



Article

Daniel Sennert's Corpuscularian Reforms to Natural Philosophy

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Abstract: Daniel Sennert (1572–1637), professor of medicine and natural philosophy in Wittenberg, defended a highly unusual philosophical system. This paper examines Sennert's vision of natural philosophy within the context of the rapidly changing environment of the seventeenth century and relates his philosophical innovations to his methodology. The main result is that Sennert's postulation of corpuscles with substantial forms, though it takes place within the framework of Aristotelian natural philosophy, directly influences his philosophical view of qualities.

Keywords: natural philosophy; seventeenth century; atomism; corpuscles; Aristotelianism

1. Introduction

At the time of his death in July 1637, Daniel Sennert had been serving as a physician in and around Wittenberg for more than 35 years. Like so many of his contemporaries, he died of the plague, to which he had often been exposed in his work. While he was also a practicing physician in his chosen home of Wittenberg (he had been born in Wrocław), to the rest of Europe he was better known as a scholar and professor. At the university of Wittenberg, he taught the higher-level courses in medicine, but also more general classes in natural philosophy. Many of his published works reflect his teaching duties in so far as each of them contains a systematic account of a single discipline, starting from the most general principles. The *Institutiones medicinae*, for example, do this for theoretical medicine. Sennert also wrote works on controversial topics directed at a more critical and international audience, of which the late *Hypomnemata physica* (*Physical Memories*) is the clearest example. His work earned him lasting renown in both medicine and natural philosophy, as evidenced by the fact that his collected works were printed four times between 1641 and 1676 (almost 40 years after his death), in Paris, Venice, and Lyon. The works mentioned can be found in volumes one and two of (Sennert 1676). Sennert was also influential on one of the most famous philosophers and scientists of the late seventeenth century, Robert Boyle, and his conception of ensouled atoms was at least an indirect inspiration for Gottfried Wilhelm Leibniz. On the connection to Boyle, see (Clericuzio 2000, p. 77; Newman 1996; 2006, pp. 157–75). On Sennert and Leibniz, see (Arthur 2018, p. 113); an explicit reference to Sennert by Leibniz can be found in a letter to Thomasius, in (Leibniz 1875, vol. I, p. 15).

The biography printed in the frontmatter of Sennert's collected works gives an impression of his daily occupations and the circumstances of his passing. In terms of academic achievements, the text notes especially that Sennert was awarded a degree in medicine in 1601 and that he was the first to introduce the discipline of *chymia* to Wittenberg. Otherwise, his activities as a physician are emphasized above his duties as a lecturer and researcher: The biographer reports that between 1602 and 1637, Wittenberg and surroundings had been ravaged by the plague at least seven times. Sennert's death at the age of 55 on July 21 was quick and unexpected, a fact that only reinforces to what great danger he had been exposing himself in the intervening years, during which he never moved a foot from the observance of his duties. The Latin reads as follows: “[. . .] pro Licentia disputavit, die 3. Julii, anno 1601 & anno eodem 10. Septembris cum iis gradu Doctoris a Collegio Medico ibidem ornatus



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fuit. [...] Chymiam primus in Academiam Wittenbergensem introduxit [...] Quantum periculi, peste septies, imo saepius Wittebergae & in vicinis locis, ab anno 1602, usque ad diem mortis, satis vehementer grassante, necnon aliis serpentibus crebro contagiosis morbis sustinuerit, obitus ejus insperatus simul atque celer denique testatur. Quibus tamen temporibus ipse nunquam pedem loco moverit: utut sui juris undiquaque, minimeque obstrictus fuit. [...] At vero noster hic diem suum obiit, & in Christo placide acquievit die 21. Juli, anno 1637 quo ipso tempore etiam suis contagium vehementer grassabatur, & ipsum mors haec peremit, rebusque humanis exemit, aetatis suae 55" (Sennert 1676, pp. 10*b–11*a). For a more detailed biography, see (Lüthy and Newman 2000, pp. 262–66).

In this essay, I am mostly interested in one among Sennert's interconnected personas, that of the natural philosopher. I believe that the flexibility and staying power of that early modern intellectual discipline are well demonstrated by the reforms Sennert undertakes within it. I hope to show two things: The first is that though Sennert was a genuinely innovative thinker, scientist, and natural philosopher, his innovations are built upon a deep appreciation and knowledge of the Aristotelian tradition. The second is that Sennert played a part in reforming both the methodology and the content of natural philosophy, and that these two aspects are intimately connected. Methodologically, Sennert's most important contribution lies in furthering the integration of empirical evidence from chemistry and biology into the highly theoretical discipline of natural philosophy. As we shall see in more detail below, this integration of the empirical into the theoretical is made possible by a very unusual conjunction of claims in Sennert's philosophy, in particular in his matter theory. In short, it is a combination of the Aristotelian theory of the substantial form with the ideas of atomism, producing atoms with substantial forms. What is more, even though Sennert is challenging fundamental notions of Aristotelian philosophy, the problems he is engaged in solving had long been discussed by Aristotelian scholastics.

I begin from the methodological side, by describing how Sennert fits into the landscape of natural philosophy in his time and place. As will become apparent, he was a typical natural philosopher in many ways, though of a certain type: An Aristotelian scholastic natural philosopher and professor of medicine, working in a Lutheran context. I then move on to explain the various non-Aristotelian visions of natural philosophy that were current in early seventeenth-century Europe and that influenced Sennert. This leads into a discussion of one of the main points of opposition between Aristotelians and atomists, namely the constitution of the so-called mixed bodies from the four elements. With the benefit of all this context, I am then able to explain why Sennert's matter theory is at once very innovative and rooted in Aristotelian tradition.

2. Sennert's Natural Philosophy in Context

The division of his collected works may give an indication of Sennert's interests: Of the six tomes that comprise the *Opera omnia* published in Lyon in 1676, only the first one deals with natural philosophy in the narrow sense. Volume two contains two works on theoretical medicine, while the entirety of volumes three to six is taken up by treatises on practical medicine (the monumental *Medicina practica*, together with shorter works on particular diseases like the plague and arthritis). As this division suggests, the topics treated in the first volume (which on its own is 300 folio-sized pages thick) are both introductory and fundamental: They give Sennert's audience, i.e., the medical students of Wittenberg, a framework within which to situate the medical knowledge that was the objective of their studies. At the same time, Sennert also directs these more general works in natural philosophy at his international audience. This double character is particularly evident in the *Epitome naturalis scientiae*, which began its life as a series of student disputations supervised by Sennert in the academic year 1599/1600: This "proto-*Epitome*" (Newman 2006, p. 87) was then revised multiple times and extended into a full-length course in natural philosophy, dedicated to principal physician to the king of Bohemia, Severino Schato of Schattenthal. In the preface to the reader, Sennert describes the book as "that juvenile work"—"laborem hunc juvenilem", a set of student exercises held "almost twenty

years ago"—“ante annos quasi viginti”, which he has now edited and made available to the public after correcting some of its errors (Sennert 1618, pp. 10*–11*). In fact, the revisions between the first two editions are substantial, since the edition of 1618 introduces the textbook structure that subsequent editions follow. Two further editions of the *Epitome* were published during Sennert’s lifetime: One in 1624 and one in 1633. In both of these, the dedication and preface from 1618, as well as the concluding paragraphs at the very end of the work, were reprinted without comment, but Sennert did make some revisions and additions to the main text with each edition. The most complete overview of Sennert’s writings and their chronology is given by (Lüthy and Newman 2000; cf. also Michael 2001, p. 339). A comprehensive comparison of all the changes between the various editions of the *Epitome* does not yet exist.

In the editions from 1618 onwards, the first chapters of the *Epitome* examine the nature of philosophy in general and of natural philosophy in particular. This is followed by sections on the philosophical concepts that are needed to grasp the natural world: The Aristotelian principles of form and matter, quality and quantity, space, time, and motion. The subsequent books and chapters after these preliminaries consist in a systematic account of all natural bodies. The text is structured on the basis of two fundamental distinctions, namely those between simple and composite bodies, on the one hand, and between living and non-living things, on the other. Simple bodies are either the four elements or the celestial bodies, so these two categories are treated first. All non-celestial bodies are composed of the four elements, so the treatment of these composites is further divided into sections on non-living and on living things. The non-living bodies include *meteora*, i.e., phenomena taking place between the surface of the earth and the moon, and minerals, gems, and metals below the earth. Having treated all of these bodies, Sennert then spends the second half of the *Epitome* discussing animated things, that is, plants, animals, and humans. He moves through these three realms in ascending order from the simplest organisms (mosses and mushrooms, in his opinion) to the most complex ones (humans). In between, he has occasion to discuss such details as the distinction between cabbages and sorrel, the formation of butterflies, and the existence of basilisks (Sennert 1676, vol. I, pp. 3, 66, and 80). Since the three types of living things are distinguished by the kinds of souls they have, Sennert begins each section with an introduction on the specific soul in question: The section on plants is prefaced by a discussion of the vegetative soul, that on animals with one on the sensitive soul, and the section on humans begins with a short treatise on the rational soul. Overall, therefore, Sennert’s introduction to natural philosophy begins with a brief look at the very top of the Great Chain of Being, the celestial bodies, but then proceeds methodically from the bottom up, from the most basic and ignoble types of body to the human rational soul.

The vision of natural philosophy expressed in the structure of the *Epitome* is not unusual for the time and place in which it was written. In medieval and Renaissance Europe, the men who wrote about nature *ex professo* were scholastic Aristotelian natural philosophers, meaning that they worked in the context of the medieval university, used textbooks based on Aristotle’s writings to structure their teaching and research, and viewed their investigation into nature as a *scientia* producing universal necessary truths. Strictly speaking, the natural philosopher is only occupied with one half of a proper Aristotelian investigation of nature, namely the causal structure of the world. It is accompanied by natural history, which is tasked with establishing what things actually exist (Pliny the Elder being the most important reference for natural history).

In theory, the subject matter of natural philosophy encompasses absolutely everything and is designed to provide a complete map of the physical universe: everything that there is (or can be) has its place in the system and can be assigned a specific set of powers and properties that make its relations to other created things transparent. From a modern perspective, however, natural philosophy in its scholastic Aristotelian form provides a rather limited image of nature, despite its pretension to universal necessary knowledge. Firstly, its objects are almost exclusively located within relatively close proximity to human

experience, and the phenomena that natural philosophy is set up to explain are roughly identical to those that can be observed with the unaided senses. As a consequence, the celestial or superlunar realm (i.e., everything above the moon) was taken to be so perfect and regular that its associated science, astronomy, was seen as a branch of mathematics. The second way in which Aristotelian science is limited, as has often been noted, is that there is an anthropomorphic stamp on it: The distinction between the unchanging, perfect heavens and the changing realm below the moon is linked to a cosmology that puts humans at the literal center of the universe. Living beings and humans in particular are also the paradigmatic subject of scientific investigation for Aristotle. This last aspect is apparent from the fact that the teleological structure of human and animal behavior is part of the basic and most general scheme for understanding all of nature, since explaining a physical process according to the standards of Aristotelian natural philosophy includes giving a so-called final cause, i.e., an account of the aims for which that process occurs (Dear 2019, pp. 24–30).

This worldview was almost universally accepted in the medieval university, and it was still pervasive enough in 1632 for Galileo Galilei to spoof it in the person of Simplicius in his *Dialogo*. For example, this is how Simplicius introduces the natural motions upward and downward, ridiculously using unnecessary Latin phrases without actually explaining anything: “Now who is there so blind as not to see that earthy and watery parts, as heavy things, move naturally downward—that is to say toward the center of the universe, assigned by nature itself as the end and terminus of straight motion *deorsum*? Who does not likewise see fire and air move directly upward toward the arc of the moon’s orbit, as the natural end of motion *sursum*? This being so obviously seen, and it being certain that *eadem est ratio totius et partium*, why should he not call it a true and evident proposition that the natural motion of earth is straight motion *ad medium*, and that of fire, straight *a medio*?” (Galilei 1967, p. 32; 1890, vol. VII, p. 57).

When, how, why and with what this worldview was replaced are some of the most debated questions in the history of philosophy and science. One way to capture the long-term development of early modern thinking about nature is to view it as a shift in the professional personas involved. Under that perspective, it is a shift from the scholastic Aristotelian natural philosophy as practiced in the medieval universities to norms of education and research within which one can be a distinguished natural scientist without being a philosopher, and vice versa. Though there is still much overlap between these personas even in the eighteenth and early nineteenth century, eventually, Aristotelianism in particular and even natural philosophy in general fell from the status of unquestioned orthodoxy to that of relics. By about 1750, few philosophers and scientists of any note were either scholastics or Aristotelians or natural philosophers, at least not in the same sense. Aristotelianism as a scheme for education was kept for much longer in some places, for example at the *Academia Juliana* in Helmstedt.

In the interim period, however, some of the most important contributions to natural philosophy continued to be made by authors who retained part of the characteristics of medieval science, that is, they either still based themselves substantially on Aristotle’s writings, still worked in universities, or still followed a deductive model for natural philosophy undivorced from experimental science. Throughout the seventeenth century, and especially in its earlier decades, some of the most successful new approaches to nature let go of only one or two of the three ideas that seem so closely entwined in medieval science. In particular, the mounting critique of Aristotelianism did by no means always carry with it an attack on the discipline of natural philosophy itself. One notable example is provided by Descartes and his followers. Descartes himself, despite his opposition to Aristotelianism in many questions of philosophy and methodology, conceptualizes the aspiration of natural philosophy in a way with which Aristotle would not have disagreed: The ultimate aim is to give deductions of the causal structure of the natural world, endowed with metaphysical necessity. Not all Cartesians followed Descartes in this: When Christiaan Huygens and Jacques Rohault prepared their respective systems in the 1660s, for instance,

they chose to conceptualize the principles of physics, which Descartes had wanted to prove as necessarily true, as mere hypotheses. But others, like Pierre-Sylvain Régis, carried on the metaphysical ambition for natural philosophy (Dear 2019, pp. 151–58). One clear example of the “deductive” type of Cartesianism is (du Roure 1654; cf. Schmaltz 2018, p. 580). Cartesianism also illustrates another fact about philosophical innovation in the seventeenth century, namely that it did not always take place outside the university. Among other things, Cartesianism is a movement toward new standards of university education; for some time, there even existed such a thing as a Cartesian scholastic. See (Cellamare and Mantovani 2022) for a number of contributions on the interactions between Cartesian philosophy and teaching institutions. For the Dutch reception of Descartes, see (van Bunge 2001, chp. 2) and (Verbeek 1992). At the same time, the existing scholastic traditions continued to produce diverse and influential works, as evidenced by the current flourishing of studies of post-medieval scholasticism—see e.g., (Dvořák and Schmutz 2019).

In other words, the developments of the seventeenth century, while they certainly constituted a deep transformation of natural philosophy, were not its abolition. Especially in the earlier parts of that transformation, there was a dizzying amount of variety, a proliferation of competing, incompatible models for how natural philosophy should be conducted. Many of these new models were not based on Aristotle’s writings in the same way as it had been standard at the medieval university, though the influence of Aristotle’s writings on higher education of all kinds was still great. On an institutional level, some (but not all) of the most influential new models were formulated by writers outside the universities. On the whole, the development was a widening of the spectrum: Non-Aristotelian, non-scholastic natural philosophies were introduced, without replacing the previously existing ones.

3. Aristotelian and Paracelsian Matter Theory

What is Sennert’s place within the widening spectrum of natural philosophy at the beginning of the seventeenth century? In some respects, he would seem to be closer to the medieval scholastics than to Galileo. Firstly, he is a scholastic, simply in virtue of his position as a professor of medicine at a Lutheran university: The city of Wittenberg was a center of the Lutheran scholasticism introduced by Philipp Melancthon. Despite some changes in the organization of the universities, the textbooks and the curricula in the sixteenth century, many of the teaching methods, disciplinary boundaries and foundational texts remained the same as in previous centuries (Wisse et al. 2010; Omodeo and Wels 2019; see also Omodeo 2023). Furthermore, as we have seen, even a cursory look at the table of contents of Sennert’s *Epitome naturalis scientiae* shows that he is also an Aristotelian philosopher, with the basic metaphysical and methodological assumptions this entails. Mary Patricia Reif’s study of seventeenth-century scholasticism still provides a good overview of a reasonable selection of the most influential natural philosophy textbooks, among which she also counts Sennert’s *Epitome* (Reif 1969).

At the same time, however, Sennert also defends some opinions that are in conflict with those of both the historical Aristotle and the major currents of scholastic philosophy. If the structure, content, and style of the *Epitome* reflect Sennert at his most scholastic, this is much less so with the other two larger treatises contained in the first volume of the *Collected Works*, namely the *On the Consensus and Dissensus of the Chymists with the Aristotelians and the Galenists* (*De chymicorum cum Aristotelicis et cum Galenicis consensu ac dissensu*) and the previously mentioned *Physical Memories* (Sennert 1619, 1636). The former examines questions at the boundaries of natural philosophy, chymistry and medicine, while the latter is a collection of essays on controversial questions and first appeared only in 1636, one year before the author’s death. It is these two works that have found the most attention on the part of modern scholars, because in them Sennert explains and defends two of his most intriguing and unconventional positions. The first of these dominated his reception in the twentieth century: He defends the existence of atoms. This would seem to be at odds with his Aristotelianism since Aristotle himself was in opposition to the ancient atomists in

multiple ways. Studies in the last two decades have accomplished much to explain why from Sennert's perspective, including atoms in a broadly Aristotelian view of nature, is not only possible but also very useful. Since the fundamental work of Kurd Lasswitz, who introduced Sennert and a number of other early modern authors to modern scholarship at the end of the nineteenth century, one thing that has been clear is that the kind of atomism one finds in the early moderns is not a simple revival of the positions of the ancient atomists (Lasswitz [1890] 1984, vol. I, pp. 436–54). In addition to ever closer examinations of Sennert's works, progress on the path indicated by Lasswitz has been enabled by growing understanding of the intellectual currents that were united in early modern neo-atomism or corpuscularianism generally and in Sennert's context specifically. These currents naturally include developments within Aristotelian natural philosophy but also a wide variety of other influences. Important studies of Sennert in the context of the history of atomism are (Gregory 1966; Clericuzio 2000, pp. 9–33; Lüthy 2005). Emily Michael has shown that the central philosophical condition that enables Sennert to formulate his synthesis of atoms and substantial forms has antecedents in scholastic natural philosophy (Michael 1997, 2001). William Newman has contributed more than anyone to situate Sennert in the history of chemistry and alchemy (Lüthy and Newman 2000; Newman 2001, 2006, 2012). Newman was also the one to introduce the terms “chymical” and “chymistry” to refer to early modern chemistry and alchemy without distinction, since the actors generally do not draw one either (Newman and Principe 1998). For a confrontation of Sennert's matter theory with those of contemporary Paracelsians, as well as an appreciation of Sennert's impact on eighteenth-century chemistry, see (Klein 2014).

A number of scholars with an interest in the history of medicine have shown that there is a second question on which Sennert is both innovative and influential, namely that of the origin of life. What is more, recent research has shown that the two issues that are closest to Sennert's heart as a philosopher, corpuscular explanations and the living body, are connected: On the one hand, he leverages his moving corpuscles to solve difficult questions about the origin of animal and human souls; on the other, his account of the structure of the fundamental corpuscles is itself modeled on that of living beings. The influence between Sennert's corpuscularianism and his views on questions in the life sciences therefore runs in both directions. On Sennert's theory of life and the role of corpuscles therein, see especially (Hirai 2012) and (Blank 2011a) and, with a stronger emphasis on medical theory in the narrow sense, (Moreau 2018). (Arthur 2006) and (Blank 2011b) connect Sennert's theory of the living body with that of Leibniz. (Nejeschleba 2015) is a study of the views of Sennert and his teacher Joachim Jungius on the concept of sympathy, which has its origin in medical theories. For a combination of the medical perspective with a discussion of the possible confessional motivation, see (Stolberg 1993, 2003), and (Hirai 2021) for a discussion of the accusations of heresy leveled against Sennert by Johannes Freitag of Groningen.

Sennert's defense of atoms is closely linked to the way in which he integrated chemical theory and experimentation into his natural philosophy. The early modern science or art of alchemy was created in the intellectual environment of the Paracelsians. An essential feature of these theories is that they posit what they call the *tria prima* of Sulphur, Salt, and Mercury. According to the Paracelsians, it was these three substances, and not the four elements fire, air, water, and earth, that were the fundamental building blocks of the corporeal world. They used these blocks in descriptions of experiments and early laboratory equipment. The Paracelsian approach is an analytic one, in the sense that they aim to explain features and powers of bodies exclusively in virtue of their parts. Paracelsus' own term for this process is *spagyria*, division. This method would seem to be diametrically opposed to that of the Aristotelians, who tend to explain bodily properties “top-down” as springing from the substantial form of the whole body. In historical fact, however, the opposition was never as sharp as that since there is also a tradition of alchemy in scholastic circles. This tradition has its roots in the writings of the philosopher himself. Aristotle had been almost universally hostile to atomism, but there is one exception: In the fourth book of his *Meteorology*, he leans far more closely to corpuscular explanations. These remarks

and others by Aristotle allowed scholastics that were interested in the transformation of materials to discuss and endorse views that came close to atomism, while still claiming their allegiance to Aristotle. On the *Meteorology IV* tradition, see (Martin 2023, pp. 89–90). An influential text in this regard is the *Summa perfectionis*, an alchemical treatise that was ascribed to the semi-mythical Arab author Geber, but which was probably composed by the late thirteenth-century Franciscan Paul of Taranto (Newman 2006, p. 26). By the late sixteenth century, there were an increasing number of authors inside and outside the university who used small particles to explain the natural world and who relied on some combination of genuine Aristotelian sources, the traditions of pseudo-Geber and Paracelsus, and appeals to other schools of antiquity that had become increasingly accessible during the fifteenth and sixteenth centuries. Even when they appealed to the authority of Democritus and other ancient atomists, these early modern neo-atomists tended not to postulate atoms in the literal sense of absolutely indivisible smallest bodies. Rather, their particles or corpuscles were simply not actually divided in the normal course of nature, though they were divisible in principle.

Although a corpuscularian current existed within Aristotelian philosophy, (neo-)atomism was still perceived as a dangerous doctrine in many places. It was controversial enough to be officially condemned in 1624 in Paris, after a group around Étienne de Clave planned a public disputation of some atomist theses—for a summary of these events, see (Meinel 1988, p. 69). Conversely, many of the writers who called themselves atomists also were in conscious opposition to Aristotelianism. In 1621, for example, Sébastien Basson published a work in Geneva that was entitled *Twelve Books of Natural Philosophy, in which Aristotle's philosophy is refuted with solid reasons and the hidden wisdom of the ancients is restored* (Basson 1621). Basson tried his very best to burn all the bridges with Aristotle, and the core of the ancient doctrine that he strove to resurrect was a type of atomism: the belief that all physical changes come about through the separation and re-combination of indivisible particles.

Sennert's first public defense of atoms is in *De chymicorum* (Sennert 1619), and in later works he revised his account multiple times to make it as coherent as possible with Aristotle. More precisely, he distinguished two types of atoms, a primary tier corresponding to the four elements and a secondary one corresponding to the *tria prima* of the Paracelsians: "The use, therefore, of the chymical principles is that out of them, as if from proximate and proper principles, those properties of the mixed bodies can be deduced and demonstrated that cannot be directly demonstrated from the elements, as is particularly clear in the search for the properties of medicines"—"Usus igitur principiorum Chymicorum est, ut ex iis tanquam proximis & propriis principiis proprietates, quae corporibus mistis insunt, & ex elementis proxime demonstrari non possunt, deducantur, & demonstrantur, ut praecipue in proprietatibus medicamentorum inquirendis patet." (Sennert 1619, p. 298).

In contrast to Paracelsus and his followers, therefore, Sennert denied that Sulphur, Salt, and Mercury are the basic sorts of bodies in the physical world, even though he used them as a tool for describing chymical processes. In short, he integrated Paracelsian natural philosophy into the Aristotelian framework in a more coherent way than had been achieved before. Despite the existence of scholastic corpuscular theories in the traditions based on *Meteorology IV*, this was an ambitious project, which necessitated changes to the fundamentals of Aristotelian matter theory. As I shall argue in the concluding sections of this paper, one of the reasons why Sennert fulfills this ambition so successfully is that he not merely found a place for chymical evidence and arguments within Aristotelian natural philosophy, but that his matter theory solved a problem that had been present in scholastic matter theory, but which had always seemed unsolvable. The problem is the origin of the secondary qualities in so-called mixed bodies, which I shall use the next section to introduce.

4. The Problem of *Mixtio*

Aristotle's philosophical explanation of nature is very much a philosophy of common sense, and that extends to Aristotelian scholastic philosophy. The main goal is to give explanations of the properties and behaviors of the things we see around us in the everyday world: Animals, plants, people, materials like sand or gold or wood, water, ships, beds. Most of the things I have just listed would be regarded as *substances* by Aristotle, the basic ontological unit of his system. The most important tool for explaining these substances is the so-called substantial form, an inner principle that gives substances their properties and powers. The substantial forms of living things are their souls. For example, the walnut tree has a vegetative soul that makes it grow into a specific shape, with leaves and bark that are different from the leaves and bark of an oak tree. Among the powers that an individual receives from its substantial form is the power to procreate: a walnut tree produces nuts from which a new tree can grow, just as complex as the previous one.

Substances that are not alive, like a piece of silver or gold, do not have a soul, but they still have a substantial form. In the case of gold, its color, its weight, its resistance to rust, and all the other qualities that distinguish it from silver and from other metals result from the substantial form of gold. The simplest and most fundamental bodies, however, are the four elements fire, air, water, and earth. Each piece of one of the four elements is a substance, resulting from the union of the appropriate substantial form with matter. All other bodies, even such complex ones as the gold piece and the walnut tree, are composite in the sense that they contain these four elements in a certain proportion, and no material parts besides them. But the four elements are not atoms or particles, and gold is not an arrangement of minute particles. One might think that if one only had a microscope strong enough, or as Aristotle puts it, if one had the eyes of the mythical hero Lynceus, one would see that there is no distinct type of stuff "gold", but that what seems to us to be simply gold is really just particles of fire air water and earth (*On Generation and Corruption* I, 10, 328a15). The ancient atomists had suggested just such a solution, but Aristotle had insisted that if a true mixture had occurred, the resulting body must be homogeneous: no matter how good one's eyes might be, one will never find anything but gold in a piece of gold. The four elements are contained in it somehow in a fixed proportion, but they do not exist as separate entities anymore; they have been transformed into something new entirely, namely gold. Strange as this theory might seem today, it reflects a type of process that we encounter often in everyday life: wheat flour and water are quite different substances, one being a whiteish powder, the other a clear liquid. When both are mixed together, however, the resulting dough has entirely different properties from those of the two ingredients: it is neither a liquid nor a powder, but an elastic mass. What is more, it is quite impossible to regain either water or flour from the dough. The scholastic Latin term for this phenomenon is *mixtio*, though its meaning corresponds more closely to a chemical bond than to the meaning of the word "mixture" in modern English.

Scholastic Aristotelians differed in how exactly they explained this process. The main theoretical problem is this: do the substantial forms of the elements remain in the mixt? On the one hand, the homogeneity of the *mixtum* would seem to require that there is only one single substantial form present, which produces (for example) the color, weight, and relative softness of a piece of gold. On the other hand, for the dictum that the four elements are the fundamental ingredients of all bodies to have any foundation, the properties of the *mixtum* must also have some relation to the proportion of the four elements contained in it. The general shape of the scholastic solution is that though the elements themselves (that is to say, their substantial forms) are either destroyed or assimilated when the *mixtum* comes into being, their qualities are still the foundation of the qualities of the *mixtum*. In this way, the scholastic theories of mixture and of qualities are directly linked, which is why Sennert's postulation of atoms with substantial forms has such an immediate impact on the conception of qualities.

The basic distinction in this context is that between primary and secondary qualities. The primary qualities are the following: hot, cold, wet, and dry. Each of the four elements

was taken to have two of these four primary qualities in extreme form. The substantial form of fire, for example, produces the accidental forms of heat and dryness. The reason why a mixed body is hot, cold, dry, or wet, naturally, is that it contains one of the corresponding elements. But many or most of the remaining qualities encountered in mixts were also taken to depend on the primary ones. Which qualities exactly should be counted as secondary was a question of debate among scholastics. A minimal list includes the other “tactile” qualities given by Aristotle at *De Generatione et Corruptione* II, 22, 329b20: hard, soft, viscous, brittle, rough, coarse, fine, as well as the sensible qualities of color, smell, and taste (Pasnau 2011, p. 463). The yellowish color of gold, for example, is due to a certain proportion of the four elements. The secondary qualities are not identified with the corresponding proportion of primary ones, however: both are regarded as separate entities, even if there is a relation of dependency between them. Specifically, two relations were generally accepted by scholastics to hold between primary and secondary qualities. The first is *supervenience*—whenever a body changes one of its secondary qualities, for example when it is brittle at first and then becomes soft, there must also be a corresponding change in the primary qualities. Secondly, any causal power that a body possesses, it has in virtue of its specific mix of primary qualities. The supervenience thesis is, for example, endorsed by Caesare Cremonini, professor in Padua: “It is to be understood that nothing can change without a mutation in the qualities [of the elements]”—“intelligendum est nihil posse alterari nisi harum qualitatum [elementarum] mutatione. Naturaliter enim quicquid alteratur per aliquam mutationem in his qualitativibus alteratur” (Cremonini 1605, sect. III, chp. 9, p. 150). The causal primacy of the primary qualities is stated among others by Albert the Great: it “is in virtue of [the primary qualities] that whatever acts acts and whatever is acted on is acted on.”—“[. . .] virtute earum agit quod agit, & patitur quod patitur.” *De Praed.* 5.6, in (Albertus Magnus 1651, vol. I, p. 162a). For a lucid summary of these issues, see (Pasnau 2011, pp. 461–66).

This doctrine ascribes enormous explanatory weight to a simple quantitative relationship between the four hypothetical primary qualities and the open-ended list of secondary ones. Despite this, such quantitative theories were never spelled out, simply because any concrete articulation of this very general theory would have immediately been open to any number of objections and counter-examples. To account for the quality of brittleness, for instance, one would need to decide on a fixed proportion of cold, wet, dry, and moist that constitutes brittleness. This then implies that if the nature of a given body includes the four primary qualities in that specific proportion, it must be brittle. The problem is that the changing variety of physical reality is too complex to be expressed by a fixed relation of four numbers. To stay with the example, various brittle things may have little else in common: heavy stones and metals, relatively light wood, ice. If one assumes a common proportion of the four primary qualities in all of these materials in order to account for all of them being brittle, one thereby restricts the range of possible explanations for their differences in weight, color, and temperature. Any explanation of these further properties places additional restrictions on the proportions of the four elements that characterize each material (that stones sink in water, e.g., implies that they contain a large amount of the element earth and relatively little air and fire). One is bound to run into a property that contradicts the hypothesized proportions eventually, at the latest when one attempts to derive complex properties such as colors, tastes, and odors. Despite such difficulties, as described above, the great majority of scholastics up until Sennert’s time held on to the principle that the secondary qualities depend on the primary ones. What was generally agreed on, however, were only the general principles of supervenience and causal priority, and not any concrete derivations of specific secondary qualities.

5. The Development of Sennert’s Matter Theory

Sennert, for his part, was not only aware of the problems surrounding the relation of primary and secondary qualities, but he was also actively working to solve them. This is apparent, among other places, in the *De Chymicorum* of 1619, the book in which he

publicly endorsed the existence of atoms for the first time. In that work, he explicitly denied the derivation of the secondary qualities from the primary ones: “And although many have tried to prove that colors, odors and tastes come from the elements, they have done so in vain, as has already been demonstrated by the most learned philosophers and physicians.”—“Et licet nonnulli monstrare conati sunt, colores, odores, sapes, ab elementis provenire: irritum tamen conatu id fecerunt, ut a doctissimis Philosophis & Medicis jam demonstratum est.” (Sennert 1619, p. 283). This passage is one of the proofs adduced by Sennert for the existence of material principles distinct from the elements, i.e., what he was later to call secondary atoms. He first argued that whenever a multitude of things have a common property, that property must come about “through some common principle”—“per commune quoddam principium.” (ibid.) The conclusion, i.e., the need for corpuscles as the source of secondary qualities, then follows from the passage quoted. Sennert’s atoms are therefore closely associated with the qualities of bodies. However, as I shall argue, Sennert’s account of 1619, despite its advantages for the explanation of qualitative processes, did not contain a clear or satisfactory account of qualities themselves, precisely because he had not yet completely integrated the atoms into the Aristotelian framework of form and matter.

What are the “chymical principles” or atoms postulated by Sennert in 1619? Each of these particle types corresponds to one of the Paracelsian *tria prima* Salt, Sulphur, and Mercury, but whereas the Paracelsian principles are immaterial, Sennert’s atoms are material. They are also indivisible in the sense that no natural process or human intervention is able to divide them. As Newman in particular has shown, when Sennert came to his atomist position gradually over the course of the 1610s, it was in large part under the influence of writers interested in empirical questions of chymistry (Newman 2006, p. 124; see also Lüthy 2005).

As Newman and others have also argued, Sennert’s best arguments for his quasi-Paracelsian corpuscles made use of empirical knowledge, specifically of a chemical experiment using simple acids. As had been known for some time, it is possible to dissolve silver in *aqua regis* (nitric acid), so that it is completely invisible in the resulting liquid. It is then possible to regain the pure silver from the solution by adding a catalyst. If the dissolution of the silver in the acid were a matter of one substantial form being replaced by the other, the second part of the experiment ought to be impossible since the substantial form of silver would be destroyed by the dissolution. It would be like regaining the flour from the baked bread. Sennert used this to argue that the form of silver is not destroyed and rather remains hidden in the solution, which is only possible if there are persistent material parts to carry it (Sennert 1619, p. 362). The Paracelsian movement as a possible influence on Sennert is already alluded to in (Lasswitz [1890] 1984, vol. I, p. 441). The acid experiments are discussed in (Meinel 1988, p. 94), and the arguments are reconstructed in detail in (Newman 2006, pp. 99, 112).

There is another contrast between Sennert’s atoms and the Paracelsian principles, however: while the purpose of the original *tria prima* was to replace the four elements as the fundamental principles of material bodies, Sennert postulates his chymical principles in addition to the four elements: “Furthermore, the Aristotelian elements and principles are in no way to be rejected [. . .] both the elements and these chymical principles are to be admitted in the constitution of mixts.”—“Deinde per ea elementa ac principia Aristotelica nullo modo rejicienda sunt [. . .] tam elementa, quam haec principia Chymica in mistorum constitutione admittenda.” (Sennert 1619, p. 281). But if this is the case, how do the elements relate to the chymical atoms? Sennert remains rather vague on this point in the 1619 edition of *De Chymicorum*. In order to understand why, we have to examine the evolution of his stance on mixture theory. The central question from the scholastic point of view, as mentioned above, is whether the substantial forms of the elements remain in the mixt or whether they are replaced by a single new form. Ever since the proto-*Epitome* of 1600, Sennert had subscribed to the theory of mixture associated with the name of Averroes. According to this theory, the substantial forms of the elements do remain in the mixt,

though only in a “refracted” state, which allows the qualities of the elements to be taken over by the form of the mixt. Since the forms of the elements have merged into a single form of the mixt, this position implies that in any given mixt, the form of the mixt must be the origin of all qualities. Sennert is quite clear about his position in a passage from the *Epitome*: “We, having rejected the others, follow Averroes, who believed that not only the qualities, but also the forms of the elements themselves remained in the mixt, but refracted, so that a single form comes about from them all.”—“Nos, caeteris rejectis, Averrois sequemur, qui putavit, non solum Qualitates, sed ipsas etiam formas Elementorum manere in misto; refractas tamen, ita ut ex omnibus una forma fiat” (Sennert 1600, disp. 14, thesis 19; 1618, p. 222; 1624, p. 242). This passage was reprinted without change until 1624. It is discussed in (Michael 2001, p. 337; Newman 2006, pp. 100, 110), among others.

There is no equally unambiguous statement on mixture theory in the first edition of the *De chymicorum*, and at one point Sennert seems to leave the question open deliberately (Sennert 1619, pp. 265–66). In the second edition published in 1629, however, he had changed his mind: from that point onwards, he consistently claimed that the substantial forms of the elements remain intact when they become part of a mixt. In other words, he rejected the view of Averroes and Zabarella, which he had earlier held himself, and subscribed to the position traditionally associated with Avicenna: “But that refraction of forms is a mere figment, as has been shown sufficiently by the Latins arguing against the view of Averroes.”—“Verum refractione illa formarum merum figmentum est, ut a Latinis contra Averrois sententiam disputantibus satis monstratum est” (Sennert 1629, p. 153a). The second edition of the *De chymicorum* indeed seems to be the point at which Sennert changed his mind on the question of mixture: a similar passage calling the position of Averroes and Zabarella a “mere figment” appears in the final edition of the *Epitome* (Sennert 1633, p. 265).

This change in Sennert’s mixture theory has often been emphasized by commentators as a sign of a more explicit version of a corpuscular theory. The first to note this was (Lasswitz [1890] 1984, vol. I, p. 439), while (Michael 2001, p. 337) is particularly well documented. The reason for this emphasis is that, according to the theory that Sennert held until at least 1618, the substantial forms of the particles, and therefore the individual particles themselves, cease to exist when they become part of a mixt. According to the Avicennan theory that he endorsed from 1629 onwards, on the other hand, each particle continues to exist within the mixt in the same way as outside it. Earlier scholastics had discussed this view of mixture since the thirteenth century, but had always rejected it, because the elemental forms remaining intact seemed in conflict with the very idea of mixture and therefore with one of the fundamental tenets of Aristotelianism. The conflict is this: since every part of a mixt contains all four elements, if the forms of the elements were to remain actually present even while they are part of the mixt, then the same piece of matter would be informed by four different forms. In other words, it would be multiple elements at the same time. In Sennert’s works after 1629, this conflict is solved by abolishing the idea of perfect mixture entirely, at least in the inanimate cases. Without perfect mixture, there is no contradiction in assuming multiple levels of substantial forms in the same body. To take up the previous example, the properties of a piece of gold, according to this late theory, stem from three different types of substantial forms: some are produced by the form of gold directly, others must be attributed to the presence of atoms of Sulphury, Salt, and Mercury, and the primary qualities are produced by the forms of the four elements. Despite the presence of a structuring form of gold, the piece of gold is not homogeneous, since its smallest parts do not always contain all four elements or all three secondary atoms; rather, multiple different types of corpuscles continue to exist next to one another. The same is true of each individual atom of Mercury, Salt, or Sulphur: though they are not divisible by natural means, they are nevertheless mixts containing the four elements, created by God in the first instant (Sennert 1676, p. 118; 1619, p. 274).

There has been some debate over the importance that Sennert’s change of opinion on mixture theory. The fact that the atomist passages in the *Epitome* occur only in the last

edition of that work, as well as the fact that Sennert's corpuscularian worldview is in large part complete in the first edition of *De chymicorum*, was already documented in (Lasswitz [1890] 1984, vol. I, pp. 439, 441). For this reason, Newman has criticized Michael for seeking the origin of Sennert's corpuscularian views in mixture theory, instead of the experimental tradition of Geber. In addition, Newman has implied that the corpuscularian position already includes the change in stance on mixture theory (Newman 2006, p. 111, n. 68; Michael 1997, pp. 280–84). However, while it is certainly correct that mixture theory was not the driving factor behind the corpuscularianism of the first edition of *De chymicorum*, it seems to me that there is further development in Sennert's matter theory after that point. The most important piece of evidence for this is the fact that in the 1624 edition of the *Epitome*, five years after the publication of the *De chymicorum*, the endorsement of the mixture theory of Averroes is reprinted without change. I would therefore suggest that between 1619 and sometime before 1629, Sennert held a "mixed" theory. According to this theory, bodies are composed of the four elements and the three types of secondary atoms, but when corpuscles come together to form a true mixt with its own substantial form, their forms become diminished, and their existence is now merely potential instead of actual.

This version of the theory is perfectly capable of explaining the chymical processes that are Sennert's main interest in the *De chymicorum*. In the aforementioned experiment, for example, in which silver is first dissolved by means of a strong acid and then reprecipitated, Sennert might simply deny that the silver dissolved in acid constitutes a true mixt. However, in my view, the theory held by Sennert after 1619 has a different problem, namely that it leads to a certain inconsistency in the ontology of qualities. One consequence of mixture theory on the model of Averroes is that in a true mixt, the same substantial form produces all qualities, whether primary or secondary or otherwise. For scholastics following Averroes, like Zabarella, the fact that the forms of the four elements are contained in the mixt in a "refracted" state does therefore not mean that these elemental forms produce the primary qualities. Rather, the primary qualities are produced by the form of the mixt, which is the result of the forms of all the parts melting together into one. But although the elemental forms do not actually exist anymore and their qualities are produced by the form of the mixt, the part-forms need to remain in the mixt somehow—otherwise the concept of the elements as the fundamental material parts would have no explanatory power left at all. The commonly accepted answer to the question of how the mixt contains the elements was that, though the elemental forms do not survive the generation of the mixt, their qualities do. It is for this reason that, as discussed above, almost all scholastics agreed that the secondary qualities supervene on, and are causally posterior to, the primary ones.

We have seen, however, that Sennert abolishes precisely this connection between primary and secondary qualities in 1619, denying that "colors, odors and tastes come from the elements" (Sennert 1619, p. 283). The idea in this passage is of course that the secondary qualities ought to be attributed to the secondary atoms instead of the elements. However, the secondary atoms themselves are also mixts. What Sennert therefore seems to be claiming is that even though (on his Averroesian theory of mixture) the forms of the secondary atoms are constituted by the forms of the elements, they exhibit a totally different and causally unrelated set of qualities. The same problem also occurs with higher-order inanimate mixts, like the previously discussed piece of gold: as a perfect mixt, it has a substantial form, which is the result of the melting together of many part-forms of secondary atoms. The form of the whole produces all the qualities of gold. Many of them, like the golden color, will belong to the list of secondary qualities and can therefore be attributed to the flowing together of the part-forms. However, the purpose of postulating a form of the mixt is to explain why there seem to be qualities of the whole that are not explained by the qualities of the parts. The origin of these additional qualities is equally as mysterious as that of the secondary qualities on the theory as Sennert presents it in 1619. In my view, it is plausible that it was because of problems like these that he changed his stance on mixture theory, thereby adapting his view on the hylomorphic structure of matter to the demands of his theory of qualities.

6. Conclusions

The matter theory presented by Sennert from 1629 onwards preserves all the advantages of the corpuscular theory he introduced in 1619 while avoiding the problems in the derivation of higher qualities from lower ones. The change in mixture is decisive because it completes the development that had begun with the introduction of secondary atoms: the ontological and causal decoupling of primary, secondary, and higher-order qualities. According to this last version of the theory, the substantial forms of the elements that together constitute a Sulphur atom are neither destroyed nor refracted but continue to exist as independent entities. If the Sulphur is warm, cold, dry or wet, therefore, it is so because it in a very literal sense contains atoms of the four elements. The substantial form of Sulphur has its own characteristic qualities, which it produces independently of the elements. In contrast to the earlier theory, the form of Sulphur does not also produce the primary qualities, which are instead delegated to the primary fire, water, air, and earth atoms contained in it.

On the level of sensible bodies, there is not only a substantial form belonging to the body as a whole, but also a separate form for each of its parts *and* for each part of a part. Since the main function of a substantial form is to act as the carrier of qualities, a quality expressed in a given body can now be located on any one of three ontological levels. Primary and secondary qualities observed in a body can be attributed to the primary and secondary atoms contained in it. The dryness and coolness of an aged plank of walnut wood, for example, might be explained by a relative lack of the elements water and fire in it, while its flammability might be attributed to the fact that it contains some amount of Sulphur.

In some cases, qualities can also be attributed to the substantial form of the whole body directly. This class of qualities is by no means Sennert's invention but had long been debated by scholastic philosophers. The most commonly discussed examples of such qualities were the phenomena of magnetism and the healing power of medicines. The scholastic term for them is "occult qualities." (Note that while among critics of Aristotelianism from the middle of the seventeenth century onwards, "occult qualities" became synonymous with "incomprehensible or unexplained properties", this is not how the Sennert and other scholastics use the term.) While the concept of occult qualities is not new, however, Sennert's unusual views on mixture means that the relation of the occult qualities to the primary and secondary ones, collectively called "manifest qualities", is a different one for him than for most Aristotelians. The occult qualities are traditionally understood to be the rare exceptions from the rule that all qualities are determined by a certain proportion of the four primary qualities. Sennert had agreed that occult qualities existed since the early stages of his career. In his *Disputation on pestilence* (1607), for example, he had already argued that the actions of the four elements are not enough to explain the deadly power of contagious diseases, which must therefore come from an occult quality (Newman 2006, p. 142). In his late writings, however, he extends the same model to the primary and secondary qualities as well: now, *all* qualities are produced directly by the substantial form of the corresponding body or particle, independently of the proportion of lower-tier atoms. This extension is only possible on the mature theory of matter and mixture Sennert endorsed from 1629 onwards, since it is only the Avicennian theory of mixture that enables him to give a coherent account of forms within forms. On Sennert's uses of occult qualities, see (Stolberg 2003, pp. 185–88; Newman 2006, pp. 140–42).

This second stage in the development of Sennert's matter theory after the initial adoption of a corpuscularian view illustrates that the merging of hylomorphist natural philosophy with corpuscularian ideas required adaptations in both sets of ideas. Sennert's atomism with substantial forms goes directly against doctrines that are either founded directly in Aristotle or almost universally accepted by scholastic Aristotelians. The most striking change is that, as discussed, he argues that mixed bodies are not homogeneous all the way down. Whereas the genuine Aristotelian doctrine about a homogeneous body like a piece of gold is that it has only a single substantial form and that the four elements are at

most virtually contained in it, for the mature Sennert only a subset of the properties of gold can be attributed to its own form, while most others are properly speaking the properties of its atomic parts.

I hope to have shown that Sennert had good reason for proposing his new matter theory. There are two ways in which his synthesis manages to combine the advantages of substantial forms with those of atoms. The first virtue of his system, which it shares with other corpuscularian approaches, is that it allows Sennert to point to the persisting particles contained in all bodies whenever that seems plausible. This is a useful mode of explanation for many of the chymical and physical phenomena commonly treated in natural philosophy. In addition to that, corpuscular explanations are also a central part of Sennert's biological theories, in which he used that type of explanation to intervene in the long-standing debate of the origin of the soul in conception. He argued that when a living being is born, its soul must have been already latent in the surrounding matter, rather than being created by supernatural forces (as was the dominant theory in the case of the human rational soul) or spontaneously (as was held to be the case for some "inferior" forms of life, like worms and flies). The latent souls, Sennert argued, must be present in the form of ensouled atoms, lying dormant everywhere in matter and suppressed but not destroyed by the fact that they are part of a larger object dominated by another form (Hirai 2012).

If these creative uses of invisible corpuscles are made possible by Sennert's atomist heritage, their careful integration into the Aristotelian framework helps him avoid some of the problems that had plagued other corpuscularian systems. One of the main weaknesses of ancient atomism had been that it was unable to explain how such complex bodies like the walnut tree, the gold, or the dog come about through the simple interactions of atoms. In these cases, Sennert is able to lean on his Aristotelian heritage by giving explanations that involve substantial forms as the origins of qualities and powers. It is not surprising, then, that he was far from leaving the framework of scholastic natural philosophy entirely, despite the creative changes he made to some doctrines within it. His philosophical project is rooted in an Aristotelian vision of the investigation of nature, and many of the scholarly debates in which he intervened had been ongoing at European universities for centuries. In the interconnected cases of mixture theory and the ontology of secondary qualities, his position has clear medieval antecedents: the idea that there are certain cases where more than one substantial form can be contained in a single body, for instance, was affirmed by such prominent medieval scholars as John Duns Scotus and William of Ockham (Michael 2001, p. 346). However, even the most extreme scholastic pluralists were only prepared to admit multiple forms in a very small number of cases, notably in living bodies. By adopting the Avicennan theory of mixture, Sennert extends this idea to non-living bodies—even Zabarella, who was prepared to admit "four or a hundred [forms] together in the same subject", sided with Averroes rather than Avicenna on this issue (Zabarella 2016, p. 502; cited by Sennert 1676, p. 155a). As I have argued, Sennert did not take this additional step in 1619, when he introduced corpuscular explanations into his natural philosophy for the first time, but only a number of years later. As I have further argued, a possible motivation for this change in stance on mixture theory is that association of specific secondary qualities with specific corpuscles was ultimately in conflict with the Averroesian account. As a result, the late Sennert contradicted claims on which scholastic Aristotelians had almost unanimously agreed for centuries. The fact that he was able to do so while still being recognizable as a scholastic natural philosopher is a testament to his ingenuity, but also to the breadth and flexibility of early modern scholasticism as such.

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