The Gunpowder Reaction: A Controversy between Boyle and Spinoza?

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1. Introduction.[2]

Baruch Spinoza (1632-1677) wrote not a single letter to Robert Boyle (1627-91); nor did Boyle ever write to Spinoza. Even so, the literature refers to a 'correspondence between Spinoza and Boyle'. How did this so-called 'correspondence' start? When did it take place? What is its content? And, most important: What, if any, are the points of controversy within it?

Traditionally, when the context of this 'correspondence' has been analyzed,[3] scholars have started with biographical elements of Spinoza's life. This paper, though, uses Boyle's life and work — particularly his seminal *De Nitro* — as the frame of reference for the discussion. The aim of this paper is threefold: first, to give a more detailed modern interpretation of the central experiment described in *De Nitro*; second, to demonstrate that Spinoza and Boyle discussed because they mainly agreed on their conception of qualities of bodies; third, to show that, for Spinoza, the so-called controversy on the redintegration of niter is essentially about the nature of niter, whereas what is at stake for Boyle is the promotion of the Corpuscular Philosophy, which he first defines in his book's the preface. Finally, this paper shows that the Hartlib circle, which is hardly mentioned in the articles on this correspondence, is of greater significance than the Royal Society in study of the context as well as the content of the Spinoza-Boyle correspondence.

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[1] The author of this paper is a philosopher and chemist.

[2] All citations from Boyle's work are from: Boyle, R., *The Works of Robert Boyle*, edited by Hunter, M. and Davis, E.B., London: Pickering & Chatto, 1999-2000. All citations from Spinoza's work are from Spinoza, *Complete Works*, edited by Morgan, M.L. and translated by Shirley, S., Indianapolis/Cambridge: Hackett Publishing Company Inc., 2002.

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

2. The start of the correspondence.

Robert Boyle's family background was very different than Spinoza's although both lost their mothers at a very young age. Boyle was the fourteenth child of a very influential and wealthy Irish earl: the first Earl of Cork. At the age of three, he lost his mother. From this moment, his older sister, Catherine (1617 -1691), occupied the maternal role. She remained close to her youngest brother for the rest of his life. Indeed, Boyle (unmarried his entire life, as was Spinoza) left Oxford for London in 1668 to live with his sister, then known as Lady Ranelagh.

The young Boyle received a fairly normal education for a boy from an aristocratic family: partly from private teachers and partly in schools. He went with his brother Francis to Eton, after which, like so many boys with a similar background, he did his so-called Grand Tour (1639 -1644) through continental Europe with Francis and his tutor Isaac Marcombes, who was responsible for Boyle's development from schoolboy towards serious intellectual. This voyage through France, Switzerland, and Italy had an enormous impact on the development of the young Boyle's personality.

Marcombes, a French Calvinist, taught Robert Boyle Latin, philosophy and mathematics. The lessons were in Latin and the two brothers had to speak French throughout the tour. Based on Boyle's study notes,[4] discovered in 1995 by L. M. Principe[5] in the Archive of the Royal Society, there is no doubt that Boyle studied in detail both the universe of Ptolemy and the antique four-element theory.

It is worth noting that the theologian and Bible translator Jean Diodati (1576-1649) was an uncle by marriage to Marcombes, a friend of Boyle's father, and a family member and contemporary of Galileo's good friend and correspondent Elia Diodati (1576–1661).[6] Boyle even spent a few days at Jean Diodati's house. It is thus quite likely that Marcombes discussed with Boyle and Diodati Galileo's natural philosophy, which he probably contrasted in his teaching to the Aristotelian and Ptolemaic theories referred to in Boyle's study notes.

In 1642 Boyle and his companions travelled from Geneva to Italy. They were in Firenze at the moment Galileo Galilei died. This event had an important impact on the young Boyle, who writes with great admiration in his autobiography about the "Great Stargazer". Meanwhile Marcombes had taught Boyle Italian. Boyle writes that he read some of Galileo's works. It is likely that the seeds were laid during this period for the person who would do science according to Galileo's experimental

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[4] Boyle's Geneva Notebooks, comprising 109 folios, contain three folding pages, the second of which shows 'the qualities and combinations, etc., of the four elements' and the third 'A figure of the construction of the World' which shows the Ptolemaic Universe.

[5] Cf. L.M. Prinzipe, "Newly Discovered Boyle Manuscripts in the Royal Society Archive. Alchemical Tracts and his Student Notebook," *Notes Rec. R. Soc.*, London, 49,1 (1995) pp. 49-70.

[6] For more details about the Diodati family, see S. Garcia, *Élie Diodati et Galilée: naissance d'un réseau scientifique dans l'Europe du XVIIe siècle*, L.S. Olschki, 2004.

method and would later become "the philosopher of the qualities par excellence" as P. Anstey[7] puts it. Likewise, Boyle had a conversion experience during his grand tour that would shape his religious feelings for the rest of his life. These two important aspects of Boyle's life - science and religion - are discussed extensively in Michael Hunter's new biography, significantly titled *Boyle – Between God and Science*.

In 1644 Boyle was back in Britain. When his sister Catherine[8] needed a private teacher for her son Richard Jones, she initially thought of the poet Milton but turned to the German emigrant and the first physical science secretary[9] of the Royal Society Henry Oldenburg (1619-77) when Milton declined. It was in this context that Boyle met Oldenburg. They stayed in close contact for the rest of their lives. For more than two years Oldenburg toured Europe with Boyle's nephew. After returning to England, he spent some time in his own country. On his way back from Germany to London Oldenburg visited 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 Spinoza accepted. This was the start of a long correspondence[10] between 1661 and 1676 with a hiatus between 1665 and 1676. Even in his first letter, Oldenburg mentions Boyle's *Certain Physiological Essays* without mentioning Boyle's name explicitly, referring instead to the text as written by "an excellent English nobleman, a man of extraordinary learning." He writes that "the English nobleman" published a new book and that he will send a copy of the book. A few months later, Oldenburg sent the book to Spinoza with a letter asking him to read and comment, especially on the experiments Boyle outlines in the book.

At first glance this strikes one as a very strange request. After all, we know Spinoza now as a philosopher and not a scientist — at least not in the strict sense of the word. So why did Oldenburg send a scientific book to Spinoza and ask advice on scientific experiments? Boyle had published philosophical books — *The Aretology or Ethicall Elements*, for example — that one might expect to be of more interest to Spinoza. Moreover, Oldenburg sent the Latin version of Boyle's book, 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 it is certain based on Oldenburg's first letter that he and Spinoza talked in Rijnsburg about metaphysical subjects, there is no indication whatsoever that they talked about scientific experiments.

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[7] P.R., Anstey, *The Philosophy of Robert Boyle* London: Routledge, 2000, p. 17.

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

[9] 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 and Henry Oldenburg was the physical science secretary.

[10] This correspondence between Baruch Spinoza and Henry Oldenburg is composed of 17 letters from Oldenburg to Spinoza and 10 from Spinoza to Oldenburg. These letters are written between 1661 and 1676.

Two quite recently-found documents, though, give historical evidence that Spinoza was much more involved in science than most scholars have assumed. The first document is a letter[11] from a medical doctor, Cornelius Bontekoe, first discussed by Jonathan Israel.[12] In this letter, Bontekoe, an ex-student of the University of Leiden, writes that several students from the University of Leyden frequently visited Spinoza. Many scholars still believe (mainly based on letter 9 and 13) that Spinoza taught only one student, his co-habitant Casearius. Bontekoe's letter makes clear, though, that Spinoza was in fact a professional tutor of the new physics.

The second document is a letter by the great Danish anatomist and geologist Nicolas Steno, discovered in 2000 by Pino Totaro.[13] 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. Thus it is clear that Spinoza attended lectures at the University of Leiden although he was never officially enrolled. More precisely, Stensen writes that Spinoza visited his anatomical dissections, which were then under the direction of Franciscus Sylvius[14] (1614 - 1672), who started the first academic laboratory of Europe at the University of Leiden in 1669.

It is very likely that Oldenburg noticed Spinoza's interest and involvement in early science when he visited Spinoza in Rijnsburg. This would explain why Oldenburg asked him to comment on Boyle's scientific experiments.

3. The redintegration of nitre.

In his Letter 6, Spinoza responds to Oldenburg's request and apologizes for not reading the whole book, though indicating that he did give a critical reading to the book's second part, in which Boyle's experiments were discussed. This was the part Henry Oldenburg was most interested in. With this letter, what is known as the correspondence between Boyle and Spinoza began, ultimately consisting of letters 6, 11, 13, and 16, written in Latin between 1661 and 1663. However, this correspondence was always via Oldenburg and was thus always indirect. It was a correspondence within another correspondence.

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[11] Cf. C. Bontekoe*, Brief Aan Johan Frederik Swetser, Gesegt Dr. Helvetius, Geschreven en uytgeeven tot een Korte Apologie voor den Grote Philosooph Renatus Descartes* […], 's Gravenhage: (1680).

[12] Cf. J. Israel, "Spinoza as an Expounder, Critique, and 'Reformer', of Descartes," *Intellectual History Review* Volume 17 Issue 1 (March 2007), pp. 59 – 78.

[13] Cf. P. Totaro, " "Ho certi amici in Ollandia": Stensen and Spinoza – science verso faith," in: K. Ascani, H. Kermit, e G. Skytte, (eds.), *Niccolò Stenone: Anatomista, geologo, vescovo*. Romae: "L'ERMA" di BRETSCHNEIDER, 2000, pp. 27-38.

[14] Cf. E.D., Baumann*, François dele Boe Sylvius*, Leiden: Brill, 1949.

What was this 'correspondence' about? The part of Boyle's book on which Spinoza comments is composed of two treatises:

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. This article, however, focuses on the first part: the so-called "*Essay on Nitre*" [*De Nitro*]. In this essay, which was dedicated[15] to his nephew Richard Jones, Boyle presents an experiment which he indicates with a neologism as the "redintegration of *Nitre"* [*experimento de redintegratione nitri*]. In a modern interpretation, this redintegration experiment amounts to what we now call a sequence of two chemical reactions: the analyses or decomposition [*decompositio*] and syntheses [*redintegratio*] of saltpeter ($KN0_3$).

We cannot say for certain what the reaction was because we do not know the precise temperature, but very probably it is the following reaction sequence:

1. <u>Analysis</u>: [*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:

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

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

[15] 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 first edition.

2. Synthesis : [*redintegratio*][16]

Main reaction:

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

At a lower temperature:

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

Boyle put a piece of glowing charcoal (substantially 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 next combining fixed nitre with *Aqua fortis* - "whose active part is little else than Spirit of Nature" - in water, Boyle obtained saltpeter, the product with which he started.

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

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

Neither Spinoza nor Boyle had the concept of a chemical reaction yet. However, in a modern chemical interpretation[17], the phenomenon in question amounts to an exothermic reaction of carbon (C) with saltpeter (KNO_3) to form several gasses: carbon dioxide (CO_2), nitrogen (N_2) and nitrogen dioxide (NO_2), which partially escape from the vessel at the given high temperature. In addition to these gasses, there is also formed a white salt potassium carbonate (K_2CO_3), for which Boyle uses different names: Salt of Tartar and Potash. In the second step, the syntheses, spirit of nitre (NO_2), first reacts with some water (H_2O) that was present in the vessel to form two acids: nitric acid (HNO_3) and nitrous acid (HNO_2). Furthermore, nitric acid - which is part of *aqua fortis*[18] - reacts with potassium carbonate from the first reaction to form saltpeter, the substance with which Boyle had started.

[16] Other expressions Boyle uses to indicate 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 second edition of this book (1669) he begins section XXXIII with "Redinetegration (or Reproduction)" instead of "Redintegration".

[17] Cf. F. Buyse, *La Chimie de Spinoza*, dissertation sous la direction d'Isabelle Stengers, ULB/UCL/ULg, 2006.

[18] *Aqua Fortis* is a corrosive solution of nitric acid in water.

When sulfur is added to the reactants the well-known gunpowder reaction is produced:[19]

$$2KNO_3 + S + 3C \rightarrow K_2S + N_2 + 3CO_2$$

In his redintegration experiment, Boyle does not use sulfur, which, along with salt and mercury, was one of the three principles of the "chymists". However, in Section XIX of *De Nitro* he does consider the use of this substance: "Secondly then, the proposed Experiment seems to make it somewhat questionable, whether or no Inflammability doth strictly in all mixt bodies require a distinct Sulphureous ingredient; …". And to illustrate the violence of this kind of reaction, he gives the example of the reaction between Spirit of Nitre and a piece of iron, which he describes in detail:

> " … those active parts do presently begin to penetrate, sever, and scatter abroad the parts of Iron (almost as Gunpowder doth the pieces of breaking Granadoes) with such rapidity, and in such plenty and throngs, that being themselves also put into a very swift and irregular motion (whence soever it proceeds) there is hereby produc'd a heat capable (if the quantity of the Liquor and Metall be great enough) to burn his hand that holds the Vessel, and perhaps break the Vessel (if it be not very open) all to pieces; …"

Even without sulfur, though, the reaction has a certain gunpowder-reaction effect, described as usual in empirical detail by Boyle in Section XIV:

> And such a kind of sound, but much louder, was produc'd by the impetuous eruptions of the halituous flames of the Salt-Petre upon the casting of a live coal upon it. What interest such a smartnesse in striking the air hath in the production of Sound, may in some measure appear by the motion of a bullet, and that of a switch or other wand, which produce no sound if they do but slowly passé through the air; whereas if the one do smartly strike the air, and the other be shot out of a Gun, the celerity of their percussions on the air puts it into an undulating motion, which reaching the Ear, produces an audible noise even at a good distance from the body, whose swift passage causes those nimble vibrations in the air, as we may alsewhere have occasions to declare.

Boyle neglected the role of charcoal in the first reaction and he did not use the spirit of niter he obtained in the first reaction to realize the second. So, strictly speaking, the reaction in question is not a simple reversible process that was realized in two directions. Globally speaking, however, the global reaction amounts to a decomposition (or analysis) and a synthesis (or redintegration) of one and the same substance: niter (saltpeter).

[19] Boyle discusses Gun-powder more explicitly in his *Of the Excellency and Grounds Of the Corpuscular Mechanical Philosoph*y: "Gun-powder it self owes its aptness to be fir'd and exploded to the Mechanical Contexture of more simple portions of Matter, *Nitre*, *Charcoa*l, 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; …"

3. Spinoza and the heterogeneity of niter.

In his answer to Henry Oldenburg, Spinoza starts his critical comments by criticizing what he took for Boyle's conclusion of the redintegration experiment: the fact that saltpeter is a heterogeneous compound composed of two different substances: fixed niter and spirit of niter. These two substances are different from saltpeter (niter), as Boyle makes clear in the first sentence of his chapter of his comments on Nitre [*Primò colligit es suo experimento de redintegratione Nitri, Nitrum esse quid heterogeneum, constans ex partibus fixis, & volatilibus,* …].

Spinoza disagrees with this conclusion and argues that saltpeter is homogeneous. According to Spinoza, the only difference between saltpeter and spirit of niter is that the parts of saltpeter are at rest; the parts of volatile niter, in contrast, are in motion. Furthermore, fixed saltpeter is not a significant part of niter; rather, it is an impurity [*Foeces Nitri*]. It is a compound that does not play an active role in the process; it is only what Spinoza calls an "*instrumentum*" [*tanquam instrumentum adhibetur*] comparable to what we know today as a catalyzer, a compound that facilitates the reaction but does not participate in the reaction and is left unaltered after the reaction.

With the contemporary interpretation of the reaction as a reference, it is clear that even at this early date Boyle, sometimes called the 'father of chemistry', interprets the reaction as a kind of chemical reaction — a conversion from a substance with a certain stability to another substance. Spinoza, by contrast, sees this process instead as a physical process: a transformation of the same substance into a different state as a consequence of a different type of motion of the parts of that substance — comparable to phenomena like the melting of ice, the vaporizing of water, and so on. However, Spinoza could have interpreted this phenomenon in a more chemical way within his own philosophical system by arguing, for example, that saltpeter's ratio of motion and rest [*motûs, et quietis rationem*] had changed as the result of affections by the parts of carbon to produce a new physical individuality[20] characterized by a new ratio of rest and motion: a new modus. But he eschewed this interpretation in favor of a purely mechanical one. Ultimately, Spinoza and Boyle seem to be on different wavelengths.

[20] For Spinoza's definition of a physical individuality, see the definition of a physical individuality or a body [*unum corpus, sive Individuum componere*] in the *Physical Interlude* between proposition 13 and 14 of the second part of the *Ethics*.

4. Boyle and The Corpuscular Philosophy.

Two of the four letters of the Boyle/Spinoza correspondence are letters from Oldenburg. In each of these letters, Oldenburg makes clear in the first paragraph that it was not the nature of niter as such which was important for Boyle. In Oldenburg's first letter (letter 11) of the Spinoza/Boyle – correspondence, he paraphrases Boyle's first 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.

In this passage, Boyle seems to indicate to Spinoza that he has missed the point completely. His intention is 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 in the first paragraph[21] of his second and final letter (letter 16) of the Boyle/Spinoza correspondence, in which he invites Spinoza to read the preface of Boyle's book. Boyle explains in this preface that his 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) to replace the peripatetic philosophy of qualities of bodies. As the full title[22] of the second treatise of the *Physiological Essays* suggests, the redintegration experiment is merely a demonstration that his new philosophy was right. Boyle comes back to his essay on niter in his *Enquiry*, not to refer to the redintegration as such but rather to refer 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 problem with the peripatetic philosophers was that they "give only a general and superficial account of the Phaenomena of Nature" 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 Unintelligble". Thus, real qualities and substantial forms were the true focus of Boyle's attack. According to the peripatetic

[21] 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."

[22] The full title is: "Some Specimen of an Attempt to make Chymical Experiments useful to illustrate the Notions of the Corpuscular Philosophy".

doctrine, a corporeal substance was composed from two distinct metaphysical components: matter and form. Furthermore, they made a distinction between substantial forms, which are essential to individual things, and accidental forms, without which individual things can exist. The substantial form was responsible for the essential accidents of the corporeal substance. Sensible qualities such as colors were considered to be accidents that bodies really have. This idea was contested by Boyle and his followers.

Boyle argued that, in principle, each natural phenomenon could be explained by only two Catholic Principles: matter and motion. This theory contrasted with the Aristotelian theory of four elements and the three principles of the spagynsts who followed views of Paracelsus (1490- 1541). Each phenomenon could be explained in an intelligible way by changes to the parts of bodies that had only mechanical properties such as motion, size and figure. In Boyle's view, the body was intelligible; it was a piece of matter that had only primary qualities, whereas all the other qualities were not real qualities but existed only in the mind. A body was thus a way or a modus of a way being primary quality.

With this project Boyle did not simply want to attack the theories of the 'peripatetics' and the chemical principles of the 'chymists'. It is obvious that Boyle wants to unite different groups of natural philosophers, an aim he would pursue for the rest of his life. He argues that, in contrast to the "Peripatetick and other vulgar Doctrines", the Cartesians and the atomists explained the same natural phenomena in a much more intelligible way by "little bodies variously figur'd and mov'd". With his 'Corpuscular Philosophy', Boyle wanted thus to unite atomists like Gassendi (1592-1655), who believed that indivisible parts or atoms really exist and Cartesians like Spinoza, for whom the parts of bodies are not indivisible parts or atoms and for whom there is no vacuum for the atoms to move in. Hence he introduces the terminology of 'corpuscularians and corpusculism' instead of 'atomists and atomism'. Nonetheless, Boyle also mentions differences among the groups he wanted to unite. However, this differences are - according to him - either metaphysical rather than physical or of minor importance. Boyle concludes with a definition of a common project, which he indicates for the first time as 'The Mechanical Philosophy' although it was, very probably, Henry More[23] who introduced this term in English. In his preface, however, Boyle defined this term in the sense in which most philosophers would later understand it and gave his definition at a time when the term still sounded very odd in all European languages and in Latin. It is thus likely that Spinoza[24] first

[23] See H. More, *The immortality of the Soul* (ed. Alexander Jacob), Dordrecht: Martinus Nijhoff Publishers, 1987, pp. 4 – 21. The first version of this book was published in 1659, the second revised edition in 1662.
[24] On Spinoza and the definition of Mechanical Philosophy, see: F. Buyse, "Spinoza and Robert Boyle's definition of Mechanical Philosophy," *Historia Philosophica* volume 8 (2010), pp. 73-98.

encountered the term “Mechanical Philosophy” in Boyle’s *De Nitro*. However, he never used the term in his writings.

> 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 should be explained in terms of the primary qualities of the minute parts of bodies. In his definition he thus makes a distinction not only between primary and secondary affections but also between the macro and the micro world. Moreover, it was Boyle who introduced this primary/secondary terminology[25] in English although it is Locke (1632-1704) who is much more famous than his mentor for the distinction. It was, however, Galileo, who published the distinction for the very first time since antiquity in his popular book the *Assayer* (1623). Therefore we may not exclude the possibility that Boyle was directly influenced by Galileo or indirectly by philosophers who knew Galileo’s work well, such as Gassendi (1592-1655), Mersenne (1588-1648), Descartes (1596-1650) or Hobbes (1588-1679). The work of Galileo was well-known in the *Republic of Letters* at that time, and the members of the Royal Society discussed his work, especially after the publication of Thomas Salusbury’s English translation[26] in 1661. Moreover, Oldenburg wrote on 28 October 1661 (that is, during the year of his visit to Spinoza) a letter to Viviani, Galileo’s final pupil and first biographer. Oldenburg’s colleague Wilkins had popularized before Galileo’s philosophy in England.

The redintegration experiment was an ideal phenomenon to show by analysis and synthesis that a substance was composed of corpuscles and could be recombined, which is a central idea of Boyle’s definition of Mechanical Philosophy. Furthermore, niter was interesting not only to early chemists but also to alchemists. According to the alchemist Glauber, mixed niter was a “hermaphroditic substance” containing both a volatile substance that he called volatile niter (spirit of niter) and a solid caustic substance that he called fixed niter (potassium caronate). Thus, mixed niter was a kind of

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[25] 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.”

[26] Salusbury, Thomas, *Mathematical collections and translations ... , vol. 1 & 2*, London: printed by William Leybourn, 1661-1665

universal solvent capable of dissolving all kinds of substances. The quest for a universal solvent, the so-called alkahest, was a very important question for alchemists in the seventeenth century.

After having explained the redintegration phenomenon in *De Nitro*, Boyle explains the different effects on the senses of the *redintegratio* phenomenon. In section XIII he discusses its tangible qualities. In section XIV he discusses the "very audible sound". In section XV he discusses the changes of color. 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'. In section XVII he discusses the taste of the different bodies. With many empirical details, Boyle explains how these sensible results were the result of the changes of the minute parts of the bodies at the micro level.

Amazingly enough, Boyle does not present his new philosophy as new. On the contrary, he refers to antique atomism as much as possible. First he mentions Democritos (ca. 460 BC – ca. 370 BC) and his supposed teacher Leucippus (first half of 5th century BCE). He furthermore refers to a certain Phoenician, Mochus,[27] who was believed to be an atomist prior to Leucippus. Boyle explains in the preface, before his definition, that he had learned to know the atomists and 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*,[28] that he read "the lives of the old Philosophers" at that time. Based on his early works, such as *Of the Atomical Philosophy*, it is also obvious that Boyle was studying atomism at the time he was still developing his own view on qualities of bodies. These atomists explained natural phenomena as a result of variations of the parts of bodies that had only mechanical properties.

5. The point of agreement between Boyle and Spinoza.

Most commentators who have discussed the Boyle/Spinoza correspondence directly contrast Boyle with Spinoza. Henri Daudin opposes "*l'expérimentateur, le technician"* to "*le philosophe métaphysicien*"; Boas Hall opposes the "rationalist" to the "empiricist" and Antonio Clericuzio opposes "the radical mechanist" to the "chemist" Boyle. In my view, however, the fact that Boyle and Spinoza had a correspondence indicates first and foremost that they fundamentally agree on the subject discussed — although there are indeed differences, which we will touch on later. In short, Boyle and Spinoza refuse to discuss subjects on which they fundamentally disagree. Two examples will make this clear.

Spinoza does not really engage with Boyle on the existence of a vacuum. Oldenburg tries repeatedly to launch the discussion on the vacuum in several letters, but Spinoza never really

[27] Cf. Sailor, D.B., Moses and Atomism, Journal of the History of Ideas, 25, 1964, p. 3-16.
[28] According to Michael Hunter, Boyle wrote 'Philaretus' in 1648 or 1649. Cf. M. Hunter, *Boyle – Between God and Science*. New Haven and London: Yale University Press, 2009, p. 63.

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. It is as follows. […]

Despite Oldenburg's efforts to mediate,[29] emphasizing that the experiments were "warmly welcomed" by philosophers who were plenists like Spinoza, there was nonetheless no real discussion. Spinoza never discussed the *machina boyleana*, which was so important for Boyle at that time, because for Spinoza, as for Descartes, there simply is no vacuum due to metaphysical reasons:

> 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.[30]

Boyle realized that Spinoza did not want discuss this question. In letter 16, Oldenburg postpones this 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 remarked rightly that this is probably the most important difference in ontology between 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*,[31] where it is still hard to distinguish his views from Descartes', in the *Short Treatise,*[32] which still is quite Cartesian and can be regarded as a proto-*Ethica*, and in Spinoza's main work, the *Ethics*, where he mentions 'vacuum' only once - in the scholium of proposition 15 of *De Deo* - referring to his earlier work:

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

[30] From Letter 11.

[31] A vacuum is extension without corporeal substance. (PPC, II, def. 5); that there should be a vacuum is a contradiction. (PPC, II, prop. 3)

[32] 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."

> 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.

Likewise, in the correspondence with Spinoza , Boyle does not engage with Spinoza's ideas about the general relation between God, nature, and man or other metaphysical subjects. Based on the first letter (Letter 1) Oldenburg sent to Spinoza, though, it is clear though that Oldenburg and Spinoza discussed such metaphysical items. And Spinoza's metaphysics was already well-developed at that time. Despite this, however, Boyle does not engage with such ideas although he had written a text containing his ideas about Spinoza's metaphysics.

Indeed, Boyle wrote a text that he described not as a text *on* Spinoza but as a "text *against* Spinoza".[33] In this polemic text - the only text in which Boyle actually mentions Spinoza's name - Boyle criticizes and categorically refutes Spinoza's standpoints on the existence of miracles, his arguments against divine teleology, his idea that God has no will, his identification of God with nature, and so on. Boyle wrote this text later on in the 1670s but could have written it in the period of the correspondence, for Spinoza already had these ideas at that time and had discussed them with Oldenburg during his visit. Boyle could have sent such a text to Spinoza to discuss these items but did not. Moreover, he never published the text.

It is worth noting that Boyle also criticizes certain essential elements of Spinoza's metaphysics, such as the concept of *natura naturans*, in his *A Free Enquiry into the Vulgarly Received Notion of Nature*, a book he published in 1686, though mainly written just after the period of the correspondence with Spinoza, according to Davis and Hunter.[34]

In sum, we can conclude that the differences in ontology and metaphysics between Boyle and Spinoza are very important. There was, as it were, enough gunpowder on both sides for the whole discussion to explode. However, the discussion did not explode, given the fact that they did not discuss items on which they fundamentally disagreed.

Spinoza and Boyle should have discussed their points of agreement in their discussion on the redintegration experiment. On what, precisely, did they agree? In the preface to Part Two of Boyle's book - the part Spinoza read closely - Boyle explains that, like so many early modern philosophers, he wanted to get rid of the qualitative explanation of nature and natural phenomena in terms of substantial forms and real qualities. Spinoza basically agreed with Boyle's critique of the peripatetic

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[33] 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.

[34] See the preface of Boyle 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 R. Boyle, *A Free Enquiry into the Vulgarly Received Notion of Nature*, Edited by E. Davis and M. Hunter, Cambridge: Cambridge University Press, 1996, p. xxiii.

theory of qualities. 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 as well, although he criticizes 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, in contrast, only qualities such as motion and rest are intrinsic qualities of bodies. A. Clericuzio argues that Spinoza is a stricter mechanical philosopher than Boyle, because Boyle 's bodies had both mechanical properties and chemical properties that were not reducible to mechanical properties.

For both Boyle and Spinoza, bodies had only a limited set of intrinsic qualities. Other sensible qualities, such as beauty, ugly, perfection, imperfection, colors, odors, and so on, were only 'ideas of the affections of the body' that represent[35] for Spinoza more the own body and the external bodies. Spinoza applied this central idea on many occasions in several texts, from his first texts[36] to his *Ethics,*[37] which contains his natural philosophy in most mature version.

And, like Boyle in his preface, Spinoza shows in the last paragraph of his correspondence on the existence of ghosts with Hugo Boxel a good deal of sympathy for atomists who, in contrast to Plato and Aristotle, do not use "bits of nonsense" like "occult qualities, intentional species, substantial forms" and instead explain qualities of bodies solely in terms of mechanical qualities of underlying parts — even though, according to Spinoza, there are no atoms[38] and there is no vacuum:

> 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.[39]

Thus, both Spinoza and Boyle refer to atomists when they criticize the theory of the Peripatetics without labeling themselves atomists. Boyle develops the ideas expressed in the definition of Mechanical Philosophy in *De Nitro*, in *Of the Excellency and Grounds Of the Corpuscular Philosophy*.

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[35] Cf. *Ethics*, II, proposition 16 with corollary I and II.
[36] See for example chapter 6 of the first part of the *Metaphysical Thoughts*; the appendix of *Ethics*, I and the preface of *Ethics*, IV.
[37] See for example the appendix of the first part of the *Ethics*.
[38] 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.
[39] From letter 56 from Spinoza to Hugo Boxel, written in 1674.

In this text he makes clear he is not an atomist in the general sense of the word because of theological reasons, though his new philosophy is indeed 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 be even more convinced about the new doctrine of qualities than Boyle. Boyle clearly presents his *Corpuscular Philosophy* as a hypothesis, thus implying that it had to be validated in some way. Boyle did an impressive set of experiments, reported in his books, essays and tracts, to show that this new philosophy was right. Boyle explained this hypothesis further in ‘About the Excellency and Grounds of the Mechanical Hypothesis”. As “The Publisher’s Advertisement” makes clear , this essay was intended as an appendix to Boyle’s dialogue about the requisite of a good hypothesis, which is now largely lost.

Spinoza did not need any of these sophisticated experiments, which he opposed to ordinary experience [*experientiâ vagâ*] in order to validate the hypothesis. The problem was not that Spinoza disliked science. On the contrary, his first argument against these experiments was precisely that they were not scientific enough. Moreover, Spinoza did not need any of these experiments because Bacon and Descartes[40] had already demonstrated in a convincing way that the mechanistic theory of qualities was right. In letter 13, Spinoza makes clear to Boyle that the “mechanical principles” have to be accepted before doing experiments, suggesting that Boyle tries to impart too much new knowledge via his experiments although he pretends repeatedly that he only wants to illustrate that the Mechanical Philosophy was the right alternative for the Peripatetic doctrine. A major problem was that Boyle’s experiments are too empirical for the rationalist Spinoza. In letter 6, Spinoza 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 last letter (letter 16) of the Spinoza/Boyle correspondence, Oldenburg tries to bring both philosophers together 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 repeated here in fact 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.”

[40] Cf. Letter 6.

This was the end of the discussion between Boyle and Spinoza. However, Oldenburg continues to inform Spinoza about Boyle and his publications in letters 25, 29 and 31. Spinoza mentions Boyle in his letters 26, 32 and 33. 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 explains he had seen Boyle's *Treatise on Colours* in the house of C. Huygens (1629-1695), the most important Dutch physicist of the time. Huygens was Spinoza's neighbor when he lived in Voorburg. Spinoza discussed Boyle's work with Huygens and Huygens would have lent him the *Treatise on Colours* if he could read English.

4. Glauber and the redintegration.

As explained above, for Spinoza the discussion is primarily about the nature of niter, whereas what counts for Boyle is the promotion of the Corpuscular Philosophy. However, another interesting element plays a role.

First, Boyle's position on the heterogeneous character of saltpeter is actually the position of the chemist and alchemist Johann Rudolph Glauber (1604-1670).[41] This well-known German chemist explicitly argued long before Boyle that saltpeter was composed of two substances that could be recombined into saltpeter. Moreover, it was Glauber[42] who first did the redintegration experiment. In the last section of the second part of *On Niter* Boyle suddenly begins to refer to Glauber and claims that he never really read Glauber's "small treatises freshly publish'd", referring to the *Prosperitatis Germaniae* (1656-1661). Likewise, in his preface, Boyle tries to convince his readers that he never really read Glauber's books and that he did his experiments long before Glauber had published his works. Moreover he argues that what Glauber did with saltpeter was very different: "He but prescribing as a bare Chymical Purification of Nitre, what I teach as a Philosophical Redintegration of it".

Boyle's claims are not convincing. Glauber's works were very well-known at that time among early English chemists such as Boyle. Moreover, a letter by Hartlib from 1656 makes it clear that Boyle 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 Benjamin Worsley who had visited[43] Glauber's lab in Amsterdam in 1648-

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

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

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

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 another reason for Boyle to have known the work of Glauber. In February 1648, while Worsley was in Holland, Robert Boyle made a trip to Holland. Spinoza was sixteen years old at that time. The reason for Boyle's trip was to help his older brother Francis and to hush up as far as possible a major Boyle family scandal, as Lisa Jardin[44] puts it. The Robert's elder brother's wife, Elizabeth Killigrew, was pregnant by the exiled Prince Charles who would later become King Charles II of Britain. While in Holland, however, Robert Boyle visited Amsterdam and the University of Leiden and met many intellectuals. He included in his visit the anatomy division of the University of Leiden, where Spinoza would later regularly visit anatomy dissections.

Many of the intellectuals whom Boyle met, including Menasseh Ben Israel[45] and Adam Boreel, were Hartlibians. It is thus likely that he spoke with some of them of Glauber's work. The Hartlibian Glauber had lived in Amsterdam since 1640, although he resided in several cities between 1646 and 1652 before installing himself definitively in Amsterdam in 1652. He was well-known in Amsterdam. His chemistry was new and intellectuals discussed his work as a chemist, alchemist and pharmacist.

Boyle's repeated statements in *De Nitro* that his redintegration experiment was not based on Glauber's book does not mean that he was not 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 had obviously used certain elements from Glauber's work. At first glance this could not have happened because Glaubers' *Novi furni philosophici* was only published in 1651 in Latin. An earlier version was published in German by 1646-47. Boyle, who read many languages, could not read German. Boyle came to know this work through several copies sent to Hartlib by the mid-1640s. Boyle must have received one of this manuscript's translations because, as William R. Newman and Lawrence M. Principe[46] 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." "

[44] Cf. L. Jardin, "Foreword," in P. Mayor (Editor), *Literatures of Exile in the English Revolution and its Aftermath,1640-1690*, Surrey: Ashgate, 2010.
[45] 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.
[46] Cf. W.R. Newman and L. M., Prinzipe, L.M., *Alchemy tried in the fire: Starkey, Boyle, and the fate of helmontian chymistry*, Chicago & London: The University of Chicago Press, 2005, p. pp. 212-213.

5. Boyle, Spinoza 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 Boyle/Spinoza correspondence. This international circle was a much more heterogeneous circle than The Republic of Letters, which was primarily composed of diplomats, lawyers, doctors and scholars, and (to a lesser extent) theologians. The Hartlib circle, by contrast, was composed of all sorts of people: publishers, chemists, alchemists, theologians, mathematicians, physicists, and so on. Often, people were members of several circles. Several members of the Hartlib circle, for example, became members of Royal Society for the Improvement of Natural Knowledge after 1662. However, not all members of the Royal Society were Hartlibians.

Amazingly, everyone mentioned thus far as playing a role in the development of the Boyle/Spinoza correspondence was clearly 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 been mentioned yet: Petrus Serrarius[47] (1600-1669). Serrarius [Pierre Serrurier] was the most important link between Spinoza, Oldenburg and Boyle. He was "Spinoza's contact with the outside world", as Richard Popkin[48] puts it, and Oldenburg's "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. He visited Glauber in February 1660, during the period thus just before the Boyle/Spinoza correspondence. According to visitors such as Samuel de Sorbière, 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. De Sorbière wrote in a letter[49] to Monsieur De Bautru, Chevalier Baron de Segré, dated 13 July 1660:

> 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

[47] See E.G.E. Van der Wall, *De mystieke chiliast Petrus Serrarius (1600-1669) en zijn wereld*. Diss. Doct., Leiden: Universiteit van Leiden, 1987.
[48] Cf. R. Popkin, *Spinoza*. Oxford: Oneworld, 2004, p. 40.
[49] Cf. S. Sorbière, *Drie brieven van Samuel Sorbière over den toestand van Holland in 1660*, Uitgegeven door P. J. Bolk, Leiden: 1901, p. 81.

> façon très-bonne et très-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 very interested in science in the early 1660s, must have heard of this lab, which was situated only a ten-minute walk from his birthplace. Moreover, according to Steven Nadler,[50] Serrarius and Franciscus Van den Enden were often present at the discussions on the experiments with nitre in Glauber's laboratory. Given Spinoza's great confidence with the experiments on niter, Nadler suggests that Spinoza accompanied his former Latin teacher. This would explain why Spinoza agreed to comment on Boyle's experiments, the fluent way in which Spinoza responds to Boyle's experiments on niter and why he speaks knowledgeably about the different experiments concerning niter**.**

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[50] See S. Nadler, *Spinoza*, Cambridge: Cambridge University Press, 2003, Chapter 8.