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Victor Gysembergh

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Democritus and the ensuing degeneration of scientific atomism: a suggestion  
Victor Gysembergh  
(Trier, 24<sup>th</sup> September 2016)

In this paper, attention is drawn to an important paradox of Democritus' legacy, the degeneration, as it were, of scientific atomism after Democritus, and an attempt is made to summarize an approach towards explaining Epicurus' attitude regarding natural science, as contrasted with Democritus'. It does not, however, claim to meet historical or philological standards of rigor, which would require more thorough investigation; it is hoped that the approach suggested here will be pursued in the future<sup>1</sup>.

Democritus conducted empirical studies on natural phenomena, as evidenced by several titles in Diogenes Laertius' list of Democritus' writings as well as by numerous other fragments<sup>2</sup>; furthermore, he seems to have attempted to formulate a theory accounting for all the empirical evidence available in terms of causation at the atomic level<sup>3</sup>. Some decades later, Epicurean atomism appeared as a descendant of Democritean atomism, although Epicurus is sometimes said to have denied this in presenting himself as a self-taught man<sup>4</sup>. Most likely, it is through the philosopher Nausiphanes of Teos that Epicurus became familiar with Democritean atomism.

Yet there is a striking contrast between Democritus' prolific scientific investigation of natural phenomena and the Epicurean school's stance towards natural science. Despite the fact that they adhered to the same ontological core of atomism, Epicurus and his followers tended to (a) accept multiple explanations of physical phenomena and (b) reject the mathematical sciences as false. What happened, in the interval between Democritus' death (c. 370 BCE) and Epicurus' career, that caused the latter to all but give up on providing single scientific explanations of natural phenomena, making use, where apposite, of the powerful mathematical tools being developed in his day and age? The suggestion presented here is that Epicurus' change of attitude towards natural science resulted mainly from the emergence of rival scientific research programmes, which dwarfed the Atomists' attempt at science.

This is not to say that Epicurus' change of attitude did not have justifications internal to his philosophy, such as the subordination of scientific inquiry to the ethical concern

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<sup>1</sup> My thanks go to Christian Vassallo for allowing me to present a preliminary version of this paper at an international workshop organized by him in Trier on September 22<sup>nd</sup> to 24<sup>th</sup>, 2016 ("Presocratics and Papyrological tradition"). I am grateful to the participants for their input, and in particular to André Laks, Jaap Mansfeld and David Sedley.

<sup>2</sup> Diogenes Laertius, *Lives and Opinions of the Philosophers*, IX, 45-49 = fr. 68 A 33 Diels-Kranz = fr. CXV Luria with commentary ad loc.

<sup>3</sup> See S. Luria, *Demokrit*, Leningrad, 1970 (it. trans. A. Krivushina, *Democrito. Raccolta dei frammenti*, Milan, 2007) for an edition, translation and commentary of the evidence on Democritus; see also P.-M. Morel, *Démocrite et la recherche des causes*, Paris, 1996 for an attempt at reconstructing Democritean causality. Some of the fragments documenting Democritus' empirical investigations on nature are unduly considered spurious by Luria, see Gysembergh, "Démocrite d'Abdère et la flore asiatique", in: P.-S. Filliozat (éd.), *L'arbre en Asie. Actes du colloque de la Société asiatique, 8-9 décembre 2016* (forthcoming).

<sup>4</sup> In fact, this claim of Epicurus may well have been directed solely against his own teachers, not against earlier thinkers, as pointed out to me by David Sedley.

of preserving humankind from fear; there may have also been external philosophical influences in this regard, e.g. from Theophrastus' use of multiple explanations<sup>5</sup>. Along this line, a conventionalist<sup>6</sup> historian of science might claim that the Epicurean attitude towards natural science was motivated by considerations external to the development of science (such as philosophical presuppositions or sociological factors).

Yet Epicurus must somehow have come to the conclusion that it was impossible to formulate a scientific theory within the framework of atomism; otherwise, he would surely have enlisted the help of science in his struggle for *ataraxia*. An inductivist historian of science would look for newly discovered facts leading to new generalizations including and surpassing atomist science; but it is difficult to find such a thing in the 4<sup>th</sup> c. BCE. A fallibilist, inspired by Karl Popper, would search for a crucial counter-experience falsifying Democritean atomism; but again, such a thing is nowhere to be seen.

An alternative suggestion is that the Epicurean change of attitude towards natural science can receive a more satisfactory explanation in terms of the methodology of scientific research programmes (most often associated with Imre Lakatos despite the fact that similar insights were also at the core of Karl Popper's posthumously published *Postscript*<sup>7</sup>). Lakatos held that the internal development of scientific knowledge can be seen as the competition between rival research programmes, the most 'progressive' programme eventually winning out. Each research programme consists of

“a conventionally accepted (and thus by provisional decision ‘irrefutable’) ‘*hard core*’” and “a ‘*positive heuristic*’ which defines problems, outlines the construction of a belt of auxiliary hypotheses, foresees anomalies and turns them victoriously into examples, all according to a preconceived plan.”<sup>8</sup> “Let us take a series of theories,  $T_1, T_2, T_3, \dots$  where each subsequent theory results from adding auxiliary clauses to (or from semantical reinterpretations of) the previous theory in order to accommodate some anomaly, each theory having at least as much content as the unrefuted content of its predecessor. Let us say that such a series of theories is *theoretically progressive* (or ‘*constitutes a theoretically progressive problemshift*’) if each new theory has some excess empirical content over its predecessor, that is, if it predicts some novel, hitherto unexpected fact. Let us say that a theoretically progressive series of theories is also *empirically progressive* (or ‘*constitutes an empirically progressive problemshift*’) if some of this excess empirical content is also corroborated, that is, if each new theory leads us to the actual discovery of some *new* fact. Finally, let us call a problemshift *progressive* if it is both theoretically and empirically progressive, and *degenerating* if it is not.”<sup>9</sup>

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<sup>5</sup> See F.A. Bakker, *Epicurean Meteorology*, Leiden, 2016, 67ff.

<sup>6</sup> On the distinction between conventionalist, inductivist and fallibilist history of science, see I. Lakatos, *Philosophical Papers*, vol. 1, p. 103-110.

<sup>7</sup> K. R. Popper, *Postscript to the Logic of Scientific Discovery* (ed. W.W. Bartley), 3 vol., Totowa, 1982-1983. On the methodology of scientific research programs in contemporary debates on the philosophy and history of science, see e.g. T.A.F. Kuipers (ed.), *General Philosophy of Science. Focal Issues*, Burlington, 2007.

<sup>8</sup> I. Lakatos, *Philosophical Papers*, vol. 1, p. 110-111.

<sup>9</sup> I. Lakatos, *Philosophical Papers*, vol. 1, p. 33-34. A similar, but less complete, definition is given p. 112.

The Atomist research programme to which Democritus adhered did not allow him to explain or predict any novel empirical facts. Indeed, its ‘hard core’, the notion that the laws of nature can all be derived from the properties of atoms, could hardly have solved any problem at all in the absence of microscopic instruments. In other words, the ancient atomist programme was doomed to degenerate.

On the other hand, Eudoxus<sup>10</sup>, while taking up several scientific problems left unsolved by Democritean science<sup>11</sup>, formulated a radically different research programme, which had at its core the geometrization of the universe. Thanks to their mathematical research, he and his students were then able to formulate theories predicting novel facts (such as the solar eclipse predicted by his student Helicon of Cyzicus in Syracuse on the 13<sup>th</sup> of May 361) or explaining them (such as the modelization of planetary movements allowed by the study of geometrical volumes). In the ensuing decades, there followed a flurry of special theories that can be seen as extensions of this geometry-centered research programme, including optics and catoptrics, mathematical geography, mechanics, hydrostatics and pneumatics (with applications to civil and mechanical engineering, architecture, naval construction and instrumentation)<sup>12</sup>.

The progress of the Eudoxan research programme thus appears to have been quite beyond the reach of the Atomists. This would explain why Epicurus turned away from the natural sciences, and was mostly content to criticize scientific theories from an agnostic or skeptical vantage point. It would account, in particular, for Epicurus’ assaults on the Eudoxan school in Cyzicus<sup>13</sup>. In parallel, one might argue that a further

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<sup>10</sup> On Eudoxus see F. Lasserre, *Die Fragmente des Eudoxos von Knidos*, Berlin, 1966, and this author’s forthcoming edition, translation and commentary of the fragments.

<sup>11</sup> For instance, he demonstrated a theorem on volumes first stated by Democritus (Archimedes, *Method*, p. 84 Mugler (= p. 430 Heiberg)). A new reading in the Archimedes Palimpsest (ἐξήνευξε, “publish”, instead of ἐξήρῳηκεν, “discover”) is important in confirming that Eudoxus took the credit for demonstrating an unproven assertion by Democritus. Furthermore, he extended this field of research to other theorems on volumes. He also followed in the footsteps of Democritean geography, but introduced the decisive innovation of coordinates (geographical latitude), which Democritus was unable to conceive because he did not suppose the earth to be spherical (on Eudoxus’ geographical astronomy, see V. Gysembergh, « Émendations dans le *Commentaire d’Hipparque* : sur le *Miroir* d’Eudoxe de Cnide », *Revue de philologie, de littérature et d’histoire anciennes* LXXXVI/1, 2012, p. 43-51 ; V. Gysembergh, « Frontières et confins dans la cartographie d’Eudoxe de Cnide », in : H. Berthelot, A. Boiché, P.-A. Caltot, M. Diarra, F. Réveillac et É. Romieux-Brun (ed.), *Vivre et penser les frontières dans le monde méditerranéen antique*, Bordeaux, 2016, pp. 31-41, here: p. 35-38). The connexion between Democritus and Eudoxus was made by Eratosthenes in his so-called “Canon of the Geographers” (on which see R. Nicolai, « Il cosiddetto canone dei geografi », *Materiali e discussioni per l’analisi dei testi classici* 17, 1986, p. 9-24).

<sup>12</sup> For general overviews of the history of ancient Greek and Roman science, see G. Sarton, *A History of Science*, 2 vol., Cambridge (MA), 1959; G.E.R. Lloyd, *Early Greek Science*, London, 1970 and *Greek Science after Aristotle*, London, 1973; T.E. Rihll, *Greek Science*, Oxford, 1999; L. Russo, *The Forgotten Revolution*, Berlin-Heidelberg-New York, 2004 (marred by a lack of historical method). See also P.T. Kayser and G.L. Irby-Massie, *The Encyclopedia of Ancient Natural Scientists*, London-New York 2008.

<sup>13</sup> D. Sedley, “Epicurus and the Mathematicians of Cyzicus”, *Cronache Ercolanesi* 6, 1976, p. 23-54. Sedley’s reconstruction and the very existence of a Eudoxan school in Cyzicus has recently been questioned by P. Podolak, “Questioni Pitoclee”, *Würzburger*

research program appeared and made great progress in the fields of anatomy and biology, reaching its peak with the work of Herophilus of Alexandria; indeed, an impulse to collect empirical biological facts and offer causal explanations of phenomena in all areas of the living world was given by Aristotle and Theophrastus, and Herophilus does seem to hark back to this tradition<sup>14</sup>; however, it is not clear how to define the “hard core” of such a research programme.

If this suggestion seems plausible, it should be noted that it explains an historical paradox in terms not of individual behaviour but of general regularities regarding how science progresses. It would, then, be worthwhile to seek a more systematic application of the methodology of scientific research programmes to the history of ancient science.

Victor Gysembergh  
Friedrich-Meinecke Institute  
Koserstr. 20  
14195 Berlin  
victor.gysembergh@fu-berlin.de

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*Jahrbücher für die Altertumswissenschaft*, N.F. 34, 2010, p. 39-80. However, Podolak did not notice the dedication of a statue of Eudoxus' student Callippus by the Cyzicenes in the Panhellenic sanctuary of Delphi (Hansen, *Carmina epigraphica graeca*, n° 881 = J. Bousquet, « Inscriptions de Delphes », BCH 116, 1992, p. 177-196, here: p. 180-183):

Οὔτινά σοι μερόπων, ἄστρον περὶ θεῖον ἀριθμόν,  
Κάλλιππ' Εὐίππου, Κύζικος ἔσχε πάτρα  
θνητῶν ἴσον, ὅσους τε φέρει Διὸς ἄμβροτος αἰών·  
Φοῖβῳ δ' ἔνθα σέθεμ μνήμα πέλ' εἰν ἐτάροις.

No one versed in the divine number of the stars, o Callippus son of Euhippus, did your fatherland Cyzicus have, that were equal to you among all mortal men borne by Zeus' immortal eternity: where your monument is, go amongst the companions of Phoebus.

The statue is now lost, but the epigram shows that his scientific work was sufficiently acknowledged in Cyzicus for his fellow citizens to take up the expense of such a dedication. The poem's wording reveals that this recognition went very far indeed: the last line, reversing the usual theme of the departed leaving the sun's rays behind, introduces the bold idea that Callippus is now in the company of the sun-god. One might go so far as to speak of a form of heroization or apotheosis of Callippus. This speaks to the importance of the Cyzicene school, and confirms that it was a major rival for Epicurus.

<sup>14</sup> See esp. H. von Staden, *Herophilus: the Art of Medicine in Early Alexandria*, Cambridge, 1989, 117-124.