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PREFACE

The idea for this book was first developed in August 1996 in the course of a conference at the University of St. Andrews in Scotland which was organized by John E. Murdoch and William R. Newman. This ten-day seminar ran under the same title as this book – "Late Medieval and Early Modern Corpuscular Matter Theories" – and brought together historians of science, philosophy and medicine from three continents.

The conference was sponsored by the *Foundation for Intellectual History* in London, founded and directed by Constance Blackwell, whose characteristic generosity made the meeting possible, who contributed to its ongoing discussions, and who has in various ways encouraged the genesis of this volume. In addition, the *Istituto e Museo di Storia della Scienza* in Florence contributed financially to the conference.

Although participating in the St. Andrews conference, Roger Ariew, Ugo Baldini, Saul Fisher, Guido Giglioni, and Fred Michael are not present with their own chapter in this volume. However, the contents of their presentations and their contributions to the general discussions have left clear traces in this book. Like Stefano Caroti, who could not be present at the conference, they also participated in the ensuing exchange of papers and thereby helped to shape the contents of certain chapters.

Above all we must thank Stephen Read, of the Department of Logic and Metaphysics at St. Andrews, not only for his presence and contributions to the meeting itself, but who, in the years preceding our conference planned and met with officers of his University in order that all arrangements for the meeting be assured of utmost success. It is to him that our gratitude must be extended for receiving us with such efficiency and courtesy at St. Andrews. During the course of the conference, Chris Lindsay, now of the University of Glasgow as well as St. Andrews, was of assistance in more ways than we can number. Our appreciation must also go to Christine Gascoigne, who greatly facilitated the participants' use of the library at St. Andrews. Lastly, we must thank June Pratt for her efforts in making it possible to hold the final banquet of our conference in the Edwardian mansionhouse Hill of Tarvit.

The actual production of this book would not have been possible without the help and assistance of Julian Deahl and Marcella Mulder

FRANCIS BACON AND ATOMISM: A REAPPRAISAL

SILVIA A. MANZO

Francis Bacon's theory of matter is a controversial topic among historians. Disagreement exists in particular about Bacon's atomist and animistic ideas. Robert Kargon has maintained that Bacon progressively abandoned his early theory of atomism and replaced it with a contrasting pneumatic matter theory. Graham Rees has gone even further, claiming that Bacon never made a positive commitment to atomism, which only played a methodological role, for example in his invocation of the Democritean method of dissecting nature to uncover its subtleties. Rees also maintains that Bacon's pneumatism was the sole foundation of his so-called semi-Paracelsian matter theory. However, there also exists a very different viewpoint, which suggests that although Bacon changed his views on atomism repeatedly, he never rejected it completely (Partington, Urbach). Benedino Gemelli's recently published important study seems to substantiate the latter view. By focusing on Bacon's relation to classical atomism and its sources, Gemelli is able to conclude that although Bacon rejected the vacuum, the atom nevertheless represented for him the smallest unit of matter, though it played no direct role in his experimentalist program.[1]

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[1] All works are quoted according to the edition F. Bacon, *The Works* [Spedding e.a.], except for the English translations of *De principiis, Descriptio, Phaenomena* and *De viis*, which are quoted from F. Bacon, *The Oxford Francis Bacon* [Rees e.a.], and for the English translation of the F. Bacon, *The New Organon* [Jardine e.a.]. The short reference *Letters and Life* refers to F. Bacon, *The Letters and Life* [Spedding].

For the debate on Bacon's atomism, cf. Kargon, *Atomism in England*, pp. 37–45; Rees, "Francis Bacon's Semi-Paracelsian Cosmology," pp. 81–101; Rees, "Atomism," pp. 549–571; Urbach, *Francis Bacon's Philosophy of Science*, pp. 72–79. Partington, *A History of Chemistry*, vol. II, pp. 394–396; Gemelli, *Aspetti*, p. 195. Somewhat similar to Kargon's are the positions of Lasswitz, *Geschichte der Atomistik*, vol. I, pp. 413–436 and Hesse, "Francis Bacon," pp. 236–247. Macciò, "A proposito dell'atomismo," pp. 187–196, claims that Bacon's abandonment of atomism is neither caused by his theory of forms nor by his pneumatic matter theory, but is due to his explanation of corpuscular motion by middle causes. Rossi, *Francis Bacon* [Gómez López], pp. 194–197, 221–228, maintains that Bacon first adopted atomism and then rejected it, although he never thought it was incompatible with animistic views, and further suggests that Bacon was not convinced that science was able to find the principles of reality. Jardine, *Francis Bacon*, p. 114, speaks of Bacon's indecision about atomism. Pérez Ramos, *Francis Bacon's Idea*, p. 102, n. 8, thinks that Bacon's indecisive response to atomism is not important for our understanding of the "syntax" of his ontological

I agree with this second interpretation, which I will substantiate by paying more attention to the usually neglected allegorical works and by investigating why Bacon changed his mind on atomism in his *Novum organum*. I shall reconstruct Bacon's various opinions in chronological order to establish his final evaluation of atomism and his reasons for it. Given that Bacon never embraced a matter theory identical with Greek atomism, I shall here define atomism in the broadest sense, as a corpuscular matter theory that posits final and indivisible particles. Following this semantic delimitation, two successive Baconian opinions will be distinguished: the first took the atom to constitute an ontological and causative-operational principle; the second deprived the atom of this causative-operational ability, but did not touch its ontological priority. At the same time, I will investigate the question concerning the coexistence of atomism and pneumatism in Bacon's theory, a point that has been discussed in the influential interpretations by Kargon and Rees. I shall argue that Bacon did not regard these two doctrines as incompatible.

1. *A Good Hypothesis*

Bacon was one of the first major figures of early modern England who took ancient atomism seriously and who examined its utility for his new science. Like many others, he sought to replace Aristotelian natural philosophy, which he repeatedly rejected, with a philosophy composed of doctrines taken from both ancient and recent atomist sources. A careful look at Bacon's reaction to atomism can help us reconstruct the recovery of this doctrine in the period immediately preceding the Scientific Revolution. In addition to the undoubted influence of ancient sources, which Gemelli has traced with philological sophistication, we must also mention Bacon's relationship with contemporary authors interested in atomist theories. There is evidence of Bacon's acquaintance with members of the Northumberland Circle; we know that he had direct contact with William Lower, Harriot's disciple and a friend of the Earl of Northumberland, whom he met in 1603,[2] and with William Percy, to whom he wrote a letter in the same year celebrating Percy's scientific interests.[3] Harriot, Raleigh and the Earl of Northumberland are all mentioned in Bacon's notebooks of 1608 and described as being worthy allies in the restoration of science.[4] It is very probable that Bacon became aware of atomism through his contacts with the Northumberland Circle, since he first mentioned this doctrine precisely at the time he met Lower. Giordano Bruno might have been another important influence on him. Bruno spent time in England from 1583 to 1585 and was said to have inspired some members of the Northumberland circle with his atomist views. Although we find some traces of Bruno's definition of Pythagorean atomism in Bacon's work, there is no evidence that he was directly acquainted with the atomist theories of the Italian.

Bacon's interest in the atomist model is first manifested in his *Cogitationes de natura rerum* (ca. 1604), where atomism is considered a good hypothesis for explaining the subtlety of nature, being therefore "either true or useful for the demonstration."[5] At this stage, Bacon accepted atomism as a heuristic tool, independently of whether it was true or not, the important point being that it was a good hypothesis. During this period Bacon was convinced that science had to search for the extremely small or "subtle" entities and motions hidden in nature.[6] Bacon's complex idea of the nature of "subtlety," which was important to him, was similar to Cardano's.[7] For Cardano, "subtlety" operated on various levels: first of all, it was an intellectual process by which sensible things are perceived by the senses and intelligible things are perceived through the understanding, processes that are carried out not without difficulty. But "subtlety" also existed in the substances themselves, in their accidents and in representations (images, species, discourses, texts). In corporeal substances, it was associated with fineness, smallness of quantity, fluidity, and divis-

positions. However, I think that the concept of form can be better understood if there is a clearer view of his matter theory.

[2] Letter of William Lower to Thomas Hariot (June 1610), quoted in Rigaud, *Supplement*, pp. 68–69.

[3] On Bacon and the Northumberland Circle, see Kargon, *Atomism in England*, pp. 43–44; Jacquot, "Harriot, Hill, Warner"; Gatti, "Giordano Bruno" and "Minimum and Maximum."

[4] F. Bacon, *The Letters and Life* [Spedding e.a.], vol. III, p. 58 (1603); *ibid.*, vol. IV, p. 63 (1608).

[5] *Cogitationes*, III, p. 15: "Doctrina Democriti de atomis aut vera est, aut ad demonstrationem utiliter adhibetur."

[6] Wolff, *Francis Bacon*, vol. I, p. 274.

[7] Cardano had been suggested as a possible influence on Bacon's notion of subtlety by Rees, "Atomism," p. 568. Bacon very probably read Cardano's *De subtilitate* during his studies at Trinity College; he explicitly mentioned Cardano in *Dignitate*, I, p. 456 and *Temporis partus masculus*, III, p. 530; *Partis Instaurationis Secundae*, III, p. 571.

ibility; in incorporeal substances, it was related to God's secrets and the order of the universe. For accidents externally caused, Cardano's definition of subtlety was broad and included artificially constructed machines as well as acrostics, puzzles and mathematical problems. In such a classification, then, intellectual subtlety inevitably also turns into the subtlety of the object itself.[8]

Most of Cardano's many meanings of "subtlety" can also be found in Bacon, who speaks of it as an objective attribute embracing all of nature,[9] found not only in material textures and schematisms, in motions and metaschematisms, but also in products of art such as clocks, which he says are as subtle as the works of nature. Indeed, Bacon also admires the greatest achievements of the liberal arts and sciences for their subtlety.[10] But for him, as for Cardano, subtlety means extreme smallness or imperceptibility (that is to say, invisibility and intangibility).[11] The concept refers also to both tangible and pneumatic matter, as both are imperceptible at their corpuscular level.[12] In the *Novum organum*, the so-called dissecting instances (also called "instances of Democritus") are designed to remind the reader of the wonderful subtlety of nature: a little drop of ink spreads into many lines and letters; a little quantity of civet scents a much larger volume of air, etc.[13] Bacon showed particular fondness for the example of the solution of saffron in water.[14] He mentions this example several times, twice alone in the *Cogitationes*, where he introduces it when he declares for the first time his acceptance of atomism. Here the saffron-water solution is offered as an instance of the subtlety of nature, to which the atom is found to testify. The second time this example is invoked, it is used to furnish an analogy for the distribution of bodies in a vacuum. Bacon writes that tiny particles of saffron are distributed in a larger volume of water, just as little empty spaces are distributed inside the matter of a body. He concludes that there

[8] Cardano, *De subtilitate*, pp. 1–2; Eamon, *Science and the Secrets of Nature*, pp. 279–281.

[9] *Cogitationes*: III, pp. 15–17; *Novum organum*, I, pp. 154, 184, 306, 319; *Historia vitae*, II, p. 197.

[10] *Ibid.*, I, pp. 168, 191–192, 259, 266.

[11] *Ibid.*, I, p. 333; *Valerius terminus*, III, p. 238; *De viis*, fol. 18^{v}; *Historia vitae*, II, pp. 195–196; *Sylva sylvarum*, II, pp. 380–382; *Novum organum*, I, pp. 306–309, 318; *Cogitationes*, III, p. 30.

[12] *Novum organum*, I, p. 311. Rees' interpretation that subtlety meant pneumatic matter does not seem to be right, nor the inference that Bacon rejected atomism by accepting pneumatism in its stead. Rees, "Atomism," p. 659.

[13] *Novum organum*, I, pp. 319–320.

[14] Gemelli, *Aspetti*, p. 144, n. 10.

is no reason to deny that the same proportion of vacuum and body could exist at a cosmic level.[15] Later, in his *Historia densi et rari* (1623), Bacon was to discuss this example in a very different framework. He now wrote that the dispersal of saffron, just like other dissecting instances, belonged to a kind of dilatation called *per deacervationem*.[16] In such dilatations bodies whose parts have been agglomerated become flattened through a change in the position of their particles (*positura partium*). Because no change of volume is produced, but only a change in figure, Bacon speaks of pseudo-dilatations.[17] Certainly the processes of contraction and dilatation, which constitute the focus of *Historia densi et rari*, were central topics of the atomist worldview. Bacon's attempt to explain the subtlety of saffron as a case of pseudo-dilatation shows clearly the continuous thematic link with older atomist traditions and document his search for more adequate explanations than those provided by previous philosophers.

At the same time, Bacon attempted to give a scientific methodology that was as "subtle" as possible, for he believed that "subtlety" was an intellectual attribute necessary for the competent natural philosopher. The subtlety of nature, Bacon said, often exceeds the subtlety of human understanding. The language and literary style of the scholastics had in fact been a typical case of vain subtlety.[18] However, Bacon was convinced that if our understanding were guided by the right method, many of the secrets of nature would become open to scientific investigation.[19] But for this to happen, nature first had to be separated into subtle parts in a process comparable to atomic dissection and alchemical anatomy: *mundi dissectione atque anatomia diligentissima*. The atomist inspiration behind this program is undeniable, and is in fact confirmed by Bacon's enthusiastic acceptance of Democritus' dissecting method, which he directly opposed to Aristotle's method of abstraction.[20] Democritus' philosophy is frequently celebrated as the best approach to nature, and is compared with both

[15] *Cogitationes*, III, pp. 15, 17. Hero, mentioned by Bacon in this passage, had offered a similar example: the dispersion of a little quantity of wine in water. In order to explain this phenomenon, he argued that the empty parts inside the water were occupied by wine. Cf. Hero of Alexandria, *Spiritualium liber*, fol. B4^{v}.

[16] *Historia densi*, II, p. 285.

[17] *Phaenomena*, III, p. 707.

[18] *Novum organum*, I, pp. 158, 160–161, 190, 215–216; *Valerius terminus*, III, p. 242.

[19] *Novum organum*, I, p. 234.

[20] *Novum organum*, I, pp. 168–169; *De principiis*, III, pp. 83, 110; *Interpretatio*, III, p. 518. When characterising Democritus as a dissector of nature Bacon alludes to a pseudo-Democritean figure described in a second/third-century epistolary novel. See Rütten, *Hippokrates im Gespräch*, pp. 55–63.

ancient and contemporary philosophies. In his theory of the Idols, for example, abstract generalization is opposed to the Democritean inquiry into the particular and concrete nature of things. Indeed, Bacon frequently associated the uncovering of nature's subtlety with Democritus' strategy of dissection.[21] This dissection of the physical world, so valuable for Bacon, is in turn linked to his examination of the forms, which he presented for the first time in the *Novum organum* in connection with Democritus' method.[22]

But Bacon's notion of the anatomy of nature is also associated with the language of the alchemical tradition. In alchemy "anatomy" means more than the mere dissection of living beings as it does in medical anatomy; it sometimes refers not only to a separation of the physical parts of chemical substances, but also to the theoretical knowledge of the invisible forces involved. "Alchemical anatomy" means in this case the separation of the more general parts to gain access to the invisible virtues of nature. For example, Oswald Croll, a follower of Paracelsus, speaks of an *anatomia mundi*, which resembles Bacon's *mundi dissectione atque anatomia diligentissima*.[23] Bacon's anatomical method thus includes not only the anatomy of the physician, which distinguishes the visible components of organic bodies, but also an alchemical anatomy based on fire, heat and solvents, distillations and solutions. Particular attention goes to corpuscular anatomy, for if well guided, it can discover the homogeneous parts that constitute macroscopic bodies. But despite his iatrochemical beliefs, Bacon continues to warn that the subtlety of nature usually exceeds the perception of the anatomist. However, because the goal of science is to know not only the visible bodies, but also the invisible corpuscular bodies, iatrochemical anatomy must be complemented by an inductive anatomy.[24] Anatomy, be it ocular, mechanical or chemical, must therefore always be guided by inductive reason which is able to develop a more general, comparative and axiomatic anatomy.[25] The final object and limit of this inductive anatomy are the simple natures, just as homogeneous bodies are the limits of medical anatomy and of laboratory distillations. Bacon speaks of this search in symbolic terms: the progress from a separation through fire to a

[21] Rees, "Atomism," pp. 567–571.

[22] *Novum organum*, I, pp. 168–169.

[23] *Novum organum*, I, pp. 218, 277. On Croll's concept of anatomy see Hannaway, *The Chemists and the Word*, pp. 23–25. On anatomy in Paracelsus, see Pagel, *Paracelsus*, pp. 136–138 and Eamon, *Science and the Secrets of Nature*, pp. 157–158.

[24] *De viis*, fol. 29^{v}.

[25] *Novum organum*, I, p. 234.

separation through reason is called "from Vulcan to Minerva."[26] He believed that chemists have failed to use "Vulcan" (fire) correctly, because they underestimated the utility of "Minerva" (reason), who should have been their guide and true instrument to separate the components of nature in experimental trials.[27]

In keeping with this discussion of the subtlety of nature, Bacon distinguishes in his *Cogitationes* two meanings of "atom." The atom is first conceived as the minimal portion of matter incapable of further division. This definition implies that matter is inwardly constituted in such a way that its subtle parts are imperceptible to the senses. However, their subtlety is not infinite, because matter is not divisible *ad infinitum*. The second definition of "atom," in turn, presupposes the existence of a vacuum and describes the atom as something that is deprived of it.[28]

According to Bacon, Democritus' analysis of the principles of nature was better than his treatment of motion. Bacon tried to imagine the series of arguments that had led Democritus to his conclusions concerning atomic motion and assumed that the Abderite had begun by asking what Bacon called a *quaestio activa*, namely, "whether all can be made from all."[29] As an affirmative answer seemed contrary to reason, Bacon supposed that Democritus had subsequently concluded that all things had to come from heterogeneous atoms and that, as a result, he had formulated an ontological, speculative model to answer his own *quaestio activa*. By stating that atoms were distinct in virtue of their figures, sizes and positions, Democritus tacitly rejected Anaxagoras' *homoeomeriae* and instead established the principle *ex nihilo nihil*.[30] In Bacon's judgement, Democritus' question ignored the empirical facts, because it was unable to resolve (*premere*) the speculative question (*quaestio speculativa*) about the properties of atoms. For if we keep in mind the intermediate transformations that occur in bodies, the right question should have been "whether all things change through middle transitions and circles."[31] According to Bacon, it is not necessary to postulate that the ultimate parts of matter

[26] *Ibid.*: "et transeundum plane a Vulcano ad Minervam."

[27] *Advancement*, III, p. 325; *Dignitate*, I, p. 489.

[28] *Cogitationes*, III, pp. 16–18. Cf. Lucretius, *De rerum natura*, I.510. Urbach, *Francis Bacon's Philosophy of Science*, p. 73 is wrong when saying that Bacon first accepted this definition but later rejected it.

[29] *Cogitationes*, V, p. 422; cf. III, p. 18: "utrum omnia ex omnibus fieri possint."

[30] Gemelli, *Aspetti*, p. 147.

[31] *Cogitationes*, V, p. 422; cf. III, p. 18: "utrum etiam per debitos circuitos et mutationes medias universa non transeant."

must be diverse, because the variety of the bodies stems from the gradual transformations of the dispositions of equal material units.[32]

Perhaps influenced by his current alchemical interests, Bacon took atoms to be *equales et similares* (Pythagoras' view)[33] rather than diverse in figure, size and position (Democritus' view). He seems to have thought of figure and size as limitations to the possibilities of transformation. Unequal atoms would impede the material continuity necessary to obtain any property whatsoever from any body having the set of properties *x*. Democritus' characterization rendered one type of atom capable of one type of transformation, and another type of atom capable of another type of transformation. On the other hand, if all atoms were identical, unlimited transformations would be possible through simple "numerical" or geometrical changes. One example of this is the transformation (i.e. total alteration) of wick into fume without any resulting residue.[34] In short, then, in his *Cogitationes*, Bacon analyses Democritus' account of motion from an alchemical point of view and finds fault with it. Democritus is accused of ignoring those facts of nature that show intermediary changes; of basing his theory of motion on false assumptions; and of deriving from these false premises the equally false doctrine that atoms are of unequal shape.

For Bacon, atoms are minimal particles, which combine into distinct figures and positions and operate in the interstitial *vacua* inside particular bodies. When taken in both these senses, the atom becomes useful as a precondition of the goals and normative rules of the new science; for it firstly constitutes the ultimate particle underlying all transmutations of bodies and secondly, as a fully replete body (without any internal vacuum), it represents the constancy of the material *quantum* throughout processes of contraction, in which interstitial *vacua* are ejected from larger bodies without any matter having to be annihilated. At the same time, Bacon included in his theory a very special kind of subtle and tenuous matter, namely *spiritus*, which he claimed deserved careful observation and manipulation by the natural philosopher.[35] While Bacon did not search for an ultimate cause of atomic motions, he did look for the conditions that

[32] *Cogitationes*, III, p. 18.

[33] Giordano Bruno related atoms to numbers in a Pythagorean manner. See Gemelli, *Aspetti*, pp. 146–147.

[34] *Cogitationes*, III, pp. 18–19.

[35] Later, in *Historia densi*, Bacon distinguished several kinds of pneumatic matter, spirits being only one of them. In an strict sense, "spirit" denotes the pneumatic matter which is locked up inside tangible bodies.

were needed to explain changes, and he found them in pneumatic matter, equal atoms and interstitial *vacua*.

During that period, Bacon accepted the description of atoms associated with Democritus, i.e., that they were hard and coexisted in a vacuum, but he later questioned these aspects, though never consistently.[36] From a methodological point of view, at first, Bacon thought that the search for natural extremes was a genuine goal for the new science and accepted the atom as a good hypothesis for his corpuscular matter theory, because it served as an ontological and causative-operational principle in a theory that required the existence of a vacuum.[37]

2. *Atomic* vis *and the Beginning of the World*

The *De sapientia veterum* (1609) marks the beginning of a transition. Here Bacon becomes deeply interested in explaining causality and atomic motions. He now describes both atoms and spirits as masters (*domini*) of motions in mixed mechanistic-animistic explanations of various phenomena, which he discusses in the form of myths for which he omits all experimental data. The brief account of the myth of Cupid in *De sapientia veterum* focuses, for example, on atomic motion, with Cupid representing the natural motion of the atom. The atom is said to be an *antiquissima et unica vis*, which is found in all objects created from matter (*ex materia*). Bacon assumes the existence of interstitial *vacua* and concludes that this atomic virtue operates only at a distance. At the same time, atomic primary matter is described as possessing *stimulus*, *appetitus* and *sympathia*.[38]

Bacon notes that the atomic motions (ascent and descent) described by Democritus are insufficient, as there are many other kinds of motion.[39] Without defining primitive atomic motion, Bacon describes the conditions for their existence through the image of Cupid *sagittarius*. Action at a distance is an eminent case of the ubiquitous emanations found in nature. Thus according to Bacon, if we assume the existence of atoms and of a vacuum, then the atomic virtue nec-

[36] *Valerius terminus*, III, pp. 243, 227–228.

[37] *Temporis partus masculus*, III, p. 537. Wolff, *Francis Bacon*, vol. I, p. 274.

[38] *Sapientia*, VI, p. 655.

[39] *Sapientia*, VI, pp. 655–656; *De principiis*, III, p. 82; *Sylva sylvarum*, II, p. 346. Bacon mixed Democritus' views on motion with these of the Epicurean Lucretius. On Democritus' and Epicurus' theories of motion, see Wolff, *Francis Bacon*, vol. I, pp. 260–262 and Pabst, *Atomtheorien*, pp. 8–13, 45–49.

essarily acts at a distance. Bacon seems to assume that without action at a distance, all things would remain immovable in the vacuum.[40] In the fable of Pan, included in the same work, Bacon affirms that all things emanate immaterial virtues as if they were rays (*radii*).[41]

This idea is not unlike the *vis radiativa* of Walter Warner and Nicholas Hill.[42] In the 1620's, Warner established that matter could not be moved by itself without an external agent which he took to be a virtue or *vis radiativa*.[43] Warner believed that the nature of this force is not accessible to human knowledge. As it is interpenetrable, it can move matter in space and time. It can cause its effects either by direct contact or by a medium, by gradual transitions.[44] Like Bacon, Warner combines Neoplatonic and mechanical concepts to explain the phenomenon of visual perception. Color is nothing but the action of a *vis* on visual spirits which is reflected from the atomic structure of the body. Perception is defined in terms of atomic structures and its cause as a motion of *radiative energy*.[45] In the same way, using Democritus and Epicurus as his authorities, Bacon defines the forms of colors as the corpuscular structure of macroscopic bodies. However, he takes the emission of visible species to be radial, incorporeal, at a distance, and tenuous, and describes sense perception in terms of minute channels in the human body.[46] Nicholas Hill, whose *Philosophia Epicurea, Democritiana, Theophrastica* (1601) was the only English atomist work published before Bacon's, describes the *vis radiativa* in religious terms, as an active, divine, and causative principle.[47]

By the same token, Bacon's objections to Epicurus' doctrine of atomic motion are theological rather than physical.[48] He finds the

[40] *Sapientia*, VI, p. 656: "quisquis autem atomum asserit atque vacuum ..., necessario virtutem atomi ad distans introducit; neque enim hac dempta, aliquis motus (propter vacuum interpositum) excitari posset, sed omnia torperent et immobilia manerent."

[41] *Sapientia*, VI, p. 637; *Dignitate*, I, p. 525.

[42] Cf. the chapter by Clucas in this book.

[43] Warner, British Library, Add. MSS 4394, fols. 389, quoted in Kargon, *Atomism in England*, p. 37.

[44] *Ibid.*; Jacquot, "Harriot, Hill, Warner," pp. 117–119.

[45] On Warner's natural philosophy see *ibid.*, pp. 116–125; Kargon, *Atomism in England*, pp. 35–42; Henry, "Occult Qualities."

[46] *Valerius terminus*, III, pp. 236–239 and Rossi, *Francis Bacon* [Gómez López], pp. 333–336.

[47] This concept can also be found in Harriot's manuscripts, albeit more sporadic than in Hill and Warner; cf. the chapter by Clucas in the present book.

[48] *Sapientia*, VI, pp. 655–656; *Meditationes*, VII, p. 241.

clinamen theory and the causal account of motion to be worthy only of mockery.[49] In his religious work, the *Meditationes sacrae* (1597), Bacon distinguishes between various types of heresy. In this context, he accuses Epicurus of swapping Democritus' notion of "destiny" for his own "fortune," thereby committing an error similar to that of the heretic who neglects the equilibrium between God's power and God's knowledge. Bacon's Calvinist perspective does not allow for the view that God knows what is going to happen and yet does not predestine it. Seen in this light, the doctrine of atomic clinamen would seem to imply that God's knowledge is stronger than his power. In short, Bacon accuses Epicureanism of ignoring the rigorous causal chain of nature which reflects God's prescience.[50]

It seems, then, that Bacon understands the *fortuna* of atomic chance as the necessity imposed by divine providence. While Venus is said to represent a general procreative disposition, Cupid embodies a specific sympathy towards the individual. With the action of a minimum of providence, the atom moves blindly towards whatever it feels attracted to. The point is that Bacon considers God's providence to be admirably revealed when chance intervenes in these atomic appetites. He marvels at the notion that God makes use of a blind entity to obtain order and beauty.[51] But that very blindness comes to symbolize the fact that atomic motions are deprived of finality.[52] This is a similar concept to the wandering cause in the *Timaeus*, and in truth, Plato's view of causality and necessity in the physical world have here been assimilated by Bacon.[53]

Bacon employs other mythological figures, for example the Parcae, sisters of Pan, to designate the fates (*fata*) of individual things. This interpretation, which is briefly sketched in *De sapientia veterum*, is considered in greater detail in *De dignitate et augmentis scientiarum* (1623),[54] where Bacon compares the causal chain of actions for every individual to the Parcae's threads: both are hidden and difficult

[49] *Temporis partus masculus*, III, p. 537; *Sapientia*, VI, p. 656; *Dignitate*, I, p. 571 (only here Bacon ascribes to Democritus the thesis of *concursus fortuitus*); *Dignitate*, I, p. 634.

[50] *Meditationes*, VII, p. 241; *Dignitate*, I, p. 524. Bacon repeats in essence the usual objections formulated by Patristic authors to Epicurus' atomism. See Gemelli, *Aspetti*, pp. 20–24; Pabst, *Atomtheorien*, pp. 30–44.

[51] *Sapientia*, VI, p. 656.

[52] Rossi, *Francis Bacon* [Gómez López], p. 195.

[53] Wolff, *Francis Bacon*, vol. I, pp. 124–125; Plato, *Timaeus*, 48a. *Dignitate*, I, p. 550. On the Timaeic tradition in Bacon's work, see Briggs, *Francis Bacon*.

[54] *Dignitate*, I, p. 524; *Sapientia*, VI, p. 637.

to know.[55] However, there is nothing in the order of nature so small as to be without cause, nor again anything so great that it does not depend on something else according to a *certa lex.*

The distinction between individual and generic fate takes Bacon to the epistemological question concerning prediction, a topic commented on briefly in the fable of Proteus, where Bacon claims that once a natural philosopher knows matter, he will be able to know all present, past, and future things. However, his knowledge will be limited to particular subjects (*singularia*).[56] Obviously, this claim is not easily reconciled with the better-known assumptions of Bacon's inductive method. Yet, natural history must start from individuals in space and time, given the existence of uniformity in each species. Bacon recognizes only two *genera individuorum* as exceptions to this generic uniformity: first, those individuals that are unique in their species (such as the sun and the moon among the wandering stars); and secondly, those individuals that are so remote from the respective natures of their species that they are impossible to classify (monsters).[57] In short, the basic conception of his natural history assumes that there is a similarity among individuals of the same species, so that if their respective form is known, their motions will be predictable. In this point Bacon adopts a moderate determinist methodological program.[58]

In *De principiis atque originibus,* around 1612, Bacon offered a detailed ontological description of the atom as it had functioned at the beginning of the world.[59] At that time–so he tells us–a state of Chaos reigned. Cupid represented primary matter whose activity was represented by the *vis* imposed by God on the mass of primitive particles. In more concrete words, primary matter was then not deprived of form, appetite and virtue, although they all existed in a very simple and undetermined manner, which did not yet have the specificity of complex bodies. All subsequent specifications arose as an emanation of primary matter, primary form, and the principle of motion. Properties such as weight, hardness, etc., as well as the diverse motions are the result of the forms imposed by God's agency. This description of atomism belongs to Bacon's contemplative accounts, whose goal it

[55] *Dignitate,* I, p. 524.
[56] *Sapientia,* VI, p. 652.
[57] *Descriptio,* III, p. 729.
[58] Hesse, "Francis Bacon," p. 233.
[59] The date of *De principiis* has been much discussed. I agree with Graham Rees that the work has to be dated to a date not much after 1612. See F. Bacon, *The Oxford Francis Bacon* [Rees e.a.], vol. VI, pp. xxviii–xxix, n. 61.

is to differentiate between the principles and the origins of things; between atoms and secondary forms; between Chaos and cosmos. This essentially ontological account of the atom does not touch the question of its relationship to scientific practice.

Bacon uses the two basic concepts of principle and origin so as to organize his cosmological doctrine in his allegorical texts more clearly. These two concepts should be kept in mind if we wish to understand allegorical atomism and its relationship to later developments in Bacon's matter theory. The fable of Cupid represents the *principles* of the world, while the fable of Coelum speaks of the *origins* of the world. Since each represents a stage in the chronological epochs of the cosmos, the *principia rerum* (primary matter) must be studied before the *origines mundi* (system of the world).[60]

Bacon introduces an innovation into sixteenth-century mythology by identifying Cupid with the atom.[61] By doing so, he substantially changes the usual conception of the beginnings of the world, creating a primordial link between Chaos and Cupid. The relation of matter (Chaos) to atoms (Cupid) was in origin one of total inclusion: the total mass of matter was nothing but the aggregate of atomic particles. This coexistence of Chaos and Cupid disappeared when the phenomenal fabric of the world (also called *schematismus magnus* or *systema mundi*) was created by God, with all pre-existent matter now attaining its highest specification. According to this explanation, creation means the shift in the condition of matter from being unformed to being formed to the highest possible degree. As for Chaos, that formless representation of matter created *ex nihilo,* it ceases to exist in the process of hexaemeral creation.

This transformation of matter without annihilation is made possible because Cupid existed inside this Chaos *informis.* In other words, the mass of matter subsists, and yet changes, because atoms were already contained in Chaos. As a factor of continuity, the atom is the natural entity persisting throughout the shift from Chaos to cosmos. Through the divine Word, atoms go from disorder to order, producing orderly atomic structures without losing their essential primary form of matter. Bacon here not only appeals to mythology, but also to Holy Writ, glossing the first lines of Genesis as follows: "it is not written that God created matter in the beginning, but that He creat-

[60] *De principiis,* III, p. 87.
[61] On Bacon and the mythological tradition, see Lemmi, *The Classical Deities.*

ed Heaven and Earth."[62] This pre-hexaemeral matter was unformed *secundum totum*, because *secundum partes*, it had one primary form. In this biblical context, as in the mythological context before, "creation" is understood to mean the beginning in time of the orderly world–or its "origin," in Bacon's language.

Other features of the origins of the world are described in the fable of Coelum. Unfortunately, *De principiis* remained unfinished, and we do not know much of what Bacon intended to write. We can say that the brief reference to the myth of Coelum in *De principiis* should be read in the light of the account offered in *De sapientia veterum*, in which Bacon associated Coelum with Democritus' atomism. The myth of Coelum speaks of the several periods of the world's origin, which extended from Chaos to the present, with Coelum representing the concavity, which encloses all matter. The same myth also makes use of "the topic of infinity," because there were two theories of infinity to which Bacon pays special attention.[63] The first is Anaxagoras' doctrine of an infinite number of shaped and specific principles (*homoeomeriae*), which Bacon accuses of distorting the very notion of "principle" as it presumes original differentiation in nature that renders superfluous the search for the origin of multiplicity. To Bacon, it seemed obvious that such an infinity of *homoeomeriae* could not qualify as "principles."[64] The second infinity was the one associated with ancient atomism. Bacon alludes to it in his *Descriptio globi intellectualis* (ca. 1612), written at approximately the same time as *De principiis*. In the *Descriptio*, which is mainly concerned with astronomy, Bacon writes that Democritus had postulated an infinite quantity of matter, but a limited variety of atomic forms.[65] Although some followers of Democritus and Epicurus had claimed that their masters had torn down the walls of the world, Bacon argues that their assumptions did not entail any infinity. Multiform worlds as could be formed from infinitely many atoms could still be closed and even spherical like our visible world; and even if an infinite universe could not have an absolute center, it could still contain spherical parts. In

[62] *De principiis*, p. K4^{r}, III, p. 86. "Neque enim scriptus est, quod Deus Hylen in principio creavit, sed Coelum et Terram."

[63] *Sapientia*, VI, p. 649; *De principiis*, p. K1 I^{v}; III, p. 94: "Ille enim locus de Infinito ad parabolam Coeli pertinet."

[64] *Dignitate*, I, p. 523; *De principiis*, III, p. 87.

[65] *Temporis partus masculus*, III, p. 537; *Abdecarium*, II, p. 86. Democritus postulated an infinite variety of atomic forms. Lucretius, by contrast, postulated a limited number of forms in *De rerum natura*, I.72–79; II.1144–1145; III.522–531, 1048–1076; V.416.

other words, Democritus had analyzed the parts of the world quite correctly, but had not possessed the same ability to explain its general structure. Democritus "was a good dissector of the world, but in matters concerning its structure he was even worse than ordinary philosophers."[66]

Although Bacon rejected the notion of an infinite world, he thus still recognized the great value of Democritus' physical explanations "within the world."[67] A related judgement is expressed in Bacon's criticism of the methodological dangers arising from atomism, as is formulated in the Idols of the Cave. There he comments that while some minds tend to pay more attention to the whole than to the parts, other minds prefer the parts to the whole. Scientific research will result in blunders when unequal importance is attached to either the parts or the whole. The specific blunder of the atomist school resided in its obsession with the particles and its near neglect of the larger fabric of the world.[68] However, in his *Descriptio*, Bacon does not yet question either the ontological validity of atoms or their operative use. His point of criticism relates to cosmology and to the notion of an infinite universe–*ad parabolam Coelis pertinent.*

3. *Atomic Attributes*

In the *Cogitationes*, atoms account for the extreme subtlety of nature. In *De principiis*, Bacon goes on to ascribe a range of attributes to atoms so as to make it possible for them to express this subtlety. For he maintains that the prime entities are not abstract things, as many theories had erroneously assumed, but always conjoin in their being matter, form and action. These prime entities are precisely those atoms, of which the existence in nature must be beyond doubt.[69] The atom is a *vis vel virtus*, which is adorned (*ornatus*), i.e. a primary form from which all other attributes stem.[70] However, these atoms do not resemble any of the bodies we are perceptually acquainted with:

[66] *Descriptio*, p. E1^{v}; III, pp. 737–738: "Verum Democritus sector mundi bonus fuit, in integralibus autem mundi, etiam infra mediocres Philosophos."

[67] I disagree with Rees, who sees here a rejection of Democritus' astronomy and atomic matter. Rees, "Atomism," p. 568.

[68] *Novum organum*, I, p. 170.

[69] *De principiis*, III, pp. 82–86.

[70] On the Timaeic root of these views, cf. Briggs, *Francis Bacon*, p. 141.

> Thus atoms are not like fiery sparks, drops of water, bubbles of air, specks of dust, nor like tiny amounts of spirit or ether. Nor is their power and form something heavy or light, hot or cold, dense or rare, hard or soft, such as we find them in larger bodies, since these virtues and others of the kind are products of composition and combination.[71]

In order to justify the assertion that atoms are the principles of things, Bacon offers the following argument, by which the atom is said to be the primary matter, principle or cause of all things that possess as their first form an appetite for their self-conservation:

> Now an abstract principle is not an entity, and again, a mortal entity is not a principle; so that a clearly irresistible necessity drives men's thoughts (if they want to be consistent) to the atom, which is a true entity, having matter, form, dimension, place, resistance, appetite, motion and emanation. Likewise, amid the destruction of all natural bodies, it remains constant and eternal. For since the corruptions of the greater bodies are so many and various, it is absolutely necessary that that which remains as an unchanging center should be something either potential or extremely small.[72]

[71] *De principiis*, I, p. 11[r]; III, p. 82: "Democritus atomos sive semina, atque eorum virtutem, nullius rei similia quae sub sensum cadere posset asseruit. Itaque Atomi neque ignis scintillis, neque Aquae guttis, neque Aurae bullis, neque pulveris granis, neque spiritus aut aetheris minutiis, *similes* sunt. Neque vis et forma eorum aut grave quiddam est aut leve, aut calidum aut frigidum, aut densum aut rarum, aut durum aut molle, qualia in corporibus grandioribus inveniuntur; cum istae virtutes, et reliquae id genus compositae sint et conflatae" (my italics). According to Rees, "Atomism," pp. 563, 552, the claim here is that atoms "are not the same as" spirits; Rees therefore concludes that this passage implies an incompatibility between atoms and pneumatic matter. And since tangible matter can turn into pneumatic one, he deduces that tangible matter does not consist of atomic particles. I think that Rees is wrong, because he mistakes the very relation established in *De principiis*, III, p. 82. In order to argue for the imperceptibility of atoms, Bacon deals with a relation of external similitude (*similes*), not with a relation of ontological identity. And even if he had meant a relation of identity, Rees' conclusion would still not follow, because from "*A* is not identical to *B*," it does not necessarily follow that *A* is incompatible with *B*, nor that *B* is not composed of *A*. In conclusion, *De principiis*, III, p. 82 is not about an incompatibility between atoms and pneumatic matter.

[72] *De principiis*, p. M3[r]; III, p. 111: "Principium autem non est Ens; Ens mortale non est Principium; ut necessitas plane invincibilis hominum cogitationes (si sibi constare velint) compellat ad Atomum, quod est verum Ens, materiatum, formatum, dimensum, locatum, habens Antitypiam, Appetitum, Motum, Emanationem. Idem per omnium corporum Naturalium interitus manet inconcussum et aeternum. Nam cum tot and tam variae sint corporum majorum corruptiones, omnino necesse est, ut quod tamquam centrum manet immutabile, id aut potentiale quiddam sit, aut minimum."

It may seem surprising that Bacon wants to conclude his reasoning by such an appeal to "invincible necessity" (*necessitas invincibilis*). However, it should be understood in the light of his discussions upon various principles proposed by Greek philosophy, which involve two major premises: "an abstract principle is not an entity" and "a mortal entity is not a principle." Hence a real principle cannot be an abstract entity. However, the deduction of the other atomic properties (dimension, place, resistance or *antitypia*, appetite, motion and emanation) goes beyond these premises. Bacon's argument must have been as follows: if primary matter does have a non-specified form, this form must then be the simplest possible, i.e. corporeity, intended as a material, extended *quantum*. And lest this *quantum* of matter be destroyed, it needs resistance (*antitypia*), which protects it against annihilation. This *antitypia* serves two purposes, namely the resistance to annihilation and the conservation of matter.

The notion of atomic resistance goes back to the Stoic tradition, according to which antitypia (ἀντιτυπία) means the resistance of matter, which defines the difference between space and body.[73] In turn, Epicurus had attributed *antitypia* (resistance to penetration) to matter, and opposed it to the lack of resistance found in the void.[74] The concept of *antitypia* reappeared in contemporary authors known to Bacon such as William Gilbert and Francesco Patrizi,[75] who considered the difference between space and matter to lie in the latter's impenetrability. For Bacon, who adopts this concept, *antitypia* is, however, an essentially active property.[76]

According to the description found in the *Novum organum* (1620), *antitypia* is the primary motion as previously described in *De principiis*, that is, a motion inherent in matter, because of which the latter is able to ward off annihilation.[77] Here, the determination of primary motion is the same as the determination of primary form. Atomic *antitypia* is the manifestation of constancy in a quantity of matter at a corpuscular level, a fundamental principle of Bacon's

[73] Von Arnim, *Stoicorum veterum fragmenta*, vol. III, p. 315.

[74] Epicurus, *Opere* [Arrighetti], p. 29 ⟨24.49⟩.

[75] Gilbert, *de Mundo nostro*, p. 66; Patrizi, *Nova de universis*, fol. 78[r].

[76] As Henry, "Occult Qualities" has noted, the concept of matter as an essentially active being became commonplace in seventeenth-century English corpuscularianism. Bacon was possibly one of the first Englishmen who introduced activity as an essential property of matter, and he did so by means of the concept of *antitypia*.

[77] *Novum organum*, I, p. 330. Walter Warner also holds that matter's quiddity consists of "corporeity or resistibility (or *antitypia* or hardness)." Cf. Warner, B.M. Add. MSS. 4395, fols. 212–213 quoted by Kargon, *Atomism in England*, p. 36.

physics. For, like the Averroists, Bacon accepts undetermined corporeity, but in addition, he postulates a motion of self-conservation. It is not by chance that Bacon comes to this assumption, for it is the natural consequence of his quantitative view on nature, which pervades his speculative and practical philosophy as well as the microscopic and macroscopic realms of his natural philosophy. In the *Novum organum*, *antitypia* is the sole material appetite that does not presuppose the existence of another portion of matter, but which is inherent in every portion of matter. Other motions, by contrast, are relative to other bodies and thus presuppose a multiplicity of bodies.[78] In other words, primary matter tends toward self-conservation without needing any other entity to satisfy this desire. As for the attributes *dimensum et locatum*, they are justified by and contained in the very notion of *antitypia*. For if the atom has a resistance to annihilation, then it must have an impenetrable spatial dimension.

That matter is conserved through form was a common opinion in Aristotelian natural philosophy. In the Coimbra Commentary on Aristotle's *Physics*, the issue is brought up in the discussion concerning the difference between creation and conservation. The real distinction between the creation of matter by God and the conservation of matter by form is said to be due to the real distinction between matter and form. In other words, matter is conserved by the form, which inheres in it from the beginning of its existence; and although matter could be conserved by God, insofar as it exists in the physical world, it is in fact conserved by form. Thus, conservation constitutes the first law of the physical world *qua* physical.[79] Bacon agrees with the Coimbra Jesuits that form conserves matter, which went against the ideas of some Augustinians, who thought that matter could persist without form, at least if God should wish it.[80]

The *De principiis* offers further insights into Bacon's concept of atomic motion and his criticism of the Democritean theory. Here the parable of Cupid is used to demonstrate how the "heterogeneity" in both substance and motion of atoms is preserved. "Heterogeneous" is used here in a peculiar sense. Bacon considers Democritus' account to be incoherent, because he did not attribute a heterogeneous motion (*motum heterogeneum*) to atoms, although he did attribute heterogeneous bodies (different sizes and figures) and virtues to them.[81] And yet, Democritus did attribute a motion of descent toward the center of the Earth to heavier atoms and a motion of ascent toward the heavens to lighter atoms. This constitutes two "non heterogeneous" motions belonging to two specific kinds of larger bodies. In Bacon's opinion though, however, the primary motion (*motus primus*) of atoms had to be "heterogeneous." It is unlike the specific motions of larger bodies (ascent, descent, contraction, rotation, etc.), because the beginnings of all specific motions of larger bodies must be contained in the atomic primary motion.[82] "Heterogeneous" thus seems to mean "not yet specified."

Immutability is another attribute of atoms. While the atom undergoes changes of position, its substance remains immutable. Bacon's argument, although difficult to grasp, it goes roughly as follows. According to his first premise, immutability is a consequence either of potentiality or of minimality. The second premise says that it is not possible to ascribe potentiality to the atom, because, since the first potential entity cannot be potential in the same way that the rest of entities are, "it must necessarily be something wholly abstract, since it denies all actuality and contains all potentiality."[83] But as a principle cannot be abstract, the atom cannot be merely potential. Hence the second alternative must be valid: atomic immutability is due to minimal size of the atom. This attribute can be understood in a quantitative sense, as in the *Cogitationes*, where the atom is defined as the *minima portio* of matter, because it cannot be divided any further.[84]

As for emanation, it results from the triple atomic characterization of matter-form-action. Bacon had complained about those philosophers who postulated that action (or motion) was exclusively an emanation of an abstract form. For him, emanation was a diffusive action of the atomic *vis* which had the effect of creating the multiplicity of motions (*actiones, motus naturales*) and essences (*essentiae,*

[78] *Novum organum*, I, pp. 331–349.

[79] Collegium Conimbricense, *In octo libros Physicorum* (1616), Bk. VIII, ch. II, q. 1, a. 4. Carvalho, "Medieval Influences."

[80] Reif, "The Textbook Tradition," p. 26.

[81] *De principiis*, III, p. 82: "Democritus enim non omnino parabolae tantum, sed et sibi quoque impar et fere contrarius reperitur ... Debuit enim motum heterogeneum atomo tribuere, non minus quam corpus heterogeneum et virtutem heterogeneam."

[82] *De principiis*, III, p. 82: "Atque nihilominus et in corpore atomi elementa omnium corporum, et in motu et in virtute atomi initia omnium motuum et virtutum insunt."

[83] *De principiis*, p. M3^{v}; III, p. 111: "necesse est ut plane abstractum sit, cum omnem actu abneget, et omnem potentiam contineat."

[84] *Cogitationes*, III, p. 15. On the notion of *minimum* in Lucretius, see Gemelli, *Aspetti*, p. 162. Lucretius, *De rerum natura* [Bailey], 1.609–627. *Minimum* has other meanings in *Sapientia*, VI, p. 656.

virtutes) in this world: "matter (whatever it is) is so adorned, prepared and formed that every virtue, essence, action and natural motion can be the consequence and emanation of it."[85] Emanation seems to constitute the key by which Bacon explained the passage from unity to multiplicity, from Chaos to cosmos, and from the potency of atoms to the constitution of the real and actual world. Everything in nature, with the exception of the atom, was in his eyes an effect of atomic emanation, which is a part of the dynamic nature of atoms not objectively distinct from their appetite, motion, and action. Emanation describes a special aspect of atomic dynamics, namely their power to constitute the world's heterogeneous multiplicity. Bacon probably borrowed the term *emanatio* from Telesio, who had revived this Neoplatonist concept during the Renaissance.[86]

4. *Matter and Form*

How can atomic structure by itself produce such a cosmic multiplicity? Bacon's primary form is less specific than the rest of the forms and therefore has a distinct status. In the light of ideas introduced mainly in the *Novum organum* and anticipated in *Valerius Terminus* (ca. 1603), we may assume that atomic emanation result in forms of simple natures, the combination of which results in forms of composed nature. In his *De principiis*, Bacon denied that density, rarity, etc. were the properties of atoms, for as these qualities were more complex, they necessarily arise from atoms. If emanation depends only on motion and on the form of resistance, then it is necessary to suppose that such motion undergoes change, so that complex motions can arise from it. However, if such a change does occur, it apparently does not come from the appetite of resistance, since this is merely a search for self-conservation. Consequently, the alternative was to postulate an external cause, which Bacon identified with the Word of God. But a hitherto overlooked paradox seems to arise here. On the one hand, primary matter is always said to be fundamentally active and its appetite of resistance to motions invincible. On the other hand its activity is unable to overcome the inherently chaotic nature of matter by producing the species by itself. While the *vis* of primary matter is thus invincible and pervades nature as *a principio usque ad finem*, it does not suffice to produce a change in its own primitive state. In other words, the atom remains ineffectual as a principle of things without God's intervention.

Aware of this issue, Bacon asked himself "whether this created matter, through long revolutions of ages, by the power originally given to it, could have gathered and turned itself into that perfect schematism."[87] This question had previously puzzled such Franciscan authors as Petrus Olivus, who had claimed that matter has the capacity of moving itself, a capacity given by God at the moment of creation so that it could achieve a specific form. According to Olivus, the intrinsic mobility of matter is the manifestation of seminal reasons, which are its active causes.[88] However, neither Bacon nor Olivus concluded that created matter alone, without mediation of the divinity, could have constituted the actual world. Bacon observes that perhaps this question is something that we should not even ask. But what were the reasons behind Bacon's silence about this? The usual answer of historians to questions like this is to appeal to the philosopher's fear of possible religious censure. And perhaps this is indeed one of Bacon's reasons.[89] But perhaps another reason may have been that Bacon had doubts about this and consequently did not embrace a definitive position. In fact, in *De principiis*, Bacon seems to have attributed more power to atoms than in earlier works. In *A Confession of Faith* (1602), the laws of nature are said to have "begun to be in force" after the hexaemeral work had been completed.[90] Later, in *De sapientia veterum*, the initial intervention of the atomic force in the world is dated to a period subsequent to the creation of the species. By then, Bacon had reached the view that Cupid was the youngest of the gods, "since until the species were constituted he could not be vigorous."[91] Finally, in *De principiis*, Bacon appears to have begun to doubt whether the activity of matter

[85] *De principiis*, p. K3^{v}, III, p. 86: "asserenda materia (qualiscunque ea sit) ita ornata et apparata, et formata, ut omnis virtus, Essentia, actio, atque motus naturalis ejus consecutio, et emanatio esse possit."

[86] Cf. Telesio, *De rerum natura*, Bk. II, chs. 5–7, pp. 50–52; *De principiis*, III, pp. 96–97. A further source may be Roger Bacon, for whom the concept of emanation was central. Francis Bacon mentioned Roger Bacon in *Temporis partus masculus*, III, p. 534, but we have no evidence which manuscripts he had access to. Cf. editor's Preface to *Novum organum*, I, pp. 89–90.

[87] *De principiis*, p. M2^{v}; III, p. 111: "Utrum vero Materia illa creata, per longos saeculorum circuitus, ex vi prima indita, se in illum optimum Schematismum colligere et vertere potuisset ..."

[88] Pérez Estévez, *La materia*, pp. 331–332.

[89] Briggs, *Francis Bacon*, pp. 141–142 makes this suggestion.

[90] *Confession*, VII, p. 221.

[91] *Sapientia*, VI, p. 731; VI, p. 656: "cum non ante species constitutas vigere potuisset." I have modified the translation.

could have rendered divine intervention in the creation of species superfluous, but he cautiously seems to have preferred to conceal his doubts.

While in *De principiis*, Bacon speaks of primary form and places its ability to emanate on the same level as primary matter, in the *Novum organum*, he speaks of secondary forms (subdivided into forms of simple natures and forms of composed natures) and attributes a special emanative power to them. These forms are in fact characterized as a *fons emanationis, natura naturans*, while bodies are said to be *natura naturata*. In the seventeenth century, the fusion of Neoplatonism and Aristotelianism created the notion of form as an emanative agent, whose effects are found both in the spontaneous motions of the elements and the production of their proper accidents.[92] But in spite of this precedent, the emanative agency of form, according to the *Novum organum*, is mainly the consequence of its essentially operative character. When Bacon there introduces his own concept of form and attempts to set it off from the substantial forms of the Aristotelians, scientific applicability seems to constitute his main criterion. Baconian form is not only a theoretical law but an operative rule as well, which allows science to manipulate nature successfully. In this way, form possesses an ability to "emanate" artificial activities which matter itself does not have.[93]

Bacon's treatment of Cupid in *De principiis* distinguishes between essence and system and finds this distinction exemplified in the two entities of primary matter and forms. Bacon considers both of them laws, but with distinct tasks. Primary matter is nature's *unica et summaria lex* and lies at the top of the pyramid of knowledge, representing the element of unity in nature, which generates all variety by multiplying itself.[94] Forms, in turn, arise from the agglomeration of atoms that differ from each other in position and quantity.[95] In *De principiis*, Bacon recalls what he had already said in the *Novum organum*: "a true Form is such that it derives a given nature from the source of an essence which exists in several subjects, and which is better known to nature (as they say) than the Form itself."[96] Logically speaking, the *fons essentiae* is here the genus of a given nature (*instar generis veri*). Motion, for instance, is the genus of the form of heat.[97] Physically speaking, the notion of the "source of essence" appears to describe a nature more general than any given physical substance. In the hierarchy of physics, it would thus constitute the highest essence, which resides in primary matter.

Motion is permanent in nature; each form is ultimately reducible to the appetite of matter for self-conservation.[98] The reduction of the various forms to the primary form of resistance plays a very important role, because it demonstrates that for Bacon, motion is a universal determination of matter. There is no natural reality without motion–which is why the new philosophy must search for the *principia moventia rerum*. Forced to continue across changes, matter must always continue to move in order to conserve its identity. Passivity is thus alien to it. As a result, Bacon must reject Telesio's view that heat and cold are the principles that move an essentially passive matter.

Figure 1 provides a schema of the various themes discussed up till now. They are grouped according to the polar concepts of principle and origin. Obviously, an unfinished and posthumous work such as *De principiis* imposes severe limits to interpreters. *De principiis* is nevertheless a valuable source of Bacon's thought at the height of his reflections on matter theory. According to Rawley, the *Novum organum* was composed in the course of a twelve-year period before it was published, which means that some ideas concerning the theory of forms may have already been developed at the time when Bacon wrote *De principiis*. It may thus be possible to read the main concepts of Bacon's natural philosophy and the key introductory aphorisms of the second book of the *Novum organum* with this in mind. In addition, it helps us understand why Bacon seriously questioned the atomist model in his last major work.

[92] Reif, "The Textbook Tradition," p. 27. Pérez Ramos, *Francis Bacon's Idea*, pp. 90–91.

[93] *Ibid.*, pp. 114–115.

[94] *Dignitate*, I, p. 655, 567; *Valerius terminus*, III, p. 220; *De principiis*, III, pp. 81, 86.

[95] *Novum organum*, I, pp. 168–169, 228, 232, 262. Lemmi, *The Classical Deities*, p. 94 and Hesse, "Francis Bacon," pp. 229, 238 have noted that Baconian form is to be understood as an atomic aggregate. Gemelli, *Aspetti*, pp. 312–313 claims that the primitive inseparability and co-existence of atomism and forms is already present in *Cogitationes*.

[96] F. Bacon, *The New Organon* [Jardine e.a.], p. 104; I, p. 230: "Forma vera talis est, ut naturam datam ex fonte aliquo essentiae deducat quae inest pluribus, et notior est naturae (ut loquuntur) quam ipsa Forma."

[97] Pérez Ramos, *Francis Bacon's Idea*, pp. 120–125.

[98] On Bacon's simple natures, see Jardine, *Francis Bacon*, pp. 109–112 and Fattori, "Nature semplici."

Table 1

Matter and form during the pre- and post-hexaemeral periods

	Unity of nature	*Multiplicity of nature*
Main concept	Principle	Origin
State	Chaos Disorderly matter	Pan System of the world
Supernatural agent	Creation *ex nihilo* Work of manufacture (Matter)	Work of the six days Work of style (Acts-laws)
Allegorical figures	Mercury	Penelope and suitors[99]
Natural agent	The atom/primary matter: Highest law of essences *Fons essentiae*	Forms: Laws of acts *Fons emanationis*
Allegorical figures	Cupid	Coelum, Saturn, Jupiter, etc.[100]
Intervening forces	Primary form: *Antitypia*	Secondary forms (of simple or composed natures): qualities / species / genera

These differences between the principles of things and the origins of the world, as schematized above, can also profitably be applied to Bacon's views on the relationship between matter and form. At a first glance, Bacon's views seem to be contradictory. Yet a remarkable correlation with Plato's and Aristotle's concpet of "naked" matter may be found in his interpretation of the myth of Pan, as described in *De dignitate.* For after examining several theories about the origin of the world, Bacon says:

> But those who (like Plato and Aristotle) have represented matter as entirely despoiled, shapeless, and indifferent to forms, come much nearer to the figure of the parable. For they have presented matter as a common harlot, and forms as suitors.[101]

[99] Penelope represents matter penetrated by forms (symbolised by the suitors).

[100] Each deity represents a different aspect of the process leading to the actual world, which according to the Scriptures was God's hexaemeral work.

[101] *Dignitate,* IV, p. 320; I, p. 523: "Qui vero Materiam omnino spoliatam, et informem, et ad Formas indifferentem introduxerunt, (ut Plato et Aristoteles) multo etiam proprius et propensius ad parabolae figuram accesserunt. Posuerunt enim Materiam tanquam publicam meretricem, Formas vero tanquam procos."

This fragment is difficult to interpret, because in *De principiis* Bacon had affirmed that primary matter is neither abstract nor naked, and he had viewed the Platonic and Aristotelian cosmologies as the most false, because of their concept of abstract matter.[102] The Presocratic philosophers, by contrast, had come closer to the truth. Some, like Thales, Anaximenes, or Heraclitus, for example, had attributed mutability to the principle of nature; while others, such as Empedocles, Parmenides, and much later, Telesio, had maintained that there were many principles. Democritus' view had come closest to the nature of things, since it postulated a single and unchangeable principle.

In *De principiis* and *De dignitate,* we find two very similar fragments which appear, however, to affirm the opposite view. In order to understand what Bacon meant in each of these, their contexts are of relevance. The first fragment describes the very beginning of the history of nature–Chaos. The second fragment focuses on the post-hexaemeral epoch, over which Pan ruled as the representative deity. Consequently, "form" has a distinctly different meaning in each of these two situations. When matter is said to be "formed" *ex parte,* "form" signifies the primary determination of matter, or its resistance to annihilation. When matter is said to be "unformed" *ex toto,* "form" signifies the law by which bodies act, or its formal cause. Bacon's interpretation of Cupid's garments points to this semantic distinction.

Naked Cupid–who has *per se* an identity, but is nude–is mirrored by the atom–a simple principle and single substance. Bacon accuses rivalling theories of having overdetermined primary matter–just as if Cupid were clothed (*non exuto*). By overdetermining matter, such theories erred more gravely than those claiming matter's absolute abstractness.[103] In short, an understanding of Bacon's conceptual polarities as schematized above helps us to find a thematic continuity between those different fragments.

In his explanation of the world's origin, as portrayed in the fable of Pan, in *De dignitate,* Bacon shows a certain affinity to the notion of unformed matter. Here, the formation of the actual world is said to have taken place during successive periods and to be the work of one single God who created the material Chaos. At the

[102] *De principiis,* III, p. 84.

[103] *De principiis,* III, pp. 86–87.

historical moment of Chaos, the "matter of heaven and earth was created without the forms."[104] In other words, Bacon's agreement with Aristotle and Plato is limited to that period in the history of nature when matter was absolutely naked, unformed, and deprived of secondary forms.

By contrast, the subject of *De principiis* is the atom and its relation to Chaos, as becomes clear when we look at the role played by the fable of Cupid. Bacon emphasizes the contrast between unformed, passive Chaos and active, formed primary matter, both of which coexisted before hexaemeral creation began. For Bacon, both primary matter and the primeval chaotic mass are material entities of which the sole individuating mark is the distinguishability of the parts from the whole. Bacon continues by analyzing primary matter as a framework within which the various Greek cosmologies can be criticized. Notably, Bacon critically assesses whether either the Platonist or Aristotelian attributes of matter measure up to those provided in *De principiis.* Bacon deems that their description of prime matter as *abstracta, potentialis, informis, spoliata, passiva, fluens, tanquam accessorium formae, phantastica* as falling short of his own criteria. His analysis incidentally betrays once more a debt to both the Augustinian account of creation with its conceptual duality of *creare et facere* and to the Franciscan-Averroist conception of primary matter. In short, then, Bacon's judgements regarding Plato's and Aristotle's conceptions of unformed matter cease to be contradictory once the relevant contexts are taken into account.

Elsewhere in his writings, Bacon strongly rejects the Aristotelian distinction between the lunar and sublunar world. He comments that Aristotle's sublunar matter is like a whore yearning for forms and supralunar matter like a mother, characterizations that are closer to superstition and popular opinion than to philosophy.[105] In his critique, Bacon thus rejects once more the distinction between two kinds of matter. Note that Bacon does not categorically reject the existence of unformed matter yearning for forms, but rather the limitation of such matter to the sublunar world.

A related account is found in *Sylva sylvarum,* in which Bacon mentions experimental evidence that "dissatisfied" bodies desire to absorb other bodies. For instance, air transmits light, sounds, smells, and vapors, the cause of which remains unexplained. But Bacon writes: "as for the pretty assertion, that matter is like a common

[104] *Confession,* VII, p. 221.
[105] *Cogitationes,* III, p. 33.

strumpet that desireth all forms, it is but a wandering notion"—a notion, in other words, without solid foundation.[106]

Bacon generally views concepts of origin and principle as independent from one another. He may have thought that a theory may speculate competently about the system of the world, while simultaneously postulating wrong principles. According to Bacon, Telesio's philosophy presented such a case. It talked *non male* about the system of the world, but *imperitissime* about its principles.[107] By contrast, the Presocratics had been successful in their explanation of the fabric of the world, but they had erred when trying to establish its principle.

It may seem astonishing that after having searched for and identified the atomic principle of nature, Bacon implicitly admits that a mistake concerning the *principium* is irrelevant to the development of theses concerning the *principiata.* Although Bacon agrees with Telesio's speculations about natural species, he finds them limited insofar as they could not account for material schematisms.[108] It is then possible to speculate adequately about the phenomena of heat, as Telesio did, while at the same time ignoring its corpuscular motion?[109] Can a philosophy speculate *non male,* when it does not explain forms in terms of atomic structures? Indirectly such questions deal with the relationship between knowledge and power in Bacon's program. After all, knowing that heat is caused by atomic motion becomes less important when heat can be manipulated even without such knowledge? As Viano correctly remarks, Bacon's program of knowledge is heuristically oriented to scientific practice.[110] It reveals not the ideal, but the true relation between knowledge and power in science. Consequently, it is understandable that Bacon approves of certain Telesian theses, which served as instruments to achieve certain operative effects, despite the fact that these theories ignored the very constitution of matter.

[106] *Sylva sylvarum,* II, p. 601.
[107] *De principiis,* III, p. 110.
[108] *De principiis,* III, pp. 79, 87, 111. On the meaning of material schematisms, see footnote 114.
[109] *Novum organum,* I, p. 266.
[110] Viano, "Esperienza e natura."

5. *Latent Schematisms and Flexible Matter*

A turning-point is to be found in the *Novum organum* (1620) which, like the *Cogitationes*, considers atomic theory to be an instrument for the operative goals of science, leaving truth or falsity aside. The requirements of the inductive method had led Bacon to introduce more precise causal concepts, which could give an account of experimental evidence. As in the *Cogitationes*, Bacon writes of the atomist theory as being useful for the goals of the new science, but refrains from deciding about its truth value. In the context of the Idols of the Theatre, Bacon remarks that all ultimate explanations are worthless for scientific praxis, "since all utility and opportunity for application lies in the intermediate causes."[111] Bacon invokes this point both against the extreme abstraction of the Aristotelians and the extreme dissection of the atomist. In the *Novum organum*, he is neither concerned with Aristotelian potential matter nor with ancient atomism, but with the ability of given entities to play functional roles in an inductive science. Neither the potential and unformed matter of the Aristotelians, nor the atoms of Democritus and Epicurus can accomplish this. For even if they "were true, they could do little to improve men's fortunes."[112] Viewed in this light, the atom, an entity of extreme subtlety, can hardly serve Baconian science.

And yet, Bacon remains persuaded that natural inquiry must be exercised by means of an anatomical separation of the innermost parts. Bacon does make clear, however, that the concept of the atom, which presupposes non-flexible matter and a vacuum, may not be the analytical unit adequate to guide such an anatomy: "But we will not therefore end up with the atom, which presupposes a vacuum and rigid matter (both of which are false), but with the true particles (*particulae verae*) as they are found to be."[113]

These *particulae verae* are nothing but the first configurations of matter that Bacon called *latentes schematismi*.[114] Although material

[111] F. Bacon, *The New Organon* [Jardine e.a.], p. 55; I, p. 178: "omnis utilitas et facultas operandi in mediis consistat."

[112] *Ibid.*: "quae, etiamsi vera essent, tamen ad juvandas hominum fortunas parum possunt."

[113] F. Bacon, *The New Organon* [Jardine e.a.], p. 108, I, p. 234: "Neque propterea res deducetur ad Atomum, qui praesupponit Vacuum et materiam non fluxam (quorum utrumque falsum est), sed ad particulas veras, quales inveniuntur."

[114] Rees, "Bacon's Philosophy," pp. 223–243, distinguishes three Baconian meanings of *schematismus*: the whole fabric of the world (*schematismus magnus*), the generic name of all simple qualities (*schematismus materiae*), and the microscopic configurations (*schematismus latens*). In this paper I will use "schematism" to denote the last sense. Gemelli, *Aspetti*, pp. 182–195, explains some features of Bacon's schematism and its debt to Lucretius.

schematisms, too, are invisible, they represent the true texture of things, by which their specific virtues are determined. Admittedly, Bacon is not very clear about the meaning of these material schematisms. They are understood here as being conglomerations of particles from which the multiple heterogeneity of bodies is derived. The classical atoms of Leucippus and Democritus were assumed to be made of hard and inflexible matter (*materia non fluxa*). According to Bacon, however, such rigidity would prevent the intermediary transmutations that occur when bodies change their properties. The transmutation of bodies–incidentally the main goal of scientific practice–must occur from changes of the schematisms, not of the atoms. As for the vacuum–the other mainstay of ancient atomism–Bacon did not think it was necessary to explain changes in volume. Instead, he took recourse to so-called *plicae* (folds), which enabled matter to change its volume without any need for interstitial vacua.[115]

It is important to note that despite Bacon's re-evaluation of atomism, the corpuscular vocabulary remains intact in such later works as *De dignitate*, *Historia densi et rari*, *Sylva sylvarum*, etc. In fact, expressions like "minute bodies," *res minutae*, *particulae minutae* and *minima* are frequently invoked to describe physical activity. This shows that corpuscularianism continues to operate as one of the theoretical bases of Bacon's physics.[116] In the light of this, it is understandable why atomist concepts expressly associated with Democritus still maintained their place among the first axioms of philosophy. Thus we read for instance: "Nature shows itself most forcefully in its smallest portions."[117] Indeed, the idea that each motion has its ultimate cause at a microscopic level remains an undoubted principle. Thus each natural action is accomplished *per minima*, or at least through things too small to affect the senses. The most subtle metaschematisms are nothing but a *latio per minima*.[118] But not only motions, but also matter occur as *minima*. Phenomena are therefore explained in

[115] *Novum organum*, I, p. 347.

[116] *Cogitationes*, III, p. 31; *Novum organum*, I, pp. 265, 307; *De principiis*, III, p. 82; *Sylva sylvarum*, II, p. 381. Soon, "minute" would be used as a general attribute of atoms, for instance by Henry Power. Gemelli, *Aspetti*, pp. 150–154, 170.

[117] *Dignitate*, IV, p. 338; I, p. 541: "*Natura se potissimum prodit in minimis.*" I have modified Ellis' translation. Cf. *Dignitate*, I, p. 499.

[118] *Novum organum*, I, pp. 232–233.

terms of both *minimae lationes* and *minutae particulae.* For instance, heat is defined as the motion of *minutae particulae,* although the particles involved are not extremely subtle.[119] Minute particles are said to account also for the origin of some sounds.[120] By the same token, biological processes such as the assimilation of aliments and changes in blood temperature happen *per minima.*[121] Given the criticism of atomism voiced in the *Novum organum,* we must not identify these *minima* with the *minima portio* of the *Cogitationes* and *De principiis.* Bacon is less than rigorous in his use of vocabulary and employs *minutae, minima,* etc., as equivalent words to denote very small portions of matter, but no longer those absolutely smallest portions of which he had spoken in earlier periods of his career.

The *Sylva sylvarum* contains a fragment that indicates the levels of material reality that Bacon had come to distinguish in his last works. In this fragment, he complains that the investigation of nature has usually been limited to visible things, while "whatsoever is invisible, either in respect of the fineness of the body itself, or the smallness of the parts, or of the subtlety of the motion" is mostly disregarded. There are four types of entities that belong to this class of neglected invisibles: 1) spirits; 2) tangible parts; 3) minute particles and their postures ("the more subtle differences of the minute parts and the posture of them in the body"); 4) motions of the particles and inner motions of bodies between spirits and tangible parts. Note that the atom is not included in this list of scientifically important, invisible objects. Bacon's criticism continues thus:

> And for the more subtle differences of the minute parts and the posture of them in the body (...) they are not at all touched. As for the motions of the minute parts of bodies, which do so great effects, they have not been observed at all, because they are invisible; but yet they are to be deprehended by experience (...) Democritus said well, when they charged him to hold that the world was made of such little motes as were seen in the sun: *Atomus,* saith he, *necessitate rationis et experientiae esse convincitur, atomum nemo unquam vidit.*[122]

Pace Rees, this reference to Democritus appears to involve more than merely an invocation of Presocratic authority.[123] Rather, Bacon appears to call upon Democritus to make an epistemological point

[119] *Ibid.,* p. 265.
[120] *Sylva sylvarum,* II, pp. 343, 391.
[121] *Historia vitae,* II, p. 182, 197.
[122] *Sylva sylvarum,* II, p. 381.
[123] Rees, "Atomism," p. 564.

for him. The quotation also appears to accept the atomic basis of nature's subtlety. If Bacon had been completely opposed to the atomist theory, he would have declared his opposition in this important passage, which is one of the few in the *Sylva sylvarum* that deals with theoretical issues. Bacon usually expressed his differences with other philosophies in order to distance himself from them – but obviously, this is not the case with Democritus' atomist assumption that the ultimate corpuscles are imperceptible.

This point of view casts doubt upon Kargon's view, which holds that Bacon first subscribed to an atomistic terminology and subsequently exchanged it for the pneumatic language of alchemy. Kargon believes that Bacon's lexical shift points to a break-away from a mechanistic and atomistic theory in favor of an animistic and pneumatic one.[124] But it is impossible to find such a mechanistic-atomistic model even in Bacon's early writings. Kargon errs in thinking that Bacon's atomism was ever close to some Democritean orthodoxy.[125] In fact, we hardly ever find purely mechanistic explanations in his work. It is certainly true that mechanistic and animistic approaches were combined in later works like the *De sapientia veterum,* in which atomic motion at a distance is explained in terms of material sympathies. Yet even in Bacon's earliest writings, atomist and pneumatic vocabularies are interconnected. In fact, alchemical vocabulary and mechanical notions are interwoven: processes of alteration and separation, the flight of the spirits and the appetites of Cupid coexist with concepts such as the vacuum and minimal particles. Besides this, Bacon remains clear about the difference between atoms and pneumatic matter. He carefully distinguishes between atoms and pneuma, just as he distinguishes between atoms and all other material manifestations.[126] In fact, his early allegorical works seem to suggest that pneumatic matter is composed of atoms.

In his refutation of Kargon's claims regarding Bacon's move from atomism to pneumatism, Rees has rightly shown that Bacon never offered any purely mechanistic explanations, although traces of mechanistic thinking may of course be found throughout his work.[127] While fully agreeing with this point, I do not agree with Rees' conclusion that Bacon had therefore never been positively

[124] Kargon, *Atomism in England,* p. 42.
[125] This has already been understood by Hesse, "Francis Bacon" and has been forcefully demonstrated by Gemelli, *Aspetti.*
[126] Cf. *De principiis,* III, p. 82: "Atomi ... neque spiritus similes sunt"
[127] Rees, "Atomism," pp. 563–567.

committed to atomism. The fact that Bacon modifies Greek atomism and looks unfavorably upon mechanistic explanations does not mean that his *Cogitationes*, the *De principiis* and the *De sapientia veterum* do not propagate atomist conceptions.[128]

Rees appears to overestimate the role assigned to pneumatic matter. If, as this author himself concedes, Bacon simultaneously postulated tangible and pneumatic matter and offered mechanical together with non-mechanical explanations, what reasons are there for describing his theory of matter as exclusively "pneumatic"?[129] I do not even think that it may be maintained that Bacon favored pneumatic matter over tangible matter. Admittedly, in the *Novum organum*, Bacon attributes the typically pneumatic *plicae* to all matter; and he also conceives of all matter as of a sort of qualitative continuum ranging from the most pneumatic (ether) to the most tangible (the bowels of the earth), attributing the principal agency to the pneumatic part of the spectrum. But even here, tangible matter continues to provide all of nature with cohesion and organisation. So, if it is true that "the dichotomizing instinct is the primary feature of Bacon's metaphysical vision," then it is obvious that the activity of pneumatic matter is as necessary as the passivity of tangible matter.[130] But would it be true to say that the prevalence of non-mechanical explanations is a direct consequence of the active role of pneumatic matter? I do not think so; because Bacon's non-mechanical or animistic approach to the problem of motion is not the only one that is compatible with pneumatic matter. Bacon could have reasoned like Descartes some decades later, explaining the movements of spirits in a mechanistic way.

Although spirits, tangible matter, and their motions were distinguished in the *Sylva sylvarum*, Bacon did not use the terms "minima," "minute particles," etc. as the exclusive attributes of either tangible or pneumatic matter, but used them for both. Therefore, I see no evidence for the view that atomism and a pneumatic theory are incompatible.[131]

[128] It is noteworthy that Rees' discussion of Bacon's atomism almost entirely ignores the allegorical writings. Cf. Rees, "Atomism," pp. 562–563.

[129] *Ibid.*, p. 563.

[130] Rees, "Matter Theory," pp. 114–115.

[131] Lemmi, *The Classical Deities*, p. 100; Hesse, "Francis Bacon," p. 245; and Garner, "Francis Bacon," p. 275 also suggest that spirits and atoms are compatible.

6. *Conclusion*

We have seen that three main periods in Bacon's atomism can be chronologically distinguished. The first appears in the *Cogitationes*, in which Bacon expresses his supports an atomism that was instrumentally or heuristically conceived, without deciding whether or not atoms actually existed. He defined atoms as the ultimate equal particles of matter, which moved in the void and explained the subtlety of nature. Two central ideas led Bacon to propose the concept of atoms and that of pneumatic matter simultaneously. First, he thought both concepts were necessary conditions for explaining qualitative changes (the transmutation of bodies); for the vacuum on its own only explained quantitative change (through contraction and rarefaction). Secondly, Bacon found pneumatic matter and equal atoms to be necessary conditions for the constancy of the *quantum* of matter.

The second period is reflected in the allegorical works, in which are found Bacon's most profound ontological considerations concerning atoms. The atom is now truly considered to constitute the smallest real particle of matter. The form of resistance (*antitypia*) determines its being, for mobility, appetite, dimensionality, spatiality, emanation, eternity, and immutability are attributes arising from this resistance to annihilation. By contrast, more complex attributes are effects of atomic agglomerations.[132]

The third and last period is most clearly exemplified by the *Novum organum*, in which Bacon distinguishes between hard atoms-*cum*-vacuum and flexible matter without any vacuum. The reasons behind Bacon's modified view have nothing to do with the antithesis between mechanistic atomism and animistic pneumatism, as has sometimes been claimed. As we have seen, Bacon had always conceived of atoms and pneumatic matter as coexistent and certainly not as antithetical.[133] Nor was his criticism of atomism in the *Novum organum* accompanied by the introduction of an exclusively or even predominantly pneumatic theory of matter. His reasons were rather epistemological and operational. He felt that the atom was also scientifically unproductive. Natural phenomena were better explained by

[132] Gemelli, *Aspetti*, pp. 163–164.

[133] Bacon is not an isolated case here. Several scholars have shown that animistic and atomist world views were not understood as incompatible by various philosophers of the sixteenth and seventeenth centuries. Cf. Gregory, "Studi sull'atomismo, II"; Henry, "Occult Qualities," p. 371, n. 19; Gemelli, *Aspetti*, p. 142, n. 2; and Gatti and Clericuzio in this volume.

the more complex, but still microscopic level of the *particulae verae*, i.e., at the level of the *schematismi*. At this last stage of his development, then, Bacon did not deny the existence of the atom, at least not explicitly, but handed over all of its explanatory functions to the schematisms.

Klein rightly describes schematisms in terms of the tangible and pneumatic matter resulting from its *textura* and recognizes in it a certain dose of atomistic influence.[134] But there is more to it: as Gemelli has demonstrated, the term *textura* is taken from the Lucretian vocabulary.[135] In the light of this, we may conjecture that schematisms were understood by Bacon as being composed of ultimate minimal particles, in accordance with Lucretius, who was after all a major source of his inspiration. To be sure, it would be a mistake to identify the minute particles mentioned in the *Sylva sylvarum* and other late works with atoms; but the fact that Bacon postulated them as the last epistemologically accessible units does not necessarily imply that he denied the existence of even smaller atomic units. Indeed, the fact that in the *Cogitationes*, the atomist hypothesis is allowed to coexist with explanations based on particles of a higher level is a sign that Bacon did not consider his epistemological concern to exclude such ultimate ontological assumptions. However, after the *Novum organum*, Bacon no longer appealed directly to atoms in order to explain changes and natural actions.

Unfortunately, the textual evidence does not supply us with Bacon's final position on this issue. However, we may imagine the consequences of each possible position. On the assumption that Bacon's epistemological neglect of atoms did not imply their ontological rejection, our distinction between principle and origin (cf. fig. 1), based on the polarity of atoms and forms, would not lose its value. In fact, it would retain some hermeneutic utility in shedding light on the background of the concept of form in the *Novum organum*, insofar as the concept of primary matter still serves as the material basis for the forms. On the other hand, should it have been the case that Bacon eventually denied the existence of atoms, then it must be concluded that his allegorical account of the principles and origins of nature will not work. As a result, Bacon's ontology in the *Novum organum* could only account for the actual physical world, but could no longer give an explanation of its beginnings.

[134] Klein, "Experiment," pp. 305–306. For the debt of Boyle's concept of texture to Bacon's schematism, see Clericuzio, "Le trasmutazioni."

[135] Gemelli, *Aspetti*, pp. 196–197.

Irrespective of the correctness of either conjecture, it is evident that questions concerning the ultimate material principles of matter have no importance in Bacon's last philosophy, because no causative-operational role is assigned to atoms any longer. Atoms, if they exist, would be blind and undetermined and would therefore not be able to cause the motions of matter. Rather, the origin of these motions is to be found in the schematisms.[136]

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