

# **On Atomistic Intuitions and their Classifications.**

## **Some Remarks on Gaston Bachelard’s**

### ***Les Intuitions atomistiques (Essai de classification)***

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Gaston Bachelard explained that he had written his classificatory essay, *Les Intuitions atomistiques*, in order to help students find their way through the terrible conceptual jungle that according to him was hiding behind the simple word ‘atom’.<sup>1</sup> Bachelard’s essay of 1933 is insightful and brilliantly written. It may therefore be surprising to learn that, despite its qualities and the author’s fame, *Les Intuitions atomistiques* was reprinted only once, in 1975, and has never been translated.

#### **At the end of a century-long debate over ‘atomism’**

One of the reasons for why Bachelard’s essay did not enjoy a wider diffusion might be that it was written at the exhausted end of a long and fascinating period of controversial publications over the truth and legitimacy of atomism. This period had initiated a century earlier and had involved philosophers, chemists and physicists. By the 1930s, when Bachelard wrote his essay, the philosophy of science had turned to other issues, such as the implications of relativity theory for categories such as time and space, and the questions of regarding determinism and causality that were triggered by the Copenhagen interpretation of quantum physics.

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<sup>1</sup> Gaston Bachelard, *Les Intuitions atomistiques (Essai de classification)*. Paris: Boivin, 1933, 2: “Dans ces conditions, il est peut-être bon de procéder à une analyse, et même à un démembrement, pour bien isoler les éléments disparates des doctrines qui, sous un même nom, cachent des pensées si diverses. Notre but a été de préparer cette analyse et de fournir aux étudiants des moyens ou des prétextes pour classer leurs idées.”

In order to understand the debate of which Bachelard's classificatory essay marks the end, we must remember that until roughly 1900, the question of the existence of the atom had by no means been resolved. French chemists, for example, collectively rejected atomistic models, preferring a continuist conception of matter. Two powerful French chemists, Jean-Baptiste Dumas and, one generation later, Marcellin Berthelot, both of whom Bachelard mentions in his *Intuitions*, "at a given moment created a certain scientific dogmatism against which it was very difficult to struggle."<sup>2</sup> Dumas' view was unequivocal: "If I were master of the situation, I would efface the word atom from Science, persuaded that it goes further than experience and that, in chemistry, we should never go further than experience."<sup>3</sup> The alternative that was available in the middle of the nineteenth century was to follow Berzelius and to take 'atom' and 'volume' as interchangeable expressions, and to explain through it Faraday's discovery of the fixed proportionality between the quantity of electrochemical decomposition and the already well-known chemical equivalents.

At the 1860 Karlsruhe Congress, 140 distinguished chemists engaged in a heated debate over the scientific status of atoms, molecules, radicals and equivalents. Echoing that controversy, the Académie des Sciences battled over atomism in 1877. "Who has ever seen a gas molecule or an atom?", Berthelot asked polemically.<sup>4</sup> In *La théorie atomique* of 1879, Charles Adolphe Wurtz tried to answer Berthelot; his purpose was to show that atoms were not facts, but constituted a fertile hypothesis. What was at stake in the French debate was thus not only the possible reality of atoms, but also the role of hypothesis, of imagination – and of *intuitions scientifiques*, a term cherished by French scientists and philosophers alike, even before Bachelard used it in his *Essai de classification*.

Of course, once the atom's existence had finally been proven experimentally at the turn of the century, even the most obstinate French chemists surrendered. And yet, the atom's ultimate triumph was nothing if not a Pyrrhic victory, because what the physicists had proven to exist did certainly correspond to the ultimate quantitative unit of chemical substances, but at the same time, it turned out that it was not an 'atom' at all: it was not an 'uncuttable entity' ('a-tomos'), as its name suggested, but was instead a composite with a very small nucleus and a distant shell of electrons.

In the decades preceding this unexpected turn of events, and notably between

2 René Taton, *Causalité et accidents de la découverte scientifique*. Paris: Masson, 1955, 141, trans. and cited by Mary Joe Nye, *Molecular Reality. A Perspective on the Scientific Work of Jean Perrin*. London, Macdonald, 1973, 6.

3 Quoted in Maurice Caullery, *La science française depuis le XVIIe siècle*. Paris: Armand Collin, 1933, 6.

4 Quoted in Nye, *Molecular Reality*, 7.

1840 and 1900, numerous philosophers, physicists and chemists had defended their atomist or anti-atomist views in books, essays and pamphlets. The modern reader may be surprised to find that many of these authors took recourse to history, relying on what some of them called a ‘historico-critical method’, which combined a traditional exegetical approach to the interpretation of old texts with a Kantian meaning of ‘critique’. The epitome of this method is constituted by Kurd Lasswitz’s two-volume *Geschichte der Atomistik* of 1890, which Bachelard greatly admired as the best historico-critical treatment of atomism.<sup>5</sup> This type of argumentative recourse to the historical pedigree of atomism was also popular in France: we encounter it in Léopold Mabilleau’s *Histoire de la Philosophie atomistique* (1853) as much as in Arthur Hennequin’s *Essai critique sur l’hypothèse des atomes dans la science contemporaine* (1896), both of which Bachelard quotes repeatedly. The same also holds true for that eminent neo-scholastic French chemist, Pierre Duhem, who tried to revalidate the Aristotelian concept of mixture against the allegedly Democritean matter theory of contemporary ‘English’ chemistry. His essay *Le mixte et la combinaison chimique: essai sur l’évolution d’une idée*, which voiced its anti-atomism at a surprisingly late moment, also figures in Bachelard’s account.

Today, we are accustomed to a situation in which the ontological entities inhabiting the exact sciences lead a life that is entirely independent of all philosophical control. The nineteenth-century situation is strikingly different from ours. For, in that period, one does not only find French chemists battling their English colleagues, but also philosophical idealists, who followed Hegel in rejecting atomism, crossing their swords with Neo-Kantians, who instead defended the epistemic and scientific value of the concept of atom. We furthermore encounter philosophers trying to tell scientists which theory to accept and which to reject; and conversely, we find scientists buttressing their theories by reference, not just to epistemological and metaphysical reasoning, but also to the philosophical arguments taken from such historical authors as Democritus, Lucretius, Kant or Hegel to buttress or to rebut the validity of the concept of ‘atom’. Take, for example, Thomas Sterry Hunt’s *Chemical and Geological Essays* of 1875. Relying on an Aristotelian terminology, Hunt insists that chemical union can be no “juxtaposition, as conceived by the atomistic chemists,” but has to involve the “interpenetration” of parts (as it brings about a new ‘species’). This, Hunt adds, was clearly understood by Hegel who stated that “the chemical process is an identification of the different and the differentiation of the

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<sup>5</sup> Bachelard, *Les intuitions*, 9: “Si notre dessein était de retracer le développement historique des doctrines atomistiques – tâche vraiment inutile après l’admirable ouvrage de Lasswitz – [...].”

identical.”<sup>6</sup>

On the other side of the fence, we encounter someone like Gustav Theodor Fechner, who in his *Über die physikalische und philosophische Atomenlehre* stated that “the question concerning atoms is maybe the point where today’s philosophy and today’s natural sciences clash most severely and then again part company most widely.”<sup>7</sup> In the realm of physics, atomic material points competed with continuous fields as basic concepts in the physics of James Clerk Maxwell or Hendrik Antoon Lorentz. For many commentators, the solution was to abandon the concept of atom in favor of pure field theories. It was against such authors that the famous physicist Ludwig Boltzmann wrote in 1897 his short essay “On the Necessity of Atomic Theories in Physics.”<sup>8</sup> In exactly the same period, Arthur Hannequin published his *Essai critique sur l’hypothèse des atomes dans la science contemporaine*, which Bachelard would also quote extensively in his own *Essai*, and which combined scientific, philosophical and historical arguments ‘critically’ (as the title of his book indicates), in order to reach the following conclusion: “Thus the contemporary theories are on this point in agreement with history: they give their blessing to the predominance of the atomist hypothesis.”<sup>9</sup>

So much, then, about the epic background of this international battle over atomism, which involved various academic disciplines, including philosophy. From the authors that Bachelard cites in his *Intuitions atomistiques*, it is evident that his own *Essai* belongs to this battle. What distinguishes however his study from those of the protagonists of the nineteenth-century polemic is his awareness that ‘atomism’ does not refer to a single concept, nor constitutes one, unique *intuition*. Few authors before Bachelard had been willing to recognize that the word ‘atom’ and the school name ‘atomism’ referred to a very heterogeneous bag of ideas. The general presupposition was that there existed an identity in significance or ‘intuition’ between the ‘atom’ of the Greek Presocratics and modern chemists and physicists. Of course, the situation changed somewhat after 1900, because – as mentioned earlier – the

<sup>6</sup> Thomas Sterry Hunt, *Chemical and Geological Essays*. Boston: J.R. Osgood, 1875, 428 and 450.

<sup>7</sup> Gustav Theodor Fechner, *Über die physikalische und philosophische Atomenlehre*, 2<sup>nd</sup> rev. edition. Leipzig: Mendelsohn, 1864, “Vorwort zur ersten Auflage [1855]”: “Die Atomenfrage ist vielleicht der Punkt, in dem heutige Philosophie und heutige Naturwissenschaft am härtesten zusammentreffen und wieder am weitesten auseinandergehen.”

<sup>8</sup> Ludwig Boltzmann, “On the Necessity of Atomic Theories in Physics” transl. by T.M. McCormack. In: *The Monist*, 12, 1902, pp. 65-79.

<sup>9</sup> Arthur Hannequin, *Essai critique sur l’hypothèse des atomes dans la science contemporaine*, 2<sup>nd</sup> ed. Paris: Alcan, 1899, p. 2 : “Ainsi les théories contemporaines sont sur ce point d’accord avec l’histoire, elles consacrent la prépondérance, dans le domaine scientifique, de l’hypothèse atomistique.”

composite atom that was empirically discovered at the turn of the century was certainly not directly compatible with Democritus' ultimate, indivisible unit of being. In fact, one of the first authors to insist on the heterogeneity of atomism was Bachelard's teacher Léon Brunschvicg. In his *L'Expérience humaine et la causalité physique* (1922), he opens his chapter XXXIX, entitled "L'Interprétation critique de l'atomistique," with the following memorable quotation from Henri Poincaré:

When Democritus invented the atoms, he considered them as the absolutely indivisible elements behind which there is nothing more to be sought. That is exactly what the word expresses in Greek, and this is by the way the reason for which he had invented them: behind the atom, he wanted there to be no further mysteries. The atom of the chemist would therefore not have satisfied him, because this atom is by no means indivisible, nor is it a real element, and it is not devoid of mystery: this atom is a world. Democritus would have thought that after having worked so hard to find it, we have come no further than we were at the beginning. These philosophers are never content.<sup>10</sup>

Brunschvicg did not only dislike Poincaré's stab at the philosophers, but also took exception at his presupposition that Democritus represents the original nature of the atomistic intuition *tout court*. In Brunschvicg's eyes, there had for a long time existed different and partly incompatible notions and *intuitions* of the atom. In fact, incompatible intuitions could already been encountered in the ancient atomists themselves! It is this observation that constitutes the point of departure for Bachelard's classificatory essay, as Bachelard reveals on the very first page of his book: "M. Brunschvicg shows that already between Democritus and Lucretius, a contradiction entered into the atomical hypothesis, and that two grand doctrines, united under the same sign, but with different aspirations and fates, went together until the scientific age."<sup>11</sup>

What was before everyone's eyes after 1900, then, was that the newly found, composite atom of modern physics and chemistry did not correspond to the

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<sup>10</sup> Quoted by Léon Brunschvicg, *L'Expérience humaine et la causalité physique*, 2<sup>nd</sup> ed., Paris: Presses Universitaires de France, 1949, 375: "Quand Démocrite a inventé les atomes, il les considérait comme des éléments absolument indivisibles et au delà desquels il n'y a plus rien à chercher. C'est cela que cela veut dire en grec; et c'est d'ailleurs pour cela qu'il les avait inventés; derrière l'atome, il ne voulait plus de mystère. L'atome du chimiste ne lui aurait donc pas donné satisfaction, car cet atome n'est nullement indivisible, il n'est pas un véritable élément, il n'est pas exempt de mystère; cet atome est un monde. Démocrite aurait estimé qu'après nous être donné tant de mal pour le trouver, nous ne sommes pas plus avancé qu'au début; ces philosophes ne sont jamais contents."

<sup>11</sup> Bachelard, *Les Intuitions*, 1-2: "M. Brunschvicg montre que, déjà, de Démocrite à Lucrèce, une contradiction s'est installée dans l'hypothèse atomique et que deux grandes doctrines, réunies sous le même signe, mais d'aspirations et de destins divers, vont de conserve jusqu'aux âges scientifiques."

Democritean idea of the ultimate, simple and indivisible material unit. What Brunschvicg added to this common observation was that even *before* the experimental discovery of the physical atom, the atom had been a entity onto which conflicting intuitions had been projected, and he had traced these conflicting intuitions back to the ancient period. Bachelard's essay can be viewed as an attempt to bring order into these conflicting intuitions by classifying them.

We began this reflection by placing *Les Intuitions atomistiques* at the very end of a century of philosophical and scientific debate about the term 'atom', and to explain its limited impact by the fact that it belonged, as it were, to an era and a discussion that had come to an end. The advent of relativity theory, quantum mechanics and particle physics had ushered in a period in which philosophers could do not much more than marvel at the new directions that physics had taken. There was little space left for a dialogue, let alone for controversy, between professional philosophers and physicists about the use of the ontological apparatus employed by contemporary scientists. Put somewhat dramatically, the years 1910 to 1930 define the period in which scientists stopped listening to philosophers. Instead, many eminent scientists – Einstein, Bohr, Heisenberg, Schrödinger, De Broglie, and many others – lamented the ignorance of professional philosophers and felt that they had to take it upon themselves to work out the philosophical implications of their groundbreaking scientific theories.

In the light of this breakdown in communication, it is not entirely clear to which type of 'student' Bachelard addressed his essay: did he hope to elucidate students of physics or of philosophy?

## Strength and weaknesses

Let us now turn from our attempt to locate Bachelard's essay to a brief examination of its claims. In the eyes of today's historian of philosophy and science, *Les Intuitions* constitutes a fascinating piece of reflection, which contains a number of arguments that are fully persuasive, while others seem unacceptable. On the one hand, Bachelard recognized better than most historians of philosophy and science that there may never have been "a body of doctrines more mixed up than atomism taken in its entirety."<sup>12</sup> It suffices to look at the early modern revival of atomism to convince oneself of the wild disparateness of the entities that sailed under that name. Giordano

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<sup>12</sup> Bachelard, *Les Intuitions*, 11: "Est-il corps de doctrines plus mêlé que l'atomisme pris dans son ensemble?"

Bruno's ensouled spherical monads, Pierre Gassendi's or Giovanni Alfonso Borelli's highly complex corpuscular shapes, David Gorlaeus' atomic *entia per se*, Daniel Sennert's semi-Aristotelian atoms-cum-forms, or René Descartes' little chunks of *res extensa* have conceptually very little in common with each other, and they also look very different when drawn on paper. If we add to this that the word 'atom' was made to function within mutually incompatible natural philosophical systems, one feels forced to conclude that it possessed neither a fixed 'reference' nor a stable 'meaning', to use Frege's useful terms.

The recognition of this extreme heterogeneity could lead one to a variety of conclusions. One rather radical conclusion has been drawn recently by Robert Pasnau, who argues that at least in the early modern period, 'atomism' did not exist as a school of thought: "Atomism [was] a view that barely mattered," Pasnau argues, because "if atomism is just this – a belief in indivisible atoms – then it should be treated as a thoroughly peripheral issue, insomuch as very little turns on whether one thinks the material realm is or is not infinitely indivisible."<sup>13</sup> Pasnau's suspicion that the existence or inexistence of 'atoms' was a peripheral issue in the Middle Ages and the early modern period seems to be confirmed by the late invention of the label 'atomism'. According to Robert and Estienne's *Thesaurus Linguae Graecae* of 1572, this label was first coined, in Greek, by Theodor Gazes, who employed it in his *Antirrheticon* of ca. 1470. In his *Democritus reviviscens* of 1644, Jean-Chrysostôme Magnen spoke merely of a 'Philosophy of Atoms'. The term 'atomism' itself appeared only in the last quarter of the seventeenth century, possibly first in the works of Ralph Cudworth, who used the term 'atomicism' to denote a materialist and atheist variant of the true corpuscular philosophy.<sup>14</sup> But even after Cudworth did it not become a prominent word. When we look at the eighteenth century, we will find that the term 'atomism' was rarely used – a fact that mirrors the lack of atomistic thinking and modelling in physics, chemistry and philosophy during the Enlightenment.

But if it is indeed true that there existed no 'atomism' as a coherent school of thought prior to the ideological and scientific controversies of the nineteenth century, then it might be less surprising that the entities to which the word 'atom' referred before the nineteenth century should have displayed such disparate and indeed conflicting characteristics. *Atomus* would then have had no reason to be any less ambivalent than other frequent terms, as for example *caelum* (which could refer to the

<sup>13</sup> Pasnau, Robert, *Metaphysical Themes 1274-1671*. Oxford: Oxford University Press, 2011, 84 and 88.

<sup>14</sup> Ralph Cudworth, *The True Intellectual System of the World*. London: Richard Royston, 1678, title of ch. 2: "that the *Democritick philosophy*, made up of *Corporealism* and *Atomicism* complicated together, is essentially atheistical."

sky, the place to which the stars were attached, the domain defined by the fifth element of ether, or the place to which the blessed rise after their death) or *natura* (which could mean anything from ‘essence’ over ‘character’ to ‘landscape’). Seen in this light, Bachelard’s insistence that there is no “body of doctrines more mixed up than atomism taken in its entirety” is nothing but a rejection of the false backward projections of nineteenth-century ‘historico-critics’. Indeed, it is historically much more fruitful and accurate to embrace a non-essentialist view, according to which ‘atom’ is simply a theoretical term used in various ways across nearly two and a half thousand years – in the same diverse and often incongruent ways in which thinkers could speak of ‘cause’, ‘vacuum’, ‘seed’, ‘form’, ‘quintessence’, and so forth, without thereby becoming ‘causalists’, ‘vacuists’, ‘seminists’, ‘formalists’, or ‘quintessentialists’, let alone forming part of transhistorical schools of thoughts called ‘causalism’, ‘vacuism’, ‘formalism’, ‘seminism’, ‘collisionism,’ or ‘quintessentialism’. In sum, then, few theoretical terms are of such crucial importance that their very acceptance defines a specific school of thought – and the ‘atom’ became such a term only in the nineteenth century.

Once we understand the non-crucial nature of this term, we will be less surprised by the observation that ‘the atom’ travelled from one generation to the other without keeping a stable significance. “The definitions that are at the base [of great doctrines] darken in their reiterated application. The words themselves leave their roots; the usage tarnishes the etymology,” writes Bachelard in the opening paragraph of his book.<sup>15</sup> He wrote these lines just a few years too early to include a further destruction of the atom’s etymology: later in the same decade, nuclear fission was to be discovered. Since World War II, we have been living in an age in which the atom, which by etymology and definition should be ‘unsplittable’, is split so as to produce maleficent or beneficial atomic energy!

This ultimate and most extreme ‘tarnishing’ of the concept of ‘atom’ will probably have appeared to Bachelard like a further confirmation of his views. His insistence on the historical mutability of the meaning and connotations of atoms is valuable and acceptable even to the modern historian of philosophy and science. Less valuable seem, by contrast, his attempts to classify basic intuitions and to distinguish two ‘epistemological directions’ of atomism, in elaboration of Brunschvicg’s contrast between Democritus and Leucippus.<sup>16</sup> Not only do his classificatory axes appear to contradict his justified insistence on the concept’s continuous shifts in meaning – he himself admits that he proposes his classification “*despite* the historical diversity of

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<sup>15</sup> Bachelard, *Les Intuitions*, 1: “Les définitions qui sont à leur base s’obscurcissent dans une application répétée. Les mots eux-mêmes quittent leur racine; l’usage en ternit l’étymologie.”

<sup>16</sup> Ibid., 5: “Nous allons caractériser d’un peu plus près ces deux *directions épistémologiques*.”

doctrines”<sup>17</sup> – but they are also historically ill supported. When discussing the first ‘epistemological direction’, which is associated with Democritus, one is baffled by the simplicity of Bachelard’s characterization. The truth is that we know next to nothing about the origin of atomism: the relation of Democritus to the apparent ‘inventor’ of atoms, Leucippus, has remained entirely elusive, as has the relation of atomism to Parmenides’ immobile monism, on the one hand, and to Pythagorean numerology, on the other. Moreover, the ancient doxographer Diogenes Laertius attributed to Democritus no less than 70 books, most of which treat natural philosophical issues, but of which not a single one has survived!<sup>18</sup> What right do we therefore have to define the experimental part of Democritean atomism to be ‘extraneous’ to the basic intuition behind atomism and therefore to be weak, and to accuse the philosopher from Abdera of being blind to reality and therefore an adherent of “an idealist philosophy?”<sup>19</sup> Following Brunschvicg, Bachelard goes on to oppose Lucretius to Democritus, attributing to the former an empirical spirit, and denying to the latter any genuine influence on the atomistic renaissance of sixteenth and seventeenth centuries. For Bachelard, Lucretius’ *De rerum natura* represents an altogether new beginning for atomism; according to him, it was that didactic poem, and not at all Democritus, that brought about the revival of atomism in the early modern period. Of course, there is a lot to be said in favour of Lucretius’ influence. However, Bachelard’s account is too simplistic. He attributes, for example, no role to Epicurus, that important Greek atomist whom Lucretius explicitly emulated, and who is usually taken to constitute the bridge between Leucippus and Democritus, on the one hand, and Lucretius, on the other. If one recalls that Pierre Gassendi, a crucial figure in early modern atomism, devoted the best years of his life to the rehabilitation of Epicurus, one wonders how such an omission was possible. Possibly even more surprising is Bachelard’s total silence on Plato’s *Timaeus*, whose atomistic physiology profoundly influenced medical and physical atomism in the sixteenth and seventeenth centuries, and which stood at the cradle of the distinction between primary, geometrical and secondary, sensory qualities in Galileo’s *Assayer* (1623) and in subsequent authors up to John Locke.

Indeed, *Les Intuitions atomistiques* reduces the influence of Greek atomism on the atomistic renaissance in a manner that is hardly credible.<sup>20</sup> Even ”when Bacon

<sup>17</sup> Ibid., 12: “On peut donc espérer de trouver une classification claire, sinon rationnelle, malgré la diversité historique des doctrines.”

<sup>18</sup> Diogenes Laertius, *Lives of Eminent Philosophers*, tr. D.R. Hicks, 2 vols. Cambridge, Mass.: Harvard University Press, 1925, IX 46-49.

<sup>19</sup> Bachelard, *Les Intuitions*, 6-9.

<sup>20</sup> Bachelard, *ibid.*, mentions Epicurus *en passant*, on pp. 50 and 56; and Plato in a context entirely unrelated to atomism, on p. 36.

cites Democritus,” Bachelard insists, “this happens only so that he can acknowledge his debt for the word *atom*,” but not because there was truly anything that Bacon shared with this Greek thinker.<sup>21</sup> But is this convincing? Why should Bacon have desired to borrow the word ‘atom’ in the first place if he was subsequently going to subvert its meaning? Bacon, as we now know, was never an atomist, but he did feel that the original Democritus had been closer than Aristotle to understanding the underlying principles of matter and motion. By Bachelard’s standards, it would also have to remain mysterious why the Pavian professor of medicine Jean-Chrysostôme Magnen should have attempted to reconstruct the old atomist doctrine in his popular *Democritus reviviscens, sive de atomis* (1646), if he didn’t think that there was anything worth reconstructing.<sup>22</sup>

Given that only rumors and reports, but no coherent body of texts, had come down from Democritus, it is of course true that early modern followers could represent him and his thought in any way they wished. The same may a fortiori also be said of Bachelard’s own description of Democritus as an ‘idealist’ and a ‘positivist’. In the absence of a solid textual basis, any doctrinal exegesis must remain hypothetical. With respect to the early modern period, however, one ought to keep in mind that there actually did exist a body of pseudonymous literature that was at the time believed by many to be genuinely Democritean. In fact, one can distinguish between four distinctive Democritean figures: besides being a philosopher who in his explanation of natural phenomena relied on atoms, Democritus was also featured as the ‘laughing philosopher’ (who was contrasted with the Heraclitus, the ‘weeping philosopher’), as the father of comparative anatomy and teacher of Hippocrates (thanks to a pseudo-Hippocratic body of letters) and as one of the earliest alchemists (thanks to an equally pseudonymous treatise that was published under his name).<sup>23</sup> In other words, one could in the seventeenth century be a self-professing Democritean while subscribing to doctrines that had little or nothing to do with the thought of the historical Democritus. We may therefore conclude that, at least in the early modern period, neither of the two clean types of *intuitions* that Bachelard postulates actually existed.

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<sup>21</sup> *Ibid.*, 10.

<sup>22</sup> Johannes Chrysostomus Magnen, *Democritus reviviscens sive de atomis*. Pavia: J.A. Magrius, 1646. From the second edition onward, the book carried the title *Democritus reviviscens, sive vita et philosophia Democriti*.

<sup>23</sup> See my own “The Fourfold Democritus on the Stage of Early Modern Science”. In: *Isis*, 91, 2000, pp. 442-79.

## Atomistic realists, positivists, critics, axiomatists

When Bachelard duplicates his basic contrast between Democritean and Lucretian atomism into four main schools of thought – *l'atomisme réaliste*, *l'atomisme positiviste*, *l'atomisme critique*, and *l'atomisme axiomatique* – he explicitly “borrows examples taken from very different moments of the philosophical evolution” of the term ‘atom’. “We wish,” Bachelard declares, “to mix epochs rather than mixing genres. We also discard whatever is accidental and specifically historical in certain conceptions.”<sup>24</sup>

There is no doubt that such a method can lead to very interesting results – as has been demonstrated anew by Andrew Pyle’s more recent and unrelated attempt to distinguish in all periods of atomism four basic themes.<sup>25</sup> But such an approach is, by Bachelard’s own admission, not interested in the historical evolution of the concept ‘atom’ itself, nor even in the historical dimensions of any given conception he examines. Instead, Bachelard is seeking and presenting *Idealtypen* – and while this is certainly a legitimate enterprise, it cannot satisfy the historian of philosophy and science.

One of the greatest paradoxes of the Renaissance revival of atomism is constituted by the fact that already in the sixteenth century, Lucretian *imitatores* (such as Scipione Copece, Girolamo Fracastoro or Giordano Bruno), theologically motivated ontologists (such as Nicolaus Taurellus or Eilhard Lubin) and physicians (such as Nicolaus Biesius) began to re-introduce atoms into their different disciplines, using them in the most disparate ways, thereby answering questions as diverse as the temporal relation between man and God, the diffusion of diseases, the structure of chemical substances, the growth patterns of divine ideas, the origin of evil, or the numerical identity of things in the middle of ubiquitous change. In the seventeenth century, the situation became even more rich and confusing. There simply is no way in which a single, sufficient reason could be given for why atomistic ideas could flourish so much in that century. The arguments proffered in their favor could be empirical, logical, theological, monadological, empirical or even historical. Some of

<sup>24</sup> Bachelard, *Les Intuitions*, 12: “... nous prendrons donc le droit d'emprunter des exemples à des moments très différents de l'évolution philosophique. Nous mêlerons les époques plutôt que de mêler les genres. Nous écarterons aussi ce qu'il y a d'accidentel, de spécifiquement historique, dans certaines conceptions.”

<sup>25</sup> Andrew Pyle, *Atomism and its Critics. From Democritus to Newton*. Bristol: Thoemmes Press, 1997. Pyle attempts to extract from all periods of atomistic thinking the following elements: (1) indivisibles; (2) vacuum; (3) matter, forms, and qualities; and (4) a mechanical philosophy.

the appeal of atomism consisted simply in the fact that it appeared to offer a venerably ancient alternative to Aristotle's natural philosophy, which in the seventeenth century looked increasingly discredited. Take, as an example, Giordano Bruno, who admired Democritus for his theory of infinite worlds, and therefore also came to embrace atomism.<sup>26</sup> Or take the Aristotelian Julius Caesar Lagalla, who in response to Galileo's telescopic discovery that the moon had a rugged surface like the Earth and that Jupiter also possessed moons found it necessary to reject, in one and the same treatise, Giordano Bruno's theory of infinite worlds and Democritus' theory of atoms.<sup>27</sup> These cases show that the appeal of a concept often lies in the field of associations with which it is connected.

In his famous essay, *La Formation de l'esprit scientifique*, Bachelard has drawn attention to yet another element that promoted early modern atomism: it was the invention of the microscope, which seemed to suggest that entities existed below the threshold of natural vision, and which allowed for all kinds of implausible expectations, or dreams, about what could be found by means of the new instrument.<sup>28</sup> 'Atoms', in that world of seventeenth-century dreams and expectations, played a prominent role; but because no one ever found these atoms, their status, shape and typology remained vague.

In sum, then, there was no coherent program, let alone a unified epistemology or 'intuition', behind early modern atomism. One finds empirical, alchemical arguments next to invocations of the sacred, Mosaic origin of atomism; van Leeuwenhoek's detailed microscopical reports appear next to René Descartes' entirely imaginary illustrations of material particles, and Pierre Gassendi's philological reconstruction of Epicurus' teaching appears next to the *atomi non quanti*, those mathematical point-atoms of the old Galileo Galilei. Of course, it would be admissible to seek, in each of these instances, the realist, positivist, criticistic or axiomatic component. However, in most cases, one will not only find an inextricable mixture of these basic types of *intuitions*, but also argumentative vectors that cannot be fitted into any single box of Bachelard's matrix. David Gorlaeus' class of atomic entities (*entia per se*), for

<sup>26</sup> The link between the theories of infinite worlds and of atomism becomes clear, for example, in Giordano Bruno's *De l'infinito, universo et mondi*. Venice [= London]: without publisher, 1584, dialogue II: "Son terre infinite, son soli infiniti, è etere infinito; o secondo il dir di Democrito ed Epicuro, è pieno e vacuo infinito."

<sup>27</sup> Julius Caesar Lagalla, *De phaenomenis in orbe lunae novi telescopii usu a D. Galileo Galilei nunc iterum suscitatis physica disputatio*. Venice: Tommaso Balioni, 1612.

<sup>28</sup> See Gaston Bachelard, *La Formation de l'esprit scientifique. Contribution à une psychanalyse de la connaissance objective*. Paris: J. Vrin, 1938. On the atomistic expectation of seventeenth-century atomism, see Christoph Lüthy, "Atomism, Lynceus, and the Fate of Seventeenth-century Microscopy". In: *Early Science and Medicine*, 1, 1997, 1-27.

example, comprise physical, extended atoms of matter, space and time, as well as souls, angels and God. Given this extraordinary set of entities, his proof of the existence of atoms must evidently defy the four categories that Bachelard has in store for us.

Precisely the conceptual, methodological and disciplinary mess that surrounded the atom in the seventeenth century also led to its downfall in the eighteenth. The incongruent atomist revival of the early modern period was followed by an anti-atomistic reaction. In the middle of the eighteenth century, it was possible to write an elegant Lucretian poem against Lucretius! This is exactly what the French Cardinal Melchior de Polignac achieved with his *Anti-Lucretius*, which was published posthumously in 1745 and refuted ancient and modern atomistic arguments drawn from Democritus, Lucretius, Descartes, Boyle, Newton, and many others. As mentioned before, there was little talk of atoms in the eighteenth century, and it was only thanks to late eighteenth-century English chemists that atomistic views returned to the scientific discourse in the nineteenth. However, as we have seen, this second atomistic revival was once again an uphill struggle, with chemists, notably in France, combating it until about 1900. There is therefore much truth in the suggestive title of Pierre Thuillier's article, "The Resistible Rise of the Atomic Theory"<sup>29</sup>!

If the arguments of this article are correct, it may be concluded that the sources quoted in Bachelard's *Intuitions atomistiques* demonstrate that his essay belongs to the debates surrounding this second renaissance of atomism, and may even be regarded as a twentieth-century postface to it.

Historians of philosophy and science will continue to appreciate this essay as a valuable source of inspiration. Bachelard is always lucid and sharp, and he always has important points to make. Faced with the extremely messy history of the word 'atom', they will agree with his claim that there has probably never been "a body of doctrines more mixed up than atomism taken in its entirety." But for the reasons mentioned above, they will continue to refrain from applying his categories as a means to bring classificatory clarity into the historical mess, deeming these categories to be inadequate to the task.

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<sup>29</sup> Pierre Thuillier, "La résistible ascension de la théorie atomique". In: *La recherche*, 4, 1973, 705-9.