

LUCRETIUS' RAZOR ON EPICURUS' ATOMIC THEORY*

ABSTRACT

This article investigates why Lucretius does not dedicate any section of his poem to atomic size or provide a technical term to describe the concept. This absence is particularly significant because Epicurus' Letter to Herodotus both uses the term μέγεθος to indicate atomic size and contains a passage reporting specifically on this property. First, the article argues that atomic size and shape are causally redundant in Epicurus' ontology. Second, it demonstrates that the origin of both shape and size is found in the smallest magnitudes in Epicurean physics, the minima. Drawing on these findings, it concludes that, since atomic size violates the law of parsimony, it is a superfluous entity in the Epicurean system. After analysing passages from the De rerum natura, it suggests that the absence of atomic size in Lucretius may be deliberate. Lucretius' microphysics works perfectly without introducing a philosophical notion of atomic size, and is more economical and efficient than that of Epicurus.

Keywords: Lucretius; Epicurus; atomism; history of metaphysics

Epicurus and Lucretius deal with size and shape as properties of atoms in two different ways. While Epicurus devotes a portion of the *Letter to Herodotus* to both size and shape, nowhere in his work does Lucretius say anything about the size of atoms.¹ I will here argue that Lucretius *de facto* eliminates atomic size from his ontology.

Epicurus uses the term μέγεθος to indicate atomic size and identifies it as a property, explicitly listed among the features of atoms:²

καὶ μὴν καὶ τὰς ἀτόμους νομιστέον μηδεμίαν ποιότητα τῶν φαινομένων προσφέρεσθαι πλὴν σχήματος καὶ βάρους καὶ μεγέθους καὶ ὅσα ἐξ ἀνάγκης σχήματι συμφυῆ ἔστι.

Moreover, we must suppose that the atoms do not possess any of the qualities belonging to perceptible things, except shape, weight and size, and all that necessarily goes with shape.

Size is a quantitative property of the atom. Consequently, it is measurable and must be characterized by an amount, a quantity. This quantity is what differentiates two atoms differing in size. As Epicurus states, the unit of measurement (καταμέτρημα) of the lengths of atoms is the *minimum*:³

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¹ 'Lucretius himself does not have a separate section of argument dealing with the size of atoms' (E. Asmis, *Epicurus' Scientific Method* [Ithaca, NY, 1984], 268). Cf. C. Giussani (ed.), *T. Lucreti Cari De rerum natura* (Turin, 1896), 1.64 and 2.212, where he also holds that such a section is lost.

² *Ep. Hdt.* 54.1–3, text and translation by C. Bailey (ed.), *Epicurus. The Extant Remains* (Oxford, 1926).

³ *Ep. Hdt.* 59.3–8. The words minimum and minima are henceforth non-italicized. This work is concerned exclusively with the notion of minima as magnitudes and units of measurement. With regard to their nature, I follow the theory that they are physical minimal magnitudes existing only in the atom and inalterable in the atomic structure. This has been argued by e.g. F. Verde, *Elachista: la dottrina dei minimi nell'Epicureismo* (Leuven, 2013), 325–6, but cf. G. Vlastos, 'Minimal parts in Epicurean atomism', *Isis* 56 (1965), 121–47, at 135–9.

ἐπεὶ περ καὶ ὅτι μέγεθος ἔχει ἢ ἄτομος, κατὰ τὴν <τῶν> ἐνταῦθα ἀναλογίαν κατηγορήσαμεν, μικρόν τι μόνον μακρὰν ἐκβάλλοντες. ἔτι τε τὰ ἐλάχιστα καὶ ἀμιγῆ πέρατα δεῖ νομίζειν, τῶν μικρῶν τὸ καταμέτρημα ἐξ αὐτῶν πρώτων τοῖς μείζουσι καὶ ἐλάττωσι παρασκευάζοντα, τῇ διὰ λόγου θεωρίᾳ ἐπὶ τῶν ἀοράτων.

For indeed we have already declared on the ground of its relation to sensible bodies that the atom has size, only we placed it far below them in smallness. Further, we must consider these least indivisible points as boundary-marks, providing in themselves as primary units the measure of size for the atoms, both for the smaller and for the greater, in our contemplation of these unseen bodies by means of thought.

This entails that the minima are the units we use to measure atomic size.⁴ Then, since the minima are constant quantities, we define atomic size as a certain multiple of one minimum.⁵ It follows that different sizes are simply differing amounts of minima.

However, Epicurus' atomic size is more than this. In the *Letter to Herodotus*, μέγεθος is also responsible for differences we perceive in reality:⁶

ἀλλὰ μὴν οὐδὲ δεῖ νομίζειν πᾶν μέγεθος ἐν ταῖς ἀτόμοις ὑπάρχειν, ἵνα μὴ τὰ φαινόμενα ἀντιμαρτυρῇ· παραλλαγὰς δὲ τινὰς μεγεθῶν νομιστέον εἶναι. βέλτιον γάρ καὶ τούτου προσόντος τὰ κατὰ τὰ πάθη καὶ τὰς αἰσθήσεις γινόμενα ἀποδοθῆσεται. πᾶν δὲ μέγεθος ὑπάρχον οὔτε χρήσιμόν ἐστι πρὸς τὰς τῶν ποιότητων διαφοράς, ...

Moreover, we must not either suppose that every size exists among the atoms in order that the evidence of phenomena may not contradict us, but we must suppose that there are some variations of size. For if this be the case, we can give a better account of what occurs in our feelings and sensations. But the existence of atoms of every size is not required to explain the differences of qualities in things, ...

Epicurus states that a finite amount of atomic sizes is enough to explain the differences we experience in the world.⁷ Hence, we deduce that differences in atomic size yield qualitative differences in the sensible world. This is problematic, because it seems that atomic size would be endowed with a power—that of making a qualitative difference in the world—which was originally the prerogative of another fundamental property: atomic shape. Shape, σχῆμα, is the qualitative property par excellence.⁸ The atomic shapes, in their variety, are unambiguously indicated by Epicurus as responsible for the rich qualitative multiplicity dwelling in the world.⁹ So it seems that there is an

⁴ I see no problem with moving from the notion of μήκος (*length*) to that of μέγεθος. Paragraph 59 is the conclusion of an analogical argument started at *Ep. Hdt.* 58, which goes as follows: a) things have a sensible minimum; b) this minimum, in its individuality, can measure the μέγεθος of bigger sensibles; c) therefore, the same must happen at the atomic level, where a minimal quantity must be able to be the measurement of atoms (cf. Vlastos [n. 3], 143).

⁵ As Euclid says (5.2), πολλασπλάσιον δὲ τὸ μείζον τοῦ ἐλάττωτος, ὅταν καταμετρήται ὑπὸ τοῦ ἐλάττωτος ('A greater magnitude is a multiple of a lesser one, when it is exactly measured by the lesser one'; text by E.S. Stamatis [ed.], *Euclidis Elementa* [Leipzig, 1970]; my translation). καταμετρέω is cognate to Epicurus' καταμέτρημα. However, it is not clear whether Epicurus developed his own mathematics independent from the Euclidean type (cf. Vlastos [n. 3], 123–35; D. Sedley, 'Epicurus and the mathematicians of Cyzicus', *BCPE* 6 [1976], 23–54, at 23–6).

⁶ *Ep. Hdt.* 55.9–56.2.

⁷ 'They vary in size but are not of all sizes. A certain amount of variation in size is sufficient to account for the varieties in phenomena' (Bailey [n. 2], 204).

⁸ Verde (n. 3), 32 regards all the properties of the atoms as quantitative; my terms reference the events the properties produce; so shape is qualitative, as it results in the differences in quality in the world we experience.

⁹ See *Ep. Hdt.* 42.6–10, where Epicurus points out that the immense variety of beings inhabiting the sensible world could not come to be if there were not many differing atomic shapes.

overdetermination here. The same qualitative variations in the world are explained by two causes: shape and size.

However, Epicurus' account would not be complete without Lucretius' seminal account of the role played by the minima in *De rerum natura* Book 2.¹⁰ In the first part of Lucretius' argument that atomic shapes are finite in number, we understand that different amounts and configurations of minima composing atoms result in different shapes:¹¹

... fac enim minimis e partibus esse
 corpora prima tribus, uel paulo pluribus auge:
 nempe ubi eas partis unius corporis omnis,
 summa atque ima locans, transmutans dextera laevis,
 omnimodis expertus eris, quam quisque det ordo
 formai speciem totius corporis eius,
 quod superest, si forte uoles uariare figuras,
 addendum partis alias erit; inde sequetur,
 adsimili ratione alias ut postulet ordo,
 si tu forte uoles etiam uariare figuras.
 ergo formarum nouitatem corporis augmen
 subsequitur. ...

Suppose, for instance, the first bodies to consist of three smallest parts, or increase that number by a few more; naturally, when you take all those parts of one body, and by placing them top or bottom, and transposing right and left, you have tried in all possible ways what shape of that whole body each order gives, if after all you wish perhaps to vary the shapes, other parts must be added; and it will follow that in like manner the arrangement will demand other parts, if you perhaps wish to vary the shapes yet further. Therefore, *the growth of the body follows the novelty in shape*.

Lucretius argues that the number of possible configurations of a certain amount of minima is limited, so to obtain additional novel shapes we should add more minima, causing the growth of the body of the atom. Since, as shown above, a certain amount of minima is a size, it follows that a new size is always a new shape. There is a necessary connection between the variation in size and the variation in shape, the former must result in the latter, different sizes yield different shapes.¹² However, this does not necessarily happen in reverse, because different shapes may share the same size. A certain amount of minima produces a certain number of shapes in accordance with how they are naturally configured within the atomic structure,¹³ and this admits various solutions for each size.¹⁴ And Lucretius' testimony sheds more light on Epicurus' passage above: size inherits a qualitative power from shape, because different sizes

¹⁰ At this point, the reader is already familiar with the notion of minima, introduced at 1.599–634.

¹¹ Lucr. 2.485–96, text and translation by W.H.D. Rouse (ed.), *Lucretius: On the Nature of Things* (Cambridge, MA, 1992⁴); I italicize a sentence in the translation which I have changed to bring it as close as possible to the original Latin.

¹² This phenomenon is labelled *co-variance* in D. O'Brien, 'La taille et la forme des atomes dans les systems de Démocrite et Épicure', *RPhilos* 172 (1982), 187–203, at 194.

¹³ Cf. T. Bindseil, *Nonnulla ad Lucretii De rerum natura carminis librum primum et secundum qui sunt de atomis* (Halle, 1865), 30: 'ut uario ordine uariaque positura collocatae [mimimae partes] discrepantes primordium figuras efficerent, in quibus una spes explicandae rerum creatarum uarietatis posita esset'.

¹⁴ Cf. the dice analogy: if we assume that three six-faced dice can only be in full contact with each other, we will be able to form only two shapes with them. Further discussion may be found in e.g. Giussani (n. 1), 2.213–14; C. Bailey, *The Greek Atomists and Epicurus* (Oxford, 1928), 287.

yield different shapes. Shape produces differences in reality, as does size by acquiring such a power from shape.

This leads to two critical observations:

- a) if both size and shape are causally responsible for the very same effect, namely the differences our senses grasp in reality, they are causally redundant.
- b) Minima already measure atoms and their differing configurations yield all the shapes of atoms, something size alone cannot achieve.

With regard to a), atomic shape and atomic size should not produce the same event, especially in the Epicurean theory of knowledge that relies on inference from the sensible world.¹⁵ The only event we can experience with our senses is the difference in reality, so it follows that we have no reason to postulate the existence of two properties causally responsible for it. We can infer from the variety of reality that, at the atomic level which our senses cannot reach, the prime bodies must differ in quality, hence in shape. However, the same argument cannot be used for size. Different sizes are necessarily different in shape, but not necessarily vice versa, as the difference in shape does not find its ultimate origin in the amount of the minima but in their configuration in the atom. One size may take the form of multiple shapes. Consequently, difference in size cannot account for every event we experience, as there might be different events created by two atoms differing in shape but sharing the same size. Therefore, size may be renounced without affecting the explanation of the world we can give by sense perception.

Observation b) is complementary to observation a) and draws on *Lucr.* 2.485–96 and on this article's first paragraphs. The minima are already magnitudes measuring atoms; as I have shown above, size is simply the result of an amount of minima. In this sense, both minima and size act as measurement. Moreover, differing sizes alone are not capable of yielding all differing shapes, while every amount of minima may differ in configuration atom by atom and can then produce all possible differing shapes.

In light of the observations above, we can conclude that size is an entity ontologically in the middle, between minima and shape. This happens for two reasons: first, atomic size cannot account for every difference in the world, while shape can, as there may be multiple shapes for each size, which may be responsible for multiple events. Second, size is the product of an amount of minima, but cannot create every atomic shape like the minima. Two different sizes, again, are two different shapes, but two different amounts of minima may account for many more shapes, according to the order in which they are naturally disposed inside the atoms. This reveals the inconsistency of μέγεθος in Epicurus' atomic system. Atomic size is a renounceable intermediate entity between the quantitative basis provided by the minima and the qualitative result of shape. This leads to the problem with Epicurus' atoms: they do not respect the principle of ontological parsimony.

At this point, one may object that Epicurus accepted multiple explanations for certain phenomena, so there would be no reason for his atomic properties to be considered redundant. Shape and size would simply be two non-conflicting possible causes producing the same effect. However, in Epicureanism the doctrine of multiple explanations is applied exclusively to meteorology, telluric phenomena, or astronomical

¹⁵ Epicurus' empiricist positions are well known; see e.g. the key passages *Ep. Hdt.* 38.4–8; *RS* 24; *Sext. Emp. Math.* 8.9.1–2. Cf. E. Asmis, 'Epicurean empiricism', in J. Warren (ed.), *The Cambridge Companion to Epicureanism* (Cambridge, 2009), 84–104; Bailey (n. 14), 237–8.

events. Epicurus himself indicates where multiple explanation can be applied, and enquiries about the foundations of natural philosophy are excluded. There are two methods of investigation: a method admitting only one cause, applied to fundamental truths of physics; and the other, applied to celestial manifestations accepting more than one cause, that is, the doctrine of multiple explanation.¹⁶ Multiple explanation is not applicable to the issues regarding shape and size, as they fall under the first category.¹⁷ Atomic shape and atomic size overdetermine the variety of the world we experience, and differences in size cannot account for all the differences in the world that differing atomic shapes produce.

In Lucretius, atomic size fades away. No section of the *De rerum natura* elucidates the size of atoms, nor is a philosophical concept introduced for it. Lucretius has no corresponding term for atomic μέγεθος.¹⁸ Yet we would expect to find it, for example in the well-known hexameter listing the atomic properties. In this passage, Lucretius explains that if the bodies that beget fire had the nature of fire they could not create anything but fire. But the nature of the compound changes in accordance with the contribution of different atomic properties (1.680–6):

nil referret enim quaedam discedere abire,
atque alia adtribui, mutarique ordine quaedam,
si tamen ardoris naturam cuncta tenerent;
ignis enim foret omnimodis quodcumque crearent.
uerum, ut opinor, itast: sunt quaedam corpora quorum
concursus motus ordo positura figurae
efficiunt ignis, ...

¹⁶ See *Ep. Pyth.* 86.1–8. Cf. F.A. Bakker, *Epicurean Meteorology* (Leiden, 2016), 8, 20–1; R.J. Hankinson, ‘Explanation and causation’, in K. Algra, J. Barnes, J. Mansfeld and M. Schofield (edd.), *The Cambridge History of Hellenistic Philosophy* (Cambridge, 2008), 479–512, at 505–6; Asmis (n. 1), 321.

¹⁷ Below I examine a passage from Lucretius (2.391–4), which someone might interpret as multiple explanation at the atomic level. Lucretius says that two liquids flow through a colander at different speeds owing to either the bigger nature of the atoms composing one of them or their more ‘hooked’ shape. However, this is not really a double explanation as, for Lucretius, only shape is in consideration, as we will discuss below, and the difference between the two liquids is only caused by the difference in the shapes composing them.

¹⁸ Cf. K.C. Reiley, *Studies in the Philosophical Terminology of Lucretius and Cicero* (New York, 1909), 35–62, a thorough analysis of the terminology for shape but which does not consider the lexicon for atomic size. A word suitable for meaning atomic size in Lucretius is *filum* (2.341, 4.88, 5.571, 5.581, 5.589). However, 2.341, the only occurrence where the term refers properly to atoms, seems to contain a hendiadys where *filum* is a synonym of *figura* and simply means shape (2.340–1 *debent nimirum non omnibus omnia prorsum | esse pari filo similique adfecta figura* ‘They must assuredly not be all of like frame with all and marked by the same shape’); see C. Bailey (ed.), *T. Lucreti Cari: De rerum natura libri sex* (Oxford, 1947), 860: ‘it is used by Lucretius in 4.88 meaning texture, in 5.572, 581, 589 size (of the sun and moon) and here shape, being the equivalent of *figura*’. With regard to the occurrences of Book 5, *filum* might indicate the magnitude of heavenly bodies and Bentley reads it as *magnitudo*, but Lachmann points out that it should be more properly intended as *crassitudo* ‘thickness’; see both interpretations in K. Lachmann (ed.), *De rerum natura libri sex. Commentarius* (Berlin, 1882⁴), 300. In any case, these occurrences do not concern atoms, and the term itself does not mean size but thread, hence texture *sensu lato* (cf. Cic. *De or.* 2.93; Varro, *Ling.* 10.4.6–7). One may object that the common Latin words meaning size available to Lucretius would not have been used owing to their cretic nature (e.g. *magnitudo*, *amplitudo*; cf. P.M. Brown (ed.), *Lucretius: De rerum natura III* [Warminster, 1997], 12). However, putting forward a *metri causa* argument to justify the overt absence of a doctrinal notion is a weak argument, as Lucretius has been proven to be able to shape language to fit his purposes elsewhere.

For it will be of no use that some should separate and depart, and others be added, and some change place, if nevertheless all retained the nature of fire; for whatever they should make would be altogether fire. But, as I think, the truth is this: there are certain bodies which by their concurrences, motions, order, positions, shapes, produce fire, ...

The properties listed in Lucretius' passage are qualitatively powerful as they are responsible for (*efficiunt*) an event in the universe which can be perceived by our senses, in this case fire (*ignis*). However, shape (*figura*) is the only intrinsic property of atoms and this is also highlighted by its position in *clausula*.¹⁹ This list does not mention atomic size. Additionally, every time we would expect Lucretius to use a word signifying size, he rather opts for opaque expressions, for example *auctus corporis* and *augmen corporis*. These two should not be regarded as technical terms in lieu of the word size, because, if that were the case, we would find them used in that way by Lucretius, whereas they only occur in unrelated contexts.²⁰

The absence of a word for size is not only a linguistic issue. After the section on atomic motion, Lucretius introduces the topic of the shapes of atoms.²¹ He clearly states that the following elucidation will concern the differences in shapes. However, in the passage reporting the effects of the differing shapes, we also find natural events listed that, on the basis of Lucretius' words, we would probably consider to be caused by atomic size. The passage explains how oil and wine pass through a sieve at different speeds (2.391–4):

et quamuis subito per colum uina uidemus
perfluere, at contra tardum cunctatur olium,
aut quia nimirum maioribus est elementis
aut magis hamatis inter se perque plicatis,
...

And we see wine, as quickly as you will, strain through a colander; but contrariwise olive oil lags and lingers, either to be sure because its elements are larger, or because they are more hooked and entangled more closely, ...

Wine and oil are perceived to act in different ways either because the atoms of oil may be bigger than the atoms of wine, or because the atoms composing oil are more 'hooked' than the atoms that make up wine.

In this context, we would naturally interpret this passage as saying: 'either the atomic shape or the atomic size is responsible for the different speeds of oil and wine'. However, again, there is no reference to a quantitative property that we would call

¹⁹ We find all these terms together, covering the extent of a whole hexameter, twice again, but they are usually mentioned either in isolation or in a group: 1.384, 1.634, 1.677, 1.999, 2.480, 2.484, 2.493, 2.672, 2.761–9, 2.895, 2.947, 3.395, 4.655–67, 4.943, 5.420, 5.439 (listed by I. Dionigi, *Lucrezio, le parole e le cose* [Bologna, 1988], 22–3).

²⁰ This is not the case for other periphrases, such as *primordia rerum*, which are charged by Lucretius himself doctrinal relevance owing to their formulaic nature and very high frequency (cf. the presentation of the atomic lexicon at 1.58–61). With regard to the two phrasal terms *augmen corporis* and *auctus corporis*, cf. their other occurrence at 3.268 and 5.1171 respectively. As for *augmen*, it is probably Lucretius' coinage: D. Fowler, *Lucretius on Atomic Motion* (Oxford, 2002), 156–7. Another similarly opaque expression probably coined by Lucretius is *maximitas* (2.498), a hapax legomenon.

²¹ The arguments in support of the fact that atoms vary in shape are: 1) since atoms are infinite, they must differ in shape (2.333–41); 2) since difference dwells in the physical world, then it must be the case for the atomic level (2.342–80). Cf. Bailey (n. 18), 859.

size, and this section of the poem explores the effects of differing shapes, as Lucretius himself indicates. These bigger atoms differ from smaller ones exclusively in quality, as we perceive a qualitative difference between two compounds, namely their differing texture.

Another example proves even more interesting. In the lines before the passage above, Lucretius shows that bigger or smaller atoms may be the only cause for an event to happen, as is the case for different types of fire (2.384–90):

dicere enim possis caelestem fulminis ignem
 subtilem magis e paruis constare figuris
 atque ideo transire foramina quae nequit ignis
 noster hic e lignis ortus taedaeque creatus.
 praeterea lumen per cornum transit, at imber
 respuitur. quare? nisi luminis illa minora
 corpora sunt quam de quibus est liquor almus aquarum.

For you could say that lightning, the heavenly fire, is finer and made of smaller shapes, and therefore passes through openings through which this fire of ours, sprung from wood and made from a torch cannot pass. Besides, light passes through horn, but rain is rejected: why? Unless those bodies of light are smaller than those which make up the nourishing liquid of water.

Again, no term for size is found, but this passage is much more precise as we can see that what is smaller is actually the *figurae*, the atomic shapes, in the sense of the atoms themselves. The extensive and formulaic usage of the word *figura* in this section reiterates that, for Lucretius, only atomic shape is in consideration among the properties. The term in the plural is often used to indicate the atoms by extension. Shape is the property that identifies the atom as the begetting principle of the world, and the world is variety. This is something that is not found in Epicurus with regard to σχῆμα that refers exclusively to the property.²² We can conclude that for Lucretius bigger or smaller atoms are in fact bigger or smaller in *shape* and not in size, given the qualitative experience we perceive in their effect.

Lucretius' omission of atomic size might betray a deliberate modification to produce a more efficient and easily conveyable atomic model; he eliminates atomic size to solve the issue of a possible causal redundancy. The hypothesis that Lucretius made a considered change is supported by two factors: Lucretius' use of Epicurus' Περὶ φύσεως as the almost exclusive source for the composition of his poem, and his restructuring of the original exposition of this source.

Lucretius probably only availed himself of part of Epicurus' monumental treatise. Similarly, it is likely that Lucretius was largely detached and isolated in his poetic effort, not only from recent Epicurean literature but also from contemporary intellectual debate.²³ There is evidence that Lucretius actively reworked the original Greek treatise to accomplish his poetic and philosophical task. One of the reasons Lucretius reorganized its arguments and topics was to convey a more engaging exposition of Epicurean philosophy. Some material originally discussed in Epicurus' major work is

²² Reiley (n. 18), 58–9; A. Traglia, *De Lucretiano sermone ad philosophiam pertinente* (Rome, 1947), 22.

²³ D. Sedley, *Lucretius and the Transformation of Greek Wisdom* (Cambridge, 1998), 62–165. Sedley's work is the richest and most pioneering study on Lucretius' sources and his attitude towards them.

not found in the *De rerum natura*, while some has been rearranged from their original order in the Περί φύσεως.²⁴ More deeply, it has also been observed that some arguments have been actively reshaped and adapted by Lucretius.²⁵

The absence of any significant philosophical interference between Lucretius and Epicurus' major work and the changes Lucretius made to the original matter are crucial. In *De rerum natura* Book 2, atoms, through their motion, shapes and compounds, are presented as fully capable of explaining the phenomena of the sensible world. The explanatory potency of atomic shape might have been compromised by the existence of a causally overlapping property. Atomic size was probably discussed by Epicurus in his treatise,²⁶ but it is not by Lucretius. He only deals with shape. It might have been complicated to dedicate a section to size in the didactic discourse and then try to distinguish its role from both the minima and shape. Moreover, the result might have been otiose and difficult. Atomic shape is sufficiently explanatory with regard to our everyday experience. Retaining size in addition might have made the impact of the poetic and philosophical exposition less powerful and effective.

Lucretius still had to indicate the total quantity of an atom that would have normally been called size. To achieve this, he uses general comparative adjectives such as bigger and smaller, which implicitly express a variation in size, and expressions such as *corporis augmen*, which are rare and sufficiently vague to avoid any doctrinal commitment. In any case, his omission seems to benefit his atomic model. He does not need to introduce any other notion to make his system work. In Lucretius' atom the minima are the only quantitative entity. Shape comes consequently from their number and configuration. Quality still comes from quantity, but this time the relation between them is devoid of theoretical hindrances.

I have shown that atomic shape and atomic size are two causally redundant properties in Epicurus. This is because size comes to have a qualitative power inherited from shape. This phenomenon is explained by the fact that size co-varies with shape—that is, different sizes of atoms always have different shapes—and shapes are responsible for the qualitative variety we experience in reality. However, this makes both shape and size qualitative properties, yielding the same result, which is an observable event, and this is a causal redundancy. Also, both size and shape exist because of the minima. The first is a multiple quantity of one minimum, the second is the yield of differing configurations of the minima within the atom. My conclusion is that in Epicurus' system, while differing atomic shapes are necessary to explain the world surrounding us, size is not, and can be abandoned without producing any significant explanatory loss. Lucretius, who might have appreciated the difficult role of atomic size in Epicurus' microphysics and needed to convey an impactful and immediate exposition

²⁴ See the chart in Sedley (n. 23), 136.

²⁵ See e.g. the differences between Epicurus and Lucretius in the presentation of the secondary qualities discussed by D. Clay, *Epicurus and Lucretius* (Ithaca, NY, 1983), 160–8; or in the argument for the minima in Book 1, see Sedley (n. 23), 199–201; F. Montarese, *Lucretius and his Sources: A Study of Lucretius, De rerum natura I 635–920* (Berlin, 2012), 152–7; or for the multiplicity of atomic shapes, see Giussani (n. 1), 2.197–8; Bailey (n. 18), 859.

²⁶ Probably in the fifth book of the Περί φύσεως: Sedley (n. 23), 136.

of the atom, did not account for it in his elucidation on the atomic properties. I offered some *comparanda* showing the absence of a term for atomic size in his lines and the innovative fact that the variety in our world is caused exclusively by atomic shape. In this respect, Lucretius presents a more economical metaphysical approach to the original source.

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