten vastgepind), de aarde en alles daartussenin. De studie van de *kosmos*, die wij nu met een modern woord *kosmologie* noemen, omvatte niet alleen zaken die de kosmos als geheel betreffen, maar ook astronomische en meteorologische verschijnselen. Met deze tak van de natuurfilosofie hebben ook Epicurus (341-270 v.C.) en zijn volgelingen, de Epicureeërs, zich bezig gehouden.

Van de talrijke geschriften van Epicurus zelf resteren tegenwoordig nog slechts een paar samenvattende werken; de belangrijkste voor dit onderzoek zijn de *Brief aan Herodotus*, over de grondslagen van de Epicureïsche fysica, en de *Brief aan Pythocles*, over astronomische en meteorologische kwesties.[*] Daarnaast beschikken we over verkoolde papyrus-fragmenten van delen van zijn werken (met name zijn magnum opus *Over de natuur*), en verder nog citaten en testimonia bij latere auteurs. De belangrijkste en meest gedetailleerde bron voor onze kennis van het Epicurisme is echter het Latijnse leerdicht *De rerum natura* ('Over de natuur der dingen') van de Romeinse dichter-filosoof Lucretius (ca. 99-55 v.C.), waarin met name de natuurfilosofie van Epicurus uitgebreid wordt behandeld.[**] Andere Epicureïsche auteurs die in dit onderzoek worden genoemd zijn Philodemus (ca. 110-40 v.C.) en Diogenes van Oenoanda (2^{e} eeuw n.C.). De eerste was gevestigd in Herculaneum in Zuid-Italië, waar zijn bibliotheek, die gevuld was met zijn eigen en andere Epicureïsche werken, inclusief enkele van Epicurus zelf, in 79 n.C. door een uitbarsting van de Vesuvius is verwoest en geconserveerd; met moderne technieken en grote toewijding heeft men uit de verkoolde resten nog vele fragmenten kunnen ontcijferen en reconstrueren. De tweede is de auteur en opdrachtgever van een enorme filosofische inscriptie te Oenoanda, in Zuidwest-Turkije, waarvan nog vele brokstukken bewaard zijn en kunnen worden gelezen.[***]

De dissertatie die voor u ligt bestaat uit drie min of meer onafhankelijke studies naar verschillende aspecten van de Epicureïsche kosmologie (volgens

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[*] Deze beide brieven, tezamen met de *Brief aan Menoeceus*, de *Authentieke leerstellingen* en de *Vaticaanse leerstellingen*, zijn vertaald door Keimpe Algra, in *Epicurus, Over de natuur en het geluk*, Historische Uitgeverij, Groningen 1998, ISBN 90 6554 291 4.

[**] Lucretius' leerdicht is recent vertaald door Piet Schrijvers, in *Lucretius, De natuur van de dingen*, Historische Uitgeverij, Groningen 2008, ISBN 90 6554 424 7.

[***] Een uitgebreide selectie uit de fragmenten van Diogenes' inscriptie is vertaald door Simone Mooij-Valk, in *Diogenes van Oinoanda, Levenslessen in steen*, Styx Publications, Groningen 2000, ISBN 90 5693 037 0.

bovenstaande definitie) zoals die naar voren komt in de bovengenoemde werken van Epicurus zelf en van zijn latere volgelingen.

Hoofdstuk 1: Meervoudige verklaring

De eerste studie heeft betrekking op de methode van de meervoudige verklaring. Hiermee wordt de gewoonte van de Epicureeërs bedoeld om voor afzonderlijke astronomische en meteorologische – en bij Lucretius ook enkele wonderbaarlijke 'aardse' – verschijnselen steeds een aantal alternatieve verklaringen te geven. Zo kunnen volgens Epicurus en Lucretius zonsondergang en zonsopgang zowel verklaard worden door de aanname dat de zon 's nachts onveranderd onder de aarde door gaat, als door de veronderstelling dat de zon in het westen uitdooft en dat er de volgende morgen in het oosten een nieuwe zon ontstaat. *Geen* van beide verklaringen wordt, volgens Epicurus, 'door de verschijnselen weerlegd'. Dezelfde of verwante formuleringen vinden we ook bij alternatieve verklaringen voor andere verschijnselen. Nu wil het geval dat deze zelfde uitdrukking, *niet-weerlegging door de verschijnselen*, door Epicurus elders (*Hdt*. 51) als een algemeen criterium voor de waarheid van uitspraken wordt gehanteerd. De conclusie ligt voor de hand: als *niet-weerlegging door de verschijnselen* de waarheid van een uitspraak garandeert, en als bij astronomische en meteorologische verschijnselen verschillende verklaringen de toets van *niet-weerlegging door de verschijnselen* doorstaan, dan moeten die verschillende verklaringen allemaal waar zijn. Hoewel deze conclusie logisch uit de beide premissen voortvloeit, is het toch moeilijk om je voor te stellen hoe verschillende, vaak onderling onverenigbare, verklaringen tegelijkertijd waar zouden kunnen zijn. Een mogelijke oplossing wordt geboden door Lucretius. In *DRN* V 526-33 stelt hij, met betrekking tot een aantal alternatieve verklaringen voor de bewegingen van de sterren aan de hemel, dat in onze wereld weliswaar slechts één verklaring de juiste is – al weten we niet welke – maar dat in de oneindigheid van het heelal alle verklaringen waar zijn. Deze passage wordt over het algemeen uitgelegd als een toepassing van het *beginsel van plenitude* – het beginsel dat, gegeven de oneindigheid van tijd en/of ruimte, alles wat mogelijk is ook verwezenlijkt wordt. Toch is deze oplossing niet zonder problemen. Epicurus' methode van *niet-weerlegging* om uitspraken te toetsen wordt door Sextus Empiricus (*Math*. VII 213-4) uitgelegd als weerlegging van de contradictoire hypothese. Zo bewijst Epicurus het bestaan van lege ruimte door aan te tonen dat de contradictie hiervan, nl. 'lege ruimte bestaat *niet*', onverenigbaar is met het bestaan van beweging, waarvoor immers – althans volgens Epicurus – lege ruimte noodzakelijk is. Deze methode is volkomen anders dan wat Epicurus in zijn *Brief aan Pythocles* onder de term *niet-weerlegging* verstaat, maar komt

precies overeen met de manier waarop in de *Brief aan Herodotus* de fundamentele theorieën van de Epicureïsche fysica worden bewezen (al wordt daar de term *niet-weerlegging* niet genoemd). Het lijkt er dus op dat de uitdrukking *niet-weerlegging* op twee verschillende manieren wordt gebruikt: wanneer het gaat om fundamentele fysische theorieën verstaat Epicurus – althans volgens Sextus Empiricus – onder *niet-weerlegging* de weerlegging van de contradictoire hypothese waaruit dan noodzakelijkerwijs de enkelvoudige waarheid van de uitgangshypothese volgt; wanneer het echter gaat om astronomische en meteorologische opvattingen betekent *niet-weerlegging door de verschijnselen* niet veel meer dan verenigbaarheid met de verschijnselen, een eis waaraan verschillende verklaringen tegelijkertijd kunnen voldoen.

Sommige moderne geleerden nemen daarom aan dat Epicurus twee verschillende vormen van *niet-weerlegging* hanteerde, waarvan de ene dienstdeed als *waarheids*criterium van exclusieve hypotheses, en de andere slechts de *mogelijkheid* aantoonde van elk van een aantal alternatieve verklaringen. Anderen, daarentegen, zijn van mening dat Epicurus maar één vorm van *niet-weerlegging* erkende, namelijk die van verenigbaarheid met de verschijnselen, en dat elke verklaring die deze toets doorstond volgens het *beginsel van plenitude* noodzakelijkerwijs *waar* was; de andere vorm van *niet-weerlegging*, namelijk weerlegging van de contradictoire hypothese, was dan ofwel een speciaal geval van *niet-weerlegging*, waarvan de uitkomsten slechts om die reden *waar* waren, of een methode zonder zelfstandige bewijskracht en daarom geen onafhankelijk waarheidscriterium.

Tussen deze beide posities stel ik een middenweg voor. Epicurus' onvoorwaardelijke claim dat elke *niet-weerlegde* hypothese waar is, moet betrekking hebben op *elke* vorm van *niet-weerlegging;* wanneer meerdere verklaringen deze toets passeren zijn deze dus alle *waar*. Deze gelijktijdige waarheid van verschillende verklaringen kan worden begrepen in het licht van het *beginsel van plenitude*. Tegelijkertijd echter maakt Epicurus een nadrukkelijk onderscheid tussen enkelvoudige en meervoudige verklaringen en eist hij dat de fundamentele theorieën enkelvoudig worden verklaard. Hieruit blijkt dat in de praktijk de ene waarheid toch hoger wordt aangeslagen dan de andere: enkelvoudige, en daarmee universele, waarheden zijn te verkiezen boven meervoudige, en in die zin meer *waar*. Dit blijkt ook hieruit: in de *Brief aan Pythocles* spreekt Epicurus regelmatig over de 'mogelijkheid' van afzonderlijke alternatieve verklaringen, maar nooit over hun 'waarheid'.

In de twee daarop volgende paragrafen bespreek ik de werking en toepassing van *weerlegging* en *niet-weerlegging*. *Weerlegging* blijkt voornamelijk te worden toegepast op verklaringen die een rol toekennen aan de goden, een rol die volgens Epicurus in strijd is met de goddelijke gelukzaligheid. Bij Lucretius zien we een aantal concrete toepassingen van deze *weerlegging*.

Terwijl strijdigheid met de verschijnselen automatisch leidt tot verwerping van een verklaring, is strijdigheid met verklaringen voor andere verschijnselen geen reden voor verwerping. *Niet-weerlegging* is meer dan de afwezigheid van *weerlegging:* het is de zekerheid dat de betreffende verklaring nooit weerlegd zal worden. Deze zekerheid wordt bereikt door analogie van het te verklaren hemelverschijnsel met de verschijnselen om ons heen. De vele concrete analogieën die Lucretius geeft in de astronomische en meteorologische passages van zijn werk dienen dus primair om de mogelijkheid van de betreffende verklaringen aan te tonen.

Een ander onderwerp dat in dit hoofdstuk aan bod komt is de bewering van Diogenes van Oenoanda dat van verschillende alternatieve theorieën de ene *waarschijnlijker* is dan de andere, een bewering waarvoor bij andere Epicureeërs geen parallellen te vinden zijn. Een mogelijke verklaring voor Diogenes' eigenzinnige beroep op waarschijnlijkheid is zijn wens om zich, zonder Epicurus helemaal af te vallen, toch aan te sluiten bij de algemeen aanvaarde sterrenkundige theorieën.

Aansluitend ga ik in op Bailey's bewering dat Lucretius, door bij de bespreking van sterrenkundige kwesties de theorieën van de mathematische astronomen vaak als eerste te vermelden, blijk zou geven van een heimelijke voorkeur voor deze theorieën. Nauwkeurig onderzoek van de betrokken passages laat echter een heel ander motief zien: door deze theorieën voorop te plaatsen verraadt Lucretius niet zozeer zijn eigen voorkeur als wel de bevoorrechte positie van deze verklaringen bij zijn tijdgenoten en dus ook bij zijn beoogde publiek: uitgaande van de op dat moment bijna universeel aanvaarde opvattingen betoogt Lucretius dat deze geen zekerder basis hebben dan een aantal alternatieve verklaringen die hij ertegenover stelt.

Vervolgens ga ik in op de relatie van Epicurus' en Lucretius' alternatieve verklaringen met doxografie, d.w.z. lijsten van opvattingen van vroegere filosofen gerangschikt per onderwerp, zoals die te vinden zijn in de werken van o.a. Aristoteles en Theophrastus, en als zelfstandig genre bij Aëtius. De belangrijkste aanwijzingen voor zo'n relatie zijn de vrijwel zekere doxografische herkomst van *DRN* I 635-920, waar de opvattingen van Heraclitus, Empedocles en Anaxagoras worden bestreden, en de grote mate van overeenkomst in de volgorde van onderwerpen tussen boek III van het doxografische werk van Aëtius enerzijds en boek VI van Lucretius' *De rerum natura* en de tweede helft (vanaf hoofdstuk 17) van Epicurus' *Brief aan Pythocles* anderzijds.

Tenslotte behandel ik enkele auteurs en werken die als inspiratiebron of voorbeeld voor Epicurus' methode van meervoudige verklaring kunnen hebben gediend. Hoewel de Epicureïsche fysica grotendeels teruggaat op Demo-

critus, en hoewel deze voor aardbevingen een aantal alternatieve verklaringen schijnt te hebben gegeven, zijn er geen aanwijzingen dat Democritus ook voor andere problemen gebruik maakte van meervoudige verklaring, laat staan dat hij daarvoor een consequente epistemologische onderbouwing had. Interessanter in dit verband zijn Aristoteles en Theophrastus. Bij beiden vinden we gevallen van meervoudige verklaring, en beiden verwijzen in dit verband soms ook naar analogieën met verschijnselen hier bij ons. Toch moeten de verschillen niet worden onderschat. Bijvoorbeeld, wanneer het gaat om niet-evidente verschijnselen, d.w.z. verschijnselen die wij niet of slechts beperkt en van een grote afstand kunnen waarnemen, zoals in de astronomie en meteorologie, maken Epicurus en Lucretius bijna standaard gebruik van meervoudige verklaringen, waarbij het aantal alternatieven kan oplopen tot wel acht of negen. Daarentegen is het aanbieden van meerdere verklaringen bij Aristoteles en Theophrastus eerder uitzondering dan regel, en gaan zij zelden verder dan twee alternatieven. En terwijl Lucretius zijn alternatieve verklaringen, vooral op het gebied van de meteorologie, vaak ondersteunt met verwijzingen naar analoge verschijnselen uit onze directe ervaring (dit geldt in veel mindere mate voor Epicurus' *Brief aan Pythocles*, waarschijnlijk vanwege het samenvattende karakter ervan), maken Aristoteles en Theophrastus maar zelden gebruik van analogieën bij hun alternatieve verklaringen. En, tenslotte, terwijl de meeste alternatieve verklaringen bij Epicurus en Lucretius ontleend lijken te zijn aan eerdere denkers, zijn de alternatieve verklaringen bij Aristoteles en Theophrastus dat meestal niet.

In de bovenstaande beschouwing heb ik één werk, dat tegenwoordig vrijwel zonder uitzondering aan Theophrastus wordt toegeschreven, *niet* meegerekend. Het gaat om een meteorologisch werk dat in een Syrische en twee Arabische versies bewaard is gebleven en dat in de handschriften wordt aangeduid als een 'verhandeling over verheven verschijnselen, door Theophrastus'. Terwijl in zijn overige werken Theophrastus, zoals boven vermeld, maar beperkt gebruik maakt van meervoudige verklaringen, past deze *Syrische meteorologie*, zoals ik haar verder zal noemen, meervoudige verklaringen toe op een manier die in alle opzichten meer aan Epicurus en Lucretius dan aan Theophrastus doet denken. Om die reden is wel eens gesuggereerd dat niet Theophrastus maar Epicurus de auteur zou zijn, maar die suggestie is nooit verder onderzocht. Voor de vraag naar de bronnen van Epicurus' methode van de meervoudige verklaring is het auteurschap van dit werk van groot belang: als het werk toch van Theophrastus is, moet deze als de eigenlijke grondlegger van de methode worden beschouwd, maar als het op de een of andere manier voortkomt uit het werk van Epicurus zelf, mogen we Theophrastus op grond van zijn overige werken hoogstens als inspiratiebron

en voorbeeld beschouwen. In het volgende hoofdstuk kom ik daarom terug op het auteurschap van de *Syrische meteorologie*.

Hoofdstuk 2: Epicurus & Lucretius en de stof en structuur van de antieke meteorologie

Een belangrijk deelgebied van de kosmologie is de meteorologie, die het onderwerp is van het zesde boek van Lucretius' *De rerum natura*, en van de tweede helft van Epicurus' *Brief aan Pythocles*. Hoewel een groot deel van de onderwerpen die Lucretius en Epicurus hier behandelen hetzelfde is – donder, bliksem, wolken, regen, sneeuw, hagel, etc. – is de overlap niet volkomen. Bij Epicurus sluiten de meteorologische hoofdstukken zonder enige overgang aan op de astronomische, bij Lucretius is meteorologie uitgebreid met een bespreking van 'aardse', vaak uitzonderlijke en plaatselijke, verschijnselen. Een vergelijkbare variatie in de afbakening van de stof zien we door de hele antieke meteorologische literatuur. Soms wordt de stof nog verder onderverdeeld, en ook daarin is variatie. Tenslotte variëert ook nog eens de volgorde waarin de meteorologische onderwerpen worden gepresenteerd. Het tweede hoofdstuk van mijn dissertatie is gewijd aan deze verschillen en overeenkomsten in de afbakening, onderverdeling en volgorde van onderwerpen in de antieke meteorologische literatuur. Een min of meer volledig en samenhangend overzicht van de meteorologie wordt geboden door de volgende werken:

- Aristoteles, *Meteorologie,* boeken I-III
- [Aristoteles], *De mundo,* hoofdstuk 4
- Aëtius, *Placita*, boek III (+ IV 1)
- Plinius, *Naturalis Historia*, boek II, §§89-248
- Seneca, *Naturales Quaestiones*
- De Stoïcijnen volgens Diog. Laërt. VII 151-4
- De *Syrische meteorologie*
- Epicurus, *Brief aan Pythocles*, 16 e.v. [98 e.v.]
- Lucretius, *De rerum natura*, boek VI

Allereerst geef ik in een grote tabel (zie p.91) van elk van deze werken aan welke onderwerpen zij behandelen, hoe zij de meteorologie afbakenen ten opzichte van andere terreinen van de kosmologie (m.n. astronomie) en hoe zij, indien van toepassing, de stof verder onderverdelen. Uit deze tabel kunnen allerlei conclusies worden getrokken maar in dit verband gaat het met name om Epicurus en Lucretius, maar ook, vanwege de grote inhoudelijke verwantschap met deze twee werken, om de *Syrische meteorologie*. De belangrijkste conclusies met betrekking tot deze drie werken zijn de volgende:

(1) Anders dan vaak wordt verondersteld zou de Syrische meteorologie, afgezien van het ontbreken van de regenboog, heel goed compleet kunnen zijn. Voor de afwezigheid van kometen en vallende sterren biedt Lucretius VI een parallel, terwijl het ontbreken van 'aardse' verschijnselen – afgezien van aardbevingen – kan worden vergeleken met zowel Epicurus' *Brief aan Pythocles* als het overzicht van Stoïsche meteorologie bij Diogenes Laërtius.

(2) Bij de Stoïcijnen worden aardbevingen behandeld onder de noemer van atmosferische verschijnselen omdat ze, net als bij Aristoteles, veroorzaakt zouden worden door onderaardse wind. Hoewel deze ene verklaring in de *Syrische meteorologie* en de *Brief aan Pythocles* wordt aangevuld met een aantal alternatieve theorieën, verraden beide teksten door de plaatsing van het hoofdstuk over aardbevingen hun afhankelijkheid van een traditie waartoe ook de Stoïcijnse meteorologie behoort en die teruggaat op Aristoteles' *Meteorologie*.

(3) Bij Lucretius kan erover getwist worden of aardbevingen nog tot de voorafgaande atmosferische, of de erop volgende aardse, verschijnselen behoren. Een vergelijking met Epicurus' *Brief aan Pythocles* en de *Syrische meteorologie* ondersteunt de eerste optie.

Het volgende deel van dit hoofdstuk is gewijd aan Lucretius' behandeling van aardse verschijnselen (anders dan aardbevingen). Terwijl dergelijke verschijnselen in de *Brief aan Pythocles* en de *Syrische meteorologie* geheel ontbreken, blijkt ook de overeenkomst met andere meteorologische werken, zoals Aristoteles' *Meteorologie* betrekkelijk gering. Waar Aristoteles zich hoofdzakelijk bezighoudt met het algemene, heeft het merendeel van Lucretius' aardse verschijnselen betrekking op lokale en uitzonderlijke gevallen. Hoewel zulke verschijnselen ook wel worden vermeld in meteorologische werken, zijn zij toch typerend voor een ander genre: de paradoxografie, die zich bezighoudt met de beschrijving van wonderlijke zaken. In de tabel op p.106 van deze dissertatie heb ik in kaart gebracht welke van de verschijnselen die Lucretius bespreekt ook voorkomen in andere meteorologische en/of paradoxografische werken. Lucretius' behandeling verschilt van de benadering van zulke verschijnselen in beide genres: noch in de overige meteorologische, noch in paradoxografische werken is het gebruikelijk om dergelijke verschijnselen fysisch te verklaren. Lucretius daarentegen voorziet de verschijnselen die hij verkiest te behandelen van uitgebreide, vaak meervoudige, verklaringen. De keuze van onderwerpen lijkt overigens wel gebaseerd op paradoxografische literatuur, en als het correct is dat dit genre pas door Callimachus (ca. 310-240 v.C.) is geïnaugureerd, dan is het onwaarschijnlijk dat dit deel van Lucretius' werk teruggaat op Epicurus (341-270 v.C.).

Van de negen eerder genoemde meteorologische werken vertonen vier een grote mate van overeenkomst in de volgorde van de onderwerpen die ze

behandelen. Deze vier zijn Aëtius' *Placita* III, de *Syrische meteorologie*, Lucretius VI en Epicurus' *Brief aan Pythocles* (zie de tabel op p.117). Een gedetailleerde vergelijking toont aan dat het mogelijk is om een oorspronkelijke volgorde vast te stellen waarop de volgorde van alle vier de werken kan worden teruggevoerd (zie de tabel op p.125). De onderlinge relaties tussen de vier werken zijn moeilijker vast te stellen. Hoewel Lucretius herhaaldelijk claimt in de voetsporen van Epicurus te treden kan Epicurus' *Brief aan Pythocles* onmogelijk Lucretius' directe voorbeeld zijn geweest. Aangezien Epicurus de brief zelf omschrijft als een samenvatting van wat hij elders heeft geschreven, ligt het voor de hand dat een en dezelfde uitgebreidere tekst van Epicurus als voorbeeld heeft gediend voor zowel de *Brief aan Pythocles* als Lucretius' bespreking van meteorologische verschijnselen in boek VI. Zoals boven reeds opgemerkt vallen de aardse verschijnselen in het tweede deel van boek VI hier waarschijnlijk buiten. De vraag naar de relatie van de *Syrische meteorologie* tot de overige drie werken is nauw verbonden met de kwestie van de identiteit van het werk (zie boven). Zowel het overwegende gebruik van meervoudige verklaringen als enkele andere aspecten van de *Syrische meteorologie* doen meer aan Epicurus denken dan aan Theophrastus, aan wie het werk standaard wordt toegeschreven. Daarentegen blijken andere facetten toch moeilijker te rijmen met de hypothese van een Epicureïsche herkomst van het werk. In veel opzichten staat Aëtius' werk het verst af van de andere drie, zowel in opzet – doxografie i.p.v. meervoudige verklaring – als in bepaalde keuzes in de organisatie van de stof, zoals de overheveling van aardbevingen en kwesties die de aarde als geheel betreffen naar 'aardse verschijnselen'. In het licht van Epicurus' en Lucretius' vermoedelijke afhankelijkheid van een eerder doxografisch werk ligt het voor de hand dat de gemeenschappelijke bron voor de volgorde van onderwerpen in de vier werken een doxografisch werk was.

Hoofdstuk 3: De vorm van de aarde

In verschillende encyclopedieën en overzichtswerken wordt beweerd dat Epicurus en Lucretius meenden dat de aarde plat is. Dit is een opmerkelijke claim. Niet alleen zou dat een anachronisme zijn – de laatste zekere vertegenwoordiger van de platte-aarde-theorie, Democritus, was al 70 jaar dood toen Epicurus zijn school stichtte –, maar ook zou het in strijd zijn met de vele empirische bewijzen vóór een bolvormige en tegen een platte aarde, die sinds Aristoteles bijeengebracht waren. In werkelijkheid zijn in het werk van Epicurus en Lucretius geen uitspraken over de vorm van de aarde te vinden, en zelfs Epicurus' tegenstanders hebben hem nooit op zo'n achterhaald stand-

punt kunnen betrappen. De toeschrijving van een platte-aarde-theorie aan Epicurus en Lucretius blijkt gebaseerd te zijn op louter indirecte bewijzen.

In hoofdstuk 3 van mijn dissertatie onderzoek ik deze toeschrijving van zoveel mogelijk kanten. Daartoe behandel ik allereerst een aantal zaken die als achtergrond voor dit onderzoek kunnen dienen. Zo geef ik een historisch overzicht van het antieke denken over de vorm van de aarde, en een overzicht van de antieke empirische bewijzen voor de bolvorm van de aarde. Tevens ga ik in op David Furley's onderscheid tussen twee soorten kosmologieën: de parallelle kosmologie, waarbij alles langs evenwijdige banen naar beneden valt en waarbij de aarde plat is, en de centrifocale kosmologie, waarbij alles naar het middelpunt van de kosmos en van de aarde valt en waarbij de aarde bolvormig is. Daarna begint mijn eigenlijke onderzoek. Ik heb daartoe een inventarisatie gemaakt van alle passages in de werken van Epicurus, Lucretius en andere Epicureeërs die op de één of andere manier verband zouden kunnen houden met de vorm van de aarde (zie de tabel op p.163).

Een van de belangrijkste passages die ik in dit kader behandel is *DRN* I 1052-93, waar Lucretius de Stoïcijnse theorie van een centripetale valbeweging verwerpt. In aanvulling hierop wijzen andere passages, bij zowel Lucretius als Epicurus, op de aanvaarding van het alternief van de parallelle valbeweging. Slechts één passage bij Lucretius strookt niet met dit beeld. De kosmogonie in *DRN* V 449-508 kan alleen, zo betoog ik, begrepen worden onder de aanname van een centripetale valbeweging en is daarmee onverenigbaar met de eerdergenoemde passages. Het gaat hier vermoedelijk om de insluiping van een latere theorie die door Lucretius niet goed in de rest van zijn systeem is geïncorporeerd. Voor het begrip van het systeem als geheel laat ik de kosmogonie daarom buiten beschouwing. Doorgaans wordt aangenomen dat de keuze voor een parallelle valbeweging ook een platte aarde impliceert, en hoofdzakelijk daarop is claim gebaseerd dat Epicurus en Lucretius geloofden dat de aarde plat is. Deze claim wordt echter maar ten dele bevestigd door andere passages.

De opvatting van Epicurus en Lucretius dat de zon bij het ondergaan zou kunnen uitdoven en bij opkomst weer ontbranden lijkt te vooronderstellen dat zonsondergang en -opgang voor iedereen op hetzelfde moment plaatsvinden, en dus dat de aarde plat is. Hieruit kunnen we verder nog concluderen dat Epicurus en Lucretius niet wisten van, of onverschillig waren voor, de in hun tijd gemaakte observatie dat zonsondergang en zonsopgang variëren met geografische lengte en breedte. Overigens moet wel worden opgemerkt dat deze theorie voor Epicurus en Lucretius maar één van de twee mogelijke theorieën is: de andere theorie – dat de zon onveranderd onder de aarde door gaat – heeft geen implicaties voor de vorm van de aarde.

Ook Epicurus' opvatting dat de zon zo groot is als hij lijkt (en dus, volgens oude en moderne interpretaties, erg klein)* wordt wel in verband gebracht met de theorie van een platte aarde. Volgens David Furley zou de waarneming dat de zon in het noorden lager aan de horizon staat dan in het zuiden (één van de standaardbewijzen voor de bolvorm van de aarde) verzoend kunnen worden met een platte aarde indien we aannemen dat de zon dicht bij de aarde staat en relatief klein is. Een kleine zon zou dus noodzakelijk zijn om een platte aarde met zekere astronomische waarnemingen te harmoniëren. Deze interpretatie wordt echter weersproken door één van de door Epicurus en Lucretius geaccepteerde verklaringen voor maansverduisteringen. Volgens deze verklaring zou de maan verduisterd worden wanneer hij in de *kegelvormige* schaduw van de aarde valt. Een schaduw van deze vorm impliceert echter dat de zon groter is dan de aarde! Blijkbaar was de afmeting van de zon voor Epicurus helemaal niet zo belangrijk en was hij er helemaal niet op uit om één specifieke opvatting over de vorm van de aarde met bepaalde astronomische waarnemingen in het reine te brengen. Hier mag ook worden opgemerkt dat Epicurus' keuze voor een parallelle, i.p.v. een centripetale, valbeweging conceptueel weliswaar beter te rijmen valt met een platte dan een bolvormige aarde, maar de bolvorm niet noodzakelijkerwijs uitsluit.

In dit licht mag de afwezigheid van specifieke uitspraken over de vorm van de aarde in de werken van Epicurus en Lucretius misschien worden uitgelegd als het zich bewust onthouden van een eenduidig oordeel, vergelijkbaar met wat zij soms expliciet uitdrukken door het geven van meerdere alternatieve verklaringen.

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* Een andere interpretatie wordt gegeven door Keimpe Algra, in Algra (2001) en (nog te verschijnen), die suggereert dat Epicurus en Lucretius verwijzen naar de relatieve afmeting van de zon, d.w.z. dat deel van ons gezichtsveld dat door de zon wordt ingenomen, hetwelk evenredig is met de verhouding tussen de afmeting en de afstand van de zon, ofwel met de hoekdiameter. Volgens deze interpretatie hebben Epicurus en Lucretius zich helemaal niet verbonden aan een kleine afmeting van de zon, maar in plaats daarvan afgezien van het toekennen van een specifieke diameter.

CURRICULUM VITAE

Frederik Bakker werd op 19 mei 1971 geboren te Amsterdam. In 1989 behaalde hij zijn gymnasiumdiploma aan het Gemeentelijk Gymnasium te Hilversum. Aansluitend studeerde hij Civiele Techniek aan de Technische Universiteit Delft, waar hij in 1995 zijn ingenieursdiploma behaalde. Ondertussen onderhield en verdiepte hij zijn kennis van de klassieke talen bij de leesgroep 'Obscuri', en vervolgens als acteur in een Griekse opvoering van de Antigone door het Homerustheater. Daarna werkte hij eerst een tijd als projectleider aan het Maritiem Research Instituut (MARIN) in Wageningen en vervolgens als onderzoeker in opleiding bij het KNMI in De Bilt. In 1997 begon hij aan de studie Griekse en Latijnse Taal en Cultuur aan de Universiteit van Amsterdam, waar hij eind 2001 *cum laude* afstudeerde met een scriptie over 'De vorm van de aarde bij Lucretius' onder begeleiding van professoren Daan den Hengst en Keimpe Algra. Op uitnodiging van professor Keimpe Algra begon hij in april 2002 als promovendus aan de Universiteit Utrecht met een onderzoek naar de kosmologie van Lucretius. Van 2007 tot 2009 gaf hij Latijn, Grieks en Klassieke Culturele Vorming (KCV) op het Werenfridus-college te Hoorn. Sinds augustus 2009 werkt hij als universitair docent Antieke en Patristische Wijsbegeerte aan de Vrije Universiteit te Amsterdam.

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