
Julius Caesar Scaliger on Corpuscles and the Vacuum

Andreas Blank
Tel Aviv University

This paper investigates the relationship between some corpuscularian and Aristotelian strands that run through the thought of the sixteenth-century philosopher and physician Julius Caesar Scaliger. Scaliger often uses the concepts of corpuscles, pores, and vacuum. At the same time, he also describes mixture as involving the fusion of particles into a continuous body. The paper explores how Scaliger's combination of corpuscularian and non-corpuscularian views is shaped, in substantial aspects, by his response to the views on corpuscles and the vacuum in the work of his contemporary, Girolamo Fracastoro. Fracastoro frequently appears in Scaliger's work as an opponent against whom numerous objections are directed. However, if one follows up Scaliger's references, it soon becomes clear that Scaliger also shares some of Fracastoro's views. Like Scaliger, Fracastoro suggests corpuscularian explanations of phenomena such as water rising in lime while at the same time ascribing some non-corpuscularian properties to his natural minima. Like Scaliger, Fracastoro maintains that there is no vacuum devoid of bodies since places cannot exist independently of bodies (although their opinions diverge regarding how exactly the relevant dependency relation might be explicated). Finally, like Scaliger, Fracastoro connects a continuum view of mixture with a theory of natural minima.

1. Introduction

Due to pioneering studies by Norma Emerton and Christoph Lüthy, the Padua-trained, Agen-based philosopher and physician Julius Caesar Scaliger (1484–1558) is by now widely recognized as a seminal figure in the development of early modern corpuscularian matter theory. Scaliger's matter theory is expounded in the *Exoteric Exercises* (1557), a work consisting of almost 1000 pages of polemical remarks on Girolamo Car-

dano's *On Subtlety* (1550). As Ian Maclean has pointed out, there is a strongly sceptical strand to Cardano's and Scaliger's conceptions of subtlety (Maclean 1983, especially pp. 146–147; Maclean, 1984). Cardano devotes an entire book to “useless subtleties” (Cardano [1550] 1663, pp. 587–592). Likewise, Scaliger laments the weakness of the human mind in gaining insight into eternal things (EE, fol. 2r). He takes an agnostic stance towards some issues in natural philosophy and metaphysics, e.g., as to the causes of the motion of the heart (EE, fol. 417r) or as to the nature of the union of soul and body (EE, fol. 416r). Nevertheless, like the twenty other books of Cardano's *On Subtlety*, Scaliger's *Exoteric Exercises* contains a wealth of miscellaneous remarks on an exhaustive variety of topics in metaphysics and natural history and, as many of his marginal notes indicate, Scaliger felt that he had something subtle to say about these topics.¹

The presence of both Aristotelian and corpuscularian strands in Scaliger's matter theory explains why recent interpretations of his metaphysics of nature differ widely. On one side, Emerton emphasizes the importance of the concept of *minima naturalia* in Scaliger's thought. She writes that “[o]f all the distinctions between minimism and atomism, the most important and fundamental was that minimism was indissolubly tied to the concept of form, which supplied the basic definition of the scholastic *minimum naturale* as the unit material embodiment of the form” (Emerton 1984, pp. 90–91; see also Maier 1949, pp. 181–182). According to Emerton, it is Scaliger who, alongside Agostino Nifo (1473–1538) and Jacopo Zabarella the elder (1532–1589), did most to develop minimism in the sixteenth century (*ibid.*, p. 92). Emerton maintains that minimism is not intended to function as a comprehensive matter theory but rather provides explanations of a limited range of phenomena, in particular in chemistry (*ibid.*, pp. 101–102). According to her reading, Scaliger suggests a minimalist definition of mixture, when he writes: “mixtion is the motion of the minimum bodies so that union is achieved” (*ibid.*, p. 101; see Scaliger 1557 [henceforth: EE], fol. 143v).²

By contrast, Lüthy maintains that “much in the *Exercitationes* is utterly un-Aristotelian, notably the doctrines of the temporal creation *ex nihilo*

1. The full title of Scaliger's book implies that it is the fifteenth in a series of *Exoteric Exercises* about various other matters—but no trace is left of any of the fourteen other volumes. Scaliger's son Silvius Caesar reports that the household of his father, who died deeply in debts, was sacked by his creditors who took anything of value, including his manuscripts, with them (see Scaliger 1584, p. 81). Maybe, just maybe, the fourteen other volumes did exist, but probably we will never know. On the creation of Scaliger's autobiographical myths, see Billanovich 1968.

2. “Mistio est motus corporum minimorum ad mutuuum contactum, ut fiat unio.”

of the world; of the substantial independence of prime matter; of the vacuum; of space; and of the soul” (Lüthy 2001, p. 548).³ According to his reading, “[a]lthough Scaliger explicitly condemns atomism, his *Exercitationes* contain numerous explanations of natural phenomena that rely on pores and particles, *minima* and *vacua* . . .” (ibid., p. 549). On the basis of passages invoking pores and particles, *minima* and *vacua*, Lüthy claims that there is a “corpuscularian treatment of matter theory” in Scaliger’s work and that this derives from the corpuscularian views in the Fourth Book of the Aristotelian *Meteorology* (ibid.). In Lüthy’s view, the following are examples of such corpuscularian explanations of natural phenomena: “the structure of the *minima naturalia* in an anvil is so dense that it cannot be further condensed . . . , fire is stronger or weaker depending on whether its particles are close or farther apart . . . , the varying density of *minimae partes* in substances explains their specific properties . . . , [and] some substances have round or oblong *corpuscula*” (ibid., p. 550).⁴ Lüthy concedes that in his official definition of mixture, Scaliger does not regard *corpora minima* as atoms, “first, because atoms can only be contiguous to each other, while mixtures are continuous, and second, because adjacent atoms cannot form a new mixture, whereas ‘the form of a mixture is different from that of the element.’” Nevertheless, Lüthy claims that “frequently in his *Exercitationes*, Scaliger views these ‘minimal bodies’ as independently existing corpuscles having certain shapes and as touching each other contiguously, but not continuously, with small interstitial voids filling the remaining spaces” (ibid., p. 551).

In what follows, I suggest that Scaliger’s numerous references to Girolamo Fracastoro (ca. 1478–1553) give important clues for understanding Scaliger’s conception of corpuscles and the vacuum. Fracastoro had an important role in early modern life sciences with his views on the constitution of matter that laid the foundation for his medical theories, especially his theory of contagion and disease. In his *On Contagion* (1546), he develops the view that diseases that traditionally had been ascribed to influences of the air and the receptivity of the organism are in fact caused by minimal particles (*particula minima*) (Fracastoro [1546] 1550, pp. 218–219; see Hirai 2005, pp. 74–80). Moreover, in *On the Sympathy and Antipa-*

3. On the creation of the world, see EE, fol. 17r–v; on the substantiality of prime matter, see EE, fol. 467r–v. By contrast, Raimondi 2003 maintains that Scaliger’s thought is in line with the Scholastic tradition also in a variety of respects such as creationism, providentialism, and teleology.

4. On the closeness of particles in fire, see EE, fol. 20v. Clericuzio, too, holds that Scaliger interpreted *minima* as particles (see Clericuzio 2000, pp. 9; 11–13). On the influence of Scaliger on Gaston DuClo’s corpuscularian alchemy, see Principe 1998, pp. 189–190.

thy of *Things* (1546), he repeatedly uses the term “atom” to characterize such natural *minima*. Christoph Meinel holds that Fracastoro was probably “the first of the humanists to use the ancient atomic theory in explaining physical and chemical phenomena” (Meinel 1988, p. 71; see also Cleruzio 2000, p. 17, note 35; Lüthy 2000, p. 450). Moreover, as Vivian Nutton has brought to light, an atomistic reading of Fracastoro’s theory of contagious seeds was first used for polemical purposes by the sixteenth-century Paduan professor of medical theory, Giambattista da Monte (Nutton 1990, pp. 208–213). Nevertheless, Fracastoro maintains that minimal particles can be joined together such as to form composite substances that are more than mere aggregates of true, simple unities. He also holds that in cases of genuine mixture natural *minima* form a continuum. His conceptions of the unity of composite substances and of the continuity of the constituents of genuine mixtures indicate that Fracastoro’s corpuscularianism is not an unmodified atomistic variety with perfectly hard, impenetrable bodies floating in a void. While I will not be concerned here with his views on contagion and disease, the way Fracastoro combines corpuscularian and non-corpuscularian intuitions turns out to be highly relevant for understanding Scaliger’s views on corpuscles and the void.

2. Fracastoro on Corpuscles and the Vacuum

The following is a passage from Scaliger’s *Exoteric Exercises*, which Lüthy invokes to support his interpretation of Scaliger’s notion of a vacuum:

[T]hose who attributed certain shapes to the natural minima as their principles are necessarily forced—as no body made up of globules can cohere on a continuous line because of their rotundity—to posit also a vacuum in nature, by means of which all becomes one by contiguity, not by continuity, as the wise philosophers (*Sapientes*) know well. (EE, fol. 6v)⁵

According to Lüthy, Scaliger here appears to side with the *Sapientes* (Lüthy 2001, p. 551). Yet, while the choice of the term “sapientes” obviously sug-

5. “[Q]ui minimis naturalibus tanquam principiis constitutis certas figuras attribuerunt: cum globulis ob rotunditatem cohaerere nequeat perpetuo tractu corpus ullum: necessario coacti sunt, vacuum altrinsecus statuere in natura. Quibus omnia fiebant unum per contiguitatem, non per continuationem: quemadmodum agnovere Sapientes.” Lüthy’s translation. All subsequent translations are my own. I have normalized the use of “u”, “v”, “i”, and “j” in the Latin quotations and omitted the accents used in the Latin of Scaliger’s time; also, I use a capital letter for the first word of sentence, even where the original sources do not do this. Apart from these changes, the spelling, use of capitalization, and punctuation are those of the original texts.

gests an affirmative attitude towards what the wise philosophers know, it is not so clear what it is that Scaliger thinks they know. Is it, as Lüthy would have it, the claim that it is necessary to posit a vacuum in nature? Or is it, as an alternative reading would have it, that the *Sapientes* know well that it is necessary to posit a vacuum in nature *if* one makes the assumption specified in the first sentence—namely, the assumption that natural minima are characterised by certain shapes. This, of course, is a central assumption of classical atomism.⁶ However, is it an assumption that Scaliger would share? If he would not share this assumption, then the passage just cited would take on a different appearance. In this case, Scaliger would be discussing the consequences of an assumption that he rejects. According to such a reading, what the *Sapientes* know would concern the necessary consequences of an erroneous assumption and, hence, not something that is necessary *tout court*.

As Lüthy has emphasized, a passage in which Scaliger discusses the role of pores in phenomena such as water rising in lime is crucial for characterizing his views on the vacuum. Fracastoro, too, discusses cases such as water rising in lime at great length in *On the Sympathy and Antipathy of Things*.⁷ Scaliger mentions Fracastoro at the beginning of the relevant passage, where he refutes the opinions of some modern philosophers (*Recentiores Philosophi*). To be sure, the aim of the explicit reference to Fracastoro here is to point out a particular error in Fracastoro's explanation of the phenomenon. Moreover, at first glance, Fracastoro might not seem to be a promising starting point when it comes to interpreting Scaliger's views. The title of Fracastoro's book sounds hardly promising in the context of studying the origins of early modern corpuscularianism. Looking at the title, the reader would expect a Neo-platonic account of supra-natural causes of the harmony or disharmony between things. But such an expectation would soon be overturned by the anti-occultist stance that Fracastoro actually takes. Instead of invoking celestial or divine forces, Fracastoro develops thoroughly naturalistic accounts of causal interaction between bodies. However, despite his use of the term "atom" and his nods towards Epicurus and Lucretius, his matter theory should not be characterised as atomistic in an unqualified sense.

In discussing the nature of causal interaction between objects, Fracastoro holds that in nature no action can take place unless by means of contact (Fracastoro [1546] 1550 [henceforth: SAR], pp. 45–46). Nevertheless, he observes that similar things are drawn to each other and dis-

6. See Plutarch, *De placitis* 1, 2.

7. On the history of this work, see Nutton 1990, p. 199, note 7. On Fracastoro's sources, see Nutton 1983; on Fracastoro's anti-occultism, see Peruzzi 1980, pp. 43–55.

similar things move away from each other even if they don't touch. He is aware of the existence of atomistic explanations of phenomena such as magnetism: "Some of the ancients such as Empedocles and Epicurus, whom among our philosophers Lucretius followed, regarded effluvia of bodies, which they called atoms, as the cause of this attraction. These effluvia should by no means be negated . . . but the way in which these authors treated them was rather rough and unsuitable" (SAR, p. 46).⁸ The fact that Fracastoro regards Lucretius as one of "our" philosophers is striking for it shows the extent of continuity that sixteenth-century philosophers perceived between their own intellectual pursuits and Roman times. However, Fracastoro's nod towards Lucretius is seriously misleading in several respects.

As it turns out, the ancient atomists' denial of composite unities is unacceptable to Fracastoro. In his view, the effluvia connecting two similar things are such that "a certain whole and unity arises" (*totum quoddam fit atque unum*) (SAR, p. 47). Maintaining that a composite unity emerges from two objects connected by effluvia, moreover, requires a modification with respect to the nature of the effluvia themselves. Streams of atoms, understood as perfectly hard and indivisible bodies, certainly would not suffice to constitute a genuine unity. Fracastoro holds that effluvia of atoms cannot account for all cases of causal interaction between two bodies (SAR, pp. 48–49). For example, according to his view the interaction between the needle of a compass and the "magnetic mountains" at the poles of the globe, due to the great distance between them, cannot be explained by means of an exchange of atoms or corpuscles (SAR, p. 75). This indicates that a fully Lucretian interpretation of Fracastoro's view of the causal interaction between distant things cannot be adequate. To account for all phenomena of mutual attraction, Fracastoro postulates a kind of entity that differs considerably from atoms: so-called "spiritual species".

"Spiritual species" play a role not only in his theory of magnetism but also in his account of sensation and intellection. Obviously, these entities resemble the sensible and intellectual species that, according to medieval thought, could multiply and provide the perceiver with a structural analogue of the objects perceived (see Spruit 1995). Fracastoro appears to have thought of them as neither fully material nor fully immaterial, but rather as peculiar entities that share some properties with both material and immaterial entities, and yet differ from both in some respects. What distin-

8. "Antiqui quidem ut Empedocles & Epicurus, quos e nostras Lucretius secutus est, effluxiones corporum quas athomos appellabant, principium eius attractionis ponebant. Quae quidem effluxiones ne negandae quidem sunt . . . modus autem quem ipsi tradebant, sat rudis & ineptus erat."

guishes “spiritual species” from material objects are two characteristics: (1) They are “thin” (*tenuis*) in a metaphorical sense: While ordinary thin objects are still three-dimensional (with a small extension in one dimension), Fracastoro’s “spiritual species” do not possess even a small extension in a third dimension. They are two-dimensional objects that represent the surfaces of the objects from which they originate (SAR, pp. 51–52). (2) They are momentary entities: they are propagated by waves in a medium such as air or water in such a way that the medium generates at every moment a new “spiritual species” in a different location on the trajectory between one object and the other (*ibid.*). At the same time, “spiritual species” are neither quality-like nor fully immaterial. With respect to the question of whether they are qualities and immaterial, Fracastoro answers that they are substantial and bound to matter, since “nothing can by itself confer motion which is not either a body or at least a nature and substance in a body” (SAR, p. 50).⁹ Although this statement is far from clear, Fracastoro seems to have held that “spiritual species” are not fully immaterial because they are substances whose existence depends on bodies. If they are thought of as surfaces propagated in a material medium, there is a clear sense in which they can be thought of as being incapable of existing independently of bodies.

“Spiritual species” play a crucial role in Fracastoro’s account of composite substance. He maintains that by means of the exchange of effluvia of “spiritual species” a composite substance arises which “is some whole constituted by [the body] *a*, and [the body] *b*, and this spiritual something; in this whole, parts do not simply have their duty and situation, unless they are mutually constrained in such a way that *a* and *b* go together” (SAR p. 53).¹⁰ For this reason, attraction results from “a motion of parts in the whole, which are moving towards their place, and which is produced by a form that is a nature and a substance” (*ibid.*).¹¹ Fracastoro’s emphasis on the role of substantial form in the constitution of composite unities becomes also apparent when he discusses three possible explanations of the phenomenon of water rising in lime. He regards these explanations as complementary, even if he gives most weight to the third explanation. According

9. “[N]ihil per se moveri potest quod non sit aut corpus, aut saltem natura & substantia in corpore.” On the role of “spiritual species” in Fracastoro’s epistemology, see Cassirer 1911, pp. 226–232; Spruit 1995, pp. 46–49; Leijenhorst 1996, pp. 105–106, 112–117; Hoffmann 2003, pp. 157–162.

10. “[S]ubstantia . . . totum quoddam sit ex *a* & *b* & spiritali illo, in quo toto partes non plane debitum esse, & situm habent, nisi invicem ita astringantur ut simul & *a* & *b* coeant.”

11. “Qui motus tandem est partium in toto sese ad suum situm moventium a forma factus, quae natura & substantia est.”

to the first explanation, dissimilar substances have contrary substantial forms by means of which they mutually resist each other (SAR, p. 87). Although Fracastoro does not dismiss this explanation, it is clear that it could explain the phenomenon only partially: it could explain why water and air do not mix, but not why water should rise in the pores. According to the second explanation, lime attracts water not insofar as it is porous but insofar as it is dryer than in its natural state (SAR, p. 88). Following this line of argument, lime belongs to the bodies that “are by themselves and according to nature humid but accidentally dried out; and in these their form and nature with all their potencies remains . . . to which also the spiritual form belongs, which is destined to attract what is similar . . .” (SAR, pp. 88–89).¹² The third explanation, finally, complements the role of the agency of the form of a composite substance and invokes an Aristotelian theory of natural places, according to which the air enclosed in the pores strives towards the natural place of air. While air does not have enough force to do so in large pores since it would have to move a large amount of water, it does so in small pores, where it has to draw only a minimal part of water (*pars aquae minima*) (SAR, pp. 90–93). In this third explanation, Fracastoro combines corpuscularian and non-corpuscularian modes of thought: water behaves in a corpuscularian way in the sense that a minimal part of water is moved more easily than a greater amount; but at the same time the motion of natural bodies is determined by their striving towards their natural place.

Fracastoro’s distance from Lucretius also becomes clear in his treatment of place and the vacuum. At the beginning of his book, Fracastoro embraces a plenist conception of matter. He writes: “A vacuum cannot be in nature, since nature does not sustain or admit anything that is in vain, and that impedes the order and laws of the universe” (SAR, pp. 25–26).¹³ But why should vacuum be thought to be detrimental to the order and laws of nature? Fracastoro somewhat cryptically remarks that in a vacuum “nothing could happen nor could anything be received” (SAR, p. 26).¹⁴ This remark seems to be ambiguous: Does Fracastoro intend to claim that, if there were a vacuum, it could not, by its very essence, be occupied by a body? Or does he intend to claim that, as long as a portion of vacuum is

12. “Alia vero sunt quae per se quidem & natura humida sunt, per accidens autem sunt exsiccatae, remanet tamen in iis forma sua & natura cum virtutibus omnibus . . . inter quas est, & spiritualis species, quae attrahere nata est quod simile est . . .”

13. “[V]acuum in natura esse non potest, quoniam nihil natura sustinet, nihil admittit quod frustra sit, quodque universi ordinem & leges impediatur . . .” On medieval theories of interstitial voids, see Grant 1981, pp. 70–77.

14. “[Q]uae quidem contingant, si vacuus sit ullus locus, in eo enim, nec quicquam fieri poterit, nec quicquam recipi.”

contingently not occupied by a body, no change could take place and no effect could be received there? Both readings seem to be possible, and there is nothing in the immediate context of Fracastoro's remark that helps decide the matter. In any case, Fracastoro seems to maintain that a vacuum (no matter whether it essentially or contingently unoccupied by a body) is contrary to the laws of nature because no change and no causal interaction can take place there. And it is the absence of change and causal interaction that would be an instance in which nature would do something "in vain."

But then, how does nature avoid the occurrence of *vacua*? Fracastoro considers two answers that appear unsatisfactory to him:

[I]f someone is not satisfied with [knowing] the final cause but wants to know also the active cause, and what it is that resists separating forces and how it does so, probably he is not that ready to give a reason for such a connection: since the parts of the universe do not know this final cause, nor can those parts strive towards it by nature . . . It is also not to be said . . . that the parts of the universe, even if they do not know their end, are directed by a cognizant being: for here we do not ask about the universal and first cause, but about the particular and specific cause . . . (SAR, p. 26)¹⁵

His own suggestion is that bodies are preserved "by the mutual connection and contact of their surfaces" (*per mutuum nexum & contactum extremorum*), since this is how a vacuum is avoided (SAR, p. 27). He explains:

Place brings about that a body is one body with respect to another, from whence people also rightly say that place preserves the thing that is located in it: which it in fact does in the highest degree, when it protects it from a vacuum. Hence, substances and bodies that are in the universe do not know this end, but nevertheless resist by their nature, such that they are not entirely separated. For it is not necessary that the things that act for some purpose also know this end; rather, some know it, and some act by their nature. (SAR, pp. 27–28)¹⁶

15. "[S]i quis non solo fine contentus sit, sed & agens quoque requirat, & quid nam illud sit, quod divellenti resistat, & quomodo, non erit fortasse ita promptum reddere rationem tanti nexus: quoniam universi partes neque eum finem agnoscunt, neque per naturam appetere possunt . . . Neque enim dicendum . . . universi partes, tametsi non eum cognoscunt finem, dirigi tamen a cognoscente: quoniam hic non universalem & primam causam quaerimus, sed particularem & propriam . . ."

16. "[L]ocus enim fit unum corpus alteri, unde & recte aiunt locum esse locati conservativum: quod profecto maxime fit, quum a vacuo praeservet. Non cognoscunt

Hence, bodies are dependent on places. Places not only individuate bodies, they also play a role in the preservation of bodies. This is so because being at a place implies that the surface of a body is in touch and causal interaction with the surfaces of the surrounding bodies. And, according to Fracastoro's view, this is how the preservation of a given body comes about. If it were not surrounded by bodies throughout, but by portions of vacuum (which, by hypothesis, do not stand in causal interaction with their surroundings), the parts of this body would separate from each other. Due to this essential connection between place and body, space is not only contingently occupied everywhere by bodies, it is so necessarily since otherwise bodies could not persist. As we will presently see, although Scaliger's views on vacuum, place and the preservation of bodies differ markedly from Fracastoro's, the view that space is necessarily a plenum is also found in Scaliger's version of corpuscularianism.

3. Scaliger on Corpuscles and the Vacuum

Like Fracastoro, Scaliger puts forward corpuscularian explanations of various natural phenomena. Like many of his contemporaries, Scaliger uses both the conception of an actual division of natural bodies into *minima* and the conception of a natural *minimum* not as an actually existing corpuscle but as an end-point of potential division. To demonstrate the existence of actual *minima*, he uses an argument from erosion: The traces that drops of water leave in the long run on a stone indicate that water takes with it insensible portions of the stone; these smallest movable parts of the stone, Scaliger suggests, give a good idea of what a natural *minimum* is like (EE fol. 35r; see Murdoch 2001, p. 129, note 114). Interestingly, although this example and others like it are found in Lucretius,¹⁷ Scaliger refers the reader to a passage of Aristotle's *Physics*, where erosion of a stone by drops of water indeed is mentioned.¹⁸ As Scaliger puts it, the part of a stone that is carried away by a drop of water is a minimal part of the stone "because in it the first motion takes place" (EE, fol. 35r). Scaliger derives other corpuscularian explanations from the Aristotelian *Meteorology*. For example, Scaliger mentions a passage from the second book of the *Meteorology*, according to which hot vapours of water get colder by getting mixed with

igitur eum finem substantiae, & corpora, quae in universo sunt, per naturam tamen resistunt, ne separentur omnino. Non enim necesse est, quae gratia alicuius agunt, finem etiam cognoscere, sed alia cognoscunt quidem, alia per naturam agunt."

17. See Lucretius, *De rerum natura* 1. 298–299, 305–328.

18. "Quod autem minima dentur naturalia: nemo sanus dubitabit. Finita enim sunt corpora naturalia: ergo ex finitis. Hoc a praeceptore didicimus veritatis in libris Physicorum: sed manifestissime, ubi loquitur de lapidis cavatione." See Aristotle, *Phys.* VIII, 3, 253b15–23.

cold particles of air (EE, fol. 20r; see Aristotle, *Meteor.* II, 2, 354b24–33). Similarly, he points out that according to the first book of the *Meteorology* the parts of the world are one not by means of continuity but by means of connection (*coaptatione*), in the sense that supralunar and sublunar bodies are in continuity with each other not because of the unity of a form but because the supralunar bodies are efficient causes the effects of which are received by the sublunar bodies (EE, fol. 19r; see Aristotle, *Meteor.* I, 2, 339a11–24).

Like Fracastoro, Scaliger's proposes a corpuscularian explanation of the phenomena occurring when a piece of lime is immersed partly in water. To be sure, his explanation of the lime phenomenon diverges from Fracastoro's. He rejects Fracastoro's suggestion that lime might be dryer than it would be according to its own nature such that it attracts water due to the agency of the form of a composite substance (EE, fol. 8v). Moreover, he rejects Fracastoro's conjecture that the air included in lime seeks to reach to the natural place of air. As Scaliger argues, water rises in lime beyond the level of the water into which the piece of lime is immersed; hence the air included in the upper part of lime is already in the sphere of air (EE, fol. 9r).¹⁹ Nevertheless, like Fracastoro, he proposes an explanation that is both plenist and corpuscularian. He also shares Fracastoro's view that recurring to the agency of an immaterial cognizant being does not provide a satisfactory answer to the question of why corpuscles behave in a way such as to avoid a vacuum (EE, fol. 5v). However, he criticizes Fracastoro's own answer to the question:

Others believe the following: There is no vacuum because all things strive towards their preservation. Conservation, however, is brought about by the connection and the contiguity of surfaces. From this it follows that place provides preservation for what is in a place. This opinion has some probability but is not true . . . It is not true that bodies are preserved by place, but by form. (EE, fol. 5v)²⁰

Scaliger distinguishes between attraction (*tractio*) and succession (*subitio*). According to his view, attraction happens by means of an external force. This, however, is not what happens in cases such as water rising

19. Also his attitude to Fracastoro's account of magnetism is critical. He repeatedly mentions Fracastoro's hypothesis of magnetic mountains on the poles of the globe (EE, fol. 62v; fol. 186r). However, he rejects Fracastoro's suggestion that in cases of magnetic attraction a composite substance with spatially disjoint parts arises (EE, fol. 454r–v).

20. “[A]llii ita existimarunt: Non dari vacuum propterea quod appetunt cuncta sui conservationem. Eam vero per nexum, atque extremorum contiguitatem comparari. Quo fit, ut locati locus sit conservatio. Probabile hoc, non verum tamen . . . [N]on est verum, a loco servari corpora, sed a forma.”

in lime. Rather, a body that succeeds another body (such as a particle of water succeeding a particle of air in the pores of lime)

is moved by an internal form of its own . . . , namely, a secondary one, such that no vacuum occurs. For elements not only strive towards their own WHERE: but they enjoy themselves outside their natural place, such that in order to avoid serious harm for the universe the place at which they are is not occupied by the most terrible enemy. In fact, nothing is more hostile to being than non-being. But vacuum is a non-being (EE, fol. 25r; see EE, fol 6v).²¹

Hence, bodies are not only preserved by their form, they also move in a way such that no vacuum occurs due to their form. Yet, Scaliger's claim that vacuum is a non-being is puzzling since, a few lines later, he also claims that "[i]n nature a vacuum exists necessarily. For otherwise, either there would be no motion or one body would penetrate the other" (EE, fol. 6v).²² Clearly, Scaliger is committed to the view that, in some sense, there is no vacuum, while also being committed to the view that, in some other sense, there is a vacuum. What exactly does he have in mind?

Aristotle understood the vacuum as "that in which the presence of body, though not actual, is possible" (*De caelo* I, 9, 279a14–15; see Grant 1981, pp. 8–9). According to Aristotle, because a void place has size but not body, and because it fails to quality as one of the four basic causes, it is not a real entity, i.e. a privation of being. Scaliger explains the sense in which the vacuum is a non-being in exactly the same way (EE, fol. 6v). But in which sense does he think that the vacuum is a being? He does not seem to have given much thought to the Stoic conception of an extracosmic void. However, there are two other conceptions that were much debated in ancient and medieval controversies about the void, and that could be plausible candidates for a vacuum that, in some sense, is real—that of small, "interstitial" vacua between particles, and that of larger, "coacervate" intracosmic vacua (see Grant 1981, pp. 70–71). Let us first consider interstitial *vacua*.

Like Fracastoro, and *pace* Lüthy, Scaliger rejects the idea that matter is interspersed with micro-*vacua*. This becomes clear in his discussion of the phenomena of rarefaction and condensation. On the level of elements, Scaliger embraces an Aristotelian conception of rarity and density accord-

21. [M]ovetur a forma propria interna . . . , videlicet secundaria, nempe ne vacuum detur. Non solum enim appetunt suum, UBI, elementa: sed etiam gaudent esse extra ipsum, ne graviore universi iactura spatium illud a teterrimo hoste occupetur. Nihil profecto hostile magis enti, quam non ens. Vacuum autem non ens."

22. "In Natura vacuum dari necesse est. Nempe si non daretur, aut non esset motus, aut subiret corpus in corpus."

ing to which rarity and density are contrary qualities that, at different times, can be possessed by the same portion of matter.²³ His view that through rarefaction a natural *minimum* of a given element can be transformed into particles of another element is formulated within the framework of the conception of natural minima as a lower limit of matter beyond which a given form cannot be maintained (EE, fol. 28v; EE, fol. 33v). Trivially, interstitial voids do not have a place in such a view of rarefaction and condensation of elemental particles.

On the level of composite bodies—i.e., bodies consisting of more than one elemental particle—there is a strongly corpuscularian strand in Scaliger's conception of rarity and density. On this level, the question of the existence of interstitial voids is not trivial. Scaliger holds that a body is rare if between its parts there are parts of another, less solid kind, like air or water in a sponge (EE, fol. 112r; see also EE, fol. 154r). For example, he explains the phenomenon of resonance in metals by suggesting that metals are rare because they contain particles of air (EE, fol. 28r). He is also clear about the view that the particles of a different element contained in a given body can be *minima* of a given element or close to the size of such *minima* (EE, fol. 33v). In this sense, natural *minima* provide a corpuscularian explanation for the rarity of bodies above the size of elemental particles. However, the existence of interstitial voids does not figure in Scaliger's account of the rarity and density of such bodies. On the contrary, Scaliger writes: “[N]either thinness nor thickness is the cause of density, but uniformity . . . For when nothing intercedes between them, the parts of a body necessarily must be suitable to each other. For there is no vacuum. In the case of parts of various forms, however, the mutual cohesion comes about through humidity . . .” (EE, fol. 356r).²⁴ Hence, while in dense bodies particles of the same kind are packed in a way such that neither particles of another kind nor empty spaces occur between them, less rare bodies admit particles of another, but no empty spaces, between their parts.

Does coacervate vacuum—vacuum that comes in larger chunks—fare better than interstitial vacuum? Scaliger rejects the Aristotelian conception according to which place is the surface of the external surrounding bodies (EE, fol. 7r).²⁵ He holds that the vacuum is, in some sense, a being,

23. See Aristotle, *Phys.* IV, 9, 217a20–b19; *De gen. et corr.* I, 5, 321a10–29.

24. “[N]eque tenuitas, neque crassitia, causa densitatis, sed uniformitas . . . Nam inter quae nihil aliud intercedit, eius partes inter se aptas esse necesse est. Non enim datur vacuum. In difformium vero partibus, mutua cohaerentia fit per humidum . . .” On cohesion by means of “interstitial humidity” (*humidum interpositum*), see also EE, fol. 22v–23r.

25. Aristotle, *Phys.* IV, 4, 212a21. Cardano accepts Aristotle's notion of place; see Cardano [1550] 1663, 3: 367. On Cardano's rejection of the vacuum, see Schmitt 1967a.

but makes it clear that he does not want to have this claim understood “in the way of the Ancients”: “For they supposed a vacuum without body. But we maintain a vacuum in which there is a body. Vacuum and place are the same: and they do not differ except with respect to the name” (EE, fol. 6v). Such a conception of vacuum is not entirely unprecedented in early modern thought. In his *Examen vanitatis* (1520), Gianfrancesco Pico uses Philoponus’ criticism of Aristotle’s theory of place and space to formulate that theory of place according to which place is characterized primarily by its quality of receptivity, i.e., as a container. Pico also follows Philoponus in identifying place with the vacuum (Pico [1520] 1578, pp. 1187–1188; Schmitt 1967, pp. 138–159). Moreover, Charles B. Schmitt ascribes to Philoponus and Pico the view that place is not different from but also separable from the things it contains (Schmitt 1967, p. 142). Note, however, that Pico also emphasizes Philoponus’ view that “space is never devoid of bodies, just as we say that matter differs from form but is never devoid of form (Pico [1520] 1573, p. 1189). Andrew Pyle’s verdict about Philoponus’s move is unflattering: Given the view that vacuum is of its own nature independent of matter, claiming that vacuum cannot exist without being occupied by body “is perverse” (Pyle 1995, p. 76).

A similar tension can be observed in Scaliger’s account of vacuum as place. He maintains that a portion of void without body is a non-being. Consider the following passage concerning the relation between God and the world:

[The world] is constituted by parts that are contrary to each other and develop into each other by means of mutual corruption. Hence, the eternity of the world [lies] in succession, its unity in continuation . . . Hence the world must have two kinds of ideas of forms. One is particular, relating each to its own species, to generation, motion, preservation in those things by means of which it exists; which does not have unity. The other is universal, for the sake of the conservation of unity. This is why [God] neither from the beginning produced a vacuum, because it is a non-being; nor can he allow it to exist later. Therefore, in order that the vacuum does not exist he brought it about that the particular form, e.g., of fire, by means of which fire ascends, obeys the universal form: since the world is one . . . (EE, fol. 6r)²⁶

The argument appears to run as follows: Since the created world must be prefigured in the ideas in the divine mind, the forms of individual objects

26. “Ex contrariis enim ac mutua corruptione inter se grassantibus partibus [mundus] constitutus est. Eius igitur aeternitas in successione: unitas in continuatione . . . Duas

in the world, as well as the world as a totality, must be represented in the divine mind. As far as individual objects go, there can exist only ideas of (possible) beings in the divine mind, but not of non-beings such as portions of vacuum devoid of body. As far as the world as a totality goes, the idea in the divine mind can only be one of a totality without such vacua. Hence, the only conceivable unity of the world is one of continuation. However, Scaliger's view of the unity of the world does not entail the claim that matter forms a continuum. Rather, a little earlier in the same section he holds that the surfaces of neighboring particles are contiguous, but not in all cases continuous, since otherwise generation would be impossible (EE, fol. 5v).

Since a vacuum without body is a non-being, Scaliger holds that there is an essential connection between vacuum and the bodies that occupy it. He writes that place "is in some way a being, and in some way a non-being. It is a non-being, because a being is contained there; and it is a being, because it is something that belongs to something else, namely, a cavity within a body" (EE, fol. 7r).²⁷ It is quite possible that Scaliger would have been better off if he had gone all the way through to a theory of absolute space. However, he did not go the entire way. Although he embraces a theory of container space, he also thinks that portions of space are not independent of being occupied by some portion of matter or other. At any given point in time, any portion of container space must be occupied by some portion of matter since the extension of any given place is a property of the body occupying it at this moment. Place is an immaterial dimension and hence different from bodies, But it is a dimension of a body and hence cannot exist devoid of body. In this sense, Scaliger's *vacua* are dependent entities: they can be distinguished from the bodies that occupy them, but they could not exist without the bodies that occupy them.

Hence, while Fracastoro maintains that bodies depend for their persistence on place, Scaliger holds that places depend for the existence on bodies. On the one hand, Scaliger's critique of Fracastoro's view that the persistence of bodies is brought about by places leads to a profoundly different view of the relation between body and place. On the other hand,

igitur Ideas formarum habere Mundum oportuit. Una est particularis, sua cuiusque speciei, ad generationem, motum, prorogationem in iis, per quae est, non unus. Alia est universalis ad conservationem unitatis. Iccirco [Deus] neque a principio fecit vacuum, quia est non ens: neque postea dari passus est. Ergo ne daretur, effecit, ut forma particularis, puta ignis, qua ascendit, obediret universali formae: qua unus est Mundus . . ."

27. "Est autem quodammodo ens, & quodammodo non ens. Est enim non ens, quia ens continetur ibi: & est ens, quia est aliquid alicuius: nempe cavum intra corpus."

however, like Fracastoro he defends a position according to which space is not only contingently but necessarily a plenum. The view that the world necessarily is a plenum explains why both Fracastoro's and Scaliger's corpuscles move in pores so as to avoid a vacuum without body—a vacuum without body, for Fracastoro and Scaliger alike, would be a non-being. At the same time, holding that the world necessarily is a plenum implies that, necessarily, there are no micro-vacua without body. As we will see presently, the view that, necessarily, there are no micro-vacua gives important clues as to how corpuscularian and non-corpuscularian strands are connected in Fracastoro's and Scaliger's accounts of mixture.

4. Corpuscles and Mixture

Fracastoro and Scaliger adopt some elements of one of the classical solutions to the problem of mixture, going back to the Persian philosopher Ibn Sina (Avicenna), according to which the substantial forms of the elements remain in mixture while their qualities are weakened. Hence, Fracastoro and Scaliger reject two other classical solutions, the one going back to the Arabic philosopher Ibn Rushd (Averroes), according to which both the substantial forms and the qualities of the elements are weakened, and the one going back to Thomas Aquinas, according to which the substantial forms are destroyed and only qualities enter into the mixture.²⁸ In part, however, Fracastoro and Scaliger opt for a minority opinion. As John Murdoch has pointed out, medieval and most Renaissance authors regarded the areas of the theory of natural *minima* and the theory of mixture as independent areas of inquiry (Murdoch 2001, p. 130). By contrast, Fracastoro and Scaliger combine the theory of mixture with minimalism. Some North-Italian background may be helpful for understanding the peculiarity of this move.

What all three classical solutions to the problem of mixture just mentioned have in common is that they try to explicate Aristotle's enigmatic statement that, while the elements undergo a change and union in genuine mixture, the "dynamis" of elements is preserved (*De gen. et corr.* I, 10, 327a30ff). Hence, all three classical solutions to the problem of mixture defend the view that, in some sense, there is a genuine unity arises in mixture. However, minimalism is a potential threat to this consensus in the different versions of Aristotelian mixture theory. In his *On Elements* (1505),²⁹ the Bologna-based Averroist Alessandro Achillini (1463–1512) mentions

28. For an overview of the classical solutions to the theory of mixture, see Maier 1952, pp. 22–35.

29. On this work and its place in Achillini's intellectual biography, see Nardi 1954, pp. 78–85.

the following objection: “The *minima* of elements are distinct with respect to their position: for they do not penetrate each other . . . and they preserve their substantial and accidental being integrally” (Achillini [1505] 1545, fol. 116r).³⁰ The objection seems to be that as soon as one reaches the level of minimal parts of elements, these are preserved with respect to their substance and accidents. Hence, there is no clear sense in which a union of minimal parts could be produced. Since minimism in this way can be used to challenge an Aristotelian account of mixture, Achillini subsequently holds that the division of components of a mixed body has only to go far enough to make a change of the substantial forms and qualities of the components possible (ibid., fol. 116v).

Interestingly, however, his Paduan colleague Agostino Nifo, in a work published in the same year as Achillini’s *On Elements*, suggests a minimalist version of an Averroist theory of mixture:³¹

It has to be said that the elements come together at a common place by means of this celestial and divine power; that they also act on each other and suffer from each other by means of this power, and that they come together for the purposes of mixture as agents; and as soon as they are refracted, and, once they are refracted and conjoined by means of minima, matter and quantity form a continuum; and in this moment the form of the mixture is introduced by the celestial power . . . (Nifo 1505, fol. 5r)³²

For the present purposes it is not necessary to go into the intricacies of the mixture theories of North Italian Averroism. It suffices to note that the question of whether or not minimism should or should not be connected with the theory of mixture was a clearly defined and controversial issue by the time that Fracastoro and Scaliger wrote about mixture. Both Fracastoro and Scaliger took up the connection between minimism and mixture without, however, embracing an Averroist theory of the weakening of forms. Nevertheless, they use the idea that in mixture a continuum arises to explicate the unity of Aristotelian mixtures. Earlier I mentioned that Fracastoro held that in genuine cases of mixture *minima naturalia* fuse into continuum. He describes mixture as follows:

30. “[M]inima elementorum sunt positione distincta: non enim se penetrant, & . . . suam esse & substantiale & accidentale integram servant.”

31. For an overview of Nifo’s metaphysics of nature and its historical setting, see Mahoney 2000.

32. “[D]icendum elementa virtute hac celesti, et divina ad locum communem venire: virtute hac etiam agere et pati inter se, et sic ad mixtionem concurrunt ut agentia; et tam diu, quam diu franguntur, quibus fractis et per minima copulatis continuant materia et quantitas: et in eadem instanti virtute celesti forma inducitur mixti . . .”

Some liquids are well mixable with each other, others are not. Those are well mixable, which have one and the same substance, or which at least can be divided into *minima*. Water with water, and wine with wine are mixed optimally, because they are one, and go together into one continuum. Wine . . . is mixed well . . . with water, because even if it is not one with water and does not make a continuum, but only a contiguity, which differs with respect to its form and limits, nevertheless it can be divided easily into minimal particles if it is brought together with water. [Water and wine] are divided into minimal parts, because it is the nature both of elements and of liquids, that their parts take the best possible position. The best possible position, however, is the one in which the parts are away from each other as little as possible; if this is given, they become continuous with each other; if it is not given because the forms are not one, the parts want and strive nevertheless to be as close and as much united as they can be. But the closest position is the one in which they are away from each other only through the interposition of one *minimum*, which cannot be divided further. (SAR, pp. 99–100)³³

In this passage, Fracastoro combines non-corpuscularian and corpuscularian intuitions. Moreover, both intuitions are connected with the role of minimal parts in mixture. The non-corpuscularian side of his account of mixture has it that natural minima, in some cases, form a continuum. This happens, according to his view, in cases of homogenous substances as well as in cases of liquids such as water and wine. The corpuscularian side supplements this view of mixture and analyses other kinds of mixture as involving minimal parts that come as close to each other as possible? Does Fracastoro introduce in these cases a *vacuum interstitiale* under another name? It does not seem so. To be sure, the concept of minimal parts approaching each other as closely as possible without forming a continuum

33. "Liquidorum enim alia bene miscibilia invicem sunt, alia non bene. Bene quidem quae aut unam & eandem substantiam habent, aut saltem dividi mutuo ad minima possunt. Aqua igitur cum aqua, & vinum cum vino optime commiscentur, quoniam unum sunt, & unum continuum conflant. Vinum autem cum aqua bene & ipsum miscetur, quoniam si forte unum non est cum aqua, nec continuum facit, sed contiguum solum, quod forma differat & terminis, dividi tamen cum illa faciliter possit in particulas minimas. Dividuntur autem ad minimas partes, quoniam natura tum elementorum tum liquidorum est, ut eorum partes meliorem situm habeant quo possibile sit. Melior autem situs est ille, quo partes minus distant inter se quo possunt: & si quidem datur, continuae fiunt inter se, si vero non datur, quia formae non unum sint, propinquiores tamen & unitae magis quo possunt partes esse volunt & quaerunt. Propinquissimus autem situs est, quo distant solum per interpositionem unius minimi, quod ultra dividi non potest."

could be expressed in the framework of a theory of interstitial voids. In such a framework, what would be in between two minimal parts of a given substance would be a micro-vacuum. This is, however, not what Fracastoro says. What he suggests is that in cases of *minima* approaching each other as closely as possible without fusing with each other what comes in between these *minima* is a *minimum* of another natural minimum. Hence, his view involves micro-spaces between the natural *minima* of substances that mix without forming a continuum. But there is no clear indication that he thinks of these micro-spaces as micro-vacua.

Although Fracastoro's account of mixture does not coincide with Scaliger's, it contains three conceptions that are found in Scaliger's as well:³⁴ the view that the notion of a natural *minimum* is relevant for an adequate account of mixture; the view that in some cases *minima* behave in a corpuscularian way in mixture; and the view that some cases of mixture involve the fusion of minimal particles into a continuum. Note also that the way in which *minima* of a given element are distant from each other is described as involving the interposition of other *minima*, but not of a vacuum. Fracastoro distinguishes two cases in which particles can fuse into a continuum: the first case is when particles have the same form, e.g., different particles of water; the second case is when particles have been reduced to natural *minima*. Scaliger entirely dissociates the issue of mixture from the issue of sameness of form and focuses only on the role of the reduction of particles to *minima*. As he points out, experiment shows that there are mixtures of heterogeneous substances which turn out to be inseparable from each other (EE, fol. 148v). His solution is ingenious: On the one hand, he retains Fracastoro's view that in mixture minimal parts form a continuum. On the other hand, since in the case of heterogeneous substances the forms of the minimal parts are different from each other, he suggests that in the most basic cases (such as the mixture of water and wine) the constituents of the mixture retain their numerical identity since they retain their form, even if they give up their boundaries (EE, fol. 144r-v). Evidently, Scaliger's *minima*, like Fracastoro's, do not behave in a fully corpuscularian way in such contexts.

It should be clear by now that the above-mentioned passage about the view of the "wise philosophers" (*Sapientes*) concerning the vacuum should

34. Confusingly, there is an earlier discussion of mixture in the *Exoteric Exercises* (chapter 16), which is incompatible with the later discussion (chapter 101). In his first take on mixture, Scaliger defends the view that in mixture there is only a single substantial form of the composite. However, he seems to have been dissatisfied with his first discussion, and presents his second discussion—as the chapter heading tells us—as a "more subtle" take (*repetitio subtilior*) on mixture. For the purposes of the present discussion, I will focus on Scaliger's second take on mixture.

be understood not to mean that the *Sapientes* knew that it is necessary to assume the existence of a vacuum. Rather, what Scaliger wants to say is that the *Sapientes* knew that if one assumes that natural minima have immutable geometrical shapes, it is necessary to assume the existence of interstitial *vacua*. But since Scaliger rejects the assumption of interstitial *vacua*, the passage can be best understood as expressing a *reductio ad absurdum*: Since assuming that natural *minima* have rigid and immutable geometrical shapes leads to unacceptable consequences (the assumption of the existence of interstitial *vacua*), the assumption that *minima* cannot change their shape should be rejected. In this way, Scaliger's views on the vacuum play a crucial role for his views on the nature of natural *minima*: rejecting interstitial *vacua* excludes understanding natural *minima* as Lucretian atoms. Rather, natural *minima* are entities that combine corpuscularian and non-corpuscularian features: they retain their form and boundaries when they move in pores of other bodies such as in the case of water rising in lime, but they retain their form and lose their boundaries when they enter into genuine mixtures.

5. Conclusion

The foregoing considerations were not aimed at establishing that Scaliger's views on corpuscles and the vacuum coincide with Fracastoro's in all respects. I have pointed out that there are marked differences between Fracastoro's and Scaliger's explanations of phenomena such as water rising in lime. On the level of the motion of corpuscles in pores Fracastoro invokes the agency of a form of a composite substance while Scaliger in this respect tries to do without composite substances and their forms. Also, Scaliger's conception of vacuum as place differs profoundly from Fracastoro's conception of place as what guarantees the preservation of bodies. Nevertheless, various sections of the *Exoteric Exercises* indicate that Scaliger was closely acquainted with *On the Sympathy and Antipathy of Things*.³⁵ I have argued that Fracastoro brings together aspects of a corpuscularian matter theory with a continuity conception of mixture in a way that helps us to understand how the different strands of Scaliger's matter theory hang together. Both Fracastoro and Scaliger take the minor-

35. In addition to the references to Fracastoro already mentioned, see EE, fol. 28v–29r and 424v on Fracastoro's views on contrary qualities and contrary forms; EE, fol. 60r on his views on serpents; EE, fol. 290v and 455v on his naturalization of some occult qualities; EE, fol. 417r on his agnosticism regarding the motion of the heart; EE, fol. 455r on his account of sympathies between the parts of the human body; EE, fol. 358v on his account of the sense of touch; EE, fol. 371r–v on his account of tastes; EE, fol. 375v–377v, 427v, and 429r–430r on his accounts of pleasure, sadness, and love; and EE 431v–432r on his accounts of tickle and laughter.

ity view according to which minimalism is essentially connected with mixture theory. Both Fracastoro and Scaliger hold that space is necessarily a plenum, thus excluding a conception of natural *minima* as Lucretian atoms with immutable geometrical shapes. Both Fracastoro's and Scaliger's natural *minima* have some corpuscularian characteristics: they do not change their natures while they are included in the pores of larger bodies, and they retain their numerical identity in mixture. But Fracastoro's and Scaliger's natural *minima* also have some non-corpuscularian characteristics: because they do not have rigid and immutable geometrical shapes, they are capable of fusing with other natural *minima* into a continuum.

References

- Achillini, Alessandro. [1505] 1545. *De elementis*. Fol. 90v–149r in Alessandro Achillini, *Opera omnia*, Venice: Hieronymus Scotus.
- Billanovich, Miriam. 1968. "Benedetto Bordone e Giulio Cesare Scaligero." *Italia medievale e umanistica* 11: 197–256.
- Cardano, Girolamo. [1550] 1663. *De subtilitate*. Pp. 352–672 in Girolamo Cardano, *Opera omnia*. Vol. 3. Lyon: Huguetan & Ravaud.
- Cassirer, Ernst. 1911. *Das Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit*. Vol. 1. 2nd ed. Berlin: Bruno Cassirer.
- Clericuzio, Antonio. 2000. *Elements, Principles and Corpuscles. A Study of Atomism and Chemistry in the Seventeenth Century*. Dordrecht and Boston: Kluwer.
- Emerton, Norma E. 1984. *The Scientific Reinterpretation of Form*. Ithaca and London: Cornell University Press.
- Fracastoro, Girolamo (1546) 1550. *Liber I, De sympathia & antipathia rerum. De contagione & contagionibus, & eorum curatione, libri tres*. Lyon: Giulelmus Gazelus.
- Grant, Edward. 1981. *Much Ado About Nothing. Theories of space and vacuum from the Middle Ages to the Scientific Revolution*. Cambridge: Cambridge University Press.
- Hirai, Hiro. 2005. *Le concept de semence dans les théories de la matière à la renaissance. De Marsile Ficin à Pierre Gassendi*. Turnhout: Brepols.
- Hoffmann, Thomas Soeren. 2003. "Dimensionen des Erkenntnisproblems bei Girolamo Fracastoro. Ein Beitrag zur Fortentwicklung der aristotelischen Gnoseologie in der italienischen Renaissance." *Vivarium* 41: 146–174.
- Leijenhorst, Cees. 1996. "Hobbes and Fracastoro." *Hobbes Studies* 9: 98–128.
- Lüthy, Christoph. 2000. "The Fourfold Democritus on the Stage of Early Modern Science", *Isis* 91: 443–479.

- Lüthy, Christoph. 2001. "An Aristotelian Watchdog as Avant-Garde Physicist: Julius Caesar Scaliger." *The Monist* 84: 542–561.
- Maclean, Ian. 1983. "Montaigne, Cardano: The Reading of Subtlety/The Subtlety of Reading," *French Studies* 37: 143–156.
- Maclean, Ian. 1984. "The interpretation of natural signs: Cardano's *De subtilitate* versus Scaliger's *Exercitationes*." Pp. 231–252 in *Occult and Scientific Mentalities in the Renaissance*. Edited by Brian Vickers. Cambridge: Cambridge University Press.
- Mahoney, Edward P. 2000. "Philosophy and Science in Nicoletto Vernia and Agostino Nifo." Pp. 135–203 in Edward P. Mahoney. *Two Aristotelians of the Italian Renaissance. Nicoletto Vernia and Agostino Nifo*. Aldershot: Ashgate.
- Maier, Anneliese. 1949. *Die Vorläufer Galileis im 14. Jahrhundert. Studien zur Naturphilosophie der Spätscholastik*. Rome: Edizioni di storia e letteratura.
- Maier, Anneliese. 1952. *An der Grenze von Scholastik und Naturwissenschaft*. 2nd edition. Rome: Edizioni di storia e letteratura.
- Meinel, Christoph. 1988. "Early Seventeenth-Century Atomism. Theory, Epistemology, and the Insufficiency of Experiment." *Isis* 79: 68–103.
- Murdoch, John E. 2001. "The Medieval and Renaissance Tradition of *Minima Naturalia*." Pp. 101–131 in *Medieval and Early Modern Corpuscularian Matter Theories*. Edited by Christoph Lüthy, John E. Murdoch, and William Newman. Leiden, Boston, and Koeln: Brill.
- Nardi, Bruno. 1954. "Appunti sull'averroista Bolognese Alessandro Achilini." *Giornale critico della filosofia italiana*, Series 3, vol. 33: 67–108.
- Nifo, Agostino. 1505. *Averroys de mixtione defensio*. Modena: Haeredes Octaviani Scoti.
- Nutton, Vivian. 1983. "The Seeds of Disease: An Explanation of Contagion and Infection from the Greeks to the Renaissance." *Medical History* 27: 1–34.
- Nutton, Vivian. 1990. "The Reception of Fracastoro's Theory of Contagion. The Seed That Fell among Thorns?" *Osiris*, Second Series, 6: 196–234.
- Peruzzi, Enrico. 1980. "Antioccultismo e filosofia naturale nel *De sympathia et antipathia rerum* di Gerolamo Fracastoro." *Atti e Memorie dell'Accademia Toscana di Scienze e Lettere "La Colombaria"*, N.S., 31: 41–131.
- Pico della Mirandola, Gianfrancesco. [1520] 1573. *Examen vanitatis doctrinae Gentium, & veritatis Christianae disciplinae*. Pp. 710–1264 in Giovanni Pico della Mirandola and Gianfrancesco Pico della Mirandola. *Opera Omnia*. Vol. 2. Basel: Henricpetri.
- Principe, Lawrence M. 1998. "Diversity in Alchemy. The Case of Gaston

- “Claveus” DuClo, a Scholastic Mercurialist Chrysopoeian.” Pp. 181–200 in *Reading the Book of Nature. The Other Side of the Scientific Revolution*. Edited by Allen G. Debus and Michael T. Walton. Kirksville, Missouri: Sixteenth Century Journal Publishers.
- Pyle, Andrew. 1995. *Atomism and its Critics. Problem Areas associated with the Development of the Atomic Theory of Matter from Democritus to Newton*. Bristol: Thoemmes Press.
- Raimondi, Francesco Paolo. 2003. “Vanini dal plagio alle fonti: Giulio Cesare Scaligero (1484–1558).” *Bruniana & Campanelliana* 9: 357–376.
- Scaliger, Julius Caesar. 1557. *Exotericarum exercitationum liber XV. De subtilitate, ad Hieronymum Cardanum*. Paris: Vascovani.
- Scaliger, Julius Caesar. 1584. *Aristotelis liber, qui decimus Historiarum inscribitur*. Lyons: Antonius de Harsy.
- Schmitt, Charles B. 1967. *Gianfrancesco Pico della Mirandola (1469–1533) and his Critique of Aristotle*. The Hague: Martinus Nijhoff.
- Schmitt, Charles B. 1967a. “Experimental Evidence for and against a Void: The Sixteenth-Century Arguments.” *Isis* 58: 352–366.
- Spruit, Leen. 1995. *Species intelligibilis. From Perception to Knowledge*. Vol. 2: Renaissance Controversies, Later Scholasticism, and the Elimination of the Intelligible Species in Modern Philosophy, Leiden, New York, and Koeln: E. J. Brill.
- Subow, W. 1960. “Zur Geschichte des Kampfes zwischen dem Atomismus und dem Aristotelismus in 17. Jahrhundert (Minima naturalia und Mixtio).” Pp. 161–191 in *Sowjetische Beiträge zur Geschichte der Naturwissenschaft*. Edited by Gerhard Harig. Berlin: VEB Deutscher Verlag der Wissenschaften.