BOYLE, SPINOZA AND THE HARTLIB CIRCLE: THE CORRESPONDENCE WHICH NEVER TOOK PLACE

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Abstract. There is a bundle of texts that have become known as the Boyle/Spinoza correspondence, yet Boyle and Spinoza never directly communicated. How did this so-called correspondence start? Why did Boyle invite the philosopher Spinoza to comment on his scientific experiments? How can we interpret the central experiment of the controversy in a modern way? Is there any real controversy between the two philosophers?

An analysis of the context, the letters and *De Nitro* reveals that, according to Boyle at least, Spinoza never really understood what was really at stake in Boyle's important book. Furthermore, I argue, contrary to most commentators, that the philosophers actually had a kind of correspondence based on an implicit agreement regarding their doctrines of the qualities of bodies. And finally, I show that the international network which was important for the understanding of the context as well as for the content of the Boyle/Spinoza correspondence was the Hartlib circle rather than the Royal Society.

Keywords: Boyle, Spinoza, Glauber, redintegration, Mechanical Philosophy, Hartlib Circle, Royal Society

Introduction

Baruch Spinoza (1632-1677) never wrote a single letter to Robert Boyle (1627-91); nor did Boyle ever write to Spinoza. Scholarly literature nevertheless refers, curiously enough, to the existence of a 'correspondence between Spinoza and Boyle'. Those working on Spinoza and Boyle[1] have largely tended to discuss the development of this so-called correspondence from Spinoza's perspective. In the present article, I will analyze its origins by focusing instead on Boyle. As I will show, adopting such an approach sheds new light both on how the correspondence initially took shape and who played a role in it, as well as on the substance of the controversy between the two men.

There are five different points that this change in perspective will allow us to reconsider in a new light. Firstly, I will show how the correspondence started and clarify not only the role of Henri Oldenburg but also of Robert Boyle's sister. Furthermore, I will examine why Robert Boyle sent a physical book to the

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philosopher Spinoza and invited him to give comments on the scientific experiments contained therein. Secondly, I will argue that Spinoza misunderstood the true aim and significance of Boyle's work. According to the Dutch philosopher, Boyle's experiments with nitre were about the physical nature of the compound. As I will show, however, what was at stake for Boyle in these experiments was the demonstration of a new philosophy, the Mechanical Philosophy, which he defines for the very first time in his career in the preface of his *Some Specimens of an Attempt*, and which he would then advocate for the rest of his life.

Third, I will give a modern and detailed interpretation of the redintegration experiment which is central in the discussion between Boyle and Spinoza. Fourth, while scholars have tended to see the correspondence between Boyle and Spinoza as an expression of their opposition to each other, I will show how it was based primarily on widespread agreements that they shared. And finally, I will argue that the Royal Society – the first secretary of which was Henry Oldenburg, who acted as the intermediary between Spinoza and Boyle – did not play nearly as significant a role in the correspondence as the Hartlib circle did, a point which is hardly mentioned in literature on the correspondence.

1. How the correspondence started

Robert Boyle's family background is quite different than that of Spinoza, although both men lost their mothers at a very young age. Boyle was the fourteenth child (and seventh son) of a very influential and wealthy Irish earl: the first Earl of Cork. After having lost his mother at the age of three, his older sister, Katherine (1617-1691), took on the responsibility of caring for and raising him. She remained close to her youngest brother for the rest of his life. Indeed, as Boyle never married (like Spinoza), he left Oxford for London in 1668 to live with his sister, who by then had taken the title and name of Lady Ranelagh.

The young Boyle received an education that was fairly typical for a boy issuing from an aristocratic family: while some of his education was received in schools, a large part was obtained through private instruction. He attended Eton with his brother Francis, after which, like so many boys with a similar background, he and his brother went on their so-called Grand Tour (1639-1644) of continental Europe under the supervision of the French Calvinist Isaac Marcombes, who was responsible for the boys' education. This voyage through France, Switzerland and Italy had an enormous impact on the development of young Boyle's personality.

By 1644 he returned once again to Britain. When his sister Katherine[2] needed a private tutor for her son, Richard Jones, she initially thought of the poet, Milton, but after Milton declined her request she turned to the German emigrant and the first secretary of physical science[3] for the Royal Society, Henry Oldenburg (1619-77). It was in this context that Boyle first met Oldenburg, with whom he would stay in close contact for the rest of his life. For more than two years, Oldenburg toured Europe with Boyle's nephew. Upon returning to England, he left to spend some time in his native country. On his return trip to London, he paid a visit to Spinoza at his home in Rijnsburg, a small village near Leiden. Once back in London, he wrote to Spinoza and invited him to stay in contact – an invitation which Spinoza accepted. This was the

beginning of a lengthy correspondence[4] which stretched from 1661 to 1676, with a hiatus between 1665 and 1676. As early as his first letter to Spinoza, Oldenburg made mention of Boyle's *Certain Physiological Essays*, though without mentioning Boyle's name explicitly. Referring obliquely to "an excellent English nobleman, a man of extraordinary learning", he informed Spinoza that "the English nobleman" had published a new book and that he would soon send a copy.

2. Why did Spinoza accept Oldenburg's invitation?

A few months later, Oldenburg sent a copy of the book to Spinoza along with a letter asking him to read and comment on it, and to focus especially on the experiments that Boyle had outlined in the book. At first glance, this is liable to strike one as a rather strange request. After all, we are normally inclined to think of Spinoza as a philosopher and not as a scientist – at least not in the strict sense of the term. Why then did Oldenburg send Spinoza a scientific text and ask for his views on scientific experiments? The question becomes all the more pressing once one considers the fact that Boyle had previously published philosophical works (e.g. *Seraphic Love*, 1659), which one would expect to have been of more interest to Spinoza. Even more curiously, Oldenburg sent a Latin version of the work, which appeared under the title *Tentamina quaedam physiologica diversis temporibus et occasionibus conscripta a Robert Boyle*, before it was actually published in the same year. Moreover, while Oldenburg's first letter to Spinoza reveals that, during his visit to Rijnsburg, they had discussed metaphysical subjects, there is no indication whatsoever that they had talked about scientific experiments.

Two documents have quite recently come to light that bear evidence in favor of Spinoza's interest in and knowledge of science, or at least more interest and knowledge than scholars have tended to assume that he had. The first document is a letter[5] penned by a medical doctor, Cornelius Bontekoe, which was first discussed by Jonathan Israel.[6] In this letter, Bontekoe, who was an ex-student of the University of Leiden, writes that several students from the University frequently visited Spinoza. Many scholars still believe (citing letters 9 and 13 as evidence) that Spinoza had only taught a single student at Leiden: his co-habitant Casearius. Bontekoe's letter nevertheless makes quite clear that Spinoza had worked as a professional tutor of the new Cartesian physics.

The second document is a letter composed by the great Danish anatomist and geologist, Nicolas Steno, which was discovered as recently as 2000 by Pino Totaro.[7] In this letter, Steno writes that Spinoza visited him daily while he was studying at the University of Leiden in 1661, the year that Oldenburg visited Spinoza. This supports the argument that Spinoza had attended lectures at the University of Leiden, even though he was never officially enrolled. More precisely, Steno writes that Spinoza visited his anatomical dissections, which were then under the direction of Franciscus de le Boë Sylvius[8] (1614 - 1672), who opened the first academic laboratory of Europe at the University of Leiden in 1669.

It is very likely that Oldenburg had taken note of Spinoza's keen interest and involvement in the sciences during his visit to Rijnsburg. It is only in this light, as I

would argue, that we can make sense of Oldenburg's request for Spinoza to comment on Boyle's scientific experiments.

3. The redintegration of nitre

In letter 6, Spinoza responds to Oldenburg's request and apologizes for failing to read through the whole book. At the same time, he also indicates that he managed to carry out a critical reading of the book's second part, in which Boyle's experiments were discussed. This is the part that Henry Oldenburg had been most interested in. With this letter, what is commonly referred to as the Spinoza-Boyle correspondence began. It was written in Latin between 1661 and 1663 and consists of letters 6, 11, 13 and 16. It is crucial to bear in mind that this correspondence was always carried out via Oldenburg, and that it was thus always indirect in nature. It was, if you will, a correspondence (of ideas) within a correspondence (of letters).

What then was the subject matter of this 'correspondence'? The part of Boyle's book on which Spinoza commented is composed of two treatises, which bear the following titles:

1. Two Essays concerning the Unsuccessfulness of Experiments, etc.
2. Some specimens of an Attempt to make Chymical Experiments useful to illustrate the Notions of Corpuscular Philosophy.

2.1 A physical-chymical Essay containing An Experiment with some Considerations touching the different Parts and Redintegration of SALT-PETRE.

2.2 The history of Fluidity and Firmness.

In his longest extant letter (letter 6), Spinoza critically commented on both parts of the second treatise. The present article, however, will focus on the first part, that is, on the so-called *Essay on Nitre* [*De Nitro*]. In this essay, which was dedicated[9] to his nephew Richard Jones, Boyle discusses an experiment that he designates by means of a neologism: the "redintegration of *Nitre*" [*experimento de redintegratione nitri*]. In the language of modern science, what this redintegration experiment amounts to is what we now call a sequence of two chemical reactions: the analysis, or decomposition [*decompositio*], and synthesis [*redintegratio*] of saltpeter (KNO_3).

We cannot say for sure what reaction Boyle produced in his experiment because we do not know the precise temperature at which it was carried out, but it is quite likely that it referred to the following sequence of reactions:

1. Analysis: [*decompositio*]

Main reaction:

$$4\ KNO_3 + C \rightarrow CO_2\uparrow + 2\ NO_2\uparrow + N_2\uparrow + 2\ K_2CO_3$$

Further reactions in the presence of water:

$$2NO_2 + H_2O \text{ -> } HNO_3 + HNO_2$$

$$H_2O + CO_2 \text{ -> } H_2CO_3$$

2. Synthesis: [*redintegratio*][10]

Main reaction:

$$K_2CO_3 + 2\ HNO_3 \rightarrow 2\ KNO_3 + H_2O + CO_2\uparrow$$

At a lower temperature:

$$K_2CO_3 + 2\ HNO_3 \rightarrow 2\ KNO_3 + H_2CO_3$$

In the experiment, Boyle had placed a piece of glowing charcoal (primarily composed of carbon) in saltpeter. As a result, two substances were formed: volatile nitre, or Spirit of Nitre [*Spiritus Nitri*], and fix'd Nitre [*salis fixi*], which is "of an Alkalizate nature". By then combining fixed nitre with *Aqua fortis* – "whose active part is little else than Spirit of Nitre – in water, Boyle obtained saltpeter, the product with which he had started. These two processes can be summarized as follows:

A. Salt-petre (nitre) [*Nitri*] -> volatile nitre [*Spiritus Nitri*] + fixed nitre [*salis fixi*]

B. Volatile nitre [*Spiritus Nitri*] + fixed nitre [*salis fixi*] -> Salt-petre (nitre) [*Nitri*]

It is crucial to keep in mind here that neither Spinoza nor Boyle had any clear concept of a chemical reaction as of yet. In the language of modern chemistry,[11] what the experimental phenomenon in question amounted to was an exothermic reaction of carbon (C) with saltpeter (KNO_3) that gave form to several gasses: carbon dioxide (CO_2), nitrogen (N_2) and nitrogen dioxide (NO_2), which partially escaped from the vessel due to its high temperature. In addition to these gasses, a white salt potassium carbonate (K_2CO_3) was also formed in the original experiment, for which Boyle used different names: Salt of Tartar and Potash. In the second step of the experiment (viz., the synthesis), spirit of nitre (NO_2) was made to react with water (H_2O) that was present in the vessel, and this gave form to two acids: nitric acid (HNO_3) and nitrous acid (HNO_2). Furthermore, nitric acid – which is part of *aqua fortis*[12] – reacted with potassium carbonate from the first reaction to form saltpeter, the substance with which Boyle had started. When sulfur is added to these reactants, the well-known and explosive gunpowder-reaction is produced:[13]

$$2KNO_3 + S + 3C \text{ -> } K_2S + N_2 + 3CO_2$$

In these accounts, it is important to point out, firstly, that Boyle neglects the role played by the charcoal in the first reaction; and secondly, that he did not use the spirit of nitre obtained in the first reaction to carry out the second. As such, the reaction in question is not, strictly speaking, a simple reversible process that was realized in two directions. Leaving these details aside, however, what the global reaction amounts to is a decomposition (or analysis) and a synthesis (or redintegration) of one and the same substance: nitre (saltpeter).

4. On the aim of the redintegration experiment

a. Spinoza on the heterogeneity of nitre

In his answer to Henry Oldenburg's letter, Spinoza opens his comments by criticizing what he takes to be Boyle's conclusion of the redintegration experiment; namely, the fact that saltpeter is a heterogeneous compound composed of two different substances: fixed nitre and spirit of nitre ["*Primò colligit es suo experimento de redintegratione Nitri, Nitrum esse quid heterogeneum, constans ex partibus fixis, & volatilibus,* ..."]. According to Boyle, these two different substances are different from saltpeter (nitre).

Spinoza disagrees with this conclusion and argues that saltpeter is homogeneous. According to the author of the *Ethics*, the only difference between saltpeter and spirit of nitre is that the parts of saltpeter are at rest, whereas the parts of volatile nitre are in motion. Furthermore, as he argues, fixed saltpeter is not a significant part of nitre, but an impurity [*Foeces Nitri*]. Instead of being a compound that plays an active role in the experimental transformation, he insists that it is only an '*instrumentum*' [*tanquam instrumentum adhibetur*], which is comparable to what we know today as a catalyst (i.e. a compound that facilitates a reaction without directly participating in or being altered by it).

Taking the contemporary interpretation of the reaction as a point of reference, it is clear that, even at this early date, Boyle, who is sometimes called the 'father of chemistry', interprets the reaction as a process of chemical conversion of one substance, with a certain stability, into another substance. Spinoza, by contrast, sees nothing more in the experiment than the physical transformation of the self-same substance. According to the Dutch philosopher, the transformation consists in a different type of motion at work in the parts of the substance, such as when ice is melted into water, or when water is vaporized. It is important to point out, however, that Spinoza *could* have just as easily interpreted the same phenomenon in a more chemical way within the framework of his own philosophical system. He could have argued, for instance, that saltpeter's ratio of motion and rest [*motûs, et quietis rationem*] had been altered as the result of affections taking place in the parts of carbon, thereby producing a new physical individuality[14] (or more to the point, a new modus) characterized by a new ratio of rest and motion. But he eschewed this interpretation in favor of a purely mechanical one. Ultimately, the issue boils down, not to two radically different sets of conclusions, but to two different ways of understanding the experimental results. We might say that, instead of simply disagreeing with one another, Spinoza and Boyle seem to be on different wavelengths.

b. Boyle and the Mechanical Philosophy

Two of the four letters that make up the Spinoza-Boyle correspondence are letters from Oldenburg. In each of these letters, Oldenburg makes clear in the very first paragraph that it was not the nature of nitre as such that was of interest to Boyle. In the first letter (letter 11), he paraphrases Boyle's initial reaction to Spinoza's critical comments:

> Before I deal with matters that concern just you and me alone, let me deliver what is due to you on Mr. Boyle's account. The observations which you composed on his short Chemical-Physical Treatise he has received with his customary good nature, and sends you his warmest thanks for your criticism. But first he wants you to know that it was not his intention to demonstrate that this is a truly philosophical and complete analysis of Nitre, but rather to make the point that the common doctrine of Substantial Forms and Qualities accepted in the Schools rests on a weak foundation, and that what they call the specific differences of things can be reduced to the magnitude, motion, rest and position of the parts.[15]

In this passage, Oldenburg seems to be indicating to Spinoza that he has missed Boyle's point completely. His intention was not to give a "truly philosophical and complete analysis of Nitre" but "to make the point that the common doctrine of Substantial Forms and Qualities accepted in the Schools rests on a weak foundation". Oldenburg repeats this point in the first paragraph[16] of his second and final letter (letter 16) of the correspondence, in which he invites Spinoza to read the preface of Boyle's book. In this preface, Boyle explains via Oldenburg that the redintegration experiment had to be understood in the context of the promotion of a mechanical or corpuscular philosophy (which he favored as a synonym for mechanical philosophy) over against the peripatetic philosophy of qualities of bodies. As the full title[17] of the second treatise of the *Physiological Essays* suggests, the redintegration experiment is merely a demonstration that his new philosophy is right. This is confirmed by the fact that Boyle comes back to *De Nitro* in his *Enquiry*, not to refer to the redintegration as such, but rather to "the discourse made in certain papers, occasioned by 'A Chemico-Physical Essay about Salt-petre', against the pretended origin and inexplicable nature of the imaginary substantial forms of the Peripatetics".

According to Boyle, the main problem with the peripatetic philosophers is that they "give only a general and superficial account of the Phaenomena of Nature", an account based on "certain substantial Forms, which the most ingenious among themselves confess to be incomprehensible, and certain real Qualities, which knowing men of other Perswasions think to be likewise Unintelligible". Thus, the true targets of Boyle's attack are the doctrines of real qualities and substantial forms. According to the peripatetic doctrine, a corporeal substance is composed of two distinct metaphysical components: matter and form. Furthermore, they make a distinction between substantial forms, which are essential to individual things, and accidental forms, without which individual things are capable of existing. The substantial form is responsible for the essential accidents of the corporeal substance, while sensible qualities, such as colors, are considered to be accidents that bodies really have. These are the ideas that Boyle and his followers are contesting.

According to Boyle, each natural phenomenon can be explained, in principle, by two 'Catholic Principles': matter and motion. This theory clearly contrasts with the ancient Aristotelian doctrine of the four elements, as well as with the three principles espoused by the spagyrists, who followed the views of Paracelsus (1490-1541). According to Boyle's new account, each phenomenon of nature can be explained in

an intelligible way by changes affecting the parts of bodies with only mechanical properties, such as motion, size and figure. In this view, the body alone is understood to be intelligible, for it alone possesses primary qualities, whereas all other qualities are not real, existing only in the mind. A body is thus defined by Boyle as a way (or mode) of being a primary quality.

With this experiment, Boyle had not simply wanted to attack the theories of the 'peripatetics' and the chemical principles of the 'chymists'. It is also clear that he wanted to reorganize the various studies of natural philosophy along new lines; indeed, this was an aim that he would pursue for the rest of his life. As he argued, in contrast to the "Peripatetick and other vulgar Doctrines", the Cartesians and the atomists had explained the same natural phenomena in a much more intelligible way; namely, in terms of "little bodies variously figur'd and mov'd". With his 'Corpuscular Philosophy', what Boyle wanted to do was to unite atomists (such as Gassendi (1592-1655), who believed that indivisible parts, or atoms, really exist) and Cartesians (such as Spinoza, who believed neither in the indivisibility of the parts of bodies, nor in the existence of a vacuum in which atoms would be able to move around). It is for this reason that we find Boyle introducing the terminology of 'corpuscularians and corpusculism' in the place of 'atomists and atomism'. At the same time, however, Boyle also seeks to introduce new differentiations among the new groupings. According to him, the only differences separating these schools of thought are either strictly metaphysical in nature (e.g. on the question of the vacuum's existence), or they are of minor theoretical importance. Irrespective of these differences, what Boyle wants to stress is the shared stance *against* the earlier doctrines and the promotion of the new 'corpuscular' science. He then concludes the article with the definition of a common project, which he defines as 'The Mechanical Philosophy', although it was very likely Henry More[18] who first introduced this term into English. In his preface, Boyle defines this term in the sense in which most philosophers would *later* understand it, but during his own time, it would still have sounded quite odd both in European languages and in Latin. In any case, it is more than likely that Spinoza[19] first encountered the term 'Mechanical Philosophy' in Boyle's *De Nitro*, even if he never decided to make use of the term in his own writings. Consider Boyle's explication of the term in the following passage:

> That both parties agree in deducing all the Phaenomena of Nature from Matter and Local motion; I esteem'd that notwithstanding those things wherein the Atomists and the Cartesians differ'd, they might be thought to agree in the main, and their Hypotheses might by a Person of a reconciling Disposition be look'd on as, upon the matter, one Philosophy. Which because it explicates things by Corpuscles, or minute Bodies, may (not very unfitly) be call'd Corpuscular; though I sometimes stile it the Phoenician Philosophy, because some ancient Writers inform us, that not only before Epicurus and Democritus, but ev'n before Leucippus taught in Greece, a Phoenician Naturalist [Moschus] was wont to give an account of the Phaenomena of Nature by the Motion and other Affections of the minute Particles of Matter.

> Which because they are obvious and very powerfull in mechanical Engines, I sometimes also term it the Mechanical Hypothesis or Philosophy.

According to this definition, all natural phenomena can and should be explained in terms of the primary qualities of the minute parts of bodies. In this definition, we not only find a distinction between primary and secondary affections, but also between the macro and micro worlds. It was Boyle, moreover, who introduced this primary/secondary terminology[20] into English, even though Locke (1632-1704) would later gain greater fame than his mentor for employing it.

The redintegration experiment offered Boyle an ideal means to show that a substance was composed of corpuscles that could be broken down and recombined. This was a central idea at work in his definition of Mechanical Philosophy. It is also important to note that nitre was of interest not only to early chemists but also to the alchemists. According to the alchemist, Glauber, mixed nitre was a 'hermaphroditic substance' containing both a volatile substance that he called volatile nitre (spirit of nitre) and a solid caustic substance that he called fixed nitre (potassium carbonate). Thus, mixed nitre was a kind of universal solvent capable of dissolving all other kinds of substances. The quest for a universal solvent (the so-called alkahest) had been a very pressing issue for alchemists of the seventeenth century.

Following his account of the redintegration phenomenon in *De Nitro*, Boyle then explains the different effects produced in the senses by the *redintegratio* phenomenon. In section XIII, for instance, he discusses the processes' tangible qualities, whereas in section XIV he discusses the "very audible sound" it produced. In section XV he discusses the changes of color, and then in section XVII he discusses "the very strong and offensive smell, proceeding from the Spirit of Saltpeter" and "the odour of the fix'd Nitre". Lastly, in section XVII he discusses the taste of the different bodies. Providing many empirical details at each level of the account, he explains how these sensible results were the product of changes taking place in the minute parts of the bodies.

Quite surprisingly, Boyle does not present his new philosophy *as* new. On the contrary, he refers himself quite frequently to the precedent of ancient atomism. Firstly, he mentions Democritus (ca. 460 BC – ca. 370 BC), as well as his supposed teacher, Leucippus (first half of the 5th century BCE). He also refers to a certain Phoenician, Mochus,[21] who was believed to be an atomist prior to Leucippus. As he explains in the preface, before putting forward his own definition he had learned about the atomists and the theory of atomism from 'The Lives of the Atomical, among other Philosophers, in Diogenes Laertius'. It is likely that Boyle had already read this text in Italy during his Grand Tour. As he writes in his autobiography, *Philaretus*,[22] he had read 'the lives of the old Philosophers' at that time. In his early works, such as *Of the Atomical Philosophy*, he makes quite clear that he had been studying atomism at the same time as he was developing his own views on the qualities of bodies. Like Boyle, these atomists had also explained natural phenomena as being the result of purely mechanical variations at work in the parts of bodies.

5. The point of agreement between Boyle and Spinoza

Most commentators who discuss the Spinoza-Boyle correspondence place the two thinkers in direct contrast with each other. Henri Daudin opposes '*l'expérimentateur, le technician*' (Boyle) to '*le philosophe métaphysicien*' (Spinoza), whereas Boas Hall opposes the 'empiricist' to the 'rationalist', and Antonio Clericuzio opposes the 'chemist' to 'the radical mechanist'. As I would argue, however, the very fact that Boyle and Spinoza were in correspondence already indicates that they stood – by and large – in relative agreement on the subject under discussion; even if it is clearly true, at the same time, that there were many points of conceptual divergence between them, as we shall see. In short, as I would argue, Boyle and Spinoza simply refuse to discuss subjects on which they fundamentally disagree. Two examples will make this clear.

Firstly, Spinoza does not really engage with Boyle on the debate concerning the existence of the vacuum. While Oldenburg makes repeated attempts to launch a discussion of the vacuum in several letters, Spinoza never really responds. For example, he does not respond to Oldenburg's letter 14, in which Oldenburg speaks with enthusiasm about Boyle's air-pump:

> Recently an excellent experiment has been performed which greatly perplexes the upholders of a vacuum but is warmly welcomed by those who hold that space is a plenum.

Despite Oldenburg's efforts to broach the subject[23] and despite the emphasis he places on the fact that the experiments were "warmly welcomed" by philosophers who were plenists, like Spinoza, no real discussion of the vacuum ever took place. Spinoza never discussed the *machina boyleana*, which was so important for Boyle at that time, because for Spinoza, as for Descartes, metaphysical commitments precluded even the possibility of the vacuum's existence:

> But I do not know why he [Robert Boyle] calls the impossibility of a vacuum a hypothesis, since it clearly follows from the fact that nothing has no properties. And I am surprised that the esteemed Mr. Boyle doubts this, since he seems to hold that there are no real accidents. Would there not be a real accident, I ask, if Quantity were granted without Substance.[24]

Boyle realized that Spinoza had no real interest in discussing this question. As such, in letter 16, Oldenburg decided to postpone the discussion to another occasion – an occasion that would never take place:

> As to the argument you employ to deny the possibility of a vacuum, Boyle says that he knows it and has seen it before, but is not by any means satisfied with it. He says there will be an opportunity to discuss the matter on another occasion.

Pierre Macherey rightly remarks that this is more than likely the most important ontological point of contention shared by Spinoza and Boyle. Spinoza never changed

his position on the existence of the vacuum. We find the same categorical rejection of the vacuum in the *Principles of Cartesian Philosophy*,[25] where his views are still quite difficult to distinguish from those of Descartes; as well in the *Short Treatise*,[26] which is also quite Cartesian and can be regarded as a sort of proto-*Ethica*; and finally in his magnum opus, the *Ethics*, where, in reference to his earlier work, he mentions the vacuum only once, in the scholium of proposition 15 of *De Deo*:

> Since therefore there is no vacuum in Nature (of which more elsewhere) and all its parts must so harmonize that there is no vacuum, it also follows that the parts cannot be distinct in reality; that is, corporeal substance, insofar as it is substance, cannot be divided.

In a similar way, in the correspondence with Spinoza, Boyle refuses to engage with Spinoza's ideas concerning the general relation between God, nature and man, as well as with other metaphysical claims put forward by Spinoza. It is nevertheless clear, as we see in the first letter that Oldenburg sent to Spinoza (Letter 1), that Oldenburg himself was quite eager to discuss such metaphysical issues; a fact which is not entirely surprising, moreover, since Spinoza's metaphysics had already been well-developed by that time. Boyle, for his part, never engaged in the debate, even though he had already written a text containing his ideas about Spinoza's metaphysics.

Indeed, Boyle wrote a text that he described not as a text *on* Spinoza so much as a "text *against* Spinoza".[27] In this polemic text – the only one in which Boyle actually mentions Spinoza by name – Boyle criticizes and categorically refutes Spinoza's arguments against the existence of miracles, divine teleology, the reality of the divine will, as well as his arguments concerning the identification of God with nature, and so on. While Boyle wrote this text in the 1670s, he could have just as easily written it in the period of the correspondence, for Spinoza had already had these ideas at that time and had discussed them with Oldenburg during his visit. While Boyle could have sent such a text to Spinoza, he did not. Moreover, he never published the text, either.

It is worth noting that Boyle also carried out a critique of certain essential elements of Spinoza's metaphysics (e.g. the concept of *natura naturans*) in his *A Free Enquiry into the Vulgarly Received Notion of Nature*. This book was published in 1686; although, according to Davis and Hunter,[28] it had been composed in large part just following the period of the correspondence with Spinoza.

In sum, we can conclude that the differences in ontology and metaphysics that separated Boyle and Spinoza were very important. There was, as it were, more than enough gunpowder on either side for the whole discussion to explode. The fact that such a discussion did not erupt in the correspondence attests to the likelihood that the two thinkers were not interested in discussing issues on which they fundamentally disagreed.

So, it is likely that the reason they discussed a given topic was because they agreed on it. But, on what, precisely, did they agree? In the preface to Part Two of Boyle's book (i.e. the part that Spinoza had read closely), Boyle explains that, like so many early modern philosophers, he too wanted to get rid of the qualitative

explanation of natural phenomena in favor of substantial forms and real qualities. Spinoza basically agreed with Boyle's critique of the peripatetic view on this point. Moreover, he agreed with a central idea of the Corpuscular Philosophy; namely, that the qualities of bodies should be explained in terms of the mechanical properties at the micro level. At the same time, he criticized Boyle in letter 6 for having an overly broad list of bodily qualities:

> In my view, notions which derive from popular usage, or which explicate Nature not as it is in itself but as it is related to human senses, should certainly not be regarded as concepts of the highest generality, nor should they be mixed (not to say confused) with notions that are pure and which explicate Nature as it is in itself. Of the latter kind are motion, rest, and their laws; of the former kind are visible, invisible, hot, cold, and, to say it at once, also fluid, solid, etc.

For Spinoza, only qualities such as motion and rest were counted as being intrinsic to bodies. As A. Clericuzio argues, Spinoza was far stricter in his mechanical philosophy than Boyle, for Boyle conceived of bodies as bearing both mechanical *and* chemical properties, and held that chemical properties were not reducible to mechanical ones.

For both Boyle and Spinoza, bodies possessed only a limited set of intrinsic qualities. Sensible qualities, such as beauty, ugliness, perfection, imperfection, color, odor, and so on, were held by Spinoza to be mere "ideas of the affections of the body",[29] by which he meant that they were much more closely related to the perceiver's own body than to external bodies themselves. He applied this central idea time and again in several of his texts, both in his early texts[30] and in his *Ethics*,[31] where his natural philosophy assumed its most mature form.

And, like Boyle in his preface, the last paragraph of Spinoza's correspondence with Hugo Boxel (in which he deals with the existence of ghosts) shows that Spinoza bore a great deal of sympathy for atomists who, in contrast to Plato and Aristotle, did not use "bits of nonsense", such as "occult qualities, intentional species, substantial forms", but who explained the qualities of bodies solely in terms of mechanical qualities of underlying parts. This is particularly striking once one considers that Spinoza accepted neither the notion of the vacuum nor that of the atom:[32]

> The authority of Plato, Aristotle and Socrates carries little weight with me. I should have been surprised if you had produced Epicurus, Democritus, Lucretius or one of the Atomists or defenders of the atoms. It is not surprising that those who have thought up occult qualities, intentional species, substantial forms and a thousand more bits of nonsense should have devised spectres and ghosts, and given credence to old wives' tales with view to disparaging the authority of Democritus, whose high reputation they so envied that they burned all the books which he had published amidst so much acclaim.[33]

Thus, both Spinoza and Boyle made reference to atomists when they criticized the theory of the Peripatetics, even though neither of them directly identified themselves as atomists. In *Of the Excellency and Grounds Of the Corpuscular Philosophy*, Boyle further developed the ideas on Mechanical Philosophy that he had expounded in *De Nitro*. In this text, he makes clear that, for theological reasons, he is not an atomist in the general sense of the word, even though his new philosophy is itself derived from atomism: "But when I speak of the Corpuscular or Mechanical Philosophy, I am far from meaning with Epicureans, that Atoms, meeting together by chance in an infinite vacuum, are able of themselves to produce the World, and all its Phaenomena."

Spinoza seems to have been even more convinced than Boyle about the new doctrine of qualities. Boyle clearly meant to present his *Corpuscular Philosophy* as a scientific hypothesis, which implies that it still had to be validated through experimentation. Towards this end, he carried out an impressive set of experiments, which were reported in his books, essays and tracts, in order to show that this new philosophy was correct. He explained this hypothesis further in *About the Excellency and Grounds of the Mechanical Hypothesis*. As "The Publisher's Advertisement" of this text (which is now largely lost) makes clear, this essay was intended to function as an appendix to Boyle's dialogue concerning the requirements of a good hypothesis.

Spinoza, for his part, did not feel any similar need to carry out such sophisticated experiments (which he opposed to ordinary experience [*experientia vaga*]) in order to validate the same hypothesis. The issue here is not simply that Spinoza harbored distaste for scientific experimentation. On the contrary, his first argument against these experiments was precisely that they were not scientific enough. Moreover, the reason that Spinoza did not feel any need to experiment was that Bacon and Descartes[34] had already convincingly demonstrated the mechanistic theory of qualities. In letter 13, Spinoza makes clear to Boyle that the "mechanical principles" must be accepted prior to carrying out any experiments; he argues that, in spite of Boyle's claim to want nothing more than to illustrate the truth of the Mechanical Philosophy (and the falsity of the Paripatetic doctrine), Boyle tries to draw too much new knowledge from experimentation. The major problem Spinoza had, in this case, was with the empiricist underpinnings of Boyle's experiments. In letter 6, he argues: "One can never confirm it by chemical or any other experiments, but only by demonstration and by calculating. For it is by reason and calculation that we divide bodies to infinity, and consequently also the forces required to move them."

In the last paragraph of the final letter (letter 16) of the Spinoza-Boyle correspondence, Oldenburg makes an attempt to reconcile the two philosophers before closing the discussion, arguing that he is quite convinced that Spinoza and Boyle fundamentally agree. "May I urge you especially, with your keen mathematical mind, to continue to establish basic principles, just as I ceaselessly try to entice my noble friend Boyle to confirm and elucidate them by experiments and observations repeatedly and accurately made." He repeats here what he had already said in his letter 11, where he writes: "Our Boyle belongs to the class of those who do not have so much trust in their reason as not to want phenomena to agree with reason."

Even though Oldenburg continued to inform Spinoza about Boyle and his publications in letters 25, 29 and 31, this point marked the end of the Spinoza-Boyle correspondence. Spinoza, for his part, makes mention of Boyle in letters 26, 32 and 33. And in letter 25, Oldenburg writes, "Mr. Boyle and I often talk about your profound reflections." Likewise, Spinoza continued to follow Boyle's work. In letter 26 (1665), he writes that he had seen Boyle's *Treatise on Colours* (1664) in the house of C. Huygens (1629-1695), the most important Dutch physicist of the time. He and Huygens had been neighbors in Voorburg and discussed Boyle's work. Spinoza writes in the same letter that Huygens would have lent him the *Treatise on Colours* if he had known English.

6. Boyle, Spinoza and the Hartlib Circle

a. Glauber and the redintegration

As was explained above, from Spinoza's perspective, the discussion that took place in the correspondence was primarily centered on the nature of nitre, whereas what counted for Boyle was the promotion of the Corpuscular Philosophy. However, another interesting element also plays an important role in this complex correspondence.

Firstly, Boyle's position on the heterogeneous character of saltpeter is actually the same position that the chemist and alchemist Johann Rudolph Glauber (1604-1670) had held before him.[35] This well-known German chemist had explicitly argued, long before Boyle, that saltpeter was composed of two substances that could be recombined into saltpeter. Moreover, it was R.S. Glauber[36] who first performed the redintegration experiment and introduced the term "redintegratio" into Latin. In the last section of the second part of *On Nitre*, Boyle makes reference to Glauber; though he claims never to have read Glauber's "small treatises freshly publish'd", and refers instead to the *Prosperitatis Germaniae* (1656-1661). Likewise, in his preface of *Some Specimens*, Boyle makes an attempt to convince his readers both that he had never read Glauber's books, and that he carried out his experiments long before Glauber's works had been published. Moreover, he argues that what Glauber had achieved with saltpeter in his experiments was very different in nature: "He but prescribing as a bare Chymical Purification of Nitre, what I teach as a Philosophical Redintegration of it".

Boyle's claims in these instances are not entirely convincing, for Glauber's works had been quite well-known among English chemists at the time. Moreover, a letter from Hartlib in 1656 makes clear that Boyle had read some of Glauber's works, such as "the annexed discourse of saltpeter De Nitro" found in Glauber's *Tractatus de Prosperitate Germaniae.* Furthermore, as a member of the Hartlib circle, Boyle was in contact with the Irish chemist Benjamin Worsley, who had visited[37] Glauber's lab in Amsterdam in 1648-49 on the demand of Durie and Hartlib himself. In the mid-1650s, Worsley even wrote a book on Nitre, *De Nitro theses quaedam*, in which he discusses Glauber's redintegration theory.

There is yet one further reason to doubt Boyle's assertions. In February 1648, while Worsley was in Holland, Boyle also made a trip to Holland. At the time, Spinoza was sixteen years old. The purpose of Boyle's trip had been to help his older brother Francis in covering up, as far as possible, what Lisa Jardin[38] refers to as a major

scandal in the Boyle family. The wife of Robert's elder brother, Elizabeth Killigrew, had become pregnant with the child of the exiled Prince Charles, who would later become King Charles II of Britain. While in Holland, Boyle also managed to pay a visit to Amsterdam and the University of Leiden and to meet with many intellectuals. He included in his visit the anatomy division of the University of Leiden, where Spinoza would later regularly visit anatomy dissections under the direction of Sylvius who, in 1658, had accepted an appointment as Chemistry Professor of Medicine at Leiden. Prior to this appointment, Sylvius had done scientific research in chemistry in close co-operation with J.R. Glauber.[39]

Many of the intellectuals with whom Boyle met, including Menasseh Ben Israel[40] and Adam Boreel, were Hartlibians. It is quite likely that he spoke with some of them about Glauber's work. Glauber, also a Hartlibian, had lived in Amsterdam since 1640; although residing in other cities from 1646 to 1652, he settled down definitively in Amsterdam in 1652. He was well-known in Amsterdam, his chemistry was novel and exciting, and intellectuals discussed his work as a chemist, alchemist and pharmacist.

Boyle's repeated claims in *De Nitro* that his redintegration experiment was not based on Glauber's book do not necessarily imply that he had not been inspired by Glauber's works. On the contrary, in his much earlier "Of the Study of the Booke of Nature" (written in c. 1650), Boyle made obvious use of certain elements from Glauber's work. At first glance, one is likely to hold such a fact in suspicion, for Glauber's *Novi furni philosophici* was only published in 1651 in Latin. While it is true that an earlier version of the same text had been published in German in 1646-47, Boyle, who read many languages, could not read German. Instead, Boyle came to know the work through several copies that had been sent to Hartlib by the mid-1640s. He must have received one of this manuscript's translations because, as William R. Newman and Lawrence M. Principe[41] put it, "Glauber is clearly the source not only of Boyle's denomination of sand as 'Metallicke Wombe' of gold, but also of all the other comments on sand and flints made in the 'Booke of Nature'."

b. The context of the correspondence and the Hartlib Circle

The circle around Samuel Hartlib (ca. 1600-1662), John Durie (1596-1680) and Jan Amos Comenius (1592-1670) played an important role in the Spinoza-Boyle correspondence. This international circle was much more heterogeneous in nature than The Republic of Letters, which was primarily composed of diplomats, lawyers, doctors, scholars, and (to a lesser extent) theologians. The Hartlib circle, by contrast, was composed of a much wider variety of people: publishers, chemists, alchemists, theologians, mathematicians, physicists and so on. Often, people were members of several different circles at once. After 1662, for example, several members of the Hartlib circle became members of the Royal Society for the Improvement of Natural Knowledge. However, not all members of the Royal Society were also Hartlibians.

Quite surprisingly, everyone mentioned thus far as playing a role in the development of the Spinoza-Boyle correspondence was also a Hartlibian: Boyle, Oldenburg, Durie, Boyle's sister, Glauber, Worsely, Menasseh Ben Israel and so on. But there is another important member who has not yet been mentioned: Petrus

Serrarius[42] (1600-1669). Serrarius [Pierre Serrurier] was the most important link between Spinoza, Oldenburg and Boyle. He was, as Richard Popkin[43] puts it, "Spinoza's contact with the outside world", his "reliable correspondent in Amsterdam" who brought Spinoza's letters to Oldenburg and vice versa. Moreover, the millenarian Serrarius was also a collegiant. The collegiants had their center at that time in Rijnsburg, the small village near Leiden, where Spinoza lived after his ban in 1656. As a collegiant, he was in contact with other collegiants, some of whom were good friends of Spinoza.

Serarrius was also in contact with Glauber and visited him in February of 1660, that is, just prior to the period of the Spinoza-Boyle correspondence. According to visitors such as Samuel de Sorbière (1615-1670), who visited Glauber's lab in the same year, this was an impressive lab. It was a place not only for experiments but also for teaching and discussion. In a letter that De Sorbière wrote[44] to Monsieur De Bautru, Chevalier Baron de Segré, dated 13 July 1660, we read:

> Revenons à Glauber, après cette digression contre les charlatans qui gastent son métier. Il est sans doute le plus excellent ou le plus noble de tous, comme il semble que l'élément, dont il se sert, a quelques prérogative par dessus les autres; et si j'en estois le juge, la pyrotechnie précéderoit tous les arts libéraux et iroit de pair avec quelques sciences.
> Nous trouvasmes Glauber dans un de ses laboratoires. Car il n'en a pas moins de quatre sur le derrière d'une grande maison, qui paroist estre de quatre ou cinq cens escus de loiiage. Il y occupoit cinq ou six hommes, et nous remarquasmes qu'il avoit bon nombre d'enfans. Son âge nous parut de 66 ans et sa façon trés-bonne et trés-sincère. Ses discours ne furent point recherchés, il ne nous fit point d'excuses de sa mauvaise latinité. Il ne se trouva point embarassé de nos questions ; il répondit à tout en homme de bon sens et nous monstra tout son logis avec une grande familiarité."

Spinoza, who was keenly interested in science in the early 1660s, must have heard of this lab, which was only a ten-minute walk from his birthplace. Moreover, according to Steven Nadler,[45] Serrarius and Franciscus Van den Enden (1602-1674) were often present at the discussions on the experiments with nitre in Glauber's laboratory. Given Spinoza's finesse and acuity in the experiments on nitre, Nadler even suggests that Spinoza accompanied his former Latin teacher. This would explain why it is that Spinoza agreed to comment on Boyle's experiments, why he was able to do so with such finesse and acuity, and why he was able to speak so knowledgeably about the different experiments on nitre.

Conclusion

Spinoza and Boyle never had a direct correspondence. Their so-called correspondence was always mediated by Henri Oldenburg. Moreover, I have shown that in Boyle's view, Spinoza did not really understand the true aim of the redintegration experiment, which the English experimenter used in order to show that his Mechanical Philosophy was the right alternative for the Peripatetic doctrine of the

qualities of bodies. As a consequence there was, from Boyle's standpoint at least, never a real correspondence between both philosophers on the central issue of his work. This was one of the main reasons why, in letter 16, Oldenburg ultimately stopped the discussion between "the keen mathematical mind" and his own noble friend Robert Boyle.

Amazingly enough, it seems that all protagonists who are important for the understanding of the context and the content of the Boyle/Spinoza correspondence were members of the Hartlib circle, even though this international network is hardly mentioned in scholarly literature on this correspondence. Instead, scholars suggest that the Royal Society was important precisely because the intermediary Henri Oldenburg was the secretary of the Royal Society. However, Oldenburg, Boyle and Lady Ranelagh were obviously hartlibians. Furthermore, the chemist who performed the redintegration experiment for the very first time, R.S. Glauber, was a member of the Hartlib Circle. Moreover, the chemist who visited Glauber's lab and informed the Hartlib Circle about Glauber's experiments on nitre was a member. Finally, the man who brought the letters from Holland to England and vice versa, Serrarius, was obviously a hartlibian and was a good friend of Comenius.

Acknowledgements. Special thanks are due to the staff of the Information Center of the Boerhave Museum in Leiden and the Royal Society Archive in London for allowing me to study several historical documents.

References

[1] The most important articles dealing with the Spinoza-Boyle correspondence are: Crommelin, C.A., *Spinoza's natuurwetenschappelijk denken* (Leiden: E.J. Brill, 1939); Daudin, H., "Spinoza et la science expérimentale: sa discussion de l'expérience de Boyle," *Revue d'histoire des sciences et de leurs applications* (Paris: PUF, tome II, n∞ 2) Janvier-Avril, 1949 ; Hall, A.R. and M.B., "Philosophy and natural Philosophy: Boyle and Spinoza," in: *Mélanges Alexandre Koyré*(Paris: Hermann), 1964, 2 vol., II, 241-256 ; Yakira, E., "Boyle et Spinoza", *Archives de Philosophie* 51 (1988): 107-124; Clericuzio, A., "A redefinition of Boyle's Chemistry and Corpuscular Philosophy," *Annals of Science* 47 (1990): 561-589 ;Macherey, P., "Spinoza lecteur et critique de Boyle", *Revue du Nord* 77 (1995): 733–774; Clericuzio, A., *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century*(Dordrecht: Kluwer), 2000; Duffy, S., "The Difference Between Science and Philosophy: the Spinoza-Boyle Controversy Revisited," *Paragraph*29/2(2006):115-138; Gabbey, A., "Spinoza's natural science and methodology", in *The Cambridge Companion to Spinoza,* ed. D. Garrett (Cambridge: Cambridge University Press), 1997, 142-191.

[2] On Katherine Boyle, see DiMeo, M.M., *Katherine Jones, Lady Ranelagh (1615-91): Science and Medicine in a Seventeenth-Century Englishwoman's Writing*, PhD thesis, University of Warwick, 2009.

[3] It is often said and written that Henry Oldenburg was the first secretary of the Royal Society. However, Oldenburg was in fact one of two first secretaries of the Royal Society. John Wilkins (1614 – 1672) was appointed the biological science secretary in 1663, while Henry Oldenburg was appointed as the physical science secretary. For more detail, see: http://royalsociety.org/about-us/governance/officers/

[4] This correspondence between Baruch Spinoza and Henry Oldenburg is composed of 17 letters from Oldenburg to Spinoza and 10 from Spinoza to Oldenburg. The 'Spinoza-Boyle' correspondence forms a part of this larger whole.

[5] Cf. Bontekoe, C., *Brief Aan Johan Frederik Swetser, Gesegt Dr. Helvetius, Geschreven en uytgeeven tot een Korte Apologie voor den Grote Philosooph Renatus Descartes* [...] 's (Gravenhage, 1680).
[6] Cf. Israel, J., "Spinoza as an Expounder, Critique, and 'Reformer', of Descartes", *Intellectual History Review* 17 /1 (March 2007): 59 – 78.
[7] Cf. Totaro, P., "'Ho certi amici in Ollandia': Stensen and Spinoza – science verso faith" in *Niccolò Stenone: Anatomista, geologo, vescovo,* eds. K. Ascani, H. Kermit, e G. Skytte, (Romae: "L'ERMA" di BRETSCHNEIDER, 2000),27-38.
[8] Cf. Baumann, E.D., *François dele Boe Sylvius*(Leiden: Brill, 1949).
[9] Robert Boyle dedicated several of his writings on natural philosophy to his sister's son, Richard Jones, for whom he uses the nickname Pyrophilus. He explains who Pyrophilus is in the "Advertisement to the reader", prefixed to the first edition.
[10] Other expressions Boyle uses in referring to the Redintegration process are: "produc'd by the coalition of two bodies" (Section XX); "produc'd by the re-union of volatile and fix'd part [...]" (Section XI); "produc'd by the coalition of two bodies" (Section XX). In the second edition of this book (1669), he begins section XXXIII with "Redintegration (or Reproduction)" instead of simply "Redintegration".
[11] Cf. Buyse, F., *La Chimie de Spinoza*, dissertation sous la direction d'Isabelle Stengers, ULB/UCL/ULg, 2006.
[12] *Aqua Fortis* is a corrosive solution of nitric acid in water.
[13] Boyle discusses 'Gun-powder' more explicitly in his *Of the Excellency and Grounds Of the Corpuscular Mechanical Philosophy*: "Gun-powder it self owes its aptness to be fir'd and exploded to the Mechanical Contexture of more simple portions of Matter, *Nitre*, *Charcoal*, and *Sulphur*, and Sulphur it self, though it be by many Chymists mistaken for an Hypostatical Principle, owes is Inflammability to the convention of yet more simple and primary Corpuscles; ..."
[14] For Spinoza's definition of a physical individuality, or a body [*unum corpus, sive Individuum componere*], see the *Physical Interlude* between proposition 13 and 14 of the second part of the *Ethics*.
[15] All citations from Boyle's work are from: Boyle, R., *The Works of Robert Boyle*, ed. M. Hunter and E.B. Davis (London: Pickering & Chatto, 1999–2000). All citations from Spinoza's work are from Spinoza, B., *Complete Works*, ed. M.L. Morgan and trans. S. Shirley (Indianapolis/Cambridge: Hackett Publishing Company Inc., 2002). All citations in Latin are from: Spinoza, B., *Opera*, im Auftrag der Heidelberger Akademie der Wissenschaften herausgegeben von Carl Gebhardt (Heidelberg: Carl Winters Universitätsbuchhandlung, 1972 [1925]).
[16] In letter 16 Spinoza writes: "He [Boyle] asks you to consult the preface which he wrote to his Experiments on Nitre, so as to understand the true aim which he set himself in that work: namely, to show that the doctrines of the more firmly grounded philosophy now being revised are elucidated by clear experiments, and that these experiments can very well be explained without the forms, qualities and the futile elements of the Schools."
[17] The full title is: "Some Specimen of an Attempt to make Chymical Experiments useful to illustrate the Notions of the Corpuscular Philosophy".
[18] See More, H., *The immortality of the Soul*, ed. A. Jacob (Dordrecht: Martinus Nijhoff Publishers, 1987), 4 – 21. The first version of this book was published in 1659; the second revised edition was published in 1662.
[19] On Spinoza and the definition of Mechanical Philosophy, see: Buyse, F.,"Spinoza and Robert Boyle's definition of Mechanical Philosophy", *Historia Philosophica* 8 (2010),: 73-98.
[20] In *De Nitro,* Robert Boyle introduces the primary/secondary terminology of qualities in section XII: "And first, this experiment seems to afford us an instance by which we may discern that Motion, Figure, and Disposition of parts, and such like primary and mechanical

affections (if I may call them) of Matter, may suffice to produce those more secondary Affections of Bodies which are wont to be called Sensible Qualities."

[21] Cf. Sailor, D.B., "Moses and Atomism", *Journal of the History of Ideas* 25(1964): 3-16.

[22] According to Michael Hunter, Boyle wrote 'Philaretus' in 1648 or 1649. Cf. Hunter, M., *Boyle – Between God and Science* (New Haven and London: Yale University Press, 2009), 63.

[23] On Oldenburg's role as a mediator, see: Avramov, I., "An apprenticeship in scientific communication: The Early Correspondence of Henry Oldenburg (1656-63)", *Notes Rec. R. Soc. Lond.* 53 /2 (1999) : 187-201, and Vittu, J.P., "Henry Oldenburg 'Grand Intermédiaire'", in *Les grands intermédiaires culturels de la République des Lettres - …études de réseaux de correspondances du XVIe au XVIIe siècles*, eds. C. Berkvens-Stevelinck, H., Bots, et J. Häseler (Paris: Honoré Champion Éditeur, 2005), 183 – 209.

[24] From letter 13.

[25] A vacuum is defined by Spinoza as extension without corporeal substance (PPC, II, def. 5). He therefore finds it to be a contradiction. (PPC, II, prop. 3)

[26] Spinoza writes in the second chapter of the first part of his *Short Treatise*: "The first will not do, because there is no vacuum, something positive and yet no body; nor the second, because then there would exist a mode, which cannot be, since extension as extension is without and prior to all modes."

[27] Cf. Boyle, R., Notes for a paper against Spinoza The Boyle Collection, Boyle Papers, volume 3, manuscript document, Fols. 102-103 (2 leaves), RB/1/3/18, 1670s-1680s, London, Archive of the Royal Society. Published for the first time in Colie, R.L., "Spinoza in England 1665-1730",*Proc. of the Amer. Phil. Soc.* 107 (1963): 183 -219.

[28] See Boyle's preface in the *Free Enquiry* where he writes that "the following discourse was written about the year 1666". This has been confirmed via the research of manuscript drafts according to E.B. Davis and M. Hunter. See Boyle, R., *A Free Enquiry into the Vulgarly Received Notion of Nature*, ed. E. Davis and M. Hunter (Cambridge: Cambridge University Press, 1996), xxiii.

[29] Cf. Spinoza, B., *Ethics*, II, proposition 16, along with corollaries I and II.

[30] See, for example, chapter 6 of the first part of the *Metaphysical Thoughts*; the appendix of *Ethics* I and the preface of *Ethics* IV.

[31] See, for example, the appendix of the first part of the *Ethics*.

[32] For Spinoza's view on the existence of atoms, which he defines in the second part of his PPC, as "a part of matter indivisible by its own nature", see for example: PPC,II,5; *Ethics*, I, 15, scholium and Letter 12.

[33] From letter 56 from Spinoza to Hugo Boxel, written in 1674.

[34] Cf. letter 6 from Spinoza to Oldenburg (Rijnsburg, 1661/ 62).

[35] On Glauber and Amsterdam, see: Wittop Koning, D.A., *J.R. Glauber in Amsterdam*, (Amsterdam: Genootschap Amstelodamum, 1950), Jaarboek XLIII, 1-6 and Jorissen, W.P., *Iets over Glauber's Amsterdamschen tijd*(Leiden: 1918).

[36] See Newman, W.N., *Atoms and Alchemy – Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago & London: The University of Chicago Press, 2006), 210.

[37] Cf. Young, J.T., *Faith, Alchemy and Natural Philosophy: Johann Moriaen, Reformed Intelligencer, and the Hartlib Circle* (Aldershot: Ashgate Publishing, 1998).

[38] Cf. Jardin, L. , "Foreword", in *Literatures of Exile in the English Revolution and its Aftermath,1640-1690*,ed. P. Mayor (Surrey: Ashgate, 2010).

[39] Cf. Beukers, J., *Sylvius*, in *Dictionary of seventeenth and eighteenth-century Dutch Philosophers*, ed. W. Van Bunge (Bristol: Thoemmes, 2003), vol. 2, 973-975.

[40] Boyle mentions the fact that he conversed with Menasseh Ben Israel while in Amsterdam in Section IV of his *Enquiry*. In 1642, the rabbi taught for some time in the Jewish school where the young Spinoza studied.
[41] Cf. Newman, W.R. and Principe, L.M., *Alchemy tried in the fire: Starkey, Boyle, and the fate of helmontian chymistry* (Chicago & London: The University of Chicago Press, 2005), 212-213.
[42] See Van der Wall, E.G.E., *De mystieke chiliast Petrus Serrarius (1600-1669) en zijn wereld*, Diss. Doct. (Leiden: Universiteit van Leiden, 1987).
[43] Cf. Popkin, R., *Spinoza* (Oxford: Oneworld, 2004), 40.
[44] Cf. Sorbière, S., *Drie brieven van Samuel Sorbière over den toestand van Holland in 1660* (Leiden: P. J. Bolk, 1901), 81.
[45] See Nadler, S., *Spinoza* (Cambridge: Cambridge University Press, 2003), Chapter 8.