The Nature of Change:

Non-Aristotelian Theories of Motion in the Early Seventeenth Century

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aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M. van Krieken,
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Gabriel Josef Müller
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General Introduction

Natural Philosophy, Change, and Local Motion

In this study, I examine the theories of local motion of four early seventeenth-century authors: Daniel Sennert (1572–1637), Sébastien Basson (ca. 1573 – post 1625), David Gorlaeus (1591–1612), and Francis Bacon (1561–1626).

The seventeenth-century event known as the Scientific Revolution was a deep transformation in both European philosophy and European science, and theories of local motion were at the core of the most important developments within it. From the perspective of the history of science, the most celebrated theories of the seventeenth century have local motions as their object: Johannes Kepler provided new mathematical descriptions of celestial motions; Galileo Galilei brought forward new arguments for the heliocentric view of the cosmos and produced a more accurate mathematical kinetics for bodies closer to Earth. On the more narrowly philosophical side of the spectrum, local motion was central as well: René Descartes, Thomas Hobbes and Pierre Gassendi proposed philosophical systems that were designed to explain all natural phenomena in terms of matter and motion. This explanatory program was taken up by others in the second half of the century and given a name by Robert Boyle: the "mechanical philosophy."[1] The natural philosophy formulated by Newton towards the end of the century was the culmination of both the mathematization and experimentation epitomized by Galilei and the reductionist program of the mechanical philosophy. At the same time, that synthesis was only achieved by letting go of the mechanist principle that all causation works by contact alone, since Newton reintroduced into his physics forces that act at a distance.[2]

What is replaced by the mechanical philosophy and the nascent experimental and mathematical physics is a single philosophical discipline, namely scholastic natural philosophy. Philosophical investigation into the natural world as taught in the schools and universities was based on the works of Aristotle, in the early seventeenth century just as in earlier centuries and in Protestant just as in Catholic countries. In the Aristotelian framework that was common to scholastics, local motion plays almost as important a role as it does in the mechanical philosophy. It is a different role, however: For Aristotle, natural things are defined by the presence of a *φύσις* or

1 Cf. ns. 8–10 below.

2 Janiak, "Natural Philosophy," 400.

inner principle of change, which is why he defines physics as the science of changing bodies. Local motion, that is, an object changing place, is however only one type of natural change among others. There is also substantial change, in which some object comes into or goes out of existence, and there is qualitative change, that is, change in properties other than place.

1. Ancient Greek accounts of change

Why this scheme of the types of natural change is fundamental to Aristotelian natural philosophy can be best understood through the context of its inception. The very first Greek philosophers that we know of, the three Milesians Thales, Anaximander and Anaximenes, already postulated different kinds of originating stuff, material principles from which all the various things in the world emerge. They thereby introduced the theme of trying to understand the ever-changing natural world through some regular and permanent entity. Heraclitus, after them, not only posited fire as the stuff that everything is made from, but his *panta rhei* formulated the problem that there are everyday objects that require constant change in order to retain their identity. Ultimately, however, while the early Presocratics inaugurated change as a topic, none of these early figures managed to give a coherent account of it.[3]

The Eleatics, first Parmenides and then Melissus and Zeno, were the first to make a systematic attempt at coming to terms with the phenomenon of change. They did so in the most radical way possible, by denying the reality of all change whatsoever, along with any other heterogeneity within Being. If a natural philosophy must include an explanation of change, then to take the Eleatic position is to deny the possibility of a natural philosophy.

The teachings of the first atomists, in turn, may be read as a reaction to the Eleatic challenge. The philosophy of Leucippus and Democritus was designed to solve the problem that change and variety seem to involve the being of non-being. It did so by conceding much of the Eleatic position: The atomists agreed that there is no change in any being, with the sole exception of change in place. They located the unchangeable, homogeneous being in their atoms and the equally unchanging non-being in the void. Empedocles and Anaxagoras followed a similar strategy as the atomists in that

3 On the doctrines of the Milesians and Heraclitus, see Barnes, *The Presocratic Philosophers*, 9, 24, 46, and especially 65–69. Pyle, *Atomism and Its Critics*, 83, summarizes the "inability to come to terms with the phenomena of change in all its varieties" exhibited by Presocratic philosophy.

they, too, explained the changes in various qualities through the local motions of small unchanging pieces of stuff. However, they made a compromise with common sense, since their elements themselves were the carriers of qualities. Democritus, Leucippus, Empedocles and Anaxagoras all accepted the Parmenidean thesis that what really exists has neither coming-to-be nor ceasing-to-be.[4]

Even before Aristotle, therefore, the explanation of change was a central problem of natural philosophy. Nevertheless, the problem only came into focus in Aristotle's treatment, notably because many of the relevant Presocratic fragments are preserved as quotes in his texts, especially in *On Generation and Corruption* and in the *Physics*. According to Aristotle, the basic conflict in the explanation of change up to his own time was the conflict between the monists and the pluralists:

> The principles [of physics] must be either one or more than one. If one, it must be either motionless, as Parmenides and Melissus assert, or in motion, as the physicists hold, some declaring air to be the first principle, others water.[5]

Besides his role as the first historian of philosophy, Aristotle was also crucial in that he managed to take up the issues that had occupied his predecessors and for the most part resolved their conflicts by introducing a new conceptual frame. He took the atomist solution as a starting point, but added that they conceded too much to the Eleatic denial of change. According to Aristotle, it is not necessary to posit unchanging, property-less atoms in order to resolve the apparent paradoxes of change and motion.

The strength of the Aristotelian solution lies in the fact that it is able to rescue most of the initial assumption that change takes place everywhere in nature, while answering all the Eleatic challenges and incorporating the insights of his predecessors. His concepts of form, matter, actuality, potentiality and privation are the elements of a conceptual framework designed to capture all possible kinds of change in all possible things. As he does in his philosophy generally, he defends what he sees as the common sense interpretation of change in the natural world. That means accepting that there appear to be different kinds of changes and assigning the same

4 Pyle, *Atomism and Its Critics*, 87 f. The phrase "answers to the Eleatic challenge" is from Barnes, *The Presocratic Philosophers*, 307. See also ibid., 316, on through-lines between Parmenides and the neo-Ionians.

5 Aristotle, *Physics* I, 2, 184b15–184b22, ed. Barnes, 3.

type of reality to each of them. For him, all types of accidental change, as well as change in substance, are to be described with the same concepts and are equally real.

While Aristotle engages with the positions of all the Presocratics on change, the atomist position is the foil against which the core of the account on change is developed in *On Generation and Corruption*.[6] The reason why Democritus and Leucippus are the natural opponents in this question is that their attempts at reducing the number of types of change are the most radical (with the exception of the Eleatics'). In contrast to Aristotle's inclusive approach, their strategy had been to recognize only local motion as real and to reduce all changes in property and in substance to it. As Aristotle describes it:

> [Leucippus and Democritus] are able, as has been said, to produce alteration equally with generation by transposing the same thing in respect of position and order and by the differences between the figures, as Democritus does.[7]

In other words, Aristotle's position in natural philosophy is distinguished from that of his atomist opponents by the fact that the atomists are reductionists with regards to alteration and substantial change. What is more, Aristotle only introduces the distinction between local motion, change in properties and substantial change in the course of answering the Presocratic arguments about change. With regards to local motion, however, there is less of an opposition. None of the ancient sources proposes a natural philosophy in which local motion is reduced to another kind of change. The only ones who deny the reality of local motion are the Eleatics, who also deny the possibility of natural philosophy. Since ancient times, therefore, it was one of the most fundamental questions of dispute between Aristotelians and their opponents whether qualitative and substantial change ought to be regarded as real in the same sense as local motion.

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6 Aristotle, *De Gen. et Cor.* I, 8, 325a33–35 and I, 1, 315b, ed. Williams, 6–9. Cf. Pyle, *Atomism and Its Critics*, 87, 103–109.

7 Aristotle, *De Gen. et Cor.* I, 2, 315b33–316a2, ed. Willliams, 5.

2. Mechanical philosophy

The conflict between early modern Aristotelians and early modern non-Aristotelians is different and arguably more complicated than that between Aristotle and his predecessors. Despite all the differences, however, the situation with regards to the explanation of change is comparable, if we limit ourselves to one specific movement in seventeenth-century natural philosophy, namely the mechanical philosophy. There have been a number of different interpretations of what constitutes the mechanical philosophy, beyond its realization in the writings of a few paradigmatic exponents such as Robert Boyle.[8] Most descriptions build on a combination of three themes: The analogy of natural philosophy with the science of machines, the mathematization of nature, and a reductive ontology according to which all there is are matter and motion. The two scholars who introduced the mechanical philosophy into modern historiography differed about which of these themes was most important: Dijksterhuis saw the key in progressive mathematization, whereas Boas Hall emphasized the ontological thesis.[9] Recent scholarship has introduced more refined distinctions between currents and meanings of the mechanical philosophy and has "deconstructed both the belief that it is an adequate historical category and the conviction that it made a positive contribution to the sciences."[10]

Despite all the problematization of the last twenty years, the mechanical philosophy has survived as a historical category. The reason for that is that the criteria used in the conflicting definitions by Dijksterhuis and Hall are fulfilled by many philosophies from the second half of the seventeenth century, even if more recent work has shown that they form a less coherent movement than it was once assumed. From Descartes on, there are a number of writers who propose to reduce physical phenomena to corpuscles of different sizes, shapes and motions.[11]

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8 Roux and Garber, "Introduction," xi, distinguish four meanings of the term "mechanical philosophy." Cf. Gabbey, "What Was 'Mechanical' about 'the Mechanical Philosophy'?" on the early modern polysemy of the word "mechanical."

9 Roux, "What To Do With the Mechanical Philosophy?," 75 f.; Boas, "The Establishment of the Mechanical Philosophy," 520; Dijksterhuis, *Mechanization of the World Picture*, 495–500. Cf. also Westfall, *Construction of Modern Science*. What has most vehemently been put into question about these classic accounts is the causal role they ascribe to their respective interpretations of the mechanical philosophy for the development of science. My point here is purely about the mechanical philosophy as a descriptive term.

10 Roux, "What To Do With the Mechanical Philosophy?," 76.

11 Roux bases her overview on the ontological definition, see Ibid., 83. Hattab, "The Mechanical Philosophy," 75, instead opts to compare "different kinds of early modern philosophy that were regarded

With regards to the explanation of change, therefore, the front lines between the Aristotelian and the most prominent anti-Aristotelian camp are still in the same place in the seventeenth century as they were in 300 BC. Whereas Aristotelians consider the fundamental types of natural change to include substantial and qualitative change, the explanatory program of the mechanical philosophy consists in explaining all processes in the natural world in terms of the local motions of matter particles only. Robert Boyle summarizes the reductionist program as follows:

> We teach then [...] that motion, not belonging to the essence of matter (which retains its whole nature when it is at rest) and not being originally producible by other accidents, as they are from it, may be looked upon as the first and chief mood or affectation of matter.[12]

Boyle still views himself as arguing against the Aristotelian division of natural change, which is illustrated by the fact that the chapter in which the above quotation occurs is entitled "Of Generation, Corruption, and Alteration."[13] Again, both sides of the conflict agree about what is to be explained: Neither the ancient atomists nor the mechanical philosophers deny that the natural world *seems* to contain all the sorts of changes that are accepted as real by Aristotle.

3. A period of expectation

The authors that are the subjects of this study, however, are neither mechanical philosophers nor Aristotelians. It is therefore an open question how they explain change and what role local motion plays in their respective philosophies. The time in which they produced their works, the first two decades of the seventeenth century, was one of the most turbulent phases of the development that eventually led to Newtonian science. These early years were not so much a time in which an old philosophy was being replaced by a new one, but rather a time of great intellectual insecurity. In terms of the university curriculum, Aristotelianism was still dominant, but under that institutional umbrella, a wide field of different doctrines had

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as 'mechanical' in some sense."

12 Boyle, *The Works of Robert Boyle*, 35.

13 On Boyle, see Anstey, *The Philosophy of Robert Boyle*, especially ch. 5 on Boyle's engagement with the Aristotelian notions of natural and violent motion.

recently sprung up.[14] In addition to its internal diversity, there had come to exist a widespread impression that there were fundamental problems with the Aristotelian approach. Load-bearing parts of the Aristotelian framework within which the debates of scholastic philosophy had taken place were in the process of breaking down, creating the need for a new comprehensive picture of the natural world to replace the Christian Aristotelian one.

The task of finding an alternative to Aristotelian natural philosophy was made more difficult by the fact that the entire scholastic university program was based on Aristotle, not just in natural philosophy, but also in all other subjects, from rhetoric and logic to metaphysics and ethics. As a consequence, while a great number of different approaches to natural philosophy were available, none of them seemed entirely satisfactory to contemporary observers. As one scholar writes in an overview:

> People produced such new philosophies because there was a demand for a new philosophy, that is, a current expectation of what a philosophy should do, and a sentiment that the old philosophy was not doing it properly. Indeed, one may say that the chief philosophical legacy which the sixteenth century bequeathed to the seventeenth was not any particular new philosophy but just this expectation of a new philosophy.[15]

The four authors whose natural philosophies I study in this thesis are in many ways typical for this time of uncertainty. They all write natural philosophies and all disagree with Aristotle on fundamental points, although none of them managed to convince his contemporaries that his own system was the one that ought to replace Aristotle once and for all. The outward circumstances of my four authors are extremely different: Sennert was a physician and professor of medicine in Wittenberg; Basson also had a degree in medicine, but taught Latin in a Huguenot school in the small town of Die in the south-east of France; Gorlaeus died while still a student of theology at Leiden; and Bacon spent his life in the highest political functions of the English

14 Leijenhorst, Lüthy, and Thijssen, "The Tradition of Aristotelian Natural Philosophy," 8–11 set out eight ways in which Aristotelian natural philosophy, though defined by the common reference to Aristole's *libri naturales*, went beyond the content of those books. See also Schmitt, "Towards a History"; Schmitt, "Rise of the Philosophical Textbook"; Gaukroger, *Emergence of a Scientific Culture*, 118, on sixteenth-century scholasticism compared to that of previous centuries.

15 Menn, "The Intellectual Setting," 34. Gaukroger, *Francis Bacon*, 108, gives examples of thinkers from the 16th century and earlier trying to overthrow Aristotelianism as a whole.

crown. Besides all being contemporaries from Protestant parts of Europe, there is little in these four men's lives that would otherwise connect them. More importantly, they were not mechanical philosophers in the way that Hobbes or Descartes were going to be mechanical philosophers: None of them explained all change only through the mechanical interactions of particles. In older historiography, this has often led scholars to pay less attention to them and other allegedly transitional authors. The following quotation from Maier articulates this sentiment well:

> Wie nun die atomistischen Systeme dieser ersten Zeit – in denen die Mischung von alten und neuen Gedanken gerade bei der Deutung der Qualitäten oft zu wunderlichen Resultaten führt – im Einzelnen ausgesehen haben, ist für unsere Frage ohne Interesse. […] Erst in der zweiten Hälfte des Jahrhunderts kommt es zu einer Wirkung von System auf System, und damit zu einer gewissen Kontinuität der Lehre.[16]

Writing about Gorlaeus and Basson in particular, Maier argues that one can safely disregard these early atomist proposals and concentrate on the more coherent conceptions articulated in the second half of the century. One category that both contemporaries and more recent historians have sometimes used to describe early non-Aristotelian natural philosophers is that of the *novator*. This category, which was invented in their own time and which was also applied to Basson, Gorlaeus and Bacon, also included such prominent figures as Girolamo Cardano, Bernardino Telesio, Petrus Ramus, Julius Caesar Vanini, Jean Chrysostome Magnen, Thomas Harriot, the Boate brothers, and others more. However, the diversity of that list only reinforces that to label them as *novatores*, by itself, says very little about their philosophical ideas and motivations.[17] Besides, Sennert, despite his atomist ideas, was not seen as a *novator* by his contemporaries.

16 Maier, *Mechanisierung des Weltbildes*, 26 f.

17 See Garber, "Novatores" for the historiographical value of the label, as well as for who was regarded to fall under it. Garber argues that the label is essentially polemical and therefore straddles the border between analyst's and actor's categories.

4. Substantial forms and moving particles

Daniel Garber has suggested a useful distinction that makes clear what separates *novatores* like Basson, Gorlaeus and Bacon from later mechanical philosophers. According to Garber, mechanical philosophy proper was introduced by Boyle as a combination of two programs: The "explanatory program," which is broadly identical with the ontological formulation of the mechanical philosophy, and the "irenic program." In Garber's scheme, Descartes, Gassendi and Hobbes are the three mechanical philosophers *avant la lettre* in the sense that they all pursue the explanatory program of reducing qualities to matter and motion. Boyle then constructs a common movement by adding the irenic program, that is, by consciously emphasizing the shared commitments of mechanical philosophers over their oppositions. *Novatores* before Descartes, therefore, cannot be said to be mechanical philosophers even in the broader sense, because they share neither program. As for the explanatory program, they can in retrospect be seen to articulate one or the other idea that would later be associated with the mechanical philosophy (say, machine analogies or a quantitative approach to some natural phenomena), but reducing all properties of bodies to matter and motion is not part of a project they themselves would have recognized. Likewise, they were far from subscribing to an irenic program: They would have seen themselves as proposing mutually incompatible alternatives to the Aristotelian framework. From the perspective of one *novator*, the other *novatores* were as wrong as the Aristotelians. In light of this, Garber suggests treating these *novatores* as part of the pre-history of the mechanical philosophy.[18]

The reason why Basson, Gorlaeus and Bacon fall into the pre-history of the mechanical philosophy even though they do not subscribe to its explanatory program is that they all reject the substantial form. This makes them anti-Aristotelians automatically: For late medieval scholastics, various sensible things in the natural world are substances invested with causal powers that flow from their substantial forms. The claim that natural causation can be reduced to the interaction of particles leaves simply no room for such substantial forms. This does not automatically imply the abolition of the *terms* 'matter' and 'form', which were still widely used.[19] But in the

18 Garber, "Remarks on the Pre-History of the Mechanical Philosophy," 26. The case of Bacon is discussed explicitly by Garber, while Gorlaeus and Basson are only mentioned.

19 The term "hylomorphism" itself is an invention of the nineteenth century. "Matter" and "form," on the other hand, though they are part of the philosophical vocabulary of the seventeenth century, are used by exponents of the new philosophy just as much as by orthodox Aristotelians. Manning,

sense of an immaterial entity inhering in material things and acting as a cause that is not reducible to the interactions of particles, mechanical philosophers must reject substantial form. Conversely, to reject substantial forms, on its own, is a sufficient criterion for belonging to the opposition to Aristotelian philosophy.

With Sennert, the case is less clear, since he does not reject the substantial form as such. However, he fulfills another necessary condition of the mechanical philosophy, since his ontology includes unchanging corpuscles. In contrast to abolishing the substantial form, accepting corpuscles is not in every case in conflict with following Aristotle in natural philosophy, and Sennert is certainly the most scholastic among our four authors.[20] However, the purpose of positing unchanging corpuscles in natural philosophy is to explain qualitative and substantial changes by means of the local motions of particles, so with regards to the explanation of change, Sennert necessarily deviates from the Aristotelian scheme.

Our four authors combine these two themes in different ways. As mentioned, Sennert is an atomist who nevertheless uses substantial forms of sensible bodies to explain various natural processes. Bacon entertained atomism for a good part of his life, but ultimately excluded it from the ultimate version of his vision of natural philosophy. By contrast, Basson and Gorlaeus are corpuscularians who explicitly abolish the substantial form. The philosophical premises of all four authors therefore commit them to a view of natural change that is different from Aristotle's, but for different reasons in each case. The question that stands at the center of this study is what role local motion plays in these non-Aristotelian, non-mechanist natural philosophies. This includes both the motions of perceptible bodies and those of imperceptible corpuscles, and local motion both as a physical phenomenon that needs to be explained and as a theoretical postulate that can be mobilized to explain other types of changes and properties.

"Three Biased Reminders," 32, and Lüthy and Newman, " 'Matter' and 'Form,' " 221. Emerton, *Scientific Reinterpretation of Form*, is the classical demonstration of the extensive use of the term "form" in corpuscular conceptions. Emerton places Scaliger, Gorlaeus, Sennert, Basson, Bacon and many others into a history of "form" that sees the concept evolve from something abstract, almost logical, to a description of crystalline structures.

20 Aristotle is generally hostile to atomism, except in *Meteorology* 4, about which Pietro Pomponazzi said that "Aristoteles democritizat." Pomponazzi, *Dubitationes in quartum meteorologicorum, dubitatio* 92, fol. 43^{v}–44^{r}. Cf. Newman, "Corpuscular Alchemy"; Lüthy, "Aristotelian Watchdog," 545.

5. The four authors in the history of atomism

Sennert, Basson and Gorlaeus are best known to modern scholars as examples of a specific type of early modern corpuscularianism. That is due to the treatment they received in Kurd Lasswitz' *Geschichte der Atomistik*, whose history of corpuscularian accounts in the Middle Ages and the early modern period has exerted a great influence on scholars of the history of atomism during the twentieth century. Writing at the end of the nineteenth century, Lasswitz rediscovered many otherwise neglected figures and showed how rich the landscape of corpuscularian accounts was. Lasswitz devotes an entire section to each of our four authors and provides accurate reconstructions of their philosophies. Sennert, Basson and Gorlaeus have been regarded as corpuscularians first and foremost ever since, both in studies of each of them individually and as a group.[21] Francis Bacon has had a much wider reception, but when he is compared with the other three authors, this usually happens on the basis of the question of his atomism. Although matter theory is not the main topic of this study, the nature of the fundamental particles will be quite important to the argument of the chapters to come.

As a result of the work of the scholars who have walked in the footsteps of Lasswitz, we now have a reasonably clear idea of the corpuscular theories of all four authors. They are generally in line with other corpuscularian theories in the early seventeenth century: 1) Their corpuscles are extended bodies that serve as a hypothesis in physics first and foremost, where they serve to explain certain natural phenomena. 2) As a consequence, the authors do not show much interest in the question of whether there is an absolute limit to division of either geometrical space or of physical bodies. This is in contrast to the situation in the fourteenth century, where the debate between divisibilism and indivisibilism was the dominant one.[22] 3) They either deny the existence of an intramundane vacuum or remain agnostic about it. 4) While they all take inspiration for their corpuscularism from the ancient atomists, their non-acceptance of the vacuum shows that their theories are not simply a revival of Democritean atomism. Lasswitz instead points to another ancient origin for the corpuscular theory, namely

21 Lasswitz, *Geschichte*, I, 332–339 and 413–481. See Gregory's classic articles from the 1960s: Gregory, "Sebastiano Basso"; Gregory, "David van Goorle e Daniel Sennert"; Nielsen, "Seventeenth-Century Physician," 348, takes Sennert, Gorlaeus and Basson as the three examples for early seventeenth-century atomists. See also Meinel, "Early Seventeenth-Century Atomism"; Clericuzio, *Elements, Principles and Corpuscles*; van Melsen, *From Atomos to Atom*. The debate on Bacon's atomism is summarized by Manzo in "Francis Bacon and Atomism."

22 Murdoch, "Beyond Aristotle."

writings of such authors as Hero of Alexandria. The more immediate influence for the seventeenth-century theories, as Lasswitz also documents, was the medieval alchemical tradition, which was in turn inspired by medieval Arabic sources.[23] 5) Two aspects that were not known to Lasswitz, but that have been documented since, are the following: First, the influence of scholastic Aristotelianism on the alchemical tradition (and generally the existence of a corpuscular tradition within Aristotelianism, mainly based on book four of the *Meteorology*).[24] Secondly, some of the most innovative theories of matter in the sixteenth century were formulated by physicians and informed by medical theories.[25] Of special interest in this respect is the influence of the school of Padua, and in particular of Julius Caesar Scaliger.[26]

6. Order of the four chapters

The body of the thesis consists of four chapters, each of them devoted to one of the four protagonists. In a certain sense, the chapters therefore constitute individual studies, though with a common goal in mind and with cross-references where appropriate. The order of the chapters is not chronological with regards to the lifetimes of the authors, but it is roughly chronological with regards to their earliest publications of their non-Aristotelian ideas. Sennert is treated first, since he wrote in favor of unchanging corpuscles already in the first edition of his *De chymicorum cum Aristotelicis et Galenicis consensu ac dissensu* of 1619. Although he became a committed atomist eventually, he also remained a conventional Lutheran scholastic in many other respects. For that reason, chapter one serves also as exposition of the spectrum of scholastic positions on motion and change from which the other authors deviate to a higher degree than Sennert. After the chapter on Sennert, chapter two will treat Basson, whose *Philosophia naturalis* was first published in 1621 and who shares with Sennert a keen interest in medical questions as well as in theories of matter. As for David Gorlaeus, although his *Exercitationes philosophicae* were printed in 1620 and thus a year before Basson's work, his arguments are much less related to medical

23 Lasswitz, *Geschichte*, vols. 1, 217–218, 224. As Newman has shown (cf. next note), Lasswitz was mistaken about the identity of Geber, who is the central figure in this history of transmission.

24 Lüthy, Newman, and Murdoch, "Introduction," 12 f.; Newman, "Corpuscular Alchemy"; Newman, *Atoms and Alchemy*; Clericuzio, *Elements, Principles and Corpuscles*.

25 Hirai, *Medical Humanism and Natural Philosophy*; Hirai, *Le concept de semence*; Moreau, "Eléments, atomes & physiologie."

26 Lüthy, "Aristotelian Watchdog."

and chemical questions than those of Sennert and Basson, which explains why he is treated in chapter three. As for Bacon, an argument could be made that he is the earliest of the four innovators, since the *Advancement of Learning* appeared already in print in 1605, and the *Novum organum* in 1620. His placement as the last author to be treated has to do with the fact that some of the most crucial passages for our study are found the *Abecedarium novum naturae*, which Bacon wrote in 1622. What is more, although all four authors have very different approaches to the project of renovating natural philosophy, Sennert, Basson and Gorlaeus have not without justification been grouped together since the time of Lasswitz. Bacon's emphasis on the reform of method leads him to structure his natural philosophy in a considerably different way than the other three authors do. Beginning with Sennert and ending with Bacon, the progression of the four chapters is therefore also one of an increasing distance from the formal aspects of scholastic natural philosophy.

Within each chapter, our primary text basis will most often be the passages where the respective author writes about the foundational aspects of his physics and metaphysics, especially the descriptions of the fundamental types of particles and bodies and the types of change in each of them. However, on many occasions, physical examples will also be discussed, since often an author's claims about concrete examples allow us to draw conclusions about physical and metaphysical principles not explicitly discussed otherwise. As it turns out, two main examples occur again and again: A stone falling from some elevation downwards to the earth, and a stone being thrown forward or upward. These examples, which are part and parcel of scholastic natural philosophy, are discussed by all our protagonists. They serve as test cases in which enable us to analyze how each author envisions the relationship of the visible local motions of bodies and the postulated motions of the invisibly small parts of matter.

CHAPTER 1

Daniel Sennert

1. "Motus" in Sennert's physics

1.1. *Introduction*

Daniel Sennert (1572–1637), born in Breslau, was a professor of medicine who spent almost his entire career in Wittenberg. As a physician, he was particularly interested in the constitution of human bodies, their health and sickness, their birth and death, as well as in the pharmaceutical powers of natural substances living and dead. Sennert also had a profound interest in chymistry, which manifests itself in the many long sections that he devoted to the transformations of natural substances. He was a prolific and well-respected scholar during his lifetime: His collected works comprise several big tomes, and his name was well known among people interested in medicine and chemistry, even in the second half of the seventeenth century.[1]

In one way, Sennert was a conservative thinker: His works are not discourses meant to sway the opinion, but handbooks and teaching manuals meant for university students. It is therefore with good reason that Mary Patricia Reif included Sennert in her overview of seventeenth century scholastics.[2] At the same time, Sennert is known to scholars as one of the first early-modern atomists, atomism being one of the positions which Aristotle himself had combated most fervently.[3] And yet, Sennert's own atomism is quite different from that of the ancient atomists who had been the targets of Aristotle's critique, though Sennert often cites Democritus in particular

1 The fact that Sennert's collected works were printed several times (first in 1641 in Venice, then at least three more times between 1650 and 1676 in Lyon) can serve as a proxy for his fame around the middle of the century. Newman, *Atoms and Alchemy*, 160 argues that the young Robert Boyle "borrowed heavily and without acknowledgment" from Sennert. See also Klein, "Corporeal Elements and Principles in the Learned German Chymical Tradition"; Klein, "Daniel Sennert and the Chymico-Atomical Reform of Medicine" on Sennert's importance for the development of chymistry.

2 Reif, "Textbook Tradition," 19.

3 Stolberg, "Particles of the Soul"; Debus, *The Chemical Philosophy*, 191–200; Pagel, *The Smiling Spleen*, 86–90; Niebyl, "Medical Ontology," 115–137; Ramsauer, "Die Atomistik des Daniel Sennert"; Lasswitz, *Geschichte*, I, 436–454; van Melsen, *From Atomos to Atom*, 81–88; Hooykaas, *Het begrip element*, 160–166; Thorndike, *A History of Magic*, vol. VIII, 203–217.

with approval. For one thing, he is agnostic about whether the "atoms" that he posits from 1619 on are absolutely indivisible; moreover, instead of Democritus' infinite number of atom-types differentiated by their shapes, Sennert posits only a few types of atoms corresponding to the four elements and to the Paracelsian *tria prima* Salt, Sulphur and Mercury. What is more, he holds that each type of particle has its specific substantial form which is responsible for its own qualities. In this way, he manages to be an Aristotelian as well as an atomist.

As mentioned, Sennert's two main interests in natural philosophy are the constitution of living bodies and the transformations of chemical substances. Both of these topics would seem to have very little to do with local motion, but the concepts in Aristotelian natural philosophy are so tightly connected that one's opinion on one topic will influence most others. In Sennert's case, it is clear that the most interesting and innovative aspects of his system lie in his ideas about the structure of animate as well as inanimate bodies. His claims about local motion, by contrast, do not deviate from the standard Aristotelian account. Because of this, I will use the first half of this chapter to introduce the main lines of the scholastic Aristotelian theories and debates on motion alongside Sennert's views on the same topics.

As will be seen, however, Sennert's innovative matter theory is not truly separate from his account of motion. The complex way in which he combines substantial forms of visible bodies with those of invisible particles implicitly saddles him with an account of the motions of both particles and of bigger bodies that is much more complex than it would seem at the outset. To explain why that is, I discuss Sennert's matter theory and the scholastic debates it depends on in part three of the chapter. In the fourth part, I then examine in what ways Sennert harmonizes his quite conventional account of motion in general with his corpuscularian matter theory.

Sennert came to his hylomorphic atomism not all at once, but gradually over time, being bound by his obligations as a teacher to present his philosophy as a coherent whole compatible with the Aristotelian conception of the sciences. He became interested in chymistry sometime in the 1610s, and by 1619, he had become convinced that many changes in physical substances are to be explained by the configurations of invisibly small particles. Because of these and other gradual changes in Sennert's views, a few words are in order about the texts that will form the basis of the analysis in this chapter.

Over the four decades of his university career, Sennert produced several versions of his main works, and his textual revisions reflect his changing views. The one work that underwent most revisions is probably the *Epitome naturalis scientiae*. The

book that appeared under that title in 1600 is a collection of disputations defended by Sennert's students in the academic year 1599–1600.[4] What was published under the same title in 1618, however, is an elaborate course in natural philosophy, which was revised at least two more times during Sennert's lifetime.[5] The earliest work in which he endorses a corpuscular view is the *De chymicorum cum Aristotelicis et cum Galenicis consensu ac dissensu* of 1619. Later editions of the *Epitome* are at least compatible with the atomism of *De chymicorum* and also reflect Sennert's changing views in other areas, although the *Epitome* remains clearly a textbook of Aristotelian natural philosophy.[6]

Apart from the *Epitome* and *De chymicorum*, the work that I will be quoting from the most is the *Hypomnemata physica*, Sennert's last work. These "Physical Memories" are a collection of essays on the most controversial aspects of his natural philosophy, which "encompasses the cluster of issues raised by the early seventeenth-century intersection of matter theories and the life sciences."[7] Of all these texts, I will use the late versions as they appear in the *Opera omnia* of 1676 whenever it is not necessary to establish Sennert's change in opinion.[8]

1.2. *The proper subject of physics*

What is the status of motion in Sennert's physics? The first two chapters of the first book of the *Epitome* – on "The Nature of Philosophy" and on "The Nature of Physics" – are the obvious place to begin answering this question. As is typical for the textbook style of the *Epitome*, Sennert debates a number of different views on the nature of philosophy in chapter one, but ultimately agrees with Aristotle in saying that there are three sciences, each of which considers being in a specific way. Metaphysics is

4 Lüthy, "Sennert's Slow Conversion"; Lüthy and Newman, "Sennert's Earliest Writings," 264.

5 Newman, *Atoms and Alchemy*, 91 n. 20, claims that the 1618 *Epitome* "reflects a set of uncorrected views belonging among Sennert's juvenilia" and calls the *Epitome* "manifestly nonatomist." The preface to the reader of the 1618 *Epitome* does call it "laborem hunc juvenilem" on the third page, and says that it started "annos quasi viginti" out of some student dissertations – the original 1600 version. However, later editions include significant revisions in the body of the text, even while reprinting the preface from 1618.

6 About the changes in the *Epitome*, see Lasswitz, *Geschichte*, I, 438; Michael, "Sennert's Sea Change," 333–338. In what exact sense Sennert can be called an atomist is the subject of section 3.1, p. 60 below.

7 Hirai, "Sennert, Daniel," 2.

8 I quote the first volume of the edition Lyon 1676 under the sigil "SO," followed by page and column.

the study of being as such; mathematics is the science of being in so far as it can be separated from matter in cognition; and physics considers being as it is in matter and not knowable without matter.[9] In the second chapter, Sennert turns to the question of what the appropriate subject of physics is:

> The adequate subject is therefore the *natural body*, that is, insofar as it has in it a nature, a principle of motion and rest. For the 'natural' [...] is properly taken to be that which contains in itself a nature, that is, a certain internal principle of motion and rest; and so neither motion nor matter are said to be natural, but only bodies composed of matter and form.[10]

Sennert here alludes to Aristotle's definition of "nature" from *Physics* II, 1 as "a source or cause of being moved and of being at rest in that to which it belongs primarily, in virtue of itself and not accidentally."[11] In Aristotle as well as in Sennert, the definition of nature is used to delineate the proper subject of physics in multiple directions. For Sennert, it is necessary to specify that the subject is the natural *body*, because otherwise, matter, form and motion by themselves would also have to count as "nature."

The word "motion" or "motus" here means "natural change." Local motion is just one example of motion in this wider, technical sense, albeit a very important one. That nature is a principle and cause *of motion and rest* separates natural things from those that cannot themselves be moved. First and foremost, this serves to exclude the products of art:

> And even though natural things differ from artificial ones in many ways [...], this difference is enough for us: that natural things have an inner principle of their motion and rest, while artificial ones are not by themselves and insofar as they are artificial outfitted with such a

9 Sennert, *Epitome 1676*, I, 1, SO 3a. Aristotle divides the theoretical sciences into first philosophy, mathematics and physics in book six of the Metaphysics, at 1026a17–32.

10 "Subjectum igitur adaequatum est corpus naturale, hoc est, quatenus in se naturam, principium motus & quietis, habet. Naturale enim [...] proprie sumitur pro eo, quod in se continet naturam, id est, internum quoddam ad motum, & quietem principium; & sic nec motus, nec materia naturalis dicitur; sed sola corpora, ex materia & forma composita." Sennert, *Epitome 1676*, I, 2, SO 4a.

11 Physics II, 1, 192b20, translation from Lang, *The Order of Nature*, 40.

> principle. For that the statue tends downward occurs not insofar as it is a statue, but insofar as it consists of stone or wood.[12]

The distinction of the natural from the artificial is Aristotle's main concern in *Physics* II, and Sennert accepts his solution: Although some things, like a statue, may legitimately viewed as artificial, they can always be viewed as natural as well, and it is only in so far as they are natural that they have an inner principle of motion and rest. Sennert then offers a definition of the subject of physics: The natural body. The "natural" here is meant to denote the distinction from the artificial just outlined, while the restriction to bodies takes up another question raised by Aristotle, namely what distinguishes physics from the other two theoretical sciences, mathematics and metaphysics//theology. These two other theoretical disciplines both have to do with non-bodies: Metaphysics is the study of being *qua* being and mathematics the study of incorporeal mathematical forms. Another convenient effect of the definition, as Sennert remarks, is that it excludes spiritual entities like God and the angels.

Other Aristotelians use other parts of the definition to explain why the natural is distinguished from the non-natural. The Jesuit Aristotle commentators in Coimbra, known as the *Conimbricenses*, for example, argue that the powers of God and the angels constitute an *active* principle of motion, but not a passive one, while mathematical forms have no principle of motion at all.[13] Jacopo Zabarella, whom Sennert quotes often throughout the *Epitome*, explains that the phrase of nature as an "inner principle" does not mean that a nature can *only* be the cause of effects in its own body; that a nature is able to produce such immanent effects in addition to to external ones is merely what distinguishes it from the form of an artifact.[14] On the whole, however, Sennert's definition of the subject of physics has the same extension as that of most other scholastic natural philosophers: it is about corporeal things in the visible world and the changes they undergo naturally, that is, neither by human intervention nor by supernatural powers.

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12 "Etsi vero multis modis res naturales ab artificialibus discrepent [...], hoc tamen discrimen nobis sufficiat: quod Naturalia internum sui motus & quietis habent principium: Artificialia vero per se, & quatenus artificialia, tali principio non sunt praedita: Quod enim statua deorsum tendit, non fit quatenus statua est, sed quatenus ex lapide vel ligno constat." Sennert, *Epitome 1676*, I, 4, 50 9a.

13 Conimbricenses, In Phys. 1594, II, 1, q. 2 a. 3, 208. Cf. Des Chene, *Physiologia*, 232.

14 Zabarella, *De rebus naturalibus*, lib. 4, cap. 1, 315.

1.3. *The nature of motion*

On the face of it, then, the notion of motion – in the technical sense of "natural change" – defines what is natural and therefore the subject of natural philosophy for Sennert, just as it does for Aristotle. But what exactly is motion itself? Chapter nine of the first book of the *Epitome* is dedicated to this question. Sennert accepts again Aristotle's definition, as he did for natural philosophy as a whole. He quotes it as "motus est actus eius, quod est in potentia, quatenus in potentia; vel mobilis, quatenus mobile" – "motion is the act of that which is potentially, in so far as it is potentially; or of the mobile, in so far as it is mobile."[15] The most difficult part of the definition, according to Sennert, is the word "actus" respectively "ἐντελέχεια." He comes to the conclusion that motion is best characterized as an "actus imperfectus":

> For this reason, it is said also in the definition of motion that "motion is the act of that which is potentially." For everything that is moved (as is clear from what has been said) is partly actual, partly potential. [It is] actual with respect to the form and the *terminus* that it has already attained in motion and that it possesses actually; [it is] potentially with respect to [the *terminus*] which it has not yet obtained, and for the sake of which it is still moved. For example, water that becomes hot is said to be moved, namely altered. For it obtains already some degrees of heat and has the potential to acquire more, and reaches them through heating: After it has reached them all, it is said to be heated, no longer to be heating, being altered, and being moved.[16]

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15 Sennert, *Epitome 1676*, I, 9, SO 17b. Sennert quotes Physics III, 1 text. 9 and text. 16, which correspond to 201a13 and 202a7–8 in Bekker. The greek original phrasings are "ἡ τοῦ δυνάμει ὄντος ἐντελέχεια, ᾗ τοιοῦτον, κίνησίς ἐστιν·" and "διὸ ἡ κίνησις ἐντελέχεια τοῦ κινητοῦ, ᾗ κινητόν." The Latin translation that Sennert gives corresponds most closely to the passage at 201a13, which in a modern translation reads "The actuality of that which potentially is, qua such, is change." Aristotle, *Physics III and IV*, 2.

16 "Qua de causa etiam in definitione Motus dicitur: Motum esse actum eius quod est in potentia. Omne enim quod movetur, ut ex dictis patet, partim est actu, partim potestate. Actu respectu formae, & terminus illius, quem iam motu acquisivit, & actu possidet: potestate, respectu illius, quem nondum obtinet, & cuius gratia adhuc movetur. V.g. Aqua quae calefit, dicitur moveri, alterari scilicet. Gradus enim caloris aliquos iam obtinet, potestatemque plures adhuc acquirendi habet, ipsosque etiam calefactione adipiscitur: quos postquam omnes acquisiverit, dicitur calidatum non amplius calefieri, alterari, & moveri." Sennert, *Epitome 1676*, I, 9, SO 18a.

This passage and the definition above use some technical scholastic vocabulary that deserves to be introduced briefly. Firstly, the participles of the verb *movere* are used to distinguish the conceptual elements of the process of natural change. The *motum* is the object that is in motion, also called the *mobile* when one wants to emphasize that it is the specific kind of object that can be moved. Both forms imply a passivity. The active counterpart of the *motum* is the *movens*, the object that does the moving. Finally, *motus* or *motio* denotate the motion itself.

Furthermore, Aristotele teaches that having a form, whether accidental or substantial, is the realization of a specific potential. In the Latin terminology, each form is an *actus* corresponding to a certain *potentia*. Using the classic example that Sennert cites, the accidental form of heat that inheres in the water is the actualization of the water's potential for being warm. Furthermore, each change is the replacement of one form with another: The actualization of the form of heat is also the de-actualization of the form of cold. This means that each change takes place between two forms that are opposed to each other. Since these two forms constitute the two endpoints of the change, they are called its *termini*. When Sennert speaks of the "*terminus* it has already attained," he is therefore drawing attention to the fact that we can think of an ongoing change as a smaller one that is already finished: Water that is in the process of being heated by a certain number of degrees has already been heated by some number of degrees. That smaller number of degrees cannot be the final one, because that would mean that the change is over; neither can it be zero, because then there would not yet be any change.

The change that consists in water heating up is called an "alteration" by Sennert. That refers to the fact that according to Aristotle, change can only take place between forms within the same category and that the character of the change depends on the category that it takes place in. The change in water temperature is a change in the category of quality, and "alteration" is the technical name for such changes. Besides alteration, motion in the wider sense of "natural change" encompasses also change in quantity (augmentation respectively diminuation), change in place (locomotion or *latio*), and change in substance (generation and corruption). The first three are successive changes, while substantial change is instantaneous.[17]

These pieces of terminology are a part of Aristotle's toolkit for describing natural processes, but they seem to complicate rather than clear up the ontological status of motion itself. Accidental and substantial forms taken together describe all that is

17 Aristotle, Physics III, 1, 200b32; Thijssen, "The Nature of Change," 279–290, 281.

real in Aristotle's ontology: Whenever something is real, it is actual and therefore a form. But precisely because of their actuality, forms are static, and motion is defined as that which takes place between one form and another. There seems therefore to be no space for motion itself in the ontology.

That is the problem to which Sennert presents his solution just after the passage quoted above. Ongoing motion, he explains, includes three distinct elements: 1) "Something of the form" that is already actual; 2) a part that is yet unactualized; and 3) a "flow and progress, or, so to speak, a tendency to that form."[18] But what is that "flow and progress," if it is not identical to one of the first two elements? In his most explicit passage on the ontological status of motion, Sennert specifies that it is a "flow" (*fluxus*) rather than a "flowing form" (*forma fluens*):

> For since in whatever motion there are two things, one the flowing form itself, the other the flow of the form, motion is formally neither simply the form nor the flowing form, but rather the continuous acquisition of the form, and the flow of it being partly acquired, partly to be acquired. For to be moved is not to have a form, but to be moved is to tend towards form.[19]

This statement contains more terminology. This time, however, it is not directly related to Aristotle's texts, but was created in the course of the scholastic debates. To appreciate the extent to which Sennert takes a position on the ontological status of motion in the passage just quoted, I will now summarize the main lines of that scholastic debate.[20]

As with most other issues in Aristotelian philosophy, the discussion about the ontological status of motion has its roots in tensions between various passages in Aristotle's own writings. Due to the direct link between the natural and that which has a principle of motion, almost any part of his natural philosophy is potentially relevant, but the single most important stretch of text on the definition and nature of motion are the first three chapters of the third book of the *Physics*. In the first two

18 "aliquid formae"; "fluxus, & progressus, seu, ut loquuntur, tendentia ad illam formam." SO 18a.

19 "Cum enim in quolibet motu duo sint, vnum ipsa forma fluens: alterum fluxus formae: Motus formaliter neque est forma simpliciter, neque forma fluens, sed continua acquisitio formae, eiusque partim acquisitae, partim acquirendae fluxus. Moueri enim non est habere formam; sed moueri est tendere ad formam." SO 18a.

20 The entire debate on the ontological status is distinctly medieval, since neither Aristotle himself nor his Greek commentators raise it explicitly. Trifogli, "Change, Time and Place," 268.

chapters alone, there are four slightly different definitions of motion: three in chapter one and one in chapter two. The definition quoted by Sennert is the last of the four.[21]

However, the systematic issue about the nature of motion arises not so much from these varying definitions within the same treatise as from a tension between the perspective of the *Physics* and that of the *Categories*. At the very beginning of his treatment in the *Physics*, Aristotle divides change into local motion, qualitative change, quantitative change and generation//corruption:

> There is no change apart from actual things; for whatever alters always does so in respect either of substance, or of quantity, or of qualification, or of place, and there is, as we assert, nothing to be found as a common item superior to these, which is neither a "this" nor a quantity nor a qualification nor any of the other occupants of categories; and so there is no change or alteration either of anything apart from the things mentioned, because nothing *is*, apart from the things mentioned.[22]

This passage states quite clearly that change takes place within the categories or at least is not something outside the categories. That has a certain anti-realist import, since it would seem to imply that motion as such is not in one category, but in several, and therefore is not itself an "actual thing," in the phrasing of the quotation above.

In the *Categories*, Aristotle gives three more definitions of change. In chapter fourteen, he calls it a post-predicament that belongs to several categories, which is compatible with *Physics* III.[23] But in chapters five and nine, he seems to imply that change is in the category of passion, which would of course mean that it is in a single category after all.[24] This is not a direct contradiction, since Aristotle does not directly say that change is a passion, but he does use instances of natural change as examples of passions, namely warming up and cooling down.[25]

The two greatest Arabic commentators of Aristotle, Avicenna and Averroes, are both central to how the scholastics received this exegetical problem. Avicenna (in

21 The four definitions are at 201a13–14, 201a28–29, 201b4 and 202a7–8 in Bekker, which corresponds to textus 6, 9, 10 and 16 in the *translatio nova*. See Maier, *Zwischen Philosophie und Mechanik*, 5–9 for a discussion of the various definitions of motion in *Physics* III, 1 and of the Latin text known to the early scholastic authors.

22 Physics III, 1, 200b33–201a3. Translation from Hussey, *Physics III and IV*, 2.

23 *Categories* 14, 15a15–15b5.

24 *Categories* 5, 4a10–4b4 and *Categories* 9, 11b1–7. Cf. McCullough, "St. Albert on Motion," 129–153, 131 f.

25 Maier, *Zwischen Philosophie und Mechanik*, 61 n. 1.

book two, chapter two of his *Sufficientia*), takes the opposite position of Averroes' on this question. Avicenna is of the opinion that the provision of new forms is outside the order of nature: Natural processes are restricted to the preparation of matter for the reception of forms. Consequently, Avicenna's opinion is that motion is neither an action nor a perfection, but that rather the four types of natural change are four species within the genus of passion. Not only is change therefore within a single category, but it is practically identified with the category of passion.[26]

Averroes' influence on the Latin scholastic discussion on the nature of motion is due to two "digressions" on *Physics* book III and V.[27] In those digressions, he solves the apparent contradiction between the *Physics* and the *Categories* by distinguishing two aspects of motion: Viewed from one perspective, motion is in the genus of the perfection (i.e., the form) towards which it is a motion and differs from that perfection only in degree. From the other perspective, motion is the *way* towards that perfection, and as such it is in its own genus. The first perspective, according to Averroes, is the one of the *Physics*, while the second one, defended in the *Categories*, is more famous but less true. In his second digression, Averroes calls the latter "change according to form" and the first "change according to matter." His later medieval readers understood Averroes as preferring the perspective of the *Physics*.[28] Albert the Great then takes into consideration the positions of both Averroes and Avicenna and coins the expressions by which they would be referred to by later authors. Motion, he explains, can be understood either as a *forma fluens* or as a *fluxus formae*. The first corresponds to what Averroes, according to his scholastic readers, calls motion *secundum materiam*: Motion is the successive acquisition of the *terminus ad quem* and falls under the category in question.[29]

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26 Avicenna, *Sufficientia*, II, 2, in Avicenna, *Liber primus naturalium* I, 175–185; McCullough, "St. Albert on Motion," 133 f.; Maier, *Zwischen Philosophie und Mechanik*, 72.

27 The two digressions are on book III, 1, text. 4 and book V, 1, text. 9 in Averroes' own division in his *Long Commentary*, which correspond to 200b32 and 225b5 in Bekker. See Averroes, *Opera*, IV, 87A and 215B.

28 Thijssen, "The Nature of Change," 285; Maier, *Zwischen Philosophie und Mechanik*, 62–67.

29 Maier stated this first in "Die scholastische Wesensbestimmung der Bewegung"; then in more detail in *Zwischen Philosophie und Mechanik*. The latter account gives more attention to the origins of the distinction in the two Arabic authors. McCullough, "St. Albert on Motion," 152 f., criticizes Maier by claiming that firstly, Albert's contribution is more original versus his sources than her reconstruction suggests and secondly, Albert's own account is more ambiguous than suggested by the dichotomy of *forma fluens* and *fluxus formae*. In any case, what is at issue here is that Albert's successors until the 14th century understood the issue as a simple dichotomy, and in this sense, the origin of the debate lies with him. On Albert's position and argument, cf. also Hossfeld, "Das dritte Buch der Physik"; Meyer, "Bewegung bei Albert dem Grossen."

To go back to the example quoted by Sennert, the qualitative change of water becoming gradually hotter is the acquisition of the quality of heat. What the theory of *forma fluens* claims for this case is that the intermediate states of the changing object are simply imperfect actualizations the final degrees of heat. In other words, becoming hot is the same as being hot, but in the mode of becoming. Local motion, seen through this lens, is the successive acquisition of the *ubi* of the motion's endpoint, with the intermediate positions as incomplete actualizations of that endpoint. This amounts to the claim that motion has no nameable reality that is distinct from the forms being actualized. Understood as a *fluxus formae*, on the other hand, the same process of water becoming warmer is the way towards the *terminus* and categorically distinct from it. Albert attributes this latter view to Avicenna.[30]

Within the two main alternatives opened up by Albert's distinction, later scholastics made further specifications. On the whole, scholastics of the fourteenth century and later tended to lean more towards the "realist" option of *fluxus*, while earlier medieval scholastics tended to downplay the independency of motion from form. William of Ockham stands on the extreme antirealist side of the spectrum. According to him, local motion is identical, not to an *ubi fluens*, but to the moving thing that is in changing places itself.[31] Ockham argues against the *fluxus formae*-account that it implies the existence of successive entities: If motion is distinct from the *terminus*-forms as well as from the moving thing, as these are all the permanent things that are involved, motion itself will have to be a successive thing with its own reality. But it is unwarranted to assume the existence of successive things when all notions that seem to involve them can be analyzed in terms of concrete singulars, which is what Ockham does in his own, more minimalist account.[32]

Up to Ockham's time, some version of *forma fluens* had been the majority position. However, all the most prominent natural philosophers of the late fourteenth century, i.e., John Buridan, Nicolas Oresme, Albert of Saxony and Marsilius of Inghen, took the realist stance. They accepted the conclusion that had seemed impossible to Ockham

30 As Maier remarks, this is one of the points on which Albert misrepresents Avicenna: The *fluxus formae* is outside all categories according to Albert, while it is a passion for Avicenna. *Zwischen Philosophie und Mechanik*, 77.

31 Ibid., 100; Shapiro, *Motion, Time and Place*, 38–40.

32 Thijssen, "The Nature of Change," 286 f.

and regarded local motion as a successive entity, rather than the changing relations of the *motum* to external place. Some of them extended this view to all change, others restricted it to local motion only.[33]

Buridan is among the latter: He treats qualitative change separately from change in place. He agrees with Ockham that alteration is nothing over and above the changing thing and its qualities, but holds that local motion is internal to the moving thing. Part of Buridan's reason for holding that motion is independent from the relation to space is the condemnation of 1277: The Bishop of Paris had condemned a series of propositions, among them the proposition that "God could not move the heavens in a straight line."[34] This condemnation established that it is possible for God to move even the outermost sphere; Buridan draws the conclusion that since there is no external place to which a local motion of that sphere could be referred, it must have an additional internal component in relation to which the cosmos in motion can then be said to be "one way earlier, one way later."[35] From this supernatural case, Buridan argues that all local motion is a successive entity distinct from the *mobile*.[36]

Albert of Saxony agrees with Buridan that the *fluxus*-account is in fact true, although it is in his opinion not the correct interpretation of Aristoteles and Averroes.[37] Nicolas Oresme sees himself as a proponent of the *fluxus* side of the argument as well, but also distinguishes his own interpretation of the *fluxus* from Buridan's and Albert's. Oresme maintains that motion, while it is a successive entity, it is not a *res* but a *modus rei*, an internal process within the changing thing that can serve the function of Buridan's successive *res*. What is more, he distinguishes his own view and one that amounts to Buridan's as two versions of the view that motion is a *fluxus*:

> From what has been said before, the fifth opinion can be drawn out, namely that motion is a successive thing simply distinct from the permanent ones. And [this] can be understood in two ways: First, that it is one thing inhering in an incomplex signifiable like a form, and so it is not true; second, that it is a condition or a mode of the moving thing itself, and so it is true.[38]

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33 Pasnau, *Metaphysical Themes*, 381; Thijssen, "The Nature of Change," 288–290.

34 Hissette, *Enquête sur les 219 articles*, 118 f., n. 66.

35 Thijssen, "The Nature of Change," 288; Buridan, *Ultima lectura* lib. III, q. 7, concl. 6, 79.

36 Des Chene, *Physiologia*, 38.

37 Thijssen, "The Nature of Change," 288 f.

38 "Ex predictis potest elici quinta opinio, scilicet quod motus est res successiva distincta simpliciter a permanentibus. Et potest dupliciter intelligi: primo, quod sit una res inherens significabilis incom-

Oresme therefore strikes a compromise between a reductionist and a realist ontology of motion: That motion is a *fluxus* and a successive entity is a concession to Buridan, while the insistence that it is nevertheless not properly speaking an *ens* or a *res* is indebted to Ockham.[39] As we will see in section 2.8, the late medieval realists about motion are the same philosophers who introduced the theory of *impetus*. Although connected, these are two separate issues, since the notion of *impetus* is meant to solve a conundrum about causality that occurs only in the specific case of projectile motion.

Many scholastics wrote on the nature of motion in the two centuries between the late fourteenth century and the beginning of the seventeenth, but rather than introducing any genuinely new solutions, most of them fall somewhere on the spectrum defined by the reductionist and the realist option. For example, both Francisco Toletus and Eustachius a Sancto Paulo lean more towards Ockham than towards Buridan, as they agree that there is no real distinction between a motion and its *terminus*.[40] The same is true of the Coimbrans, who specify the type of distinction further by claiming that it is a formal distinction of two modes within the same essence:

> We respond to the opinion of those who hold that motion is nothing other than the flowing form itself, [by saying that] motion is not distinct from the term, *except as a different mode of the same essence* [...]. And according to the opinion of others, which we stated, judging that motion properly and formally is the flow itself, or the progression towards the form, it would have to be said that motion is essentially distinct from the term. Indeed, motion is by its nature something successive, as we have shown above. However, that is not so with the form which is acquired, like for example the heat, even in the meantime until the acquisition ends. For if it were successive by its nature, then its nature would surely also consist in succession after the acquisition, the motion having ended, which is far from the truth.[41]

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plexe sicut una forma, et sic non est verum; secundo quod sit conditio vel modus ipsius mobilis, et sic est verum." Oresme, Quaestiones super Physicam III, quest. 6, l. 90–94, cited after Caroti, "Oresme on Motion," 24.

39 Ibid., 32 f.

40 Toletus, *Commentaria in octo libros Aristotelis de physica auscultatione* III, 2, q. 3, in *Opera philosophica*, IV, 87ra-b; Eustachius a Sancto Paulo, *Summa philosophiae*, III, 163. Cf. Des Chene, *Physiologia*, 38 f.

41 "Respondemus in eorum sententia, qui motum nihil aliud esse, quam ipsam formam fluentem opinantur, non distingui motum a termino, nisi penes diversum modum eiusdem essentiae

Although their ultimate stance is rather anti-realist, the Coimbrans see themselves as making a compromise between the two main options: Motion is not the flowing form, since it differs from the *terminus* as a mode of the same essence; but at the same time, motion is also not the flow, since that would imply that it is distinct in essence from the form of the terminus. To mention a last example, Zabarella follows Averroes in saying that the definition of motion properly belongs only to local motion, to motus in the other categories only analogously.[42] In sum, the ontology of change is a difficult problem for scholastic Aristotelians. In their solutions, they take advantage of the leeway offered by the ambiguity of the relevant passages in Aristotle, some ascribing more independent reality to local motion than others. The general tendency is that the theories first proposed in the fourteenth century lean more realist than earlier ones, but all the major variants are still known around 1600.

Where does Sennert fit into this framework? As we are now able to tell, the fact that he defines motion as a *fluxus*, while not entirely devoid of meaning, is not particularly unusual either. After all, by 1600, it had become quite uncommon to maintain the alternative opinion that motion is the flowing form. Although his definition of motion signifies a step towards realism, it does not commit Sennert to the claim that motion is its own being, since there are non-realist interpretations of motion as a flux. We might recall the position of Oresme in particular, who treads a fine line between the realist and the antirealist options by maintaining that motion is a mode.

In the end, however, Sennert does not seem very interested in the exact ontological status of motion. Having decided that the accent should be placed on the flow rather than the form, he sets the issue aside. As far as I can see, he does not further pursue the implications of this position, for instance by asking whether the motion is really or merely rationally distinct from the flowing form. Evidently, Sennert believes that there is no need to discuss that in the introduction to a work in natural philosophy.

[…] Ac iuxta aliorum opinionem, quam statuimus, arbitrarium motum proprie, ac formaliter esse ipsum fluxum, seu progressionem ad formam, dicendum erit motum distingui essentia a termino. Enimvero motus secundum suam naturam est quidpiam successivum; ut superius ostendimus; forma autem, quae acquiritur, ut calor, verbi gratia; non ita se habet, etiam interim dum acquisitionem subit; quia si tunc secundum suam essentiam foret successivus, utique etiam post acquisitionem, finito motu eius natura in successione consisteret, quod longe aberrat a veritate." Conimbricenses, *In octo libros Physicorum* [Lyon 1594] III, 2, q. 3, a. 2, vol. 1, 342 (pagination occurs twice).

42 Zabarella, *In libros Aristotelis physicorum* (Venice 1601) III, text. 6, 70^{v}.

The questions we have addressed up to here in this chapter are the most general and abstract questions an Aristotelian can ask about local motion, namely the definitions and the nature of natural change in general. But of course, that is by no means all that can be said about local motions from an Aristotelian perspective, and Sennert does in fact say more. We now turn to discussions of local motion that are less abstract, namely concerning the local motions of concrete, visible bodies. The discussions and positions concerning these motions are still quite heavily shaped by the framework of Aristotelian physics, but nevertheless, the phenomena being explained in this part of Aristotelian natural philosophy are easily recognizable as local motions of bodies even if one does not share most of the Aristotelian assumptions.

2. Motions of visible inanimate bodies

2.1. *Subdivisions of physics and natural things*

We have seen in the previous sections that Sennert's Aristotelian framework necessitates that the subject of physics is very closely linked to the idea of an internal principle of change. One might therefore expect that the program of physics would consist in large part in developing this idea: Analyzing the types of internal principles that there are, the kinds of bodies in which they occur and the sorts of effects they usually have. After a fashion, that is exactly what Aristotelian physics consists in. Most of these principles and motions, however, remain at a very general level. When they are explicitly mentioned, it is mostly in a methodological context, since the various subdisciplines within physics are generally taken to be distinguished by their subjects. In this section, I will go over Sennert's view of the proper subdivisions of physics and their relations to the principles of change. As we have seen in section 1.1, Sennert defines the proper subject of physics as the natural body. Knowing that in his chymical writings, Sennert espouses atomist views that seem strictly opposed to Aristotle's opinion, one might suspect that he is not really committed to the physical consequences of Aristotelian definitions such as this one. The current section will show that this is not the case, and that Sennert instead has a deep commitment to the substantial form as the only causal agent in nature.

After defining physics as a whole and its subject in book one, chapter two of the *Epitome*, Sennert goes on to draw distinctions between the subdisciplines or parts of physics. There is first a "common" part, which treats all the properties that bodies have in common as far as they are natural, and which is modeled on what Aristotle

does in the *Physics*. Secondly, the "proper" part of physics treats each species of natural body in order. According to Sennert, this is what Aristotle does in his various other works on natural philosophy.[43]

The subdivisions of "special" physics therefore coincide with the distinctions among the different types of natural bodies. The top-level distinction is that between *simple* and *mixed* bodies. The celestial bodies are simple and of a completely different nature than all the bodies below the sphere of the moon, so they each have an own part in particular physics. The four elements are also simple bodies. Insofar as they are their own bodies that form part of the world, they are treated together with the celestial bodies, but they have a second role as the principles of mixed bodies. Mixed bodies, in turn, are divided into perfect and imperfect mixts. Perfect mixts are either the homogeneous parts of living things or fossils and metals. The latter two are treated in a separate part of physics, while the first are treated in the part on animals.

To judge from this division of the parts of natural philosophy, the distinction between the animate and the inanimate realm plays only a very minor role. That is surprising, since the distinction between animate and inanimate beings is the single most important distinction within nature for Aristotle as well as for most of his scholastic commentators. One of the main topics of *De anima* is how the soul and the body are related in the self-motion of animals.[44] It is a difficult question whether the powers of plants should count as self-motions for Aristotle,[45] but a certain kind of self-motion is ascertained for at least a subset of living things. Obviously, then, to have an "internal principle of motion and rest" cannot be the same as to be capable of self-motion.

For scholastic Aristotelians, there are only very few types of local motions that follow simple and general rules. To some extent, this is due to Aristotle's teachings on the motions of animals: Animal motions are not only conceptually different from other motions, but they also follow different rules. All animals move and grow to attain what is beneficial to them and to evade what is noxious, but there is no simple regularity to the movements that result from this capacity.

The number of things that are a) natural substances, b) in the sublunar sphere and c) inanimate is very limited. There are only two basic cases: The four elements and the bodies composed of them. When the pure element earth moves downwards to the center of the cosmos or the element fire moves upwards to the lunar sphere,

43 The following is a paraphrase of the last part of *Epitome 1676*, I, 2, 80 5a.

44 See De anima II, 2, 413a21.

45 See Coren, "Aristotle on Self-Change in Plants."

those are called *natural* motions, and the regions in space towards which each of them tends is their *natural place*. Actual heavy and light bodies fall and rise because of the fire, air, water and earth contained in them – their falling or rising motion is a more complex case derived from the ideal case of the elements. However, these derivative cases are still called natural motions, and the places towards which the heavy and light bodies tends are called natural places.[46]

In the next three sections, I will discuss the ideal case of the natural motion of the heavy and light elements, the scholastic debate about the efficient causes for such motions, and Sennert's position within that debate. In the section following that, I will first discuss scholastic explanations of the fact that actual heavy bodies do not fall with a uniform speed but accelerate. In a final group of three sections, I will discuss the one case of non-natural local motion in which the scholastics do acknowledge some regularity, namely the motion of projectiles.

2.2. *Why do things move?*

As mentioned, the fall of the heavy element earth and the rise of the light element fire are the simplest cases of natural motions in the Aristotelian system. Much of Sennert's position on this special case (which I will henceforth be calling "gravitational motion") is found in a relatively compact passage in the *Epitome*:

> For if it is asked what the efficient cause of the motion is, by which fire and earth, while already actually existing by their own forms, are moved, [fire] straight upwards, and [earth] straight downwards, unless they are violently detained by something else, we answer simply: Fire is moved by the form of fire, as by a proximate cause, away from the center of the world upwards, earth [is moved] downwards towards the center of the world by its form. For this motion is natural to them, which is also why it is necessary that it stems from the nature or internal principle, which is the form, not from an external [principle].
>
> Add to this that in *Physics* II, 3 text. 37, it is said that "an actually existing effect requires an actually existing cause," and this especially in effects whose entire being is in becoming, as it is with motion. For

46 Maier, *An der Grenze*, 144 f. Aristotle discusses the natural motions of the four elements in De Caelo III, 2, 300a20–302b2, among others.

> if its cause is removed, it [*sc.* the motion] is removed as well, for it can never be separated from the efficient cause. Now, the motion of elements is an actually existing effect. Therefore, it requires an actually existing cause, which can be none except the form. For the form alone exists always actually with the motion, while the other causes which some bring forwards, like the *generans* and the *removens impedimentum* can be separated from the motion and, while the motion persists, [they might] either perish or, if they do not perish, nevertheless not coexist with the motion.[47]

Sennert's opinion is that what causes gravitational motion is the substantial forms of earth or fire. After explaining what kind of motions he has in mind, he argues first that, since the substantial form of the element is its nature and nature is by definition a principle of motion and rest, the word "principle" should be simply understood as "efficient cause." In the second part of the quotation, he argues further that the substantial form is the best candidate to be the efficient cause, because it necessarily always exists whenever a motion exists and cannot be separated from it.

This seems like a plausible argument supported by two of Aristotle's fundamental principles (the definition of nature and the co-existence of cause and effect), but it is actually quite far from what Aristotle had written about the efficient cause of gravitational motion. To explain the difference, I will now have to give some context about how Aristotle poses and solves the problem and about the transformation of both problem and solution in scholastic philosophy.

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47 "Nam si quaeratur, quae sit caussa efficiens motus, quo ignis & terra, iam actu per suam formam existentia, ille recta sursum, haec recta deorsum, nisi violenter ab alio detineantur, moveatur; simpliciter respondemus: A forma ignis, ut proxima caussa, ignem a medio mundi sursum, terram a forma sua ad centrum mundi deorsum moveri. Motus enim hic ipsis naturalis est; quapropter etiam natura, seu interno principio, quod forma est proficiscatur necesse est, non ab externo. Hoc enim rerum naturalium proprium est, in se habere sui motus principium, ut 2. Physic. C. 9 t. 48 videre est. Forma etiam Elementi, quae informat, & natura est motus quoque principium est.

Accedit his & illud, quod vt 2. Physic. c. 3. t. 37. dicitur; effectus actu existens requirit caussam actu existentem, idque praecipue in effectis, quorum totum Esse in Fieri est, qualis est motus: huius enim caussa sublata, ipse etiam tollitur, nec vnquam a caussa efficiente separari potest. Motus autem Elementorum est effectus actu existens. Existentem igitur actu requirit caussam quae nulla esse potest praeter formam. Haec enim sola cum motu semper actu existit: reliquae vero quas nonnulli afferunt, caussae, vt generans, remouens impedimentum, possunt a motu separari; & eodem adhuc existente, vel interire, vel si non intereant, motui tamen non coexistere." Sennert, *Epitome* 1676, II, 3, SO 27b.

As Aristotle sees it, there are two general issues with gravitational motion. A first, lesser complication is that it is not completely clear what role the medium should play. Since Aristotle does not recognize the possibility of a vacuum, even the idealized natural motions of fire and earth are thought of as taking place in a medium that offers some resistance. But there is also a more conceptual problem, one that calls the distinction between animate and inanimate substances into question. Since these are the two main types of physical substances, both have an inner principle of motion; but one of the distinguishing properties of animals is that they have self-motion, so inanimate natural substances must have an inner principle of motion without being capable of self-motion. Two dangers arise from this: on the one hand, there is the risk of conflating natural inanimate motions with animal self-motion and thereby depriving oneself of a principled distinction between the animate and the inanimate; on the other hand, there is the opposite risk of drawing the distinction in so sharp a manner that it becomes impossible to explain why both types of substances are natural.

Aristotle distinguishes these two types of physical substances by way of the relations of their forms to their motions. The elements are natural things, that is, they have an inner principle of motion. But the motions of which their natures are the principles are not of the same kind of motions as the self-motions that define living substances.

As is spelled out in these distinctions, gravitational motion is natural, which means that it does not depend on the motion of another visible body but is also not caused by the heavy object itself. Aristotle gives a detailed analysis of natural motions in order to explain how this is possible. In *Physics* VIII, 4, he begins by making a number of distinctions: Motion is *per se* when it seems to take place on its own, whether that impression is true or not. It is *per accidens* when it visibly depends on another motion, like that of a passenger in a ship. Motions *per se* can further be *a se* or *ab alio*. Motion *a se* is the prerogative of animates, as mentioned. Non-living things such as the elements move therefore *per se*, but *ab alio* when they engage in their natural motions.[48] All their other motions are called *violent* motions.

The difference between natural and violent motions, as Aristotle makes clear in the same chapter, lies in the fact that a substance undergoing a natural change has a specific potential for that change. Natural change can take place in the category of quality: For example, a body that has the natural disposition to be heated is already

48 Physics VIII, 4, 255a. Cf. Maier, *An der Grenze*, 146.

potentially warm. However, the main examples of both natural and violent change are local motions, most especially those of heavy bodies.

That example is analyzed as follows. A heavy body that moves towards its natural place fulfills a certain potential that is within it. When the same heavy body is lifted up, away from its natural place, there is no such potential, which manifests itself in a resistance to that motion. Because of this, natural motion fulfills the definition of motion in a stronger sense than violent motion: The fall of a heavy body is the actualization of a potential for falling.

Aristotle, still in the same chapter four, then makes another distinction: The potential of an existing heavy body to move to its natural place is a merely *accidental* potency, since motion is a change in accident rather than in essence. But before this potential can come into play, an *essential* potentiality must already be actualized, namely the potential for a body with such properties as heaviness to come into existence. Since the four elements have the potency to change into one another, such an essential potentiality remains in all actual heavy or light bodies: The same prime matter that is at one time informed by the forms of fire or air can later become informed by the forms of water or earth. The actualization of the essential potency is the tendency to move downwards (*gravitas* or *pondus*), that of the accidental potency is actual downwards motion (*gravitatio*).[49]

As Aristotle recognizes, this analysis does not yet provide a good explanation of why a concrete natural motion occurs. Three out of the four Aristotelian causes are provided by it: The natural place a falling heavy body moves towards is the final cause of its motion; the form of the falling body is the formal cause; and the falling body itself is the material cause. But there is no obvious efficient cause. One way out would of course be to suppose that gravitational motion is caused externally by another body, for example because the natural place attracts the heavy body. But since it is a principle of Aristotelian physics that efficient causation presupposes physical contact, that is not an option.[50] Aristotle's solution is that in order to give an efficient cause for the fact that a heavy body falls down, it suffices to explain how it came to have the two potentialities that are actualized in the fall. In that sense, there are two different efficient causes to a gravitational motion, one for each potentiality: The *motor essentialis* is the generating cause that gave the heavy body its essence (the *generans*, in scholastic terminology), while the *motor accidentalis* is the external cause which

49 Ibid., 149.

50 According to Physics VII, 2, 243a32, an external cause of motion either pushes or pulls, but is always in contact with the moved.

removes the obstacle impeding the natural tendency to motion, the so-called *removens prohibens*. In scholastic theories, the *motor essentialis* inducing the elemental forms into matter is a higher force coming either from the heavenly sphere or from God directly. For Aristotle, the generating cause of a piece of elemental mass is in most cases another elemental substance which surrounds and assimilates a smaller mass of foreign matter. The scholastic solution is therefore the following: A concrete natural motion is nothing more than the moved body actualizing its accidental potency for being in its natural place. As such, it does not need any efficient cause except the removal of any obstacles. In another sense, the efficient cause of the same motion is that which is responsible for inducing the essential form of a heavy or light element into matter, since it is because of that form that the body has the accidental potency for its natural place.[51]

2.3. *Why do things continue to move?*

If the issue concerned only the nature of the efficient cause responsible for the beginning of a falling motion, the theory as explicitly given by Aristotle might have sufficed. However, Aristotle does not provide a satisfactory efficient cause for the fact that heavy objects continue their motions all the way to their natural place, seemingly without any further influence from external forces. Such a cause is necessary because without it, a body in motion would naturally tend to come to rest. As Maier makes clear, this is one of the fundamental differences between scholastic and Newtonian physics: Newton's principle of intertia treats any state of motion the same, so that no explanation is needed why a moving body remains in motion.[52]

In the case of gravitational motion, Aristotle offers no clear answer what the cause of the continued motion is, so finding one is a distinctively scholastic problem. The most promising candidates are the two other causes that Aristotle mentions beside the *generans* and the *removens prohibens*. These are the *motive qualities* and the substantial form of the falling body. The key passages describing both causes are found in *De Caelo*. The motive qualities are introduced in greatest detail in *De Caelo* II, 2,

51 Maier, *An der Grenze*, 148. See ibid., 13, on the *virtus caeli* as the giver of forms. Wood, "The Influence of Arabic Aristotelianism," 261, emphasizes that this specific part of the doctrine of mixture has its origins in Avicenna, despite the fact that Avicenna's theory of mixture was otherwise almost always rejected. See below p. 69 on scholastic mixture theory.

52 Cf. Maier, *Zwei Grundprobleme*, 122; Maier, *An der Grenze*, 149, 174; Sarnowsky, *Die Aristotelisch-Scholastische Theorie*, 312.

where Aristotle offers a typology of the qualities. He teaches that most qualities of visible bodies (the sensory qualities of smell, taste and color, in particular) are *secondary* qualities that result in some way from the *primary* qualities of the elements, i.e., hot, cold, wet and dry. Each of the four elements has two out of the four primary qualities, so that fire, for example, is defined by being hot and dry. How the primary qualities of the elements relate to the secondary qualities of the other bodies is a difficult issue in matter theory, but not immediately relevant to local motion. Each of the four elements has only one other quality, namely either that of *gravitas* or of *levitas*, and these are the motive qualities. They are not active in the same sense as the primary qualities: A heavy body does not create heaviness in other bodies that it touches, whereas a hot body makes anything that it touches hot. On the other hand, heaviness and lightness *are* active in the sense that they act as efficient causes of natural motions.[53]

The last candidate for the efficient cause of natural motion is the "nature" of the moved body itself, also termed its essence or form. The most prominent passage for this is in *De Caelo* III, 2. There, Aristotle phrases the distinction between natural and violent motion in a way that can be understood as saying that the nature of a body is the cause of its natural motion:

> It is therefore obvious that every body must have a definite weight or lightness. But since a source of movement within the thing itself is its nature, while a force is a source of movement in something other than it or in itself *qua* other, and since movement is always due either to nature or to constraint, movement which is natural, as downward movement is to a stone, will be merely accelerated by an external force, while an unnatural movement will be due to the force alone.[54]

Scholastic commentators therefore needed not only to account for what Aristotle had written on the roles of the *generans*, the *removens prohibens*, the nature and the motive qualities, but they also needed to find a way to explain the continuation of motion, using the same terminological resources. The solution of the earlier scholastics was to extend Aristotle's answer: The *generans* is the efficient cause not just of the fact that a heavy body begins to fall, but also of the fact that it continues to do so. The reasoning for this is that the *generans* gave the heavy body its substantial form and with it all the

53 Maier, *An der Grenze*, 10, 150. On scholastic views of primary and secondary qualities, see p. 70 below.

54 Aristotle, *De caelo* III, 2, 301b16–21, trans. in *Complete Works*, I, 494.

qualities that flow from that form, including the *gravitas*. This enables an analysis that has a place for all of the causal factors: The continuing falling motion is the direct result of the activation of the quality of heaviness; that quality can only be effective in so far as it is an instrument of the substantial form; the form in turn cannot act directly, but only through its qualities; the *generans* is the cause of the motion insofar as it is that which introduced the substantial form and its accidents.[55]

Within this scheme of analysis, the earlier scholastic authors saw the *generans* as the only mover, while the later ones gave more importance to the substantial form. Gradually, this went so far that the later scholastics came to see the substantial form as a kind of internal mover, the origin of a force that is internal to the *motum*.[56] But irrespective of whether they recognized in the substantial form the main mover or merely a derivative one, all theories that attributed a causal role to the substantial form had to deal with the objection mentioned at the outset: Nothing can be the mover and the moved in one and the same motion. Even animal self-motion is only possible because animal bodies have distinct parts.

The debate among can be roughly divided into three chronological stages: In a first stage, Albert the Great, Thomas Aquinas, Siger of Brabant, Aegidius Romanus and others all name the *generans* as the principial agent, with the substantial form as its primary instrument. In an intermediate stage, Peter of Alvernia and Godfred of Fontaines claim that the motive quality of heaviness, not the substantial form, is the immediate instrument of the *generans*. The turn to the final stage comes with John Duns Scotus, who explicitly claims that it is an inner principle (not the *generans*) that is the main cause. All the most famous natural philosophers of the 14th century then agree with Scotus on this main point: The *generans* has become a mere general cause for John Buridan, Albert of Saxony and Marsilius of Inghen, although it is not clear in every case whether they mean the principle cause to lie in the substantial form or in the accidental form of *gravitas*.[57]

55 Maier, *An der Grenze*, 155.

56 As we will see in section 2.6 of this chapter, this development is parallel to the evolution of the impetus theory of projectile motion. Cf. Ibid., 157.

57 Ibid., 158–170. There are also other explanations of fall that were discussed by scholastics, among them the attraction of like and like, the idea that the heavy body is repulsed by the heavens above, and the idea that the natural place itself acts as an efficient cause, i.e., a form of attraction. Roger Bacon, for example, has a theory that involves something akin to a gravitational field. However, these alternative explanations did not find a broad scholastic reception. Ibid., 172–182.

2.4. *The form as cause of gravitation*

With this, we may return to Sennert. When we hear him claiming that the efficient cause of gravitational motion is the substantial form of the moving body, we may now ascertain that he is taking a position that is by no means new, though it is clearly different from that of Aristotle. Having stated his position, Sennert gives a reply to the common objection leveled against it, i.e., the objection that mover and moved must be distinct. In the continuation of the passage quoted above, on p. 31, Sennert explains:

> Neither is this opinion hindered by what was said above about motion: That the *mobile* is distinct from the *movens*, will obviously not apply to the motion of the elements if the form is said to be the *movens*. For earth, when it is moved to the center, is not moved insofar as it has matter. For matter is in itself no more apt to be moved upwards than downwards, but is able to receive all motions without distinction. But [earth is moved] insofar as it has a form, which determines and restricts the matter's potential to receiving this [specific] motion. For this reason, since the form is here the passive principle of motion, it cannot also be the active principle.[58]

Sennert here presents not just a general objection but explains why this objection is effective against a specific version of the position he himself wants to maintain. If the substantial form is understood to be the agent, so the objection goes, it needs to be distinct from the patient. But the only thing that is distinct from the form within a substance is matter. However, matter as such cannot be the patient, since being a patient requires a specific passive potential corresponding to the active potential in the agent, in this case the potential to be moved towards the natural place. Any specific potential is given to the matter by the form – by itself, matter has only the general potential to be informed by any form whatsoever. This objection is actually

58 "Neque huic opinioni officit, quod supra de motu dictum: Mobile a movente distinctum esse; quod Elementorum motui competere non videtur, si movens forma statuatur. Nam terra, dum movetur ad medium, non movetur quatenus habet materiam. Materia enim per se non sursum potius, quam deorsum moveri apta est; sed omnes motus indistincte recipere potest; verum quatenus habet formam, quae materiae potentiam ad hunc motum recipiendum determinat & restringit. Quapropter cum forma hic sit principium passivum motus, eadem non poterit esse principium activum." Sennert, *Epitome* 1676, II, 3, SO 27b.

one made by Aristotle himself, or at least implicit in what he writes about elemental motions in *Physics* VIII, 4:

> Again, how can anything continuous and naturally unified move itself? In so far as a thing is one and continuous not merely in virtue of contact, it is impassive: it is only in so far as a thing is divided that one part of it is by nature active and another passive. Therefore none of these things move themselves (for they are naturally unified), nor does anything else that is continuous: in each case the mover must be separate from the moved, as we see to be the case with inanimate things when an animate thing moves them.[59]

Any scholastic wanting to defend Aristotle's position could do what we just saw Sennert do and object that the division into form and matter is the only viable division within a given element.[60] It is not clear whom exactly Sennert has in mind for this specific objection, but in general, it seems to me that the direct source for much of Sennert's discussion is Zabarella's *De rebus naturalibus*, specifically the two books *De motu gravium et levium*. Zabarella there presents most of the same positions and arguments as Sennert does, but in much more detail. Whereas Sennert treats motion in one chapter of his introductory book, Zabarella devotes two entire books to it. On the question of the efficient cause of gravitational motion specifically, Zabarella also takes the position that it is the substantial form and gives Duns Scotus and Gregor of Rimini as his sources.[61]

As Zabarella presents it, the main difficulty in the debate whether or not the form is the efficient cause of gravitational motion is that both sides have good support in Aristotle. On the one hand, Aristotle's own testimony is that the elements do not

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59 Physics VIII, 4, 255a10–17, translation from Barnes, *Physics*, 137.

60 For instance, Averroes already interprets Aristotle in this way in his commentary on Physics VIII, 4: "Si igitur aliquis dixerit quod sunt corpora simplicia composita ex materia et forma, quorum utrumque est distinctum secundum diffinitionem a reliquo. Dicemus ad hoc quod prima materia non est existens in actu et illud quod movetur ex se debet dividi in motorem et motum in actu, quoniam illud quod est in potentia neque movetur neque movet si igitur lapis. Verbi gratia moveretur ex se contingeret, ut esset movens et motum eodem modo secundum formam, quoniam non est existens in actu nisi secundum formam, quod est impossibile." *Long Commentary on the Physics*, VIII text. 30, in Averroes, *Opera*, IV, 367G.

61 Cf. Zabarella, *De rebus naturalibus*, lib. 8, cap. 4 and cap. 8, 407 and 414–415.; Duns Scotus, In Sententiarum II, d. 2, q. 2, in *Opera*, vol. VI.1, 304–308; Rimini, Gregory of, *In Sent.*, vol. V, 1–31.

move themselves, but on the other hand, his own principles provide good arguments to support precisely that, as Zabarella points out:

> The matter is therefore not without difficulty, because on the one hand, we have the clear testimony of Aristotle that heavy and light things are not moved by themselves and do not have an internal mover, but an external one; but on the other hand, there are most valid arguments drawn from Aristotle's own principles that would seem to demonstrate that heavy and light things are moved by their forms.[62]

Sennert answers the objection that there cannot be a distinction between mover and moved within an element by introducing another way to draw an internal distinction:

> And indeed this doubt is answered if one distinguishes between "agent with transmutation of the other, "which is properly called efficient and always requires a patient that is distinct from itself, and "agent by the mere emanation of the effect" (as they say), which does not by acting transmute something else, but from the nature of which the effect spontaneously, so to speak without it acting, follows – the kind of agent that is the form with respect to all accidents that naturally inhere in the composite. For all accidents follow from the form spontaneously without any motion and transmutation of the subject. Of the "agent by transmutation" is therefore true what was said above about the distinction of *mobile* and *movens*. But the "agent by emanation" is not necessarily distinct from the patient, although also in immanent action, or that which is effected merely by emanation, it is possible to note some distinction between agent and patient.
>
> For the form acts, insofar as it is form; it is acted upon insofar as it is in matter. This is why the form, as form, is the efficient cause in the motion of the elements; but insofar as it is in matter, it is at the same time also moved. For the composite is the *mobile* or the subject of

62 "Res igitur difficultate non caret, cum ex altera parte habeamus testimonium Aristotelis clarum, quod gravia et levia non moveantur a se, neque habeant motorem internum, sed externum; ex altera vero extent argumenta validissima ex ipsius Aristotelis principiis desumpta, quae demonstrare videntur gravia et levia a suis formis moveri." Zabarella, *De rebus naturalibus*, lib. 8, cap. 4, 409.

> motion, which is distinguished from the form by way of the matter. For matter is also really distinct from form.[63]

Sennert argues that the form is the agent, but the patient is not simply matter as such, but form as united with matter, i.e., the complete substance. When this distinction is made, the principle that agent and patient are always distinct can remain in force, although in a qualified sense. To explain how this is possible, Sennert introduces a distinction between two types of effective causation: It can either be "transmutative," with the cause bringing about an effect in something else, so that it is true that agent and patient are distinct substances; or it can be "emanative," in which case it is not necessary that agent and patient are separate substances. Emanative causation, as Sennert points out, applies to any substantial form of a natural substance and to its accidents, which follow necessarily and do not involve transmutations. In the case at hand, the accident flowing from the substantial form is the motive quality, *gravitas* or *levitas*.

Sennert gives no further explanation of the transmutative//emanative distinction, nor of his view on the relation of agent and patient in gravitational motion. Zabarella, by contrast, from whom Sennert will have taken the distinction of transmutative and emanative agents, attributes it to Scotus.[64] Zabarella further argues that Averroes has also held that the form is the cause of the motion of fall. Averroes says different things when commenting on different parts of Aristotle's works, but at one point he indeed presents a similar theory. While he merely paraphrases Aristotle

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63 "Etenim huic dubitationi satisfit, si distinguatur inter agens cum transmutatione alterius, quod proprie efficiens appellatur, & requirit semper diversum a se patiens: & inter agens per solam effectus emanationem, (ut loquuntur) quod non agendo transmutat aliud, sed ad cuius naturam effectus sponte sua, ipso quasi non agente, insequitur, quale agens est forma respectu omnium accidentium, quae composito naturaliter insunt. Omnia enima accidentia sine ullo motu & transmutatione subiecti sponte formam insequuntur. De agente itaque per transmutationem verum est, quod supra de distinctione moventis & mobilis dictum est. Agens vero per emanationem non necessario a patiente distinguitur. Quanquam etiam in actione immanenti, seu quae per emanationem tantum effectus fit, aliquam agentis & patientis distinctionem notare liceat.

Forma enim, vt forma, agit; patitur; vt est in materia. Quare in Elementorum motu forma, vt forma, est caussa efficiens motus; vt verò est in materia, simul mouetur. Compositum enim mobile, seu motus subiectum est, quod distinguitur à forma ratione materiae. Nam haec à forma reipsa etiam distinguitur." Sennert, *Epitome 1676*, II, 3, 80 27b.

64 Zabarella, *De rebus naturalibus*, lib. 8, cap. 11, 420. Zabarella refers to Scotus, *Quaestiones in II Analyt. post*, q. 9, *Opera*, 425–427. In the passage in his commentary on the Posterior Analytics referred to, Scotus indeed makes the distinction and links it to the physical principle that cause and effect must always be different, but gives no further information.

when commenting on *Physics* VIII, he proposes two original accounts of gravitational motion when commenting on a passage in *De caelo* III, 2.[65]

The first of these, which Averroes ultimately rejects, comes very close to the position that the form is the main cause, which is why Zabarella is able to put Scotus and Averroes in the same camp. To explain how natural motion is distinct both from the self-motion of animals and from violent motion, Averroes makes in essence the same argument still employed by Sennert: Although there is no spatial separation of mover and moved, there is still an active and a passive part within the falling body – the form as such on the one hand and the matter-form composite on the other.

> And because the mover is distinguished in essence from the motion, as it is in animals (for in them the mover is distinct from the moved, since the mover is the soul and the moved is the body); however, in simple bodies the mover is the same according to its location as the moved, but they differ according to their mode: For the stone moves itself in so far as it is actually heavy, and it is moved in so far as it is potentially further down. And the cause for the fact that it is found to be one mode in act and another mode in potency is that it is composed of matter and form: Its form, therefore, moves in so far as it is form and is moved in so far it is in matter, for it is not potentially further down except insofar as it is in matter; and therefore the stone is not moved essentially *per se* but is assimilated to that which is moved *per se*, and therefore in its motion it lacks an external mover; but neither is it counted among the things that are moved by something external, because it is not moved to this motion by something external without a medium.[66]

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65 Averroes' digressions are at Physics VIII, text. 32 and *De Caelo* III, text. 28, in *Opera*, IV, 370A–371L and V, 197F–199E. Cf. Zabarella, *De rebus naturalibus*, lib. 8, cap. 5, 410; Maier, *An der Grenze*, 152.

66 "Et quia motor essentialiter distinguitur in esse a moto sicut in animalibus, motor enim in eis est alius a moto, cum motor sit anima et motum sit corpus; in corporibus autem simplicibus idem est motor secundum positionem et motum, sed differunt secundum modum: lapis enim movet se inquantum est gravis in actu, et movetur inquantum est potentia inferius. Et causa in hoc quod invenitur uno modo in actu et alio modo in potentia, est quia componitur ex materia et forma: forma igitur eius movet inquantum est forma et movetur secundum quod est in materia, non enim est in potentia ad inferius nisi secundum quod est in materia; et ideo lapis non est motus per se essentialiter sed assimilatur ei quod movetur per se, et ideo indiget in suo motu motore extrinseco; neque etiam nominatur inter ea que moventur ab extrinseco, quia non movetur hoc motu ab extrinseco sine medio." Averroes, *Commentary on De Caelo* III, text. 28, in *Opera*, V, 198K.

With this, Averroes is one of the first to suggest that the form could be the immediate mover in gravitational motion. However, Averroes is neither convinced that this is ultimately correct nor that it reflects Aristotle's position. He comes to the conclusion that the direct cause of gravitational motion must be spatially separated from the *motum*, not merely as form and composite. This is why he states that the primary action of the stone's heaviness is not to move itself, but rather the air, and that the air in turn moves the stone. In this way, the stone moves itself by accident, even though it is a *movens* by essence.[67] This concludes the overview over Sennert's views on simple gravitational motion and its causes as well as possible sources for it. In the next section, I turn to Sennert's treatment of a slightly more elaborate case, that of *accelerated* falling motions.

2.5. *Accelerated fall*

The preceding two sections placed Sennert's account of natural motions of the idealized heavy and light bodies, the elements earth and fire, in the context of the pertinent scholastic accounts. The phenomenon in question is the simple fact that some bodies fall down and some bodies rise up, both seemingly by themselves. It turned out that what Aristotle himself said about the issue sufficed to give an efficient cause of the beginnings of such motions, but not of the fact that they continue. For that reason, some later scholastics chose to disagree with Aristotle and claimed that not the *generans*, but the substantial form of the falling body itself is the efficient cause of gravitational motion. Sennert, as we saw, also embraces this view.

However, Aristotle and scholastic Aristotelians are aware that gravitational motion is not uniform, but accelerated.[68] Since, as we saw, for Aristotle velocity is proportional to force and inversely proportional to resistance, accelerated fall can be explained either by a decreasing resistance or by an increasing force. Since the substantial form is not changed by the motion (otherwise fall would be a substantial change, not a local motion), it cannot serve as the origin of an increasing force. So even if one accepts the substantial form as the efficient cause of the fall, it is not clear that it can also explain acceleration. The force exerted by the *gravitas*, whether caused by the substantial form or by something else, remains the same and therefore can only

67 Maier, *An der Grenze*, 153.

68 Aristotle already mentions that "all things in proportion as they are distant from the state of rest move faster" (Physics VIII, 9, 265b13, transl. Barnes), though this was generally understood to mean proportionality to distance travelled, not time. Cf. also *De Caelo* I, 8, 277a27 and II, 6, 288a19.

explain a constant falling velocity by itself. For this reason, the acceleration of fall presents itself as a separate phenomenon, and one's explanation of it is not directly related to one's stance on the cause of gravitational motion as such.

Sennert introduces the phenomenon of accelerated fall by comparing two different falling heights of a heavy body. His explanation of acceleration is that the air resistance decreases while the moving force remains the same. More specifically, he holds that the motion of the falling body itself gradually weakens air resistance:

> From what has been said so far, the reason can easily be given why heavy and light things are moved more slowly in the beginning [and] more quickly in the end. For experience testifies that a heavy thing of the same weight falling from a high place strikes more strongly than if it falls from a place that is not as high up. Although different people have thought differently about this, it must nonetheless be concluded that the true cause of this is the weakening of the resistance of the medium; of the weakened resistance, however, it is the preceding motion, which raises the velocity of the antecedent motion. For a motion that follows upon another motion is quicker than one that is not preceded by another motion.[69]

But how is a falling body able to decrease the air resistance, and why does the effect seem to become progressively stronger the longer the falling motion continues? Continuing the quotation above, here is Sennert's explanation for that phenomenon:

> The reason why a preceding motion raises the velocity of the following one and diminishes the resistance of the medium, however, is this: All movable bodies are quickly and easily moved through a medium that is moved in the same direction, more slowly through a medium at rest, most slowly through a medium that resists the movable body and goes in the opposite direction; a fact for which navigation provides

69 "Ex his, quae hactenus dicta sunt, facile caussa reddi potest: cur gravia & levia tardius in principio, velocius in fine moveantur. Nam experientia testatur, rem grauem eiusdem ponderis ex alto loco delapsam vehementiùs ferire, quàm si è loco non ita sublimi decidat. Quamuis enim varij hac de re variè senserint: tamen statuendum est, veram huius rei caussam esse imminutionem resistentiae medij; imminutae autem resistentiae, motum antecedentem, qui auget praecedentis motûs velocitatem. Motus enim qui alium motum sequitur, velocior est eo, quem alius motus non praecessit." Sennert, *Epitome 1676*, II, cap. 3, SO 28a.

> evidence. For this reason, when some heavy body begins to be brought downwards, the air at rest resists it at first, but then its resistance is overcome by the heavy body, and it drives the closest part of air downwards. This first pushed part of air pushes the second part of air next to it. Therefore, when the heavy body comes to that [second part] and finds it not resisting its motion but rather complying and moving in the same direction, it begins to move more quickly. Moved more quickly in this way, the body pushes and propels the third part of air more strongly, which, pushed before by the second part of air, will move more quickly than the second one and press the fourth one down more strongly.[70]

So Sennert argues that any body is moved more easily through a medium moving in the same direction than through one that is at rest or even moving in the opposite direction. He cites "navigation" as evidence for this principle; the example he probably has in mind is that of a ship sailing with or against a current.[71] He then proposes that this is what explains the difference in velocity between a body at rest beginning to move and a body that is already in motion for some time: The motion of the falling body gradually sets the surrounding air in motion downwards as well, which leads to decreasing air resistance.

Three things are noteworthy about this account. First, the moving bodies here are not the elements earth and fire, as they were in the discussion of gravitational motion as such. Instead, we are told about the motions of "some heavy body." Such a

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70 "Cur autem motus praecedens sequentis velocitatem augeat; & medij resistentiam imminuat, caussa est haec: Omne mobile velociter & facilè mouetur per medium, quod in eandem partem mouetur; minùs velociter per medium quiescens; tardè per medium quod mobili resistit, & in contrariam partem tendit: cuius rei nauigatio documentum exhibet. Quapropter cùm corpus aliquod graue incipit deorsum ferri, primo ipsi resistit aër quiescens, cuius tamen resistentiam vincit corpus graue, & proximam aëris partem deorsum pellit: haec prima aëris pars impulsa pellit secundam vicinam sibi aëris partem. Ad hanc igitur vbi deuenerit corpus graue, eamque in motu sibi non resistentem, sed obsecundantem, & in eandem partem motam inuenerit, velociùs moueri incipiet: velociùs ita motum corpus tertiam aëris partem vehementiùs impellet & propulsabit: haec etiam antè a secunda parte aëris impulsa velocius mouebitur quàm secunda, & fortiùs quartam deprimet." Sennert, *Epitome* 1676, II, 3, SO 28a.

71 Aristotle uses the example of a ship in a current in multiple places, e.g. at *Physics* VI, 10, 241a11. It is also one of the favorite examples of Averroes, which is why Zabarella and Basson both quote it in their discussions of natural motion. See below, p. 115; Basson, *Philosophia naturalis*, 348; Zabarella, *De rebus naturalibus*, lib. 8, cap. 16, 440.

seamless transition from the ideal case of the heavy and light elements to concrete bodies made up of all four elements is not uncommon in scholastic discussions of fall, and it does not seem to have been regarded as particularly problematic.[72] In the context of Sennert's corpuscular matter theory, however, the question is not strictly speaking the same as for other scholastics. In his theory, as we will see in part three of this chapter, both the heavy body and the elements contained in it are (in some cases at least) substances existing at the same time. According to most scholastic theories, in contrast, the elements cease to be independent entities when they become part of a larger body. In Sennert's theory, therefore, it is not obvious whether the subject of the falling motion is the heavy body as a whole or the individual particles that it consists of. Alas, he says nothing explicit about this question. I will argue in section 4.1, however, that the most plausible reading is that the fundamental particles are the proper subject of this kind of motion and not the body constituted out of them.

Second, there is a peculiar type of evidence being appealed to here: The argument starts from the observation that "experience testifies that a heavy thing of the same weight falling from a high place strikes more strongly than if it falls from a place that is not as high up."[73] We can envisage an experiment in which the same thing falls from a certain height to the ground, is picked back up and let go a second time from a lesser height. Alternatively, we might also imagine the two falls taking place simultaneously with two heavy bodies of the same weight but not necessarily the same volume. Sennert's description is ambiguous between these two variants: Grammatically, the first interpretation seems to be the obvious one, since "res grave" is the subject of both clauses; on the other hand, the qualification "of the same weight" is superfluous if it is the same heavy thing that is let go in both cases. Whether the two cases take place sequentially or at the same time, the experience of the two falling bodies then motivates a discussion of acceleration. The difference between the two cases is that one of the bodies "strikes more strongly" than the other. The tacit assumption is that the higher force of impact (however measured) is a sign of a higher velocity, and the fact that Sennert proceeds to explain why the velocity gradually grows during the fall shows that he takes the experience cited to show that both variables grow in parallel.

A third feature of Sennert's argument I want to note is that in arguing for the decreasing air resistance, he writes about "parts" of air "driving" one another. This should not be read as referring to minimal parts or particles of air, but rather to layers

72 Maier, *An der Grenze*, 145.

73 *Sennert, Epitome 1676*, II, 3, SO 28a.

of some kind. The idea is that each layer of air remains stationary and unperturbed up until the moment in which the layer above it drives it downwards, after which the heavy body itself begins pushing it as well. With each discrete step, the speed//force of both motions increases, which is what the decreasing air resistance consists in.

Where do Sennert's position and his arguments for it come from? He does not cite any authority on the issue of accelerated fall specifically, but there are good reasons for looking once more to Zabarella's *De rebus naturalibus* as his main source. For one thing, Zabarella treats accelerated motion in chapters 15–17 of book VIII, directly following the discussion of the cause of gravitational motion in the elements in the first fourteen chapters. For another, Zabarella gives precisely the same explanation as Sennert, explaining the decreasing air resistance by the air below the falling body moving downwards at increasing velocity. Zabarella even uses the same example of a ship to illustrate the principle that motion through a medium moving in the same direction is easier than through a resting or opposing medium:

> It is certain, and proved by experience, that all things are moved more easily through a medium at rest than through a medium moving in an adverse motion, but even more easily through a medium that is moved in the same direction than through one at rest. For a ship is carried most quickly through a river along with the flow, more slowly through resting water, but most slowly against the flow of the river.[74]

As was the case with the problem of gravitation, Sennert follows Zabarella's much more detailed account. In book 15, Zabarella had given an overview of the mistaken positions on this issue, their common mistake being that they did not recognize that the increasing velocity is not due to a change in absolute height, but due to a preceding motion. Experience testifies, Zabarella claims, that bodies that are in motion for a longer time move more quickly, and the acceleration that occurs in natural motions is just one example of this. To explain acceleration, it suffices to explain why this more general principle holds. To do that, Zabarella goes back to Aristotle's treatment of an important case of *violent* motion, namely the motion of projectiles. I will give a fuller

74 "Certum est, ac per experientiam comprobatum, unamquamque rem facilius moveri per medium quiescens quam per medium adverso motu latum, sed adhuc facilius per medium quod ad eamdem partem feratur, quam per quiescens. Navis enim velocissime fertur per flumen secundo fluxu, tardius per aquam quiescentem, sed tardissime adversus fluxum amnis." Zabarella, *De rebus naturalibus*, lib. 8 cap. 16, 439 f.

account of the scholastic ideas about projectile motion in the next section; here I will just reproduce what is necessary to explain Zabarella's account of the acceleration in free fall.

In *Physics* VIII, 10, Aristotle is in the middle of discussing the question whether there must be an unmoved mover. One of his main principles in this endeavor is that "everything that is moved is moved by something," and as a possible objection to that principle, he briefly discusses the motion of projectiles. Just as with gravitational motion, what is remarkable about projectile motion is that it continues even though there is no obvious efficient cause for its continuing. It should be noted, however, that in contrast to the gravitational case, the efficient cause for the *beginning* of projectile motion is uncontroversial: the throwing hand or other external cause.

Aristotle's solution is the following: When a stone is thrown, the thrower does not only impart a motion to the stone, but she also imparts on the surrounding air the power to move the stone further, that is, the air becomes an active mover. The moving power is passed on from one layer of air to the next but is diminished with each step. This explains the fact that projectiles fly forward only for a limited distance: After some number of layers, the power is diminished so far that it suffices only to move the stone, but not to be passed on to the next layer, at which point the stone falls down. This "air layer theory" is Aristotle's preferred account of projectile motion.[75]

Zabarella, on his part, is not interested in discussing the projectile case as such in this context, but only in applying the idea of layers to the case of free fall. The parallel, he argues, cannot be so strong that gravitational motion is simply a kind of projectile motion, since there is a key difference between the two cases: Projectile motion is faster in the beginning, while gravitational motion is fast towards the end.[76] Zabarella argues that Aristotle, like himself, solves this problem by claiming that the falling body is moved by its substantial form, which provides a mover that remains in contact with the moved through the entire motion. However, the moving action of the substantial form on its own provides only a constant force and therefore only explains a constant velocity, and that is why one must also involve a similar interaction between mover and medium, as in Aristotle's air layer theory.

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75 Aristotle, *Physics* VIII, 10, text. 8, 2266b27–267a20; Zabarella, *De rebus naturalibus*, lib. 8, cap. 16, 438. See also Aristotle, Physics IV, 8, text. 68, 215a15; Sarnowsky, *Die Aristotelisch-Scholastische Theorie*, 384; Franco, "Avempace, Projectile Motion, and Impetus Theory," 524. On air layer theory in the context of projectile motion, see section 2.7 below, p. 54.

76 Aristotle's description of projectile motion at *Physics* VIII, 10, 267a8, implies that such motions become progressively slower: "The motion ceases when the motive force produced in one member of the consecutive series is at each stage less [...]" *Complete Works*, I, 455.

> If we consider all that, we can conclude from it that if the natural motion of the elements were also brought about by an external mover, the same would have to occur as in the motion of projectiles. For if the reason adduced by Aristotle is true of violent motion, it must also be true of natural motion. That is to say, the last part of natural motion, which is as it were more distant from the first mover, would have to be slower; but Aristotle asserts the contrary, saying that it is faster. Therefore, he wants heavy and light things to be moved by their proper forms, so to speak as proximate movers. In fact, this is how a descending heavy body is not being removed progressively from the moving principle, because it carries its motor with it and has it joined and present to it everwhere from the beginning to the end of the motion. However, on this account, the entire motion of a descending heavy thing would have to be equally fast, since the same nature moving the same thing produces the same motion of the body. Therefore, if the velocity of the motion increases continually, it is necessary that there is some external cause of that difference, and that this is the medium through which the motion takes place, like air or water.[77]

Zabarella then goes on to explain gravitational motion in a very similar way as Sennert does in the passage discussed above. As we are now able to see, the way of arguing with "parts of air" envisaged as discrete objects, used by Sennert as well as Zabarella, is taken over from Aristotle's treatment of projectile motion. This includes the idea that the motion instantly propagates for some distance, so that each layer or "part" sets multiple other layers into motion, enabling a sort of positive feedback loop. A difference from the projectile case, which is however not mentioned by Zabarella, is

77 "Si haec omnia consideremus, colligere ex iis possumus quod si naturalis quoque elementorum motus a solo externo motore fieret, idem in eo contingere deberet, quod in motu proiectorum. Nam si ratio illa de violento motu ab Aristotele adducta vera est, vera etiam esse debet de motu naturali. Pars enim ultima motus naturalis, tanquam distantior a primo movente, deberet esse tardior, cuius tamen contrarium asserit Aristoteles, dicens esse velociorem. Vult igitur gravia et levia moveri a propriis formis, tanquam a motoribus proximis. Sic enim fit ut grave descendens non removeatur magis a principio movente, quia secum fert motorem suum, et eum ubique praesentem coniunctum habet ab initio motus ad finem. Hac tamen ratione deberet motus gravis descendentis esse totus aeque velox, quoniam eadem natura movens eumdem eiusdem corporis motum facit: ergo si crescit continue velocitas motus, necesse est aliquam esse huius differentiae externam causam, eamque esse medium per quod fit motus, ut aerem vel aquam." Zabarella, *De rebus naturalibus*, lib. 8, cap. 16, 439.

that the air layers set in motion by the throwing hand impart not only motion to the subsequent layers, but an active power to move the stone; whereas in Zabarella's account of gravitational motion, the only active mover is the substantial form, and the decreasing resistance is explained by the motion of the air layers as such, not by an additional power or force.

So Sennert takes his account of accelerated fall directly from Zabarella. But how does this theory relate to other scholastic theories of the same phenomenon? Zabarella cites only one other scholastic author who agrees with him that the cause of acceleration is decreasing resistance, namely Durandus of St. Pourçain. What Durandus argues is that the layers of air closer to the ground have less internal *levitas* to oppose the *gravitas* of the falling body. Another version of the same theory is that the resistance depends on the total amount of medium between the falling body and its destination.[78]

Among scholastics, theories that see the cause of acceleration in an increase in the driving force are actually more common than those which explain it by a decrease in air resistance. How exactly they do that depends on how they explain natural motion in the first place. For those, like Roger Bacon, who accept an attraction of the natural place as (one) efficient cause of the fall, it is conceivable that this attraction becomes stronger as the falling body gets closer to its natural place. Apart from the debate about action at a distance, this theory has the weakness that it implies that two bodies falling from different heights would have the same terminal velocities, which is clearly not the case. The same objection can of course be made against Durandus' account or against any other theory which has the velocity depend on absolute height and not on distance travelled, and in fact Zabarella directs such an objection against Durandus.[79]

The theory defended by Thomas Aquinas and Albert the Great solves this problem by postulating that the falling body acquires an "accidental gravity" during its fall. On this account, a body that arrives at some height x after beginning its fall at x + h has the same *essential* gravity as another body that begins its fall at x, but more accidental gravity and therefore more velocity. Another possibility is to postulate a further force in addition to the basic *gravitas*. Richard de Mediavilla finds this additional force in the interaction of the medium, presumably because the medium is moved and then aids the passage of the body in turn.[80] The solution that Zabarella ultimately

78 Durandus, *In Sent.*, d. 14, q. 1, 133^{rb}–133^{vb}; Maier, *An der Grenze*, 189 f.

79 Zabarella, *De rebus naturalibus* lib. 8, cap. 15, 437; Maier, *An der Grenze*, 192.

80 Maier, *An der Grenze*, 192–194.

accepts (and Sennert with him) therefore resembles that of Richard the most, though Zabarella only quotes Durandus. We will see in the next chapter that Basson's account of accelerated motion also takes Zabarella's as his starting point but argues in more explicitly corpuscular terms.[81]

2.6. *Projectile motion*

The last type of motion regularly discussed in Aristotelian textbooks is the motion of projectiles. The regularity here consists simply in the observation that a heavy object thrown horizontally through the air with some force continues to fly more or less horizontally before eventually falling down to the ground. The image is that of a stone being thrown by hand, but the principles are thought to apply to other projectiles as well, for example to an arrow shot from a bow.

Projectile motion is in many ways the analogue of gravitational motion. Both motions have in common that they lack an obvious cause for their continuation and seem to require either an inner cause or an action at a distance. An obvious difference is that projectile motion is caused (at least at the beginning) by an external mover, i.e., it is violent. As mentioned, they are also kinematically different in that gravitational motion is faster towards the end whereas projectile motion is assumed to be faster in the beginning. It is also generally agreed upon that the weight of the *motum* plays a role in both cases: Heavy things fall faster than light ones, and they can be thrown further.[82]

As we saw in the previous sections, Sennert's treatment of free fall and the problems surrounding that phenomenon was quite brief. When it comes to projectile motion, that brevity turns into almost complete silence. Sennert seems completely disinterested in the phenomenon as such and scarcely mentions it over the entirety of his works. The one passage in which he discusses projectile motion in more than one sentence is in the fourth essay of the *Hypomnemata*, which is about the procreation of living things. Specifically, that essay expounds Sennert's theory that the semen out of which a new animal eventually grows must be able to act by its own power, and therefore have a soul, from the very moment of conception.

81 See p. 115 below.

82 This is seen as an example of the general principle that "forma multiplicatur et dividitur secundum multiplicationem et divisionem materiae in qua est.," formulated for example by Richard Swineshead. See Maier, *Die Vorläufer Galileis Im 14. Jahrhundert*, 50.

The context of the passage which mentions projectiles is an argument about instrumental causation. Sennert is trying to counter the argument that a soul in the semen does not need to be posited because its powers can be explained as the actions of a distant cause which uses the semen as a mere instrument. According to this rival position, the semen eventually produces a soul "in virtute generantis,"[83] in virtue or by the power of the generating cause, without the need for a soul in the semen itself. Sennert's counter-assertion is that this is impossible and that the semen must have a soul and act by its own power.

Sennert attributes this rival position to three authors: Albert the Great, Jacob Schegk, and to Antonio Ponce, court physician to Philipp III of Spain. Now, projectile motion is one of a series of examples adduced by Ponce to illustrate this theory of a "causation by proxy." The reason why the example works for the argument is that in Ponce's view, projectiles are moved by a *vis impressa*, a force imparted on them by the mover, so although projectiles seem to cause their own motion, they are actually moved violently by the original efficient cause. Sennert's immediate source is, however, not Ponce, but Thomas Feyens' *Pro sua de animatione foetus tertia die opinione apologia aduersus Antonio Ponce Santacruz*.[84] Here is Sennert's paraphrase of Feyens' paraphrase of Ponce:

> For as we see in the motion of projectiles that they are not moved by themselves, but by a force impressed by the thrower, even though the thrower is no longer conjoined with the thrown, and as we see a product of art being produced by a hammer which does not have the disposition of art, not by its own force but by that of an artist using the hammer; so, too, is something animate produced by an inanimate seed, through the force impressed into it by the animate [agent].[85]

83 Sennert, *Hypomnemata* IV, 5, SO 127a.

84 Feyens, Apologia, 15–18 cites Ponce, De Hippocratica Philosophia, 69b [falsely printed 51] -71a. See Feyens, Apologia, 36–40 on the difficulties of the impetus theory, 40–47 on why even given the existence of an impetus, this would not prove instrumental causation. See also Blank, "Antonio Ponce Santacruz's Theory." An overview of Schegk's position on animal generation is given in Hirai, "Schegk's Theory of Plastic Faculty."

85 "Sicut enim videmus in motu proiectorum, ea moueri non à seipsis, sed vi à proiiciente impressâ, etsi proiiciens cum proiecto ampliùs non coniungatur, & a malleo artis habitum non habente aliquid artificiosum produci, non propriâ, sed artificis, qui malleo vtitur, vi; ita etiam à semine inanimato animatum produci, vi ab animato impressa." *Hypomnemata* IV, 5, SO 127a.

In his reply to the argument, Sennert is naturally more concerned with showing that the idea of an impressed force cannot be used to prove the existence of causation at a distance than with giving any detailed account of projectile motion. According to him and Feyens, the question of the real cause of projectile motion is simply not settled, and so one cannot assume a particular explanation in order to make inferences about causation in general.

> For the reason why that motion of projectiles takes place is not sufficiently clear and very controversial among the philosophers. But it is more proper that this motion takes place because of air or by way of air, rather than because of a force impressed into the projectile. [...] And there are multiple consequences of this opinion that are entirely absurd, and which therefore cannot be brought forward to confirm the received force of a separated instrument.[86]

In Sennert's view, then, there are two plausible explanations of projectile motion: Either by assuming that there is a "force impressed into the projectile" or by positing that projectile motion takes place "because of air or by way of air." The latter explanation remains very vague but is characterized as more plausible. The alternative that Sennert offers between an explanation by means of an impressed force on the one hand and an explanation by means of the air on the other accurately reflects the most important division in late scholastic theories of projectile motion. At the same time, his characterizations of both sides are too broad to pick out the view of any specific author. As for Feyens, he cites sources for the air theories but not for the *vis impressa*:

> Many claim that [the stone] is moved by air moved by the thrower, while the flight from the vacuum that follows the moved stone propels the air always from behind. This opinion was held by Plato, Simplicius and, greatest of all, Aristotle in various places, by Pereira, Dandin, Fracastoro, and many others.[87]

86 "Quâ ratione enim motus ille proiectorum fiat, non satis clarum & inter Philosophos valde controuersum est. Vero magis consentaneum, motum hunc fieri potiùs ab aëre, vel ratione aëris, quàm à vi proiecto impressâ. [...] Et plura omnino sunt absurda, quae hanc opinionem comitantur, & propterea pro confirmanda virtute recepta instrumenti separati afferri non possunt." Sennert, *Hypomnemata* IV, 5, SO 127b.

87 "Nonnulli opinantur ipsum moveri ab aëre a proiiciente moto, dum fuga vacui lapidis motum

As will become clear shortly, Feyens here mixes up at least two different air-related theories of projectile motion.

2.7. *Air theories of motion*

In this section, I will outline those theories of projectile motion that were available to Sennert, and which could have served him to make more concrete his statement that projectile motion "takes place because of air or by way of air, rather than because of a force impressed into the projectile."[88]

As I mentioned briefly in the previous section on accelerated fall, Aristotle's own theory of projectile motion uses the air as an explanatory factor. According to this air layer theory, the action of throwing a projectile forward imbues the air directly behind the projectile not just with motion, but also with a motive power. Both motion and motive power are transmitted from one layer of air to the next, carrying the projectile along but becoming weaker with each layer.[89] This genuine Aristotelian theory could very well be what Sennert has in mind, but there are also two other broadly Aristotelian explanations of projectile motion that involve air.

One of these is the theory of *antiperistasis*, mentioned by Aristotle in *Physics* VIII, 10 and IV, 8. Because Aristotle gives only the barest sketch of the theory, the source for the scholastic discussions about it was the more detailed explanation by Simplicius, the sixth-century commentator. Aristotle also does not attribute the theory to anyone in particular, but Simplicius links it to Plato, who had alleged in the *Timaeus* that something called "antiperistasis" could explain projectile motion.[90]

As presented by Simplicius, the theory of *antiperistasis*, is the following: The medium in front of a projectile, for example the air in front of an arrow, is pushed aside and moved to the back of the arrow. There, it fills the void that was left by the arrow's passing and in doing so pushes the arrow forward. Aristotle gives two

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insequens eum a tergo semper propellit. Hanc opinionem sunt secuti Plato, Averroes, Simplicius & omnium maxime Aristoteles variis locis, 4. Physicor. Tex. 68 & 8 Physicorum tex. 82 & 3 de Caelo tex. 28 & 11 problematum 6 & in mechanicis quaestionib. 33. "Pererius capite 4. lib. 14 Physicae, Dandinus lib. 2 de anima com. 96 digressione 40, Fracastorius lib. 1 de Sympathia & Antipathia cap. 4; & nonnulli alii." Feyens, *Apologia*, 37.

88 See n. 86 above.

89 See section 2.5 on accelerated fall above, p. 43.

90 Simplicius, *Commentary on Aristotle's Physics*, l. 1350 f.; Aristotle, *Physics* IV, 8 text. 68, 215a14–17, VIII, 10 text. 82, 267a3–12. Cf. Maier, *Zwei Grundprobleme*, 117, n. 6; Sarnowsky, *Die Aristotelisch-Scholastische Theorie*, 383–385. Plato, Timaeus, 80a.

reasons why this cannot be correct: Firstly, this explanation still implies the existence of a vacuum, since it assumes that during their successive circular motion, air parts move into voids left by other air parts. Even if the vacuum exists for a brief time only, that violates a principle which both he and Plato subscribe to. Secondly, the process involves a circularity: The parts of air that push the arrow forward only move there because some other parts were displaced by the tip of the arrow, so that the parts of air cannot be truly viewed as the causes of the arrow's motion.[91]

By attributing the same theory to Plato, Aristotle and Simplicius, Feyens therefore erases the differences between antiperistasis and air layer theory. His characterization that the projectile "is moved by air moved by the thrower, while the flight from the vacuum that follows the moved stone propels the air always from behind,"[92] actually resembles Aristotle's solution in the first clause and antiperistasis in the second. If Feyens is so vague about the details of his theory, it is even less plausible to attribute a precise theory to Sennert.

We saw before that Averroes uses the air in his preferred account of gravitational motion, which stands out from the rest of the tradition.[93] Averroes' account of projectile motion also uses the air. Since Averroes is important to Zabarella, and Zabarella has turned out to be the source for a number of Sennert's opinions on other types of motion, it is worth mentioning it here.

In the same *digressio* on *De Caelo* III, 2 in which he also expounds his theory that the falling body is "accidentally" the cause of its own motion because it moves the air and the air then moves it in turn, Averroes also gives an account of projectile motion. He points out that while Aristotle's air layer theory avoids positing action at a distance and self-movement, it implies that projectile motion is not continuous, since every layer of air is a distinct mover. To remedy that, Averroes argues that parts of air are able to penetrate each other and so to transmit motion from one layer to the next.[94]

91 Franco, "Avempace, Projectile Motion, and Impetus Theory," 523 f.; Sarnowsky, *Die Aristotelisch-Scholastische Theorie*, 384 f.; Simplicius, *Physics* IV, 8 215a15 and VIII, 10 267a17–21.

92 "Nonnulli opinantur ipsum moveri ab aëre a proiiciente moto, dum fuga vacui lapidis motum insequens eum a tergo semper propellit." Feyens, Apologia, 37 (quoted above).

93 See above, p. 42.

94 Averroes, *Opera*, V, 199B; Wood, "The Influence of Arabic Aristotelianism," 251.

2.8. *Impetus theories*

We just saw that Sennert's source for his opinion that the air must be involved in projectile motion is a text by Thomas Feyens; that the theory described by Feyens is a mixture of two classical air-based accounts; and that Averroes' theory is not mentioned, even though it uses the air to explain both gravitation and throw. Now for the alternative account dismissed by both Sennert and Feyens, the latter characterizes it thus:

> Conversely, others have believed that the stone is moved by an impressed force, which adheres to it and moves it, until it is made to disappear either by the resistance of the medium, or by the *gravitas* of the projectile, or by the encounter with another hard thing.[95]

Although no specific sources are mentioned, the term *vis impressa* is a clear reference to the so-called *impetus* theory of motion. Although it was initially developed by John Philiponus in the 6th century, as well as by Arabic philosophers, first by al-Fārābī in the tenth and then chiefly by Ibn-Sīna (Avicenna) in the eleventh century,[96] it was developed in fourteenth-century Paris in the context of Christian Aristotelianism. It is one of the clearest instances of scholastic natural philosophy consciously dissenting from Aristotle.

The most influential version of the theory is that of John Buridan, whose final opinion is found in a late redaction of his commentary on the classical passage in *Physics* VIII, 10.[97] There, Buridan criticizes the *antiperistasis*-theory as well as Aristotle's air layer theory in a physical way, by confronting them with a series of experiences that are difficult to explain using these air-based theories. Among these experiences are a grinding wheel that keeps on turning after the moving action has stopped, the fact that a feather cannot be thrown as far as a stone, or that a passenger aboard a ship being pulled against the current of a river does not feel the pressure of the air as strongly as one would expect if one of the air theories were true.[98]

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95 "E contra, alii putaverunt ipsum moveri a virtute impressa, quae tamdiu adhaereat ei, & moveat ipsum, quousque vel medii resistentia, vel projecti gravitate, vel alterius rei durae occursu evanescat. Utraque opinio habet suas difficultates maximas, & praecipue haec quam tenet author, & qua dari instrumenta activitate saeparata probare conatur." Feyens, *Apologia*, 37.

96 Franco, "Avempace, Projectile Motion, and Impetus Theory," 525–528.

97 Buridan, *Ultima Lectura*, VIII, q. 12, 120ra–b, ed. in Maier, Zwei Grundprobleme, 207–214, commenting on *Physics* VIII, 10, 266b27–267a21.

98 Buridan, *Ultima Lectura*, VIII. q. 12, ed. Maier, l. 40–58.

Buridan argues that the only version of the air layer theory that avoids these objections from experience is one that assumes that it is not a motion that is given to the air by the mover, but a moving force. But if this is what the air layer theory says, it is better to have the moving force imprinted directly on the *motum*:

> But if another thing or another disposition is imprinted onto the air by the thrower, which is the motive [disposition] of the air, then we can and must say that such a thing is impressed onto the stone or other projectile, which is the moving force of that projectile, and that seems better than to appeal to the air moving that projectile. For it seems rather to resist. It seems to me, therefore, that the *motor*, in moving the *mobile*, impresses on it a certain impetus or a certain force to move that *mobile* to where the *motor* moved it, whether upward or downward or laterally or in a circle, and the faster the *motor* moves the *mobile*, the stronger the *impetus* it impresses onto it is. And the stone is moved by this *impetus* after the thrower ceases to move.[99]

Buridan is not the only proponent of the *impetus* theory to present it as growing out of a correction of air layer theory, and that is no coincidence.[100] When compared with Aristotle's own theory, the idea of the *impetus* is a clear departure, but not a completely new system. The principle that every motion requires a corresponding force is common to both, as well as the principle that this moving force originates in the thrower. The difference is that according to Aristotle, the moving force can

99 "Si vero alia res vel alia dispositio imprimatur aeri a proiciente, quae sit motiva aeris, ita possumus et debemus dicere quod lapidi vel alteri proiecto imprimitur talis res, quae est virtus motiva illius proiecti, et hoc apparet melius quam recurrere ad hoc quod aer moveat illud proiectum. Magis enim apparet resistere. Ideo videtur mihi dicendum, quod motor movendo mobile imprimit sibi quendam [sic] impetum vel quandam vim motivam illius mobilis ad illam partem ad quam motor movebat ipsum, sive sursum sive deorsum sive lateraliter vel circulariter, et quanto motor movet mobile velocius tanto imprimet ei fortiorem impetum. Et ab illo impetu movetur lapis postquam proiciens cessat movere." Buridan, *Ultima Lectura*, VIII.12, ed. Maier, l. 118–130. Translation from Clagett, *Science of Mechanics*, 532–540.

100 Franciscus de Marchia before him argues in the same way in a question from his Sentences commentary (ed. in Maier, Zwei Grundprobleme, 166–180, l. 94–225) as does Marsilius of Inghen after him.

a) only be transmitted to air or water and b) must have a substrate that is distinct from the *mobile*, while impetus theory lets go of both of these principles: The moving force can be impressed directly on the projectile and from then on it can act as an inner motor.[101]

After its introduction by Buridan, the theory gradually becomes the standard position on the question of projectile motion, without any major new aspects being introduced into the theory itself. Blasius of Parma and Paul of Venice make *impetus* known in fifteenth-century Italy.[102] In the sixteenth century, Domingo de Soto assimilates Aquinas' theory of accidental gravity to the projectile case in order to argue that both Aquinas and Aristotle had already defended the impetus theory.[103] The Conimbricenses claim that both air layer and impetus theory are correct, though they do not claim that Aristototle himself accepted the latter. Suárez thinks both solutions are compatible.[104] It is worth noting that although it was originally introduced as a solution to the problem of projectile motion, those thinkers who accepted impetus tend to apply it to gravitation as well.[105]

By 1600, the Aristotelian orthodoxy has mostly accepted the impetus theory, although there are still some Aristotelians who defend the air layer theory as well. Among the authors of this time, Francisco Toletus and J.C. Scaliger are often cited as authorities in favor of impetus.[106] There is also, conversely, an anti-Aristotelian line of thinkers who defend the theory precisely because they view it as un-Aristotelian. Among these are Bernardino Telesio and Giordano Bruno, as well as Giovanni Battista Benedetti and Galileo Galilei.[107] These, therefore, were the versions of the impetus theory that were accessible by Sennert's time. When he denounces that theory, Sennert gives a brief list of objections:

> But it is more proper that this motion takes place because of air or by way of air, rather than because of a force impressed into the projectile. For nobody has so far been able to explain what and of what sort that force impressed by the mover is, and how it can be impressed by

101 Maier, *Zwei Grundprobleme*, 121.
102 Ibid., 273 and n. 18.
103 Ibid., 299–301.
104 Suàrez, *Disputationes metaphysicae*, disp. 18, sect. 8. Cf. Maier, *Zwei Grundprobleme*, 302.
105 Maier, *An der Grenze*, 199–212.
106 Ariew, "Descartes, Basso, and Toletus," 130.
107 Maier, *Zwei Grundprobleme*, 304–314; Sarnowsky, "Concepts of Impetus," 136–138.

> the local motion e.g. of an arm, and now indeed immediately, now mediated by some thing, in which it inheres; furthermore, how it is destroyed within a short time.[108]

Sennert's points are the following: Firstly, it is unclear what the ontological status of the impressed force would be. Secondly, it is equally unclear what kind of action the "impressing" of the force is. It would have to be transferred somehow from the mover to the moved, i.e., from one substance to another. In addition, the transfer must also be due not to any intrinsic property of the mover, but to its local motion as such. Thirdly, because violent motions are finite, the impressed force cannot remain in the projectile indefinitely, but must go away after some time.

Sennert's presentation of the impetus theory here is so brief that it is difficult to say which version of it the objections are directed against. Against the most well-known proponents, however, the second one is more effective than the first and the third. On the question of how the impetus fades over time, different proponents of the theory have different explanations. For Buridan, the impetus is a "thing of permanent nature" (*res naturae permanentis*), a quality inhering in the moving body that is distinct from that body as well as from the motion itself. Its gradual destruction is due to resistive forces either inside or outside the moving body. Buridan himself puts it this way:

> The second difficulty is: what thing is this impetus? [...] The third conclusion is, that this impetus is a thing of permanent nature, distinct from local motion, by which that projectile is moved. This is apparent from the two preceding conclusions and from what was said before. And it is likely that this impetus is an innate quality which innately moves the body that it is impressed onto, as it is said that the quality impressed on to the iron by a magnet moves the iron toward the magnet. And it also seems true that, just as that quality is impressed onto the *mobile* by the *motor* along with the motion, so it is also remitted, corrupted or impeded by the resistance or contrary inclination, as motion is.[109]

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108 "Vero magis consentaneum, motum hunc fieri potiùs ab aëre, vel ratione aëris, quàm à vi proiecto impressâ. Nemo enim hactenus explicare potuit quae, & qualis sit virtus illa à mouente impressa, & quomodo motu locali, brachij, v. g. imprimi potuerit, & nunc quidem immediatè, nunc mediante re aliquâ, vbi inhaereat; quomodo iterum tam breui destruatur." Sennert, *Hypomnemata* IV, 5 SO 127b.

109 "Secunda difficultas est quae res est ille impetus? [...] Tertia conclusio est, quod ille impetus est

Albert of Saxony follows Buridan in proposing a permanent impetus, whereas Marsilius of Inghen and Nicolas Oresme maintain that it goes out of existence by its own nature.[110] They all agree, however, that its ontological status is that of a real accident in the category of quality. The question of how it can act as a cause of motion is the most difficult one, as mentioned, but the impetus theorists would contend that the ability of the impetus to move a body is no more mysterious than the ability of the quality of heat to make a body hot.

3. Hylomorphic atomism

3.1. *Atoms with substantial forms*

Sennert's theory of motion as described so far in this chapter is not at all unusual for an Aristotelian in the early seventeenth century. Sennert is "Aristotelian" in the sense that on each of the standard questions about the motions of visible bodies, his position can be traced to scholastic predecessors (although with differing degrees of precision).

Nevertheless, there are types of local motion in Sennert's system that play no role in most other Aristotelian natural philosophies. The Aristotelian definition of motion normally only includes motions of visible bodies, since these are the only type of physical object that have substantial forms. In his teaching about *motus*, Sennert takes this extension of the subject as a given. But that means that there is a discrepancy between his account of what kinds of things are subjects of motion and his account of what kind of things there *are*: Sennert recognizes physical objects apart from visible bodies that have their own substantial forms, namely atoms of the elements and the chemical *tria prima*. Sennert, as we shall see in more detail shortly, accepts not only that atoms exist, but the substantial forms of the particles co-exist with the substantial form of the whole body. The scholastic writers whom Sennert relies on for the framework of his physics have no need to treat the motions of these atoms, since

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res naturae permanentis, distincta a motu locali, quo illud proiectum movetur. Hoc apparet ex praedictis duabus conclusionibus et ex praecedentibus. Et verisimile est, quod ille impetus est una qualitas innata movere corpus, cui impressa est, sicut dicitur quod qualitas impressa ferro a magnete movet ferrum ad magnetem. Et etiam verisimile est, quod sicut illa qualitas mobili cum motu imprimitur a motore, ita ipsa a resistentia vel inclinatione contraria remittitur, corrumpitur vel impeditur sicut et motus." Buridan, *Ultima Lectura* VIII, q. 12, ed. Maier l. 191, 227–235.

110 Sarnowsky, *Die Aristotelisch-Scholastische Theorie*, 394 and n. 365.

they deny their existence, but that option is not open to Sennert. My aim in the rest of this chapter is to reconstruct Sennert's account of the motions of atoms, from explicit statements where those exists and from implicit assumptions where necessary. The goal is in particular to relate the motions of the atoms to those of the visible bodies, so that we may come as close as possible to reconstructing a general theory of motion.

What atoms are, how we can know of their existence and how they and their properties relate to those of the visible bodies are some of the most complex parts of Sennert's thought, and among those least connected to scholastic orthodoxy. Still, if there is a theory of atomic motion to be found in Sennert's writings, it must be extracted from his theory of atoms. The upcoming sections will therefore introduce that theory. A first section will introduce the two types of particles that are called "atoms" by Sennert and investigate whether they both bear that name with the same right. The section after that will survey the scholastic history of the terms used by Sennert, this time to introduce the theories of perfect mixture, the debates that inform Sennert's view of atoms as parts of non-living objects. The section after that discusses how Sennert wields the concept of atom when discussing living bodies, namely as invisible seeds responsible for the reproduction of animals. A final section, using these different contexts in which Sennert invokes atoms, aims to establish a single sense in which the atoms (and their substantial forms) relate to the bodies they are part of. Only then can we tackle the question of what role atoms play in the motions and changes of visible bodies.

The place where Sennert discusses atoms in the greatest detail is in the third essay of the *Hypomnemata*, which is entitled *De atomis*. There, Sennert distinguishes two kinds of invisibly small particles, both of which he calls "atoms":

> But because there is not just one genus of atoms, but various according to the variety of natural bodies, it is good to consider them according to the simple bodies, which are called elements, as well as according to the composites. For firstly, the elements themselves are resolved into such bodies, and the corpuscles that come together again constitute the composite bodies as well as the very mass of the elements.[111]

111 "Cùm verò atomorum non sit vnum genus, sed pro corporum naturalium varietate varia; eas & secundum simplicia corpora, quae elementa dicuntur, & secundum composita; considerare libet. Primò enim ipsa elementa in talia corpora resoluuntur, & corpuscula rursum coeuntia; tum composita corpora, tum ipsam molem elementorum constituunt." Sennert, *Hypomnemata*, III, cap. 1, SO 116b.

So the atoms of the first kind are the minimal parts of the four elements, while the second kind are the three chemical principles Salt, Sulphur and Mercury. The use of these three substances as "principles" instead of or alongside the four elements originates in the Paracelsian tradition, where they are also known as the *tria prima*.[112] Sennert calls them "first mixts":

> For there is secondly another kind of atoms apart from the elemental ones, (which, if someone were to call them first mixts, he may do so in this sense) and into which, being similars, the other composite bodies are resolved.[113]

In these passages, Sennert introduces the two types of atoms by noting the substances they are the smallest parts of: The elemental atoms are those that result from the resolution of the "simple bodies," while the second kind of atoms are those into which all other bodies are resolved. The way in which the two types of particles are introduced leaves open the possibility that they are distinguished by nothing except the bodies they constitute. However, since these bodies are called the "simple bodies" and the "composites," by Sennert, it is evident that one type of atom is more basic than the other. This is confirmed by the fact that the second type of atoms is called "first mixts."

There is therefore a hierarchy between the two types of atoms: Most bodies can be analyzed in terms of Salt, Sulphur and Mercury, which in turn are composed of fire, earth, water and air. The elements are "simple bodies" because the elemental atoms of a single type come together to form masses of fire, earth, water and air directly. All other bodies, the secondary atoms included, are composed of more than one element. That means that all bodies in the sublunar world, with just four exceptions, are resolved into atoms in the second sense, that is, into particles of Salt, Sulphur and Mercury. This is reflected in Sennert's use of them: When he appeals to some particle in order to explain something in his medical or chemical works, the appeal is much more often to secondary atoms than to primary ones. The *tria prima* clearly play the more important role when it comes to explaining how naturally occurring substances come about, change and are destroyed.

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112 Hirai, *Le concept de semence*, 183, 207.

113 "Sunt enim secundò alterius, praeter elementares, generis atomi, (quas si quis prima mista appellare velit, suo sensu utatur) in quae, ut similaria, alia corpora composita resolvuntur." Sennert, *Hypomnemata*, III, cap. 1, SO 118a–b.

From a chemical or medical perspective, it can seem as if the elements play almost no role at all. This is why Newman stresses the function of Sennert's atoms as "negative-empirical principles," that is, as theoretical substances whose function is to structure the deductions one can make in the chemical laboratory.[114] Since virtually all visible bodies are composed of *tria prima* rather than of the four elements directly, Newman consequently emphasizes the former over the latter. In a similar vein, Moreau remarks that "bien que définis comme *primordia*, les quatre éléments ont un statut amoindri comparé à la forme spécifique résultant de leur composition."[115]

However, that does not mean that Sennert's elements play no role at all, or that they play a merely metaphysical role and have no significance for the empirical parts of natural philosophy. On the contrary, Sennert often attributes separate explanatory power to the elements, as for example in the following passage from D*e chymicorum*:

> The use, therefore, of the chemical principles is that out of them, as their proximate and proper principles, the properties of the mixed bodies that cannot be directly demonstrated from the elements can be deduced and demonstrated, as is particularly clear in the search for the properties and faculties of medicines.[116]

Thus, Sennert's basic view of mixed bodies is that they have some properties that can be traced back to the four elements, and other properties for which that is not possible. These other properties are instead traced back to the chemical principles. Later in the same chapter, Sennert explains what kind of properties are associated with each type of atom. By the association with different kinds of fundamental properties, the two types of atoms serve as principles of analysis for different sciences:

> Nor is it the case that, when the chemists reduce certain qualities to these principles, they teach nothing at all and beg the question. For it

114 Newman, *Atoms and Alchemy*, 127.

115 Moreau, "Eléments, atomes & physiologie," 279. Regardless of their use in explanations, the fact that Sennert holds that salt, mercury and sulphur are ultimately composed of the four elements instead of existing before them is a clear disagreement with the Paracelsian views of Petrus Severinus and Oswald Croll. See Hirai, "Daniel Sennert, Chymistry, and Theological Debates," 208.

116 "Usus igitur principiorum Chymicorum est, ut ex iis, tanquam proximis & propriis principiis, proprietates, quae corporibus mistis insunt, & ex elementis proxime demonstrari non possunt, deducantur, & demonstrentur, ut praecipue in proprietatibus & facultatibus medicamentorum inquirendis patet." D*e chymicorum* 1629, 165a.

> is necessary that each quality is reduced to its first subject; and just as the physicist can give no other cause for the fact that fire heats than that this is its property, and does not beg the question when he teaches that, so the chymist can give no other cause for why salt is savory.[117]

The crux, of course, is how exactly we are to imagine the relations of the properties of mixed bodies to those of the particles. As will become clear in the course of this chapter, Sennert usually does not reduce one set of properties at the level of mixed bodies to a completely different set of qualities at the particle levels. Rather, the presence of a property in a body is explained by the presence of an atom which has that property in the highest degree.[118] The four elements and the chemical principles each have a set of specific properties stemming from their substantial forms.

But since it is now established that Sennert's atoms have qualities, let me linger for a moment on the label of "atomist." The atoms postulated by Democritus and Leucippus, famously, have no qualities except for size and shape. It is already clear that Sennert does not agree with them on this point. But the ancient atomists had also claimed that there is an infinite number of indivisible, indestructible, unchanging atoms, and that all changes and properties of visible things can be reduced to the various combinations and arrangements in space of these atoms. The pyhsical doctrine of Democritus is descibed by Diogenes Laertius in the following way:

> His opinions are these. The first principles of the universe are atoms and empty space; everything else is merely thought to exist. The worlds are unlimited; they come into being and perish. Nothing can come into being from that which is not nor pass away into that which is not. Further, the atoms are unlimited in size and number, and they are borne along in the whole universe in a vortex, and thereby generate all composite things-fire, water, air, earth; for even these are conglomerations of given atoms. [...] All things happen by virtue of necessity, the vortex being the cause of the creation of all things, and this he calls

117 "Neque dum Chymici ad principia ista certas qualitates reducunt, nihil docent, & principium petunt. Necessarium enim est, ut qualitas quaelibet ad suum primum subjectum reducatur: & sicut Physicus caussam aliam nullam reddere potest, cur ignis calefaciat, quam quod haec ejus est proprietas, & dum id docet, non petit principium: ita nec aliam caussam reddere potest Chymicus, cur sal sit sapidus." *De chymicorum 1629*, 167a.

118 Lasswitz, *Geschichte*, I, 449.

> necessity. [...] The qualities of things exist merely by convention; in nature there is nothing but atoms and void space. These, then, are his opinions.[119]

One part of this doctrine that Sennert does subscribe to is that the combination and separation of atoms serve to explain some types of change. He associates it with the terms "*synkrisis*" and "*diakrisis*," which are used by Aristotle to describe the views of Democritus and Leucippus.[120] In fact, in Sennert's opinion, the processes of *synkrisis* and *diakrisis* are at the core of Democritus' doctrine:

> And what we have proposed is without a doubt the opinion of the most ancient philosophers about mixture, and of Democritus himself, who said that all the things are composed of atoms, and that generation and corruption are nothing but *synkrisis* and *diakrisis*.[121]

But can Sennert's atoms be divided, changed or destroyed? It would seem that if the chemical principles are ultimately composed of the elements, they must also be divisible. But Sennert maintains that "[Salt, Sulphur and Mercury] have their own forms, by which they differ, stemming not from the forms of the elements mixed among each other, but inserted [into them] by the Creator during the first Creation."[122] This implies that the forms of the *tria prima* can neither perish nor come into being by natural means. Therefore, even though the chemical principles have the elements as parts, they can never be dissolved during the ordinary course of nature. For the same reason, none of the three principles can be transformed into one another. The *tria prima*, therefore, are physically indivisible, immutable and indestructible, even though they consist of more fundamental entities.

While the chemical principles are physically simple, but contain multiple different elements as parts, the elements themselves have no further parts, except in so far as their substantial form and primary matter may be considered 'parts'. But

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119 Diogenes, Laertius, *Lives*, 9.41–46. Cf. Berryman, "Democritus."

120 *De Generatione et Corruptione* I, 2, 315b7–10, 317a13–14. Cf. Newman, *Atoms and Alchemy*, 69.

121 "Atque haec, quam proposuimus, est proculdubio antiquissimorum Philosophorum de mistione opinio, & ipsius Democriti, qui ex atomos omnes componi, & generationem nihil aliud, nisi synkrisis & diakrisis esse statuit." Sennert, *De chymicorum 1619*, 385, translated in Newman, Atoms and Alchemy, 91.

122 "Cum habeant suas, quibus differunt formas, non a formis elementorum inter se mistis ortas, sed a Creatore in prima creatione inditas." Sennert, *De chymicorum 1629*, 138b.

that the elements are simple in this sense does not mean that they are indivisible. Sennert does not speak of their forms as being given to them by God in the moment of Creation, as he does of the forms of the first mixts. Indeed, the divisibility of the four elements is one of the topics on which Sennert had the biggest change of mind, evidence of which can be found by comparing the editions of the *Epitome* up to and including 1624 to the later ones.

The early Sennert already has some corpuscularian tendencies, since he endorses the notion of *minima naturalia*: For every species of natural thing, there is a minimum size any individual can have.[123] But this is not a doctrine about absolute divisibility, but rather about the stability of a species in the process of increasing division. Furthermore, Sennert (at this stage) only applies the idea to inhomogeneous bodies, in particular living things, whereas even some Aristotelians like Francisco Toletus extended it to the elements as well.[124] For the early Sennert, homogeneous bodies contain parts below any arbitrary size. This applies to substances like gold and silver as well as to the elements, whereby Sennert uses fire as his example:

> Just as it is impossible to give a smallest non-existent quantity, since every continuum is infinitely divisible, so it is impossible to give a portion of fire for which there does not exist a smaller one within the same fire.[125]

By 1633, Sennert has made a number of revisions to this part of the *Epitome*, reflecting the more clearly atomist views he had first expressed in the *De chymicorum* of 1619. He now writes the following:

> IV. But just as the elements cannot be enlarged to infinity, so they can also not be divided infinitely, but when they are mixed with each other, they are reduced to *smikrotata moria*, as Galen calls them [in *The elements according to Hippocrates*, book 1 chapter 9], that is, to minimal particles, so that the bodies cannot be divided into smaller ones naturally, which

123 Sennert, *Epitome* 1618, 69.

124 Michael, "Sennert's Sea Change," 334 on Sennert's position from 1600 on and contemporary Aristotelian sources for the doctrine of minima naturalia. See also Emerton, *Scientific Reinterpretation of Form*, chaps. 3 and 4; Murdoch, "The Tradition of *Minima Naturalia*."

125 "Eodem modo, quo non potest dari minima quantitas inexistens; cum omne continuum sit divisible in infinitum; ita non potest dari ignis portio, qua non existat alia minor in eodem igne." Sennert, *Epitome* 1618, 72.

> is why the ancients called them atoms. v. About the inanimate mixts that exist by themselves, but are homogeneous, we should think the same as about the elements; and about the heterogeneous ones [we should think] the same as about living things.[126]

On this later account, the four elements consist of atoms in the sense that there is a certain limit below which they cannot be naturally divided. Although one is part of the other, the two types of atoms are therefore indivisible in the same sense – naturally, but not metaphysically. To support this view, Sennert now also explicitly defends Democritus' view on indivisibility. Against Aristotle's argument that any continuous quantity must be infinitely divisible, he argues that the atoms are physically indivisble, but not mathematically.[127] Concerning his doctrine in the passage above, it is worth noting that by claiming that his minimal particles arise in the process of mixture, Sennert is himself mixing two issues that are usally kept separate by scholastics: Minima naturalia are the limits of physical division, but they are not the same thing as the small parts into which two substances are divided when undergoing mixture.[128]

About the related question whether one type of elemental atom can be transformed into another, Sennert's development is less clear than on their indivisibility. On the one hand, the 1618 edition of the *Epitome* contains a passage clearly referring to such transformations: Although the elements with two opposing qualities are more difficult to transform into one another than those which share one quality, "indeed all elements can be mutually transformed, and there is none that cannot change into another." This passage, furthermore, was not changed in the later editions.[129]

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126 "IV. At vero in infinitum augeri non possunt elementa, ita etiam nec in infinitum dividi, sed cum invicem miscentur, in σμικρότατα μόρια, ut Galenus, De Elem. l. I, c. ult. docet, id est minimas particulas rediguntur, ita ut in minores naturaliter, corpora amplius dividi non possint, quas propterea Antiqui Atomos appellarunt. V. De mixtis inanimatis, per se existentibus, homogeneis quidem, sentiendum est idem, quod de Elementis: de heterogeneis vero, idem quod de viventibus." Sennert, *Epitome 1676*, SO 12a.

127 SO 11b. Cf. Lasswitz, *Geschichte*, I, 438 n. 6.

128 In the context of mixture, substances are dissolved into τά μικρά or *parva*, while division results in ἐλάχιστα or *minima*. The two discussions are also rooted in different passages in Aristotle, namely *De Generatione et Corrputione* I, 10, 327b33–328b25, and *Physics* I, 4, 187a20–b7. See Murdoch, "The Tradition of *Minima Naturalia*," 130.

129 "Et quidem omnia Elementa inter se sunt apta permutari, nullumque est, quod in aliud transire non possit." Sennert, *Epitome 1618*, 233, cf. SO 37b.

On the other hand, the passage on the minimal size of the elements quoted above originally also contained a reference to changes from one element to the other: In the 1618 edition, Sennert endorses the common Aristotelian view that a piece of air that is condensed beyond a certain limit is transformed into water. The same paragraph is reprinted in 1624, but in is replaced by the atomist one from 1633 on. The subsequent paragraph V, which draws an analogy between the elements and the homogeneous mixts, is never changed.[130]

3.2. *Atoms within the mixt*

As we have seen, Sennert argues that it is legitimate for the chymist to explain the savory quality in a substance by the presence of the principle Salt because he "can give no other cause."[131] But how do the "chymical" qualities of the first mixts depend on the "physical" qualities of the four elements? From what has been quoted so far, it would be conceivable that the impossibility of finding another cause is simply due to the limits of the chemical apparatus or human faculties. Sennert, however, goes a step further and grounds the difference in metaphysics, claiming that the qualities that are specific to the chemical principles stem from their own substantial forms. In a section on the "order of natural bodies," he notes:

> There is without doubt an ordering in natural things, so that the inferior ones serve the superior and nobler ones. And just as there is a progression in animate things from the vegetative soul to the sensible one, from there to those of various animals, and finally to the rational soul, as if to its highest step, and just as the rational soul encompasses all the potentials of the inferior souls, so it is also among bodies. First are the elements, then Salt, Sulphur and Mercury, which indeed also contain the elements themselves, but not only that, but something

130 "IV. Quia vero Elementa etiam quantitatem mutant secundum rarefactionem & condensationem: de hoc etiam sciendum, ex ipsorum natura hic ipsis certos terminos praescriptos esse. Non sine sui corruptione, quovis modo condensantur, vel rarefiant; cum utrumque fieri non possit sine alteratione corruptiva. Ipsaque experientia testatur, terram nunquam tam raram fieri, ut est ignis, nec hunc tam densum, ut est terra. Imo, cum aer nimium condensatur, in aquam convertitur, & cum aqua nimis attenuatur, in aerem mutatur." Sennert, *Epitome* 1618, 71. Cf. *Epitome* 1624, 84; *Epitome* 1633, 90; SO 12a.

131 *De chymicorum* 1629, 167a. Cf. n. 117 above.

> more: For they have their own forms, by which they differ, stemming not from the forms of the elements mixed among each other, but inserted by the Creator during first creation.[132]

Towards the end of the passage, Sennert explicitly states that the chymical principles contain the elemental ones, and that their differences are due to the fact that they have different forms. Since the fundamental particles, the elements, are never destroyed, that means that a secondary atom has at least two kinds of substantial forms, its own and those of its elemental parts. In the rest of the passage, he draws a parallel between the relations of the forms of the chymical principles and the elements on the one hand and the relations among the souls of living things on the other. Sennert seems to be implying that the forms of the elemental atoms stand in the same relation to the forms of the *tria prima* as the vegetative soul stands to the sensitive one. It is a natural comparison to draw, since in both cases, there is a single substance containing (or at least seeming to contain) multiple substantial forms. Nevertheless, from the point of view of most scholastics, the two types of cases would have seemed entirely different, so Sennert is taking an unusual position here. In order to come to a better understanding of his claim, this section and the next will treat the two cases separately: This section will relate Sennert's claims about the qualities of his two types of atoms to scholastic theories of inanimate matter. The next section will explore the connection between the qualities of the two types of atoms and Sennert's theory of the living body.

One of the central problems of scholastic matter theory is *utrum elementa maneant in mixto formaliter*, whether the substantial forms of the elements remain in the mixt. The four elements come up in two main contexts for scholastic philosophy: On the one hand, they are the four parts of the world whose relative weights are responsible for the material structure of the sublunar sphere. Earth is the heaviest element and forms the center, water and air constitute the middle spheres, and fire as the lightest

132 "Ordo nimirum est in rebus naturalibus, ut superioribus et nobilioribus serviant inferiora. Et sicut in animatis, ab anima vegetante ad sentientem; hinc ad varias brutorum; tandem ad animam rationalem, tanquam summum gradum, sit progressus, & anima rationalis omnium animatorum inferiorum potentias complectitur; ita idem fit in corporibus. Prima sunt elementa; hinc Sal, Sulphur, & Mercurius; quae quidem et ipsa elementa in se continent, sed non sola, verum aliquid amplius: cum habeant suas, quibus differunt formas, non a formis elementorum inter se mistis ortas, sed a Creatore in prima creatione inditas." Sennert, *De chymicorum 1619*, 273 f., reproduced at SO 89a.

element makes up the outermost sphere, bordering on the celestial region. These questions are discussed mainly in commentaries on D*e caelo* and play no important role in the present context.[133]

The other role of the Aristotelian elements, discussed in most detail in commentaries on D*e generatione et corruptione*, is as the ultimate components of physical things.[134] An element comes into being when prime matter is informed by one of the four elemental forms. The same form can inform more or less matter, or it can be replaced by another form, which is what happens when one element is transformed into another. Because an element is in this sense composed of matter and a form, it is a *compositum* in scholastic terms, though it is a simple body in the sense of containing only a single substantial form. All natural bodies except the elements themselves contain all four elements. These complex bodies have a matter and a substantial form as well, so they are *composita*, but they are *mixta* on top of that, because they are composed of the elements.

Since the scholastics follow Aristotle in rejecting the view of the ancient atomists that the elements are the ultimate quantitative components of things, the role that the elements play as the constituents of the mixt must be one of their forms and qualities, not merely of their matter. This requirement is fulfilled by the scholastic doctrine that the elements are the source of all qualities in the mixt. Each of the four elements has two out of the four so-called *primary qualities* which are produced as accidental forms out of its substantial form. The substantial form of fire, for example, produces the accidental forms of heat and dryness. The four primary qualities also occur in the mixts, but there, the so-called *secondary* qualities are also found, which are derived from the primary ones.[135]

But although there is a shared commitment to some kind of derivation of the secondary qualities from the primary ones, that project itself remains vaguely defined in two ways: First, it is not quite clear what makes a quality fall into one of the two classes. As Aristotle formulates it, the idea is that the tactile qualities (heat-cold, wet-dry, heavy-light, dense-thin, rough-smooth, hard-soft) must be reducible to just two pairs, namely hot-cold and wet-dry.[136] He argues that hot and cold are special in that

133 Maier, *An der Grenze*, 6.

134 Ibid., 8.

135 Ibid., 9. The scholastic usage of these terms has some parallels to the distinction made famous by Locke, although the scholastic primary qualities are a quite different sort of entity than Locke's – see Pasnau, "Scholastic Qualities." For an overview of Locke's view, see Wilson, "Primary and Secondary Qualities."

136 In *De Generatione et Corruptione* II, 2, 392b.

they are "active," and the scholastics expand on that by agreeing that all four primary qualities are active, in the sense that they have the power to spread themselves into adjacent objects.[137] According to this scholastic interpretation of Aristotle's remark, the motive qualities of heaviness and lightness are outside the scheme: They are qualities of the elements themselves and can therefore not be derived from the four primary qualities, but they do also not contribute to the secondary qualities. Furthermore, although most scholastics agree that the secondary qualities include those tactile qualities that are not primary, they disagree about which other qualities should be counted as secondary.[138]

Second, the nature of the derivation implies a quantitative account that the scholastics were unable to supply. Since secondary qualities are real accidents from the category of quality, the derivation does not mean that they are eliminated from the ontology. What the scholastics hold is rather *supervenience* – changes in the secondary qualities of substance cannot take place without changes in primary ones. Furthermore, "it became unquestioned orthodoxy among scholastic authors that the elemental qualities are the primary agents in nature."[139] In other words, any action or passion that a mixed body has, it has by virtue of the elements in it. The supervenience criterion implies that it must be possible to find for every secondary quality a corresponding proportion of the four primary qualities which produces it in every case. That is a hopeless project, and there was never a scholastic theory of such proportions.

What makes the problem of "whether the elements remain in the mixt formally" difficult from a scholastic perspective is that a satisfactory solution would need to be able to explain how it is possible both that the secondary qualities depend on the primary ones *and* that the carriers of those primary qualities, the substantial forms of the elements, are subsumed under the form of the mixt. The fact that visible bodies are *mixta* requires that the accidental forms of the primary qualities, if not the substantial forms of the elements themselves, remain present in the mixt. At the same time, the fact that the same bodies are *composita* of one substantial form and one matter would seem to require that the forms of the elements do not persist in the mixt.[140]

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137 Maier, *An der Grenze*, 10 f.; *Mechanisierung des Weltbildes*, 17, who points to Zabarella, In De Anima II, 6 and Suárez, In De Anima III, 8.

138 Pasnau, "Scholastic Qualities," 43.

139 Pasnau, *Metaphysical Themes*, 466. Cf. ibid., 464–466 on the relation of primary and secondary qualities.

140 Maier, *An der Grenze*, 4.

The textual foundation of the scholastic discussion of this particular question is found in De *generatione et corruptione* I, 10.[141] There, Aristotle distinguishes first between true mixture and *mixtio ad sensum*: The latter appears homogeneous to the senses, but in truth consists of distinct substances. True mixture, in contrast, is homogeneous in the strong sense that even its smallest parts are similar.[142] There, he also provides his famous but problematic definition of mixture: "mixtio autem est miscibilium alteratorum unio," which might be translated as "but mixture is the union of the mixables that have been altered."[143] On the question of the status of the elements in such a mixture, Aristotle remarks briefly that they do not themselves remain, but that their *dynamis* does.[144] Scholastic theories of mixture differ in how they interpret the exact nature of the "virtual" or "potential" existence of the element in the mixt.

There are three classical scholastic opinions on the existence of the elements in the mixt, associated with the names of Avicenna, Averroes, and Thomas Aquinas. Avicenna's interpretation is that the substantial forms of the elements remain 'in act' within the mixt, while their qualities undergo a so-called remission, that is, their intensity is reduced and they melt together into a "temperament" or "complexion," that is, the resulting quality of the mixt. This is not to say that the elements are the *cause* of the new form according to Avicenna; they merely produce a suitable disposition in the matter, while the form of the mixt itself is inserted directly by God. The accidents of the mixt, including the complexion, then flow from its substantial form. The reason why Avicenna's theory was almost universally rejected in the field of natural philosophy, even though his notion of *complexio* was immensely influential in medical theories, was that his account of mixture was incompatible with that of a substantial form of the elements. The nature of an elemental form is that it directly informs prime matter; if it is replaced by another elemental form, one element is transformed into another, but there can never be two or more elemental forms informing the same matter. But in perfect mixture, every part is homogeneous and contains all four elements, so one and the same piece of prime matter would be informed by multiple elemental forms at the same time, which is impossible.[145]

141 327a30 ff.

142 Maier, *An der Grenze*, 19.

143 328b22.

144 327b30.

145 Maier, *An der Grenze*, 23 f., 27. Avicenna gives his account in two places, of which the first is *Sufficientia* I, 10, ed. in *Liber primus Naturalium* I, 86–94. The other is a chapter of his commentary on De *Generatione et Corrputione*, ed. in *Liber tertius Naturalium*, 56–69.

Averroes develops his account of mixture in an extended polemic against Avicenna.[146] His solution is that it is not the *qualities* of the elements that experience a remission, but their *forms*. These *formae refractae* then constitute a *forma mixti*, a form of the mixt, which inheres not directly in prime matter but only indirectly through the forms of the elements. The issue with this theory is that it requires the elemental forms to undergo remission, which goes against the principle that substantial forms are all-or-nothing affairs. For this reason, Averroes gives the forms of the elements a status halfway between substantial and accidental forms. In contrast to Avicenna, Averroes also assumes that each element can have its associated primary qualities only in the highest degree, so that the remission of the qualities of hotness and dryness in elemental fire also means a remission of its substantial form.[147]

The third main account of the status of the elements in the mixt is that of Thomas Aquinas.[148] Aquinas' position is that the substantial forms of the elements are simply destroyed when the mixt is generated. The qualities of the elements, imperfectly mixed as they are in the first stage, interact mutually and form a middle quality that is similar to all the extreme qualities in some way, as the lukewarm is similar to both hot and cold. This middle quality then becomes that of the mixt. There are two main issues with this doctrine: First, accidents cannot migrate from one subject to another, so how can it be said that the qualities survive the destruction of the elemental forms? Thomas hints at two solutions for this: Either the primary qualities inhere directly in prime matter and not in the forms, and then the numerically identical qualities can survive the transformation; or the middle quality that resulted from the interaction of the elements is destroyed along with them and replaced by a numerically different, but similar quality of the mixt, without a causal connection between them. In this respect, the second option is very similar to Avicenna's view that God inserts the form of the mixt directly. Both of these possible interpretations of Thomas were adopted and made more explicit by later scholastics. The other issue is how it can still be said that the elements themselves are in the mixt. Thomas' answer to this is that since the primary qualities of the elements are conserved in the middle quality of the mixt, and since these qualities can only act in virtue of the forms, the substantial forms of the elements remain "virtually" in the mixt.[149]

146 In his *Middle Commentary* on *De generatione et corruptione* I, 10, text. 90, in *Opera*, V, 370K–M; and in the *Long Commentary* on *De Caelo* III, text. 67, in ibid., V, 226D–227I.

147 Maier, *An der Grenze*, 28 f.

148 In his *Opusculum de mixtione elementorum*. Thomas, *Editio Leonina* vol. 43, 157.

149 Maier, *An der Grenze*, 32–34.

In Sennert's earliest surviving writings, the original *Epitome* of 1599, his stance in this debate is that Averroes had been essentially correct. Sennert takes this position from Zabarella and defends it still in the 1619 edition of the *De chymicorum*.[150] In the 1629 version of the same work, however, he writes that he is now against Averroes and Zabarella on the question of the status of the elements in the mixt:

> But that refraction of forms is a mere figment, as is sufficiently proved by the Latins who argued against the view of Averroes. And Averroes and Zabarella can bring and show no reason, at least not a probable one, for the view that the forms of the elements receive a "more" or "less" and have multiple degrees, so that they can lose some of them while others remain, but still they simply affirm it.[151]

The *De chymicorum* of 1629 seems therefore to be the text where Sennert officially changed his allegiance from Averroes to Avicenna. Among the editions of the *Epitome*, the one of 1633 and later ones also embrace Avicenna's account and call that of Averroes a "mere figment," while the edition of 1624 still comes down on the side of Averroes.[152]

In a sense, Sennert's move to the Avicennan theory of mixture makes him more clearly an atomist, because he comes to affirm more clearly that the fundamental particles do not change their nature, but rather underly the changes in the bodies they compose. However, the earliest work in which he refers to himself as an atomist is the 1619 edition of *De chymicorum*, years before he switches his allegiance in the question of mixture.[153] There is therefore a period in which Sennert regards his fundamental particles as atoms, but nevertheless assumes that they do not keep their forms in full actuality when they become part of a body. It seems, therefore, that the two parts of his view at that time seemed to himself to be in some amount of tension, but not in outright contradiction. I would suggest that one good reason for Sennert to embrace

150 Sennert, *Epitome* 1600 XIV, th. 19; *De chymicorum* 1619, 287.

151 "Verum refractio illa formarum merum figmentum est, ut a Latinis contra Averrois sententiam disputantibus satis monstratum est; neque ullam Averrois & Zabarella pro ista sententia rationem saltem probabilem aferre, & monstrare potuerunt, formas elementorum recipere magis & minus, & gradus aliquos habere, ut aliqui tolli possint, reliquis manentibus, sed simpliciter saltem illud affirmarunt." Sennert, *De chymicorum* 1629, 153a.

152 The *Epitome*-passage starts on p. 241 in 1624, on p. 263 in 1633 and on p. 36b in 50. Sennert argues for the same theory in *Hypomnemata* III, 2, 50 120a–121a as well.

153 Newman, *Atoms and Alchemy*, 95 n. 30.

Avicenna's view on mixture eventually is that it can better explain why the atoms are able to fulfill their main function in his system, namely, to act as the subjects of qualities. We have seen above that Sennert introduces the distinction between the primary and the secondary atoms as one between the "physical" and the "chymical" qualities. He denies, already in 1619, that one type is caused by the other:

> Wherever the same affections and qualities inhere in multiple things, it is necessary that they inhere due to a certain common principle, as all heavy things are heavy because of earth, and hot because of fire. But colors, odors, tastes, the quality of being combustible and similar other things inhere in minerals, gems, stones, plants and animals. Therefore, they inhere thanks to some common principle and subject. *And the elements are not such a principle. For they have no potential to produce such qualities*. Therefore, other principles have to be sought, from which they flow.[154]

Because the secondary qualities cannot be reduced to the primary ones, each type is explained by a separate type of particle. In other words, in a body that is both hot and savory, the two qualities have to be attributed to two different types of atoms. According to the Averroesian theory of mixture that Sennert subscribes to in 1619, however, the forms of the fire atoms are in a state of remission and cannot explain heat. If the body as a whole has its own form, the same problem arises for the chymical particles that explain the savory taste. If, on the other hand, the substantial forms at each level of the hierarchy remain fully actual, they can remain responsible for their specific qualities. This suggests that more than the divisibility or reality of the elements as substances as such, the Avicennan theory is for Sennert a way to bring the metaphysical account of mixture in line with the qualitative roles of the two tiers of particles.

154 "Ubicunque pluribus eaedem affectiones & qualitates insunt, per commune quoddam principium insint necesse est: sicut omnia sunt gravia propter terram, calida propter ignem. At colores, odores, sapores, esse φλογιστον & similia alia, mineralibus, gemmis, lapidibus, plantis, animalibus, insunt. Ergo per commune aliquod principium & subiectum insunt. At tale principium non sunt elementa. Nullam enim habent at tales qualitates producendam potentiam. Ergo alia principia, unde fluant, inquirenda sunt." *De chymicorum* 1619, 283. Emphasis added. Cf. n. 117 above.

3.3. *Atoms in living things*

Up to this point, we have been occupied with the inanimate realm exclusively. But Sennert is interested in animate things as well. As we have seen at the end of section 3.1, Sennert argues in the *De chymicorum* that "just as the rational soul encompasses all the potentials of the inferior souls, so it is also among bodies"[155] – that is to say, both the animate and the inanimate realm contain a continuous hierarchy of substantial forms. There I also mentioned that it is not immediately obvious how such parallels can be drawn in the hylomorphic framework, since the scholastic debates on these cases are mostly separate. In the present section, I will explore more closely how Sennert envisions the hierarchy of forms within a living substance, and then assess how far the parallel between living and non-living things goes. Let me begin with one of Sennert's most important tools in both fields, namely the idea that a body can contain a part or particle that is "hidden" at one time and later become active and even dominant. In the following passage, he applies it across all levels of his ontology:

> For it is certain that fire, along with its form, is in iron, is in hot water, is in earth, but does not inform them. And the clearest example is found in gold that is dissolved into minimal parts in aqua regis, and in silver that is dissolved into minimal parts in aqua fortis. Even though they keep their forms intact, as is clear from the reduction, they nevertheless do not inform these solutions, but the form of gold or silver is in that solution as in a place. The same is evident also in the souls of living beings. For a seed that is dropped into the earth is in it as in a place, and the earth is not informed by the form of the seed.[156]

What Sennert calls the "clearest example" is one of his most well-known arguments for the existence of chymical atoms. It uses a well-known chemical phenomenon to great theoretical effect, namely the dissolution and re-precipitation of silver in

155 *Sennert, De chymicorum 1619, 273* f. For the full passage see above, note 132.

156 "Certum enim est, ignem cum sua forma esse in ferro, esse in aqua calida, esse in terra, nec tamen ea informare. Et, quod clarissimum est exemplum, est in aqua regis aurum in minima solutum, & in aqua forti argentum in minima solutum; ita tamen, ut formas suas, ut ex reductione patet, integras retineant, nihilominus aquas illas non informant, sed auri et argenti forma est in aqua illa, ut in loco. Idem et in animabus viventium apparet. Semen enim in terra coniectum, est in ea, ut in loco nec a forma seminis terra informatur." Sennert, *Hypomnemata* V, 2, SO p. 154a. Cf. Hirai, "Living Atoms," 91.

nitric acid. The only possible explanation of the fact that the silver can be regained from the acid solution, so Sennert's argument goes, is that the silver particles become hidden and are in the solution "as in a vessel or place,"[157] but are not destroyed by the dissolution. The point of this "reductio ad pristinum statum," as Newman in particular has shown, is to prove the existence of unchanging corpuscles of the *tria prima* and thereby to criticize other Aristotelian theories of mixture. Sennert takes up a corpuscular tradition in alchemy, combines it with Paracelsian terminology and embeds it within an Aristotelian framework.[158]

After the chymical exmple, however, Sennert also mentions a biological one, that of a seed that has been planted into the earth but has not yet started to grow. Indeed, the living body is one of the most prominent topics in Sennert's work, both in that he produced a lot of text about it and in that his positions on it are innovative.[159] He is especially interested in how the soul of an animal is generated in conception. In the course of two of the five essays contained in *Hypomnemata Physica*, he develops an account of both *univocal* generation, in which parent and offspring are of the same species, and *spontaneous* generation, in which there is apparently no form of the parent. Against accounts that posit a direct influence of celestial forces, Sennert insist that living beings must have the capacity to multiply on their own, or else there would be no such thing as univocal generation.[160] Among the accounts of univocal generation that involve no celestial influences, the main divider is whether they hold the seed to be animate.[161] Sennert's position is that the seed is in fact animated and that no new soul is generated when an animal is born, but rather that the generating soul multiplies itself, using the fine matter in the seed as its instrument.[162] On the topic of spontaneous generation, Sennert is much influenced by Fortuno Liceti, who had argued that this kind of generation is due to principles that lie hidden in matter and generate new living beings when they become active.[163] According to Sennert, the

157 "ut in vase vel loco," Sennert, *Hypomnemata* V, 2, SO 154a. The origin of this expression is Aristotle's discussion of the mutual conversion of the elements in *De Caelo* III, 7. Aristotle characterizes the view of Democritus and Empedocles as being that the apparent generation of new masses of e.g. water out of earth happens "as though generation required a vessel rather than a material." 305b3, trans. *Complete Works*, I, 499.

158 Newman, *Atoms and Alchemy*, 112–123.

159 Arthur, "Animal Generation"; Blank, "Animate Atoms"; Moreau, "Eléments, atomes & physiologie"; Stolberg, "Das Staunen vor der Schöpfung."

160 Hirai, "Living Atoms," 80. Sennert's targets here are Avicenna and Fernel.

161 Ibid., 81.

162 Ibid., 87.

163 Ibid., 89.

seeds of higher animals and plants are actual living bodies, while the spontaneously generated forms of life have an "analogue of seed" that only begins to perform the functions of a soul when it informs the right kind of matter.[164]

Sennert's accounts of matter in the realms of animate and inanimate things clearly have parallels. However, it is less clear whether the parallel goes so far that there is a single doctrine about the qualities of the whole and the parts covering both domains. The most ambitious attempt at finding such an overall theory so far has been Emily Michael's. Michael relates Sennert's corpuscular physics to the theories of scholastic philosophers who accepted multiple forms within one substance, the "Latin pluralists."[165] Since the claim that it is possible for a form to be "hidden" within a body dominated by another form has shown up in various parts of Sennert's philosophy discussed so far, it will be worthwhile to examine the notion of a "pluralism of form" more closely.

As we have seen, Sennert embraces the idea that the elements as well as the first mixts keep their substantial forms when they become parts of another substance. The resulting substance contains more than one form, so it is legitimate to call Sennert a pluralist about substantial forms in the inanimate realm. Sennert's position on the status of the elements is a very uncommon one among scholastic authors, mainly because it comes uncomfortably close to atomism. If the examples are living substances rather than inanimate ones, however, there are plenty of scholastics who accept the idea of substances with more than one substantial form. It is therefore an open question whether Sennert is also a pluralist in this more common sense.

Even when the examples are restricted to animate beings, there are in fact three distinct types of scholastic positions that attribute more than one substantial form to a single (human) body. The first two posit more than one form of the whole body, namely either that the rational, sensitive and vegetative parts of the human soul are distinct forms, or that a form of the body needs to be posited in addition to the soul or souls. The third type of pluralism attributes at least some degree of independent reality to the forms of the integral parts of the body. None of these types of pluralism necessarily entails any of the others, and for all possible combinations of the three, one can find scholastic philosophers who defend it.

As for the first type, Sennert does not view the intellectual, sensitive and vegetative souls as distinct forms, even though we have seen him compare the hierarchy of the three souls with the hierarchy of elements and chemical princi-

164 Ibid.

165 Michael, "Sennert on Matter and Form," 273.

ples.[166] In fact, he rejects the theory of multiple souls and argues that the vegetative, sensible and rational souls are merely mental categories formed on the basis of the similar faculties of certain classes of living things. A violet and a rose, he argues, share the vegetative faculties, but the two flowers are distinguished from each other by their specific forms just as they are distinguished from a lion or a human.[167]

Neither does he seem to have a need for a separate form of the body, since he argues in the context of embryology that the seed out of which the organic body grows already has the same soul as that of the grown-up animal, even though the seed does not yet have an organic structure. Therefore, argues Sennert, the soul must be able to inform the inorganic body of the initial seed and then generate all the distinctions of the body parts. The difference between a body that is simply alive and one that has functionally different parts is a difference between the first and the second act of the same single soul:

> And so the organic disposition is not necessary for the first act, but only for the second act, that is, for the operations to be carried out. And the body simply as organic is not the adequate subject of the soul, but only the organic body when it is already a finished body and must operate and conserve its own life by its operations.[168]

The second main type of scholastic pluralists are those who claim that some living bodies contain forms specific to some of their parts instead of multiple forms of the entire body. The debate here is not about the existence of the parts, since scholastics can very well accept that some parts of a whole exist while denying that these parts

166 *De chymicorum 1619*, 173, quoted above in n. 132.

167 Sennert, *Epitome* VI, cap. 1, SO 60a. Moreau, "Eléments, atomes & physiologie," 283–295 shows that Sennert postulates an "inner heat" of celestial origin in which the soul inheres directly, and that he distinguishes between the "living" constitution of the body that involves this heat and the "dead" constitution that involves merely the temperament of the four elements in each homomereous body part. Moreau also quotes *De chymicorum 1629*, 62a, where Sennert articulates the place of the human at the top of the hierarchy of creatures by means of a micro-macro-analogy: Man is best because in a human body, all types of creations are combined. Cf. Michael, "Sennert's Sea Change," 357–361 on architectonic spirit and form as efficient cause generally.

168 "Atque ita organica dispositio non est necessaria ad actum primum, sed solum ad actum secundum, seu operationes edendas. Neque corpus, ut organicum, simpliciter est subjectum adaequatum animae, sed tum solum corpus organicum, quando iam corpus perfectum est, & debet operari, & suis operationibus se in vita conservare." Sennert, *Hypomnemata* IV, cap. 7, SO 134a. In the Ur-*Epitome* of 1600, in contrast, Sennert believes in a *forma cadaveris*. See Newman, *Atoms and Alchemy*, 109.

have their own substantial forms. A case in point is Thomas Aquinas, who is as unitarian about living bodies as he is about inanimate mixts: Although for Aquinas there is only one single form in a living body, namely the rational soul, he does not claim that its parts (hands and feet, say) have no being.[169] The idea that the existence of parts does not imply that these parts have their own forms is taken very far by William of Ockham, who interprets Aristotle's notion that all continuous quantities are "potentially infinitely divisible" as implying that the infinity of parts all have actual existence.[170]

The debate is about whether the parts of substances can have substantial forms that are distinct from those of the whole.[171] There are a number of scholastics who are pluralists in this sense, but the most famous among them is John Duns Scotus.[172] Scotus holds that the heterogeneous parts of the body, i.e., things like eyes, hands and livers, each have their own substantial form. He also claims that the homogeneous substances that the organs consist of, like bone and blood, also have their own substantial forms. At the same time, Scotus teaches that there is only one single soul in each organism.[173]

The examples of these various scholastics show that an author's pluralism in the animate realm, no matter in which sense the word is taken, does not imply the kind of Avicennan pluralism in the inanimate real endorsed by Sennert. To take an extreme example, Zabarella postulates a form for each type of homogeneous matter: A form of bone, a form of blood, etc,[174] *and* he also teaches that the vegetative, sensible and rational soul are distinct parts with their own natures. On top of that, he recognizes a form of the body in addition to the three souls.[175] Zabarella's commitment to pluralism is such that he is able to say that "if it is not against reason that there sould be two, neither is it that there should be four or a hundred together in the same subject."[176]

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169 Thomas' claim is that the parts do not exist per se, but rather derive their existence on some way from the whole. Nevertheless, they do have some kind of being. Cf. Pasnau, *Metaphysical Themes*, 624, who calls this Thomistic view the "singular existence thesis," as opposed to the "simple view," according to which parts have no existence at all.

170 Ibid., 611 f. Pasnau calls Ockham's view "actualism."

171 Ward, *Scotus on Parts*, 4. Ward calls parts of a substance that have their own substantial form "partial substances," whereas Pasnau, Metaphysical Themes, 630, uses the term "partial forms" for their forms.

172 Pasnau, *Metaphysical Themes*, 630.

173 Ward, *Scotus on Parts*, 79.

174 Zabarella, *De rebus naturalibus*, lib. 11, cap. 2, 500.

175 Ibid., lib. 21, cap. 10, 850.

176 "Si duas simul esse non repugnat rationi, nec quatuor, nec centum repugnabit simul esse in eodem." Ibid., 502, cited by Sennert at SO 155a. Translation by Michael, "Sennert's Sea Change," 346.

And yet, as we saw in section 3.3, Zabarella takes the side of Averroes when it comes to the parts of inanimate substances. And Scotus allows for even less autonomy of the elements in the mixt, endorsing Aquinas' theory: Bone is a temperament of the four elements, which are contained virtually in it, but the form of bone inheres directly in prime matter.[177] Sennert is a Scotus-style pluralist who accepts specific forms of various body parts directed by a single soul:[178]

> It seems to me more suitable that in the body of a living thing there are multiple accompanying and subordinate forms, in such a way that one is the leader and ruler which informs the living thing and from which the living thing has its name, namely the very soul of each living thing; whereas the others are so to speak servants who, as long as that superior form is present, apply to the disposition and preservation of their own matter, and which therefore inform that matter in their way, so that it is a suitable subject for the specific form, and which also have their own actions.[179]

As in Scotus, both the homogeneous substances (bone, blood etc.) and the functionally distinct organs have their own subordinate forms. In *Epitome* IV, Sennert affirms that each of the homogeneous substances in a body is a perfect mixt with its own form. And in another context, he attributes medicinal or poisonous qualities of the dead leaves of a plant to the fact that while the soul of the plant as a whole is gone, the form of the leaf remains.[180]

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177 Ward, *Scotus on Parts*, 90, 125. It is debatable whether Scotus accepted a form of the body: Ward maintains that Scotus uses the expression only to refer to the collection of the partial forms of the organs. A consequence of this is that an animate body is unified only by the soul, and so ceases to be one body upon death. Pasnau, by contrast, cites Scotus as the main proponent of a "body-and-soul pluralism" precisely because he takes him to accept a form of the body distinct from the soul. Pasnau, *Metaphysical Themes*, 590 f.

178 Michael, "Sennert's Sea Change," 346 f.; Blank, "Poisons, Epilepsy, and Subordinate Forms," 197.

179 "Mihi vero magis consentaneum videtur, in corporibus viventibus plures formas succenturiatas esse, & subordinatas, ita tamen, ut una sit princeps & domina, quae vivens informat, & a qua vivens nomen habet, ipsa scilicet viventis cuiusque anima; reliquae vero ministrae quasi, quae quandiu forma illa superior praesens est, ad materiae propriae dispositionem & conditionem pertinent, & propterea materiam quidem illam, ut sit idoneum formae specificae subjectum, suo modo informant, suasque etiam actiones habent[.]" Sennert, *Hypomnemata* V, 2, SO 155a.

180 Sennert, *Epitome* IV, 4, SO 39a; *Hypomnemata* II, 3, SO 113b.

In sum, Sennert is a pluralist about the integral parts of living things just as he is about the integral parts of non-living things. The comparison with scholastic positions illustrates two points. Firstly, the fact that Sennert does not hold that there are multiple forms of the whole human body makes him a less extreme pluralist than for example Zabarella. The reason for his restraint in this respect might be that what drives him to accept distinct forms in the cases of the elements and organs is the fact that they are realized in a specific place and can be used to explain changes and properties of a specific piece of matter. Secondly, the overview of the scholastic positions has shown that even though Sennert holds a very similar position about the forms of the bodily organs within a living body as he does about the forms of the primary and secondary atoms in a mixt, that position is controversial only with regards to the inanimate case.

4. Atomic motions

4.1. *The explanatory functions of atomic motions*

In part two of this chapter, we have seen that Sennert gives fairly standard scholastic descriptions of the motions of visible sub-lunary bodies, even while contributing to the history of chemistry on both the empirical and the conceptual level. In other words, though there are few innovative claims about the motions of visible bodies to be found in his writings, he also posits invisible bodies, namely the atoms of the four elements and of the first mixts. As substances, the atoms are the subjects of certain qualities, and we saw that Sennert's Avicennan theory of perfect mixture amounts to the position that certain qualities always have a corresponding type of atom as their substrate, even when they are part of a composite substance. Towards the end of part 3, we have seen that he extends the same or a similar idea to the realm of animate bodies as well: Just as atoms of fire or sulphur may be hidden in a piece of limestone, the seeds of living things lie inactive in matter and may generate new life under the right circumstances. In both cases, Sennert speaks of the invisible particles being contained in matter "as in a vessel or place."[181]

Since atoms not only function as carriers of qualities, but are also bodies in their own right, they ought to be able to move. In principle, Sennert's hylomorphic ontol-

181 See section 3.3 above, p. 76 f. and ns. 157, 156.

ogy applies to atoms as well, since they are corporeal substances. But, as we have seen in some detail in part two of this chapter, Sennert's explicit account of local motion makes little mention of atoms, discussing the motions of visible bodies almost exclusively. It is therefore unclear how the orthodox Aristotelian positions on motion that Sennert endorses applies to the motions of atoms.

The problem lies in the relationship between the substantial forms of the atoms and those of the visible bodies. If Sennert's approach had been to abolish visible substances entirely and simply replace them with atoms, it would have been clear that all their qualities and motions must be explained by those of the atoms. What he does instead, as documented in part three of this chapter, is to introduce a plurality of substantial forms within the same body. The purpose of a substantial form, whether it is the form of an entire body or of a single atom, is to serve as the substrate for properties, and conversely, any property is a property of some substance. Indeed, the main advantage of proposing multiple forms within one body is the ability to allocate different properties to different forms, and so to explain their stability or change. That is no less true of motion than of any other property: Motion is the actualization of a potency in one specific substance and therefore presupposes a substantial form as its substrate. For any change in a visible body, therefore, there must be a single substance within which it takes place. In the context of Sennert's specific version of hylomorphist natural philosophy, this substance can either be the visible body itself or one of the invisible particles that it is composed of. The aim of this last part of the chapter will be to examine those explanatory relations between atoms and visible bodies in Sennert in which local motion is implied on at least one of the two levels.

Let me introduce a shorthand to distinguish the different levels of substances and properties that will be involved in the analyses of the upcoming sections. Let X be a visible body in which we observe some property or quality P_x. In Sennert's ontology, X is composed of some set of atoms, which we may call A, with properties P_a. The individual atoms of A are all substances. Furthermore, if X is a perfect mixt or a living being, it is a distinct substance as well. The properties and substances hiding under this notation can clearly be quite varied, so the task of finding a general rule relating all of them and their changes seems daunting. However, the task is made easier by the fact that there is an asymmetry between the two levels of substance: Only the qualities of X are observed, while A and its qualities are hypothetical entities introduced to explain them. Therefore, asking what properties of particles are postulated by Sennert means asking how those properties of particles serve to *explain* the perceptible qualities of both visible bodies and particles. The same goes, *mutandis mutatis*, for changes on those two levels.

This scheme allows us to distinguish two main types of explanatory relations between atoms and visible bodies that might obtain in Sennert's philosophy: Reductionist explanations and non-reductionist ones. If, for a given body X and its apparent property P_x, Sennert claims that P_x does not strictly speaking exist, but that all that there *really* is is the property P_a of the underlying set of atoms A, that is a reduction of P_x to P_a. If, on the other hand, Sennert claims that P_x exists independently (as an accident flowing from the substantial form of X), that is a non-reductionist explanation. A non-reductionist explanation does not necessarily mean that there is not *also* a property P_a that explains P_x in a meaningful way. There are two cases in particular in which both X and A enter into the explanation: First, Sennert might argue that there are some cases in which P_x and P_a are distinct accidents in distinct substances, but that P_x supervenes on P_a – in other words, P_x can change if and only if P_a changes. Secondly, there might also be relations of causation, in which X can act as the efficient cause of changes in A or vice versa.

In what cases can Sennert's view be reconstructed as involving a local motion either in the body X or in its atomic substrate A? In section 4.2, I begin with the simplest case, the local motion of visible bodies. What I argue, from the case of gravitational motion especially, is that although it would be possible for Sennert to treat *both* the visible body as a whole *and* its constituent atoms as subjects of a local motion, it is more plausible to view the atoms alone as subjects. In other words, when a light body (e.g., fire) rises naturally, the best description of that process in Sennert's physics is that the proper subjects of the observed motion are the elemental particles the body consists of (e.g., the fire atoms), not the entire body considered as a separate substance. The following section (4.3) treats the cases in which the observed changes are not local motions, but qualitative changes. The discussion is separated into a part about changes in perfect mixts and imperfect ones, the reason being that only perfect mixts have a substantial form that is distinct from the forms of the atoms in them. It will emerge in section 4.3 that Sennert uses atoms both in reductionist and non-reductionist ways, but that he practically never postulates relations of supervenience. He does, however, use relations of causation between atoms and visible bodies. These are the subject of section 4.4, which discusses cases in which the forms of the elements and *tria prima* can act as causal agents.

4.2. *Local motions of mixts*

The simplest case of local motion in the Aristotelian framework is the so-called natural motion of heavy things downwards and light things upwards (section 2.1). The

proper subjects of these natural motions are the element of fire, which is absolutely light, and of earth, which is absolutely heavy. The two *media* water and air can be either heavy or light, depending on the circumstances, and any mixt is heavy or light only in a derivative sense. As we have seen section 2.4, Sennert takes the position that it is the substantial form of the element, rather than the *generans* or another distant mover, that is the efficient cause for the continued gravitational motion. He motivates this by claiming that the form causes motion in an "emanative" instead of a "transmutative" way, just as it causes qualities to appear.[182]

The problem is that under Sennert's corpuscularian ontology, it would seem that there are potentially two types of motions taking place simultaneously. If the whole is in motion, then so are its parts. Since at least in some cases, both the body that is observed as falling or rising and the atoms that constitute it are substances according to Sennert, is there a separate motion for each atom? In the shorthand from section 4.1, an observed motion M_x of a visible substance X would be accompanied by a set of motions {M_a1, M_a2, M_a3, ...}, one for each atom in the set {a1, a2, a3, ... } = A. This cannot be Sennert's opinion, however, for three separate reasons. Most immediately, there is no direct evidence in favor: In his discussions of natural and violent motion, the subject is almost always a perceptible body, without any direct mention of its constituting atoms. The only exception is the ideal case of the pure, isolated heavy or light element. Secondly, the position we would be attributing to Sennert is inherently implausible. Not only would it be an unnecessary multiplication of entities, but it would also lead to a strange asymmetry between the descriptions of perfect and imperfect mixts. The falling stone that is so often taken as an example is an imperfect mixt and does not have a substantial form that is distinct from those of its constituent particles. A piece of gold, on the other hand, is a perfect mixt and does have a distinct form. According to the interpretation above, even though the heaviness of both materials is due to the presence of earth atoms in them, only the falling motion of the piece of gold would be distinct from that of its constitutent atoms. Thirdly, almost exactly the same issues arise for all the other qualities that mixts have because of their parts. Bodies are hot because they contain fire atoms, but it would be superfluous to assume that there is a quality of heat inhering in the whole and a second one inhering in each fire atom. Since we can therefore assume that Sennert posits only a single motion, the question is how he would describe it.

182 Sennert, *Epitome* I, 3, SO 27b.

To a certain degree, the question can be asked even for hylomorphic accounts that do not claim that the forms of the elements remain fully actual in the mixt. For most scholastis, there is no question of there being two or more separate motions, but there is the question of how the natural motion of the mixt arises from the natural motions of the elements. Aristotle's answer in *De caelo* I, 2 is that each mixt has the natural motion of one of the four elements, namely that which is dominant in the mixture. Sennert agrees with this:

> For we see those that are called elements, and all things that are composed of them, according to the nature of the prevalent element, be carried in a straight line towards their place.[183]

Even from the scholastic point of view, however, the difficulties only begin here. Zabarella, for his part, separates his entire discussion *De motu gravium et levium* into two books, of which the second one is devoted to the motions of mixts. There are three important questions about the natural motions of mixts, according to Zabarella: What is the proper subject of the motion, the elements or the mixt? What is the cause of that motion? And is it a simple or a mixed motion? His answer is that it is properly speaking a simple motion of the mixt, caused by the form of the mixt. In treating the first issue, the very first opponent opinion rejected by Zabarella is that of John of Jandun, according to whom the proper subject of the natural motion are the elements and not the mixt. The reason why Zabarella rejects Jandun's opinion is not that it leads to contradictions in explaining the natural motion, but merely that it would imply the Avicennan theory of mixture. The rest of the discussion then assumes either an Averroes-style remission of forms or an outright destruction of the elemental forms.[184]

Sennert says nothing about this specific question. The way in which the question is presented by Zabarella, however, makes it natural for him to assume the elements and not the mixt as the proper subject of natural motion. On the one hand, there are no obstacles for him to assume it: The objections reported by Zabarella are based on the fact that the Avicennan theory of mixture is unacceptable, and Sennert accepts this unacceptable premise. On the other hand, for Sennert to name the mixt as the proper

183 "Videmus enim haec vocata Elementa, omniaque ex his composita, iuxta naturam praevalentis Elementi, recta ad sua loca ferri." Sennert, *Epitome 1676* II, 3, 80 27a. Cf. Aristotle, *De caelo*, I, 2, 268b26–269a3.

184 Zabarella, *De rebus naturalibus*, lib. 9, cap. 1, 443 f.

subject of motion instead of the elements would mean either for him to assume two separate motions (as discussed above) or to claim that the elements, while existing actually as parts of a moving body, do not move. It seems therefore that when he is speaking of the natural motion of a mixt, he must mean a motion that is natural for some of the atoms in the mixt. In a gravitational motion, that would be those atoms which are heavy in the place in which the mixt is currently, e.g., water and earth as long as the mixt is in air. The proper subject of the natural motion, in other words, is always a primary atom, just as the proper subject of heat is always a fire atom.

4.3. *Constitution of mixtures*

The motions of atoms discussed so far had no causal interactions between the two levels of visible bodies and invisible atoms: The local motions of mixts are explained by the motions of atoms in virtue of their relationship as parts and whole, not because one substance causes a change in another. This stands in contrast to the relations between whole and parts when a new perfect mixt is generated: Here, the superior form of the mixt causes a change in the atoms which form the body in question. This case is what will occupy us in the present section. Sennert's theory of the perfect mixt was already the topic in sections 3.2 and 3.3., but, as with the rest of this concluding part of the chapter, the focus here is on the motions of the atoms.

Chapter two of the third essay of the *Hypomnemata* is dedicated to the role of the atoms within the mixt. In this chapter, Sennert first discusses whether the atoms retain their forms in mixture. This is also one of the passages in which he aligns himself with Avicenna's position that the substantial forms of the elemental atoms do in fact remain.[185] After that, he spends the rest of the chapter discussing how mixtures come about. As he puts it in the conclusion of this discussion, the main efficient cause why atoms come together and form a perfect mixt is the form of that mixt:

> And from what has been said so far, it is clear that the primary efficient cause of the mixture that is in plants and animals, nay, in all perfect mixts, for instance stones, gems, minerals and metals, to constitute their bodies, is the specific form of that natural body, which attracts matter that is suitable for it and disposes it in a certain way.[186]

185 Sennert, *Hypomnemata* III, 2, SO 120a–121a. See section 3.2 above.

186 "Atque ex his, quae hactenus dicta sunt, patet, mistionis, quae in plantis & animalibus, imò mixtis perfectè omnibus, lapidibus puta, gemmis, mineralibus, & metallis sit, ad eorum corpora con-

The opponent position in this case is that the mixts come about through a *pugna elementorum*: By themselves, the elements are in conflict, and only when their opposing qualities have diminished each other, a stable temperate quality results. Sennert argues that such a conflict of the elements, the smallest things in nature, would not be enough to bring about a more noble thing like a perfect mixt. Furthermore, the conflict of the elements is not always necessary, since they only come into contact with one another in minimal quantities, so that their conflict is hardly noticeable.[187]

Sennert also criticizes Thomas Erastus, who recognizes that the elements need some kind of direction, but sees that direction as being due to a "divine mandate" in the elements to come together and form bodies. To this, Sennert answers that there must be a more immediate natural cause:

> It is then not proved that God gave this task to the elements; rather, to dispose the elements in the mixt is the task of the form. And although God established all things, and [although] they are inferior subjects to the motions and influence of heaven, nevertheless God established Nature, through which all things are generated, which is for each thing its form and in living things the soul. The soul fashions its own body and in order to constitute it attracts elements as well as other bodies, disposes and unites them, and rules them under its direction; wherefore it happens that they are already formally one and those that were multiple in themselves become actually one, united by a single act. Therefore, the elements do not converge by themselves, but are attracted by the forms.[188]

It is the task of the substantial form of the mixt to give the particles within it their disposition and movement. Sennert locates the source of the claim that inanimate as

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stituenda, caussam efficientem primariam esse formam illam corporis naturalis specificam, quae materiam sibi idoneam attrahit, eamque certo modo disponit." Sennert, *Hypomnemata* III, 2, SO 122b.

187 Sennert, *Hypomnemata* III, 2, SO 121a and b.

188 "Neque dum probatum, quòd Deus hoc mandatum elementis dederit, sed elementa in misto disponere, formae officium est. Et licèt Deus omnia condiderit, & coeli motibus & influxui haec inferiora subiecta sint: tamen Deus Naturam dedit, per quam omnes res generantur, quae cuiusque rei sua forma, & in viuentibus anima est. Illa suum sibi corpus fabricat, & ad id constituendum tum elementa, tum alia corpora attrahit, disponit & vnit, & suo imperio regit; vnde accidit, vt formaliter iam vnum sint, & sub vno actu vnita vnum actu fiant, quae plura per se erant. Ideoque elementa non per se concurrunt, sed à formis attrahuntur." Sennert, *Hypomnemata* III, 2, SO 121b.

well as animate mixts are generated by their forms mainly in Scaliger, although he also regularly agrees with Zabarella.[189] In sum, according to Sennert, when a perfect mixt is generated, the substantial form of the mixt causes various local motions in the constituent atoms and acts on them as distinct substances. There is no trace of the claim that any of the properties of the atoms are assimilated and become properties of the mixt.

However, perfect mixts are only one of the two classes of visible bodies. Imperfect mixts, which do not have a *forma mixti*, are generated purely through the interactions of the atoms being mixed, without the direction of a superior form. The following passage is accompanied by the marginal title "Some mixtures occur through the agreement and disagreement of atoms":

> However, all the other mixtures, which are not directed by a superior form, by whatever name they may go, come about through the agreement and disagreement of atoms, by which similar things are moved towards other similar things and similar things are united with similar things. And even if that similarity or dissimilarity of bodies of the same kind is also more apt for mixture, as happens in animals, and in what is governed by a more noble form, is of no little importance, as we see that similar foods are more easily cooked than dissimilar ones; nonetheless, it is mainly found in natural or artificial fermentations and in the preparation of medicines, as well as in those [things] that are called fortuitous. And as this similitude of minimal bodies of the same genus is the foundation of a multitude of mixtures, so also of all dissolutions.[190]

189 "Nisi quatuor elementa rectorem habeant, temere ac sine modo iactabunt & iactabuntur. Quid enim illud est, quod tantum terra, tantum commiscet caeterorum? At opportet in unoquoque motu esse unum & primum. Non enim illa se movere ullum ad opus queunt, sed in compositis ad forma excellentiore; in mistis imperfectis ab externo principio cientur ad mutuam connexionem." Scaliger, *Exotericae Exercitationes*, Ex. 307, Sect. 20, cited by Sennert at *Hypomnemata* III, 2, SO 121a. On Zabarella, see. ibid., SO 121a–b.

190 "(Quaedam mistiones fiunt ab atomorum consensu & dissensu.) Mistiones autem reliquae omnes, quae à forma superiore non diriguntur, quocunque etiam nomine veniant, ab atomorum consensu & dissensu proueniunt, ob quem similia ad similia mouentur, & similia similibus vniuntur. Etsi enim haec corporum sui generis similitudo vel dissimilitudo etiam ad mistionem commodiorem, quae in animatis fit, quaeque à nobiliori forma gubernatur, non parùm facit; sicut videmus, cibos similes faciliùs coqui quàm dissimiles: tamen praecipuè locum habet in fermentationibus seu naturalibus, seu artificialibus, & medicamentorum praeparationibus, haec mistio, vt & iis, quae fortuitae

There is one mechanism in particular that Sennert uses for explanations the behavior of particles in imperfect mixts, namely the "agreement and disagreement of atoms," *consensus* and *dissensus* in Latin.[191] The basic idea is that things are attracted to similar things and tend to move away from dissimilar ones. To understand the processes described by Sennert in the quoted passage, the first question we must ask ourselves is which types of atoms he is talking about. What types of bodies or particles constitute imperfect mixts? From the examples in the quote, one might get the impression that the parts of imperfect mixts are always chemical or medical entities, that is, higher-order atoms that are already mixts themselves. That would imply a second way of contrasting perfect and imperfect mixts: The *tria prima* and other complex particles can associate in various ways, but only the four elements can be combined so intimately that a new substance is formed. But that is not how the late Sennert envisions mixture; on the contrary, there are perfect mixts that contain complex particles. One example can be taken from nutrition, namely eating meat: Meat contains blood, which is one of the four humours of the body and a perfect mixt, and Sennert holds that it is assimilated into the living body without needing to be dissolved down into the four elements.[192] More generally, as Newman has shown, Sennert denies Zabaralla's assertion that "[I]n the generation of things there must always be a resolution up to the elements, so that there can be no true mixture except among the elements."[193] What distinguishes imperfect from perfect mixts, therefore, is simply that in imperfect mixts, there is no substantial form of the mixt and that all the properties and changes in it need to be explained by means of the constituent parts alone.

Now that it is clear that both simple atoms of the four elements and more complex particles can be subjects of motions of sympathy and antipathy, we can examine how Sennert applies that idea in different contexts. His treatment of the exothermic reaction of limestone with water is a good example:

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appellantur. Et haec corporum sui generis minimorum similitudo, vt multarum mistionum, ita omnium solutionum fundamentum est." Sennert, *Hypomnemata* III, 2, SO 122b.

191 The idea of a natural sympathy was evoked since Hellenistic times and was used by many authors in renaissance medicine and philosophy. Its interpretation as a principle of natural philosophy, however, is particularly associated with the name of Girolamo Fracastoro. See Fracastoro, *De sympathia et antipathia rerum*; Pennuto, *Simpatia, Fantasia e Contagio*; Nejeschleba, "Sympathy and Antipathy in Wittenberg," 83.

192 Sennert, *Hypomnemata* III, 2, SO 122a.

193 "[A]n semper fiat resoltio in rerum generatione usque ad elementa, uta ut nulla vera mistio fieri posset, nisi inter Elementa." Sennert, *De chymicorum* (1619), 354; Newman, *Atoms and Alchemy*, 111.

> A common example of this is also found in limestone, from which, if water is poured on, the atoms of fire hidden in it flee from the water, as adverse to them, and burst forth; whence from the collected [fire atoms] heat is produced, and often so much that it is known to set nearby wood aflame.[194]

The sudden creation of heat is explained by the antipathy of fire and water particles: The water permeates into the fine pores of the limestone, and so small parts of water come into close proximity with small particles of fire being held captive within it. The result is the expulsion of the fire, which becomes immediately perceptible as heat.

Is this an instance of reductive explanation? Yes, in the sense that what appears to be a property of a visible body (the sudden heat perceptible in the piece of limestone) turns out to be a property of some of the atoms it consists of (the fire atoms held captive in its pores), which is what I have called a reductive type of explanation above (section 4.1). However, it is important to note that Sennert is *not* reductionist in the sense of eliminating any qualities from his ontology entirely. In the example, the quality of heat is instantiated as an accident in a substance; Sennert's disagreement with non-atomist hylomorphists is solely over whether the substance in question is the limestone as a whole or the atoms in it. As the example shows, changing the substrate of qualities like heat to be invisible atoms is exactly where the explanatory power of the type of atomism endorsed by Sennert comes from: By postulating that one and the same set of fire atoms changes place, Sennert is able to explain how the limestone changes from cold to hot. In this way, Sennert reduces a change in temperature to a change in place even while he retains heat as a quality separate from the spatial configuration of atoms.[195]

4.4. *Qualities as causes of particle motions*

The topic of sections 4.1 to 4.3 have been the ways in which the local motions of particles can, in Sennert's view, explain the apparent properties of imperfect and perfect

194 "Vulgatum quoque huius rei exemplum est in calce viua, cui si affundatur aqua, atomi igneae in eâ latentes, aquam vt sibi aduersam, fugiunt, atque erumpunt: vnde ex congregatis calor excitatur, saepe etiam tantus, vt vicina ligna accendisse compertum sit." Sennert, *Hypomnemata* I, 5, SO 108b.

195 The limestone example that Sennert discusses here is found in Scaliger, *Exotericae Exercitationes*, Ex. 5, arts. 8–9; its origin is probably Vitruvius, *Architectura*, I, 5; cf. Lasswitz, *Geschichte*, I, 217. Basson discusses the same passage and topic, see Basson, *Philosophia naturalis*, 98–105. Sennert treats other examples in a similiar way, cf. e.g. SO 177.

mixts. The result has been that Sennert's atoms are the carriers of the same kinds of properties normally ascribed to visible bodies, so that their motions in place can serve to explain apparent qualitative changes in the composites, without any internal qualitative changes in the atoms themselves. In the present section, I will examine the mechanism by which these atomic motions are *caused* more closely. As we have seen in section 4.3, in the case of the generation of a perfect mixt, the efficient cause of the motions of the atoms is the *forma mixti* directing its matter. In imperfect mixts, as we have also seen, the atoms themselves act as causes of one another's motions, and they do so especially by means of consensus and dissensus. What does that mean, exactly?

As in other cases, the fact that Sennert has multiple kinds of atoms at his disposal makes things more complicated. That it is not just the elementary atoms that are attracted to each other, but more complex particles as well, is shown also by a part of Sennert's explanation of the silver-and-acid experiment: He argues that the pure silver is re-precipitated from the solution because salts attract other salts and metals attract other metals.

> For the salts of which these melting powders consist, attract the salt which adheres to the calcinated metal; freed from the salts, the atoms of metal unite due to their similarity and come together in a pristine body.[196]

Sennert defends the concepts of *consensus* and *dissensus* already under the supervision of his teacher Johann Jessenius in 1599. The version of sympathy and antipathy presented in that disquisition is reliant on Fracastoro and Fernel,[197] and these two writers are Sennert's main authorities in his mature works as well. Here is how he introduces sympathy and antipathy in the *Hypomnemata*:

> Since therefore any thing whatsoever desires its conservation, it pursues [that aim] by fleeing contraries as well as by moving towards similar things and attracting them. Hence fire makes use of fire but

196 "Sales enim, e quibus illi pulveres fusorij constant; salem, qui calcinato metallo adhaeret, ad se trahunt; a quo liberatae, metallorum atomi ob similitudinem uniuntur, & ita in pristinum corpus abeunt." Sennert, *Hypomnemata* III, 2, 50 118b.

197 Jessenius, *De sympathiae et antipathiae*. See Nejeschleba, "Sympathy and Antipathy in Wittenberg," 81–91; Nejeschleba, "Johannes Jessenius and (or) Daniel Sennert on Sympathy."

> flees water, as its contrary, and vice versa. Hence water that is poured or sprinkled into the air or into dust contracts into round drops in order to guard itself from earth and air.[198]

It is a very specific similarity between two atoms that engenders the mutual attraction in this passage, namely the similarity of having the same elemental form. As becomes clear shortly after, it is not the forms themselves that are the causes of the attraction and repulsion, but the associated qualities:

> But although this agreement and disagreement of natural things depends primarily on the forms of things, since the forms act through the qualities, some furthermore agree and disagree through the manifest qualities (like water and fire), some through occult ones (which will be discussed later).[199]

Sennert shares the understanding of sympathy and antipathy as flowing from qualities with his teacher Jessenius.[200] However, he makes a further distinction between the actions of manifest qualities and those of occult ones. Since he associates manifest qualities with the elements of water and fire, it is tempting to conclude that the distinction between the actions of manifest qualities and those of occult ones maps neatly onto motions of sympathy and antipathy between atoms of the four elements on the one hand and of the *prima mista* on the other. But that is not what is intended: While only the four elements can be the subjects of manifest qualities in the strictest sense, the qualities of the *prima mista* are occult only in a restricted sense, and the most important occult qualities inhere in visible bodies directly.

There are two distinct criteria by which occult qualities are defined in the Aristotelian tradition: The first is that occult qualities are those that cannot be derived from a proportion of the four primary qualities. The second criterion that traditionally

198 "Cùm ergo res quaelibet sui conseruationem postulet; eam consequitur cùm fugâ contrariorum, tùm motu ad similia, & similium attractione. Hinc ignis igni utitur, aquam verò, ut contrarium, fugit, & contra. Hinc aqua in aërem vel pulverem effusa vel sparsa, sese in guttulas, globosas cogit, vt se à terra & aëre tueatur." Sennert, *Hypomnemata* I, 5, SO 108a.

199 "Etsi autem iste rerum naturalium consensus & dissensus primariò à formis rerum pendet; quia tamen formae per qualitates agunt, etiam alia per manifestas qualitates, vt aqua et ignis: alia per occultas, de quibus postea dicetur, consentiunt & dissentiunt." Sennert, *Hypomnemata* I, 5, SO 108a.

200 At least if we assume that Jessenius is the author of the disputation that Sennert defended in his name in 1599. Nejeschleba, "Sympathy and Antipathy in Wittenberg," 88.

defines occult qualities is that they are not directly perceptible but have to be inferred from their effects. The qualities of the *prima mista* always fulfill the first criterion since, as we have seen, Sennert denies that they emerge from a fixed proportion of the elemental qualities and claims rather that they spring from the forms of the complex particles directly. However, in Sennert's own usage, most qualities of the complex particles are manifest, not occult, and the reason is that Sennert emphasizes the second criterion over the first one.[201] This emphasis on the question of perceptibility is also apparent in the following passage:

> And these qualities are called occult, concealed, secret, in contrast to the manifest ones, which are open to the external senses, the tactile one in particular, and perceptible by them; because they, on the contrary, are not perceived by the senses, even though their operations are discerned by the senses. In this way, we see the attraction which occurs due to the magnet, but we do not perceive the quality, by which it produces the motion of the iron.[202]

The *tria prima* and other complex particles have many properties that can be directly perceived – for Sennert, they are the origin of colors, among other things.[203] But what about the properties that cause the motions of consensus and dissensus? These properties must be attributed to the particles themselves, since we have seen that motions caused by consensus and dissensus occur often in imperfect mixts where there is no form of the whole that could be the carrier of such qualities. Furthermore, motions of consensus in the particles conform to a very similar pattern as the magnetic motion mentioned in the quote above, which is the paradigmatic example of an effect caused by an occult quality. It would therefore make sense for Sennert to postulate occult qualities in the invisible parts of bodies as well as in bodies. Nevertheless, I have found no passage in which he explicitly does so.

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201 See Newman, *Atoms and Alchemy*, 139 f., on Sennert's occult qualities as a "black box" and the influences of Jessenius as well as of Galen's "qualities flowing from the whole form."

202 "Dicuntur autem istae qualitates occultae, abditae, abstrusae, ad differentiam manifestarum, quae sensibus externis, tactui in primis, sunt obviae, & ab iis perceptibiles; cum contra hae sensu non percipiantur, etsi earum operationes sensu deprehandantur. Ita attractionem, quae fit a Magnete, videmus; qualitatem autem, per quam ille ferri motus fit, non percipimus." Sennert, *Hypomnemata* II, 1, SO 110a.

203 For a list of qualities attributed by Sennert either to the secondary atoms or to some other complex particle, including color and flammability, see Sennert, *De chymicorum 1629*, 144b–145a.

In fact, all of Sennert's discussions of occult qualities point to them always having either a living body or a perfect mixt as their substrate. In essay two of the *Hypomnemata*, he makes two separate divisions of the occult qualities. In chapter three, he distinguishes them according to their "origin," i.e., according to the substantial forms from which they spring. Of the six classes distinguished here, five occur only in living things. The sixth are the qualities of perfect inanimate mixts, i.e., of gemstones, metals, minerals, and the magnet. There is no mention of qualities belonging to smaller particles. The second division is in chapter four, where Sennert divides the occult qualities into those which are "material," that is to say, those which "are in their subject and are moved with it and toward its motion,"[204] and "spiritual species, which are diffused in an orb from the body in which they originate, so to speak in a straight line, almost like rays."[205] The qualities that cause motions of consensus and dissensus in the *tria prima* and other atoms would seem to be of the material type, but there is also no reason why there should not also be material and spiritual *manifest* qualities, so that is no indication that these moving qualities must necessarily be occult. Nevertheless, the fact remains that they fulfill a very similar function for the particles as the occult qualities do for the magnet and other bodies.

In sum, local motions caused by the substantial form of the *movens* can occur at all levels of Sennert's pluralist ontology. The forms of perfect mixts can cause motions through their occult qualities, and particles of the *tria prima* as well as of the elements tend to move towards particles with shared qualities and away from those with opposite qualities. In addition to that, the substantial forms of the elements are also the causes of natural motions upwards and downwards, which are only by extension said to be motions of the heavy and light mixts.

4.5. *Conclusion*

As we have seen in some detail in the first two parts of this chapter, Sennert's natural philosophy is quite conservative in its outlines, a fact which can be attributed partly to the institutional setting in which he worked. The exposition of the *Epitome* in particular follows the familiar structure of the sixteenth-century textbook,

204 "Nam illa insunt suo subjecto, & cum eo, & ad eius motum moventur, nec ab eo sunt separabiles." Sennert, *Hypomnemata* II, 4, SO 114b.

205 "At spirituales illae species a corpore a quo oriuntur, in orbem quasi recta, radij instar, diffunduntur [...]." Sennert, *Hypomnemata* II, 4, SO 114b.

starting with the definitions of philosophy and nature and proceeding through the basic scholastic terms to the four elements and other more concrete topics. The influence of the late scholastic *cursus* is far less visible in the medical and chemical writings and the quodlibetal *Hypomnemata*. In these latter works, the less conventional structure also corresponds to more deviations from orthodoxy in content, although Sennert never presents himself as questioning the Aristotelian foundations of the project.

The passages in which Sennert treats motion exemplify, for the most part, the orthodox character of the theory as a whole. His definitions of the science of physics and its subdisciplines is based on Aristotle's definition of nature as the internal principle of change (sections 1.2 and 2.1). His remarks on the ontology of change itself can be placed in the medieval debate on *forma fluens* and *fluxus formae* (sections 1.3 through 1.5). His treatment of the traditional examples of local motions in the sublunar sphere in particular would, on the whole, not be out of place in most late Aristotelian manuals of natural philosophy (sections 2.2 through 2.8).

In his matter theory, however, Sennert is quite un-Aristotelian: Through the introduction of atoms with substantial forms, Sennert manages to integrate an Aristotelian vision of natural philosophy with elements of a corpuscularist alchemy in the tradition of Geber, Paracelsian chymistry, Galenic medicine and Liceti's theory of spontaneous generation. The result is a pluralist ontology in which a single physical object contains two or more layers of substantial forms. The properties of visible bodies can therefore either be explained as springing directly from the top-level substantial forms, or as emerging from a combination of the qualities of the atoms. Moreover, there are both atoms corresponding to the four elements and atoms of the *tria prima* adapted from chymistry. The latter are composed of the former, but each atom of each type is associated with certain qualities that originate in its specific form (section 3.2).

As a consequence of this ontology of the fundamental particles, Sennert's explanations of the qualities of visible bodies are unconventional in two ways: Firstly, both the elements themselves and the secondary particles continue to exist in full actuality within the mixt, even when there is a *forma mixti* which directs them. Secondly, if there is a quality in a perceptible body which is due to the presence of a certain type of atom, Sennert tends to view the underlying atoms themselves as the proper subjects of that quality and not the body as a whole. The difference to a non-atomist hylomorphic account is especially clear in the case of the secondary qualities: According to most scholastics, the secondary qualities are supervenient on a certain proportion of the primary qualities, but their subject is the body as a whole.

This static ontology of qualities on its own would be insufficient for explaining change and would in fact be a purely metaphysical exercise. What makes it a powerful tool of physical explanation is that the atoms can, without undergoing any internal change, move from one place to another. Common to all these cases is that there is very little attempt to reduce qualities to the shapes, arrangement and local motions of particles. On the contrary, Sennert's program is decidedly antireductionist, as the very reason why he introduces intermediate atoms with their own substantial forms is to eliminate the scholastic reduction of secondary to primary qualities.

If the motions and spatial arrangements of particles do play a role, it is as a mechanism for the "hiding" of forms: In limestone, for example, the fire particles are invisible at first because they are finely dispersed throughout the stone, but then they are pushed out all at once by their common dissensus with water.[206] In this and other examples, the motions and arrangements of the particles explain why a quality can be observed in a certain time and place, but always on the assumption that there is a stable subject of the quality that does not change except in place.[207] Newman calls this pattern the "interplay of structure and essence" in Sennert's theory. He also quotes a single exception to the rule that Sennert does not reduce qualities to spatial arrangements: In a letter to Döring, Sennert attributes the different properties of spirit of wine and spirit of vinegar to the differences in *positus* of the same types of atoms. On the whole, however, Sennert overwhelmingly explains the qualities in visible bodies by reference to the same qualities in invisible atoms.

Remarkably, Sennert uses the same strategy in the realm of living beings as in the chymical and physical examples. The idea of the hidden seeds that explains the spontaneous generation of worms works in a very similar way as the physical deactivation of fire atoms in the limestone before they are driven out by their antipathy to water. According to what might be called the doctrine of hidden forms, an atom can be latent in a visible body, i.e., without its qualities being noticeable, and be expressed only at a later point. Sennert applies this principle to all the particles that he postulates, thereby producing explanations of a broad range of processes. Among the explanations involving the *prima mixta*, the most prominent one is Sennert's demonstration of the *reductio ad pristinum statum* by means of the restitution of noble metals out of

206 See above, note 190.

207 See Newman, *Atoms and Alchemy*, 133. Sennert to Döring, letter dated 23 March 1623, *Opera omnia* (1676) VI, 592.

acid. Finally, Sennert uses hidden forms in his theory of animal generation as well, claiming that the seeds of animals can be in other bodies without informing them, and that this explains spontaneous generation (Section 3.3).

How does the orthodox Sennert whose theory of local motion was the subject of the first half of this chapter fit together with the chymical atomist Sennert of the second half? As discussed, his explicit account of motion is fairly close to those of other late scholastic authors. In particular, his language often suggests that the subject of change, the *motum*, is a visible body. It also follows from the basic Aristotelian description of change that the only things that can act as causes for a change in nature are substances and their forms. Since Sennert's atoms are bodies with their own substantial forms, their motions and changes also fall under the general Aristotelian description and should be caused either by their own forms or by the influence of some external substance. Such causal relations are not explicit in Sennert's theory; the question for us is whether that is a mere oversight for which we can fill in the blanks, or whether there is a systematic incompatibility between the Aristotelian scheme of change and Sennert's style of atomistic explanation.

I have argued in part four of this chapter that the former is the case. It would have been possible for Sennert to give a comprehensive theory of the motions of his particles and their causes, simply by explicitly extending the theory formulated for visible substances to the particles as well. I have attempted to reconstruct how the local motions of particles could be integrated with the observable changes in mixts. There are four natural processes for which this is possible. 1) As discussed in section 4.2, the local motions of mixts are founded in the elementary atoms first of all. 2) The forms of perfect mixts structure the aggregates of atoms that are their proximate matter, and therefore cause various motions in individual atoms (section 4.3). 3) Occult qualities, like the powers of magnets or poisonous plants, inhere in the whole substance but can also cause particle motions. 4) Finally, by the mechanism of *dissensus* and *consensus*, atoms that share a quality attract each other, whereas atoms that have opposite qualities tend to move away from each other (section 4.4). Since Sennert favorizes emanative causation in the case of natural motion, it seems plausible that he would also view each individual atom as the cause of its own motions of consensus and dissensus.

CHAPTER 2

Sébastien Basson

1. Basson's philosophy

1.1. *Introduction*

As we have seen in the previous chapter, Sennert is a cautious reformer who integrates his atomism as closely as possible within the hylomorphist framework. We have also seen that in order to achieve that aim, Sennert carefully engages with the Pluralist tradition within hylomorphism. In contrast to Sennert, Sébastien Basson styles himself a revolutionary rather than a reformer, wanting to raze the Aristotelian building to its foundations and to replace it with something entirely different. He is, in other words, the prototypical *novator*. Only one work was published under his name, namely the *Philosophiae naturalis libri* XII, which appeared in Geneva in 1621. The full title can be translated as "Twelve books of natural philosophy against Aristotle, in which the hidden physics of the ancients is restored, and Aristotle's errors are refuted with solid reasons."[1] It describes the work quite accurately: Basson's aim is to refute Aristotle and any Aristotelians in the domain of natural philosophy, and then to reconstruct an alternative, non-Aristotelian natural philosophy or physics. Basson claims that this alternative physics was upheld by a number of thinkers before Aristotle but was suppressed by him, so that the polemical project of criticizing Aristotle is also the constructive project of restoring the theory of the ancient sages.

Basson's work could hardly be more different from Sennert's in style and gesture. When it comes to the new natural philosophy itself, however, the similarities would seem to outnumber the differences at a first glance. Most obviously, both authors defend a natural philosophy based on unchanging corpuscles. They also

1 The full title is *Philosophiae naturalis adversus Aristotelem libri* XII, *in quibus abstrusa veterum physiologia restauratur, & Aristotelis errores solidis rationibus refelluntur, a Sebastiano* Bassone, Doctore Medico. There were two editions, an initial one in Geneva in 1621 and a second one in Amsterdam in 1649. The first edition contains some errors in the numbering of the articles. Most of these are corrected in the second edition, which however introduces some new errors. The references to the *Philosophia naturalis* in this chapter use the page numbers of the 1621 edition.

share an interest in medical and chymical questions, and as a consequence often seem less interested in the precise ontology of their particles than in how they can explain a specific natural property or transformation. Even their typologies of atoms are comparable, since Basson considers particles corresponding to the chemical principles as well as those corresponding to the four elements in some passages and endorses the idea of "secondary" particles composed out of the primary ones.[2]

In fact, Sennert knew of Basson and had read his work by 1623. As he writes to Michael Döring: "I have Basson's book, which confirms my opinion regarding atoms. Nevertheless, he supports quite a few absurd doctrines." Years later, in the *Hypomnemata*, Sennert calls Basson "sharp-sighted enough in matters of physics,"[3] but then goes on to criticize him for claiming that mixture comes about without the help of a substantial form. And that is the main difference between them: While Sennert carefully integrates his atomism into a hylomorphic framework by defending a plurality of substantial forms within one body, Basson rejects the idea of a substantial form of the visible body entirely. It is therefore already clear that in Basson's system, everything depends on the nature of the individual atoms.

As mentioned, Basson pursues both a constructive and a polemical project in his work. Both are tightly interwoven in the text and depend on each other, but it is possible to distinguish some parts that are more constructive from others that are more destructive. The overall tendency is that the first half of the *Philosophia naturalis* contains more explicit criticism of the Aristotelian foundation, while the second half focuses more on reconstructing the lost doctrine of the *veteres*. Basson says as much at the beginning of the first book on form, where he writes the following:

> Both sides of these matters having therefore been pondered, it was found to be more advisable to settle strongly on a refutation of the Aristotelian doctrine before we work on the restitution of the philosophy of the ancients. Especially as the understanding of much of what

2 Basson, *Philosophia naturalis*, 126. Cf. Clericuzio, *Elements, Principles and Corpuscles*, 40; Kubbinga, "Les premières théories 'moléculaires.'"

3 Sennert to Döring, 23 March, 1623: "Sebastiani Bassonis librum habeo, qui me in mea de atomis sententia confirmat. Idem tamen absurda dogmata non pauca fovet," *Opera omnia* (1676) VI, 592. "[…] Sebastianum Bassonem, alias in Physicis satis perspicacem," *Hypomnemata* IV, 6, SO 132a. Cf. Arthur, "Animal Generation," 25–28, who discusses Sennert's engagement with Basson.

> we are going to say about the ancients' doctrine depends in large parts on what we are going to uncover in these treatises. In destroying the Aristotelian foundations, we will lay those of the ancients.[4]

This passage comes at the end of an article in which Basson explains that the Aristotelian notions of prime matter and substantial form are mutually dependent, so that one can only accept both or neither. That is why to argue against either is to argue against both. What Basson claims in the passage itself is that refuting the conceptual base of Aristotle's philosophy is a prerequisite for the exposition of his own system for two reasons. The first is that once the reader realizes that substantial form and prime matter are untenable concepts, they will have to accept the alternative characterizations of matter and form offered by Basson. The second reason is that the argument made in the treatises on form will be important for the reconstruction of the philosophy of the ancients. Indeed, we will see in the last part of this chapter that the second book on form in particular contains Basson's arguments for viewing God as the only true cause of all physical processes, which is the starting point of the exposition of his own system that starts from book six.

The *Philosophia naturalis* is a somewhat confused book, and one in which it is at times difficult to find the thread of the argument. That is partly due to the intertwining of the polemical and the constructive project: It is often unclear whether a given passage is supposed to reconstruct some aspect of the lost theory of the ancients or whether it is part of an extended argument against a particular interpretation of hylomorphism. This, in turn, is partly because both Basson's critique of Aristotelian principles and his reconstruction of the atomist alternative depend on Aristotelian sources. For one, the topics of the titular twelve books of his work read like a list of the most important concepts in Aristotelian natural philosophy: They treat matter, form, nature, motion, action, the heavens, sight, and meteorology. It is also often unclear whether his use of Aristotelian vocabulary is orthodox or not. For example, in the first book on matter, he gives a familiar definition of nature:

4 "His igitur in utramque partem agitatis, visum est consultius in Aristotelicae doctrinae refutatione fortiter consistere, antequam Antiquorum philosophia restitutionem moliamur. Praesertim cum multorum quae de Priscorum doctrina dicturi sumus, intelligentia magna ex parte pendeat ex iis quae hisce tractatibus aperiemus. Aristotelica destruendo, Veterum fundamenta iaciemus." Basson, *Philosophia naturalis*, 136.

> By "Nature," we understand that internal principle, by which each thing whatsoever not only is and continues to be, but also has the power to act, to suffer and to cease acting and suffering. The things that have this inner principle and cause are called "natural."[5]

As we have seen in the discussion of Sennert's *Epitome*, such definitions of nature and the natural are a conventional part of late scholastic natural philosophy textbooks. Basson therefore not only adopts an Aristotelian definition, but even follows the conventions of the textbook genre further by introducing it at the very beginning of his own book. At the same time, he never explains how the definition of nature as the internal principle of motion can go together with the fact that he denies the existence of the substantial form. In addition to adopting parts of the hylomorphist conceptual apparatus, Basson also depends on scholastic authors in a more direct way: The quotations within the *Philosophia naturalis* all come from a very limited number of books, with the Aristotelians in the majority. In particular, the bulk of Basson's knowledge about the ancients whose thought he aims to reconstruct stems from Aristotelian textbooks. In addition to the Aristotle commentaries by Francisco Toletus and the College of Coimbra, the authors who Basson relies on most often are Julius Caesar Scaliger, Jacopo Zabarella, Francesco Piccolomini, and Jean Fernel.[6]

The overall structure of this chapter is the following: I begin by giving a synopsis of the initial parts of the *Philosophia naturalis* and the basics of Basson's worldview, then continue with a sketch of what we know about the author's biography and the immediate reactions of his contemporaries (sections 1.2 and 1.3). I then turn to the part of the *Philosophia naturalis* that most obviously concern our topic, namely Basson's treatment of motion in books seven and eight. The result of that investigation is that

5 "[P]er Naturam intelligimus internum illud principium, quo res quaevis cum est, & esse persistit, tum agendi, patiendique, item ab iisdem cessandi habet potentiam. Res autem quae intimum hoc principium causamque habent, naturales vocantur." Basson, *Philosophia naturalis*, 1 f.

6 See Lüthy, "Thoughts and Circumstances," 62, on Basson's very limited library. Basson, *Philosophia naturalis*, xxxvii, admits that Aristotle is one of the best available sources for the wisdom of the ancients. Thorndike even judged that Basson's work "testifies as much to the abiding influence and even dominance of the Stagirite as it does to the existence or success of opposition to his teachings." *A History of Magic and Experimental Science*, VI, 386. Basson is one of the cases brought forward by Emerton in order to show that the anti-Aristotelian movement did not abolish the concept of form, but merely reinterpreted it: Emerton, *Scientific Reinterpretation of Form*, 62–64 and 107–121.

Basson posits four rules for the microscopic motions of his atoms, and that he uses these rules to explain the traditional Aristotelian examples of the local motions of visible bodies as well as their qualitative changes (sections 2.1–2.3).

Taken together, this is a more or less satisfactory physical theory of the narrow band of phenomena discussed. However, it raises metaphysical questions, especially about the ontological status of the elements and the *spiritus*, but also about Basson's view of causation. This is illustrated by a short literature overview: Although modern commentators since Lasswitz have been mostly in agreement about Basson's status as a *novator*, two of the areas in his thought that have divided interpreters are the precise ontology of the atoms and the role of the substance called ether or *spiritus* by Basson. In other words, Basson' account of motion in general and of falling and throwing motions in particular depends on the very issues that have puzzled his interpreters (section 3.1). Finally, I offer my own reading on the relevant passages from the middle books of Basson's work, especially book 6 on nature, to find out which interpretation of the relation between God, *spiritus* and the atoms is the most plausible in light of the regular motions examined in part two of the chapter (section 3.2).

1.2. *The* Philosophia naturalis

The text of the *Philosophia naturalis* is structured into the titular "twelve books," preceded by a dedication and a *Preface to the Reader*. Each of the books in the body of the text takes up somewhere between 50 and 80 pages, and sometimes one topic extends to two or three consecutive books. Within each book, the text is structured into *intentiones*, and these are further divided into articles. On some occasions, there is either an untitled piece of text at the beginning of a book before the first *intentio*, or there is a *propositio*, both of which can contain multiple articles. In the rest of this section, I will summarize the results of the preface and the first two books. This serves as a general introduction to Basson's philosophy, because the preface sets out the overall project and the matter books introduce the basic entities of the ontology, that is, the atoms of the four elements.

The preface, which was the most widely read part of the book in its own century, sets out the overall project: To reconstruct the natural philosophy of the *prisci* or *veteres*. According to Basson, there was a consensus among most of the pre-Aristotelian philosophers that was deliberately buried by Aristotle, whose only saving grace is that most of the surviving traces of the consensus were transmitted through his writings, although in corrupted form. The most important and most unequivocally positive authority is Plato, but Pythagoras, Empedocles, Democritus and Lucretius are

all mentioned with approval as well. So is Hippocrates, about whom Basson argues that his profound knowledge of medical issues must have come from a deeper understanding of nature, and that this philosophy could have come from no other source than the *veteres*.[7]

The body of the *Philosophia naturalis* begins with two books on matter. The first *intentio* of the first book outlines the views of Aristotle and the ancients in their basics. Here, Basson gives a terse, but accurate account of the concepts of prime and informed matter and substantial form. The difference between substantial and accidental forms is introduced as a way of explaining substantial change involving one subject (*res*) being replaced by another, from accidental change, in which "what already is, is changed into something else."[8] The basic doctrine of the ancients, in contrast, is outlined in the following way:

> And indeed, Empedocles, Democritus, Anaxagoras and many other philosophers, even Plato himself, determined prime matter to be diverse very subtle natures, out of the various conjunction of which things come to be, just as out of stones, loam and clay tiles a house arises; but they were not ignorant of that other principle, from which these things obtain all motion and their active power, about which [we will speak] in its proper place.[9]

In *intentiones* two and three, Basson goes on to offer a biting and fundamental critique of the notion of prime matter. Basson criticizes the idea that matter is the principle of corruption and the doctrine of the *dispositio materiae*. The rest of the first book argues

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7 Basson, *Philosophia naturalis*, xxvi–xxxi. On Hippocrates in particular, see ixxx: "Sed quoniam aliorum scripta interierunt, doceat nos unus Hippocrates quales fuerint illi philosophi ex quorum principiis naturalibus tam foeliciter in medicina progressus est. Attendant Peripatetici, quos opinor pudeat detrahere Hippocrati cognitionem causarum quae corpus humanum immutant. Causas autem mutationem eiusmodi non potuit noscere ut medicus, nisi prius quae corporis Naturalis mutationum caussae essent ac principia, novisset ut Physicus. Medica enim cum physicae subalterna sit, principiorum suorum certitudinem ab illa mutuatur." On Basson's rehabilitation of Democritus through Hippocrates, see Lüthy, "Fourfold Democritus," 467; "Thoughts and Circumstances," 10. Sakamoto, *Julius Caesar Scaliger*, 24–28, documents the idea of a *prisca theologia* in Scaliger.

8 "[…] id quod iam est, aliter et aliter immutatur." Ibid., 6.

9 "Etenim Empedocles, Democritus, Anaxagoras, aliique complures nobiles Philosophi; Plato etiam ipse, pro materia prima constituerunt naturas diversas tenuissimas, ex quarum diversa coniunctione res fierent, quemadmodum ex lapidis, luto, lateribusque domus exurgit: nec tamen ignorarunt aliud principium, a quo motum omnem ac virtutem agendi res illae sortirentur, de quo suo loco." Ibid., 9.

that the ultimate particles keep their nature when they become part of a mixed body, that is, it argues against the notion of the homogenous mixture.[10] The five *intentiones* in the second book on matter, by contrast, are more empirical, bringing in examples from chemistry and medicine.

There is a summary in bullet-point form at the end of the section on matter, listing some of the results. We learn a few things about the basic particles that in Basson's and the ancients' view make up all things: They require "for the generation of each thing a different composition of pre-existing principles, by the changing arrangement of which the thing is constantly changed in various ways, just as we see the typesetter create different sentences out of the same characters in different dispositions."[11] The true philosophy is atomistic, in the sense that all visible things and their changing properties are due to the changing compositions of very small particles:

> The matter of things is composed of tiny particles with diverse natures. Whether those natures are the four elements fire, air, water and earth, or whether they are something else prior out of which the elements are composed, they are completely different in species.[12]

The four elements therefore play an important role in the construction of everyday things out of minimal particles, but Basson is at this point undecided whether they are to be identified with the main types of atoms directly or whether the elements are in turn made up of more basic particles. Later in the work, however, he quite consistently uses only four types of fundamental particle, corresponding to the four elements. These particles or corpuscles are physically indivisible because they were created by God and are not subject to change or destruction.[13] For this reason, I will

10 Nielsen, "Seventeenth-Century Physician," 306 f.

11 "[…] in eo tamen concordarunt, quod ad rei cujusque generationem principiorum ejusmodi praeexsistentium diversam compositionem requirerent, qua structura variante, res quotidie diversimode mutaretur: haud secus atque videmus typographum ex iisdem characteribus aliter atque aliter dispositis, alias atque alias orationes effingere." Basson, *Philosophia naturalis*, 9. For the origin of the analogy of atoms to letters, see p. 196 below.

12 "1. Materia rerum ex minutissimis particulis diversae naturae comparata est: quae quidem naturae sive sint quatuor elementa ignis, aer, aqua, terra; sive quid aliud prius, ex quo haec elementa componantur, speciei diversissimae sunt." Ibid., 125.

13 "Haec principia post primam creationem ortus, interituque sunt expertia." Ibid. See Ariew, "Descartes, Basso, and Toletus," 133, for a concise overview of Basson's corpuscle theory.

be calling these minimal particles *elemental atoms* or *atoms of the four elements* in the rest of this chapter, even though Basson uses the word "atom" only occasionally, denies the existence of a vacuum and makes no references to the shapes of the particles. The only exception to the latter are fire particles, to which Basson sometimes attributes a pointy shape.[14]

1.3. *Sébastien Basson*

There is a lot that we do not know about Basson's life and circumstances, although Lüthy has reconstructed his biography to some extent.[15] We do know that Basson calls the *Saulnois* in the Duchy of Lorraine his *patria*, and also that his early education was at the Jesuit college in Pont-à-Mousson, since he mentions a certain Pierre Sinson, who was employed there, as his teacher.[16] From Sinson's biography, we can place Basson's time at the college between 1593 and 1599 and therefore his birth between 1577 and 1583. Some 28 years later, there are the first records of Basson on the post of "first regent" in the Hugenot academy in the small town of Die-en-Dauphiné in the French Alps. The fact that by that time he is married to a woman from the Bernese territories and that he is recommended for the job by a professor at the Bernese Academy of Lausanne means that he moved to these territories sometime between his graduation at Pont-à-Mousson and his move to Die. One further hint is provided by the title page of the *Philosophia naturalis*, which advertises the author as a medical doctor. We must therefore assume that Basson studied medicine, although it is unclear when and where. The time and circumstances of his conversion to Protestantism are equally unclear, though it must have taken place between his time with the Jesuits and his arrival at the Huguenot academy.

The academy at Die was a small institution constantly beset by difficulties. As ascertained by Lüthy, Basson was not at all content with his position in the school during his twelve years as a regent, which may be related to the fact that he was a teacher of languages and rhetoric rather than having one of the more prestigious and well-paid posts teaching medicine or philosophy. After a series of conflicts with the academic senate, he was let go in September 1625. Nothing is known about him

14 On the role of geometrical shape for Basson in general and for the fire atoms in particular see Lasswitz, *Geschichte*, I, 474–476; Lüthy, "Thoughts and Circumstances," 13.

15 This biographical sketch relies on information from Lüthy, "Thoughts and Circumstances", in particular 22–24 and 38–40.

16 Basson, *Philosophia naturalis*, 647.

after that date, and there are no direct reactions at Die to the publication of his book, which was printed in Geneva in 1621. Judging from the dedication, patronage of the *Philosophia naturalis* came from the father of one of Basson's noble students. Lüthy draws the tentative conclusion that Basson wrote the *Philosophia naturalis* to make enough of a name as a philosopher of himself to be considered as the next full professor of philosophy at Die. If that was indeed his idea, it failed utterly, possibly exacerbating the animosity between him and the rest of the Academy.[17]

In contrast to the complete absence of any reaction at the Academy, the *Philosophia naturalis* made strong impressions on at least some of its readers in the rest of Europe.[18] The most unambiguous sign of the 17th-century reception is the fact that in 1649, a second edition of the *Philosophia naturalis* was published, and by no less a publishing house than Elzevier in Amsterdam. This marks the end of a first period of reception in which Basson was taken as a serious *novator* both by defenders of tradition (self-acclaimed or not) and by those seeking a non-Aristotelian natural philosophy. Basson figures in the lists of *novatores* both of Marin Mersenne and of Jean-Cécile Frey, who both dismiss his ideas out of hand without having read the *Philosophia naturalis*.[19] The reactions of Basson's fellow *novatores* is more mixed. Sennert's opinion of Basson has already been noted. Isaac Beeckman gives quite extensive evaluations in his *Journal*. He comments particularily on the physical and kinetic sections, where his overall judgement is that Basson's treatment is not mathematical enough and lacks Beeckman's own insight that it is unnecessary to assume a force that keeps moving bodies in motion.[20] As with most other writings of Beeckman, his comments on Basson were not published until the 20th century. There are also three pieces of evidence that Descartes read Basson's work. In one instance, he mentions him by name, speaking of "Telesio, Campanella, Bruno, Basson, Vanini, and all the other novatores."[21] Another occasion is in a letter to Mersenne, where Descartes writes about the position of a "physician" who has a theory of the ether: "As for rarefaction,

17 Lüthy, "Thoughts and Circumstances," 40–45, 52–57.

18 Ibid., 25–29. Cf. Also Lasswitz, *Geschichte*, I, 467; Gregory, "Sebastiano Basso," 44 n. 1; Nielsen, "Seventeenth-Century Physician," 300.

19 Mersenne, *Quaestiones celeberrimae in Genesim*; Mersenne, *L'impiété des Déistes*, I, 237; Mersenne, *La vérité des sciences*, 109; Frey, *Cribrum philosophorum*, chap. 17. Cf. Lüthy, "Thoughts and Circumstances," 25.

20 Beeckman, Journal, II, 25, 243–247. Cf. Lüthy, "Thoughts and Circumstances," 27 n. 67.

21 Descartes to Beeckman, 17 Oct. 1630: "Unum dicit Plato, aliud Aristoteles, aliud Epicurus, Telesius, Campanella, Brunus, Basso, Vanini, novatores omnes, quisque aliud dicunt; quis ex illis docet, non dico me, sed quemcunque sapientiae studiosum?" AT, I, 158.

I am in agreement with this physician and have now made up my mind about all the foundations of philosophy; but perhaps I do not explain the aether as he does."[22] Years later, he remarked to Constantijn Huygens that Basson's book was "good only for destroying the opinions of Aristotle."[23] With Descartes as with most of the other early readers, Basson's influence is mainly acknowledged when they disagree with him, although there are enough similarities to allow for speculation that there was also some positive influence.[24] The most openly positive judgements of Basson's philosophy are contained in the atomist textbook *Institutiones Physicae* by Johannes Sperling, a student of Sennert.[25]

2. Motion

2.1. *Rules of elemental motion in the book on actions*

With the basics of Basson's project out of the way, we can now examine Basson's account of the local motion of sensible bodies more closely. As we have seen, Basson's twelve books can be roughly divided into two halves. The books on matter and on form, in which the author proves that the two fundamental Aristotelian notions must be substantially revised, take up about the first half of the text body. The second half is taken up by books number 6 to 12, which contain Basson's treatment of traditional topics of Aristotelian science according to his own alternative system. Among these later books, the titles of books 6 and 8 are least recognizable as coming from a late scholastic *cursus*: Book 6 is entitled "On Nature and the World Soul," and the full title

22 "Pour la raréfaction, je suis d'accord avec ce medecin, et ay maintenant pris party touchant tous les fondemens de la philosophie; mais peut-estre que je n'explique pas l'aether comme luy." Ibid., 1, 25. Cf. Ariew and Grene, "The Cartesian Destiny of Form and Matter," 311.

23 "Le livre que vous me fîtes hier la faveur de m'envoyer, en est une bien récente, et dont je vous remercie très humblement. Mais je ne sais si j'ose vous dire que, puisque vous avez eu la patience de le lire, je me persuade que mes rêveries ne vous seront pas insupportables; car, si je m'en souviens, il n'est vaillant qu'à détruire les opinions d'Aristote, et je tâche seulement d'établir quelque chose, qui soit si simple et si manifeste, que toutes les opinions des autres s'y accordent." Descartes to Huygens, 28. March 1636, in Descartes, AT, 1, 602 f. Cf. Nielsen, "Seventeenth-Century Physician," 301 n. 18.

24 Lüthy quotes similarities in the treatment of magnetism in Descartes' *Principia* and some general features of Johannes Chrysostomus Magnenus' *Democritus reviviscens*. Cf. Lüthy, "Thoughts and Circumstances," 28.

25 Sperling, *Institutiones Physicae*. Cf. Lüthy, "Thoughts and Circumstances," 27.

of book 8 is "On Action and the Four Primary Qualities."[26] The remaining books fit in more easily: Book 7 is on motion, books 9–10 on the heavens, book 11 on sight, and the final book 12 on meteorology.

The book on motion is therefore preceded by the one on nature and followed by the one on action. In it, Basson treats many of the examples and problems surrounding the local motions of visible bodies that we have seen discussed by Sennert and in the scholastic tradition before him. In contrast to these hylomorphic accounts, however, Basson makes frequent reference to the particles that he postulated in the books on matter. What I will argue in part two of this chapter is that Basson's explanations are based on a set of rules for the interactions of the minimal particles that he postulates in the book on action, and that the program of the book on motion is to prove that Aristotelian descriptions of the behavior of visible bodies can be reduced to applications of these rules. For this reason, I shall begin this part not with the book on motion itself, but with an analysis of some passages from the book on action. The latter begins with the following passage:

> In the previous book, we treated of that motion that nobody denies to be local. In the present one, we have decided to show that it is true what we have maintained according to the teachings of the ancients: That all the most diverse changes in any thing whatsoever come to be only from the local motions of the particles out of which all things come to be. But this will have been made sufficiently evident when we will have proven that heat, cold, humidity and dryness, which they call the primary qualities, arise from such a motion.[27]

One could not wish for a clearer statement of the reductive program: The aim of Basson and the *veteres* is to show that all qualitative change can be explained by the local motion of the same particles that also explain how bodies themselves come about. There are some qualifications to be made, however: Firstly, in the last sentence quoted, Basson claims that his aim is to prove that the primary qualities as such come about

26 "De natura et anima mundi"; "De actione et quatuor primis qualitatibus," Basson, *Philosophia naturalis*, 309 and 430.

27 "Praecedenti libro egimus de illo motu quem localem esse nemo negat, praesenti statuimus ostendere quam sit verum quod superius affirmavimus ex Veterum disciplina; solo motu locali particularum, ex quibus res quaeque fit, omnes mutations fieri, quas diversissimas res quaelibet patitur. Id autem sufficienter fuerit declaratum, si calorem, frigus, humiditatem, siccitatem, quas primas qualitates vocant, ex tali motu provenire probaverimus." Ibid., 430.

(*provenire*) through particle motions, which is not easily compatible with his claim in the previous sentence that the program is to explain *changes* in things. We have seen in the case of Sennert that this is an important difference, because it determines whether the primary qualities remain as irreducible properties in the particles or whether they are themselves nothing but local motions. As we shall see in the course of this chapter, Basson's ultimate goal is indeed the more ambitious reduction of qualities themselves. Secondly, it is worthy of note that Basson's immediate target are not all the qualities, but the four primary qualities in particular. He assumes that all other qualities can be produced without complications from the primary ones. In this, as we have seen, he is in agreement with most scholastics, and he is generally just as vague as they are about how the various secondary qualities emerge from proportions of the primary ones.[28]

In the course of Basson's endeavor to explain the origin of qualities, we also clarify his basic ontology. As we have seen, the summary at the end of the first book on matter makes no commitment as to what types of atoms there are, but in the later books, it becomes clear that the primary qualities are directly associated with four types of atoms that correspond to the four elements. Furthermore, the atoms of these four types do not move of their own accord or power but are moved by another substance called the *spiritus* or ether. The ether is first mentioned in the second book on form,[29] but it is only in the book on nature that Basson explains what, in his opinion, the true meaning of that concept is. He spends the second *intentio* of that book proving that the phenomena of rarefaction and condensation, as they are desribed by the Aristotelians, lead to the impossible conclusion that there is a vacuum in between bits of matter. In the third intention, he introduces the *spiritus* as the true explanation of rarefaction and condensation, a "certain corporeal substance, most subtle indeed," which fills the spaces in between the atoms and moves them further apart or closer together. The same ether is also responsible for the other motions of the elementary atoms: Particles of fire are moved very quickly, "as the condition of their nature requires. In the same way, *if it goes into the matter of air, of water, of earth, it [...] moves each as ordained.*"[30]

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28 See p. 70 above.

29 See the second *intentio* of the second book on form in Basson, *Philosophia naturalis*, 200. Basson is quoting Jean Fernel at this point, who in turn is discussing the pseudo-Aristotelian *De Mundo*. See Fernel, *De Abditis Rerum Causis*, lib. 1 c. 10; A modern translation of *De Mundo* is given in Thom, *Cosmic Order and Divine Power*.

30 "[...] substantiam aliquam corpoream, tenuissimam quidem," and "[...] prout petit eorum naturae conditio. Hunc in modum si aeris, si aquae, si terrae materiam ineat, [...] movet unumquodque prout ordinatum est." Basson, *Philosophia naturalis*, 333 f. Nielsen, "Seventeenth-Century Physician,"

The reductionist program of the book on action is therefore to explain the four primary qualities as motions of the four elementary types of atoms, directed by the actions of the spirit. Let us for the moment leave aside the questions of what kinds of substances the *spiritus* and the particles of the elements are and how exactly it is possible for them to interact, and instead look for a description of their motions. Basson gives a detailed description of the motions of the atoms in a passage towards the end of the first *intentio* of the book on action. The passage is quite long, but we will have occasion to discuss it in its entirety:

> We have said that this universal spirit imparts to the elements to which it is conjoined a double appetite, i.e., that for conjunction with what is similar to it and that for the space and place owed to its nature. [1] The first appetite brings forth two motions, [1a] a primary one by which like attracts like, or latches on to the similar much more strongly, because such attraction comes not from force, but from love; [1b] another, secondary one by which, when like wants to connect with like, it strives to eject whatever foreign object is standing in the way of that appetite. And for that reason air, water, fire, each in its sphere, strives to throw out whatever has another nature: which is why the sea and the rivers drop all their dirt on the riverbanks, and why air, except for the very smallest particles, carries no extraneous thing and why the part of any body strives to push out anything that is alien to it. [2] By the second appetite, then, the element not only [2a] tends towards its own sphere, [2b] but also requires a certain space; in order to obtain that space, it not only contends with the dissimilar and repels it (as the rising fire moves the air aside, whose place it takes), but similar parts also move away from similar ones, as they want to have equal space and want to cohere equally. In such a way, therefore, air that is agitated by compacted vapor and steam moves air, and water moves water.[31]

321–323, collects many of the relevant passages for what he calls the "basic laws of atomic motion" and correctly points out how important such laws are for Basson's explanations of composite bodies. Lasswitz already notes the passages quoted here and in n. 31, see Lasswitz, *Geschichte*, I, 476.

31 "Diximus spiritum illum universalem elementis conjunctum duplicem illis appetitum impertiri, similis scilicet conjunctionem & spacium, locumque suae naturae debitum. [1] Primus ille appetitus duos motus excitat, [1a] unum primarium quo scilicet simile attrahit simile, vel forte potius ad simile se recipit; neque enim vi fit talis attractio, sed amore: [1b] alterum secundarium quo scilicet dum simile appetit similis connexionem, conatur ejicere quicquid alienum ingestum huic obest

As Basson writes at the outset of the passage, the *spiritus* gives each particle of earth, fire, water or air a "double appetite," that is to say, two separate appetites. He explains in the rest of the passage that each appetite has two motions as consequences. I have labeled the resulting four motions 1a, 1b, 2a and 2b, to mark out that they are grouped into two pairs: Motions 1a and 1b are the results of appetite 1, "for conjunction with what is similar to it," while motions 2a and 2b correspond to appetite 2, "for the space and place owed to its nature." Motion 1a is a motion of sympathy between similars, which Basson envisions both as a tendency in elementary particles to move closer together and as a resistance against being separated. Motion 1b is derived from 1a, since (as Basson explains) the fact that bodies of one element tend to eject small impurities of foreign particles is merely a side-effect of their tendency to move as closely together as possible. Note that here and elsewhere, Basson assumes that to explain the motions of the four elementary atoms is the same as explaining the behavior of their masses in sensible bodies. That is why he takes the fact that river water seems to eject mud and deposit it on the banks as evidence of the motion of ejection in the particles the mud and water ultimately consist of. If Basson had been as inclined to name his elementary types of motion as Francis Bacon, he might have called motion 1a the motion of elemental attraction and 1b the motion of ejection. We will have occasion to discuss Bacon's simple motions in chapter four.

The motions that follow from appetite number two are much more independent from each other than the first pair. When it moves according to motion 2a, a particle of fire, earth, water or air "tends towards its own sphere." Basson does not explain what this expression means in any more detail at this stage, but as we will see in our analysis of the book on motion, motion 2a is a tendency of each type of particle to move towards its sphere in the cosmological sense, that is, towards one of the four concentric spheres that constitute the cosmos. Motion 2a is, in other words, Basson's replacement of the Aristotelian natural motion and might be called the motion of natural place. Motion 2b has no obvious connection to motion 2a and instead would

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appetitui. Atque hanc ob causam aer, aqua, ignis, quodque in sua sphaera, quicquid diversae naturae est, nititur ex sese evomere: hinc & mare, & flumina sordes omnes in ripas abjiciunt: & aër, praeter minutissima corpuscula, nihil extraneum sustinet. Et pars quaevis corporis quicquid sibi extrarium est, conatur expellere. [2] Secundo illo appetitu dum elementum non modo [2a] in suam sphaeram tendit, sed [2b] spacium certum requirit; ut illud obtineat non modo certat in diversum, ut id à se repellat, veluti cum ignis accensus aerem submovet, cujus locum subit; sed partes similares à similaribus moventur, dum spacium aequale habere, aequaliterque invicem cohaerere volunt. Sic ergo aër à vaporibus, & halitibus compressis commotus movet aerem, & unda undam." Basson, *Philosophia naturalis*, 434 f.

at first seem to be a correlate to motion 1a, since a particle obeying it "contends with the dissimilar and repels it." In other words, whereas 1a was a motion of consensus between particles of the same type, 2b is describes a dissensus between particles of dissimilar or opposite types. However, Basson adds another type of particle behavior that is also comprised under motion 2b, namely that "similar parts also move away from similar ones, as they want to have equal space and want to cohere equally." Even particles of the same element therefore tend to move away from each other under some circumstances, namely when that allows them to equalize their distance from all their neighbors of the same type. Since motion 2b describes motions in which elements of both similar and dissimilar types are involved, we might call it a motion of elemental distance, rather than one of dissensus.

What is striking about the descriptions of these four motions is that three of them (1a, 1b and 2b) are *relative* motions in which the motion of one particle is determined by the presence of other particles, implying that individual particles react to each other according to multiple interacting rules. In contrast to the other three motions, motion 2a does not seem to depend on an interaction between multiple particles and is rather a tendency of each individual particle to move towards its natural place in the cosmos. Working in combination, the four motions constitute a crude description of the behavior of the elemental atoms. For instance, if the distance between two fire particles is too great, they will attract each other and move closer together (according to 1a); if the distance is too small, they will move further away (according to 2b).

There is a lot that remains unclear about the character of the four particle motions and the two appetites that they result from. One thing in particular that does not become clear from the definitions of the four motions is how each motion is applied to each type of elemental particles. At the beginning of the book on nature, Basson provides some of the missing information. There, he defines and contrasts the four elements according to their functions. As he explains, fire divides and is the cause of light and heat, air is responsible for the growth of plants and animals, water is the birthplace of fishes, and earth is the foundation for everything else. In each case, these functions are grounded in the size of the particles, their velocity and their distance from each other.[32] To take elemental air as an example:

> It was therefore necessary that air is also very tenuous and thin, so that it would cede easily. However, its task did not require as much

32 As mentioned above on p. 106, the only type of particle to which Basson assigns a shape is fire.

> subtlety as that of fire. For it did not need to divide things, but to conserve them. And consequently, it did not need to have as much velocity.[33]

From their different functions in nature, Basson therefore infers a hierarchy of corresponding differences between the four types of elemental atoms. While fire particles are small, quick and far apart, earth particles are relatively big, slow, and consequently "wan[t] to have only the tiniest of spaces between parts."[34]

More could be said about these characterizations of the four elements from the book on nature. What is important for our present purpose, however, is that they allow us to deepen our understanding of the interactions between motions 1a and 2b from the book on action. As we now know, the specific differences between the four elements in Basson's view include a specific distance that particles of the same type keep from one another, and that distance is smallest for earth particles and greatest for fire particles. In other words, the distance that a particle of fire tends to keep from other particles is greater than the corresponding distance for any other type of elemental atom. Therefore, if the distance between two particles of different types is intermediate between their preferred distances, they react differently: A fire particle surrounded by earth strives to move away while the earth is happy to rest in place and is not disturbed by the relative proximity of the fire particle. Separately from that, two particles might also tend to move even further away from each other than the distance either of them would naturally require, namely if they are opposed in such a way as to provoke motion of dissensus.

2.2. *Falling motion*

With the analysis of the motions that Basson ascribes to the four types of elemental particles in mind, I now turn to the book on motion itself. In that book, Basson gives, among other things, explanations of the classical Aristotelian test cases of natural and violent motion, as well as discussing various examples involving bodies swimming and submerged in water. I will endeavor to show that Basson operates in the following manner in his treatment of these examples: He accepts as far as possible the physical

33 "Necesse ergo erat aerem etiam esse valde tenuem, & raram, ut facile cederet. Non tamen tantam subtilitatem ejus officium, quantam ignis postulabat. Neque enim debuit ita res dividere, sed conservare. Et consequenter non debuit esse tanta velocitatis." Ibid., 313.

34 "Ideoque exiguum inter partes interstitium volebat." Ibid.

description of the phenomena offered by scholastics in general and by Zabarella in particular, and then demonstrates that they are the results of the elemental atoms' interactions according to the four motions defined above.

The first *intentio* of the book gives an explanation of the accelerated fall of heavy bodies. Basson begins with a discussion of some scholastic accounts, chiefly Zabarella's, with whom he agrees that there are two factors working together in the acceleration of a falling body: The decreasing air resistance on the one hand and the increasing downwards tendency of the heavy body on the other.[35] Also like in Zabarella, Basson's arguments use "parts" of air as the minimal units. Neither author explains what the material structure of these parts is, in the immediate context of the passage. In Zabarella's case, it is clear from his general ontology that the *partes* are pieces of primary matter informed by the form of air.[36] In virtue of their matter and form, they possess a small set of properties, among which are the primary qualities cold and dry in a certain intensity and a certain amount of resistance to being penetrated by another body. It is much less clear that the parts of air keep these properties when they become part of Basson's ontology. We know that they must be either atoms of air surrounded or infused in some way by *spiritus* or clusters of such atoms, but it is so far unclear what other properties they might have.

Irrespective of whether the parts of air are single atoms or clusters, Basson uses them in his explanations, and the rules that he uses to explain their behavior are the same ones as those ascribed to the pure elements in the book on action. In the case of accelerated fall, he explains the air resistance by the mutual attraction of the air parts. As he puts it, "we need to remind ourselves that the inferior air resists the descent of the stone because it resists its division."[37] In other words, the air's resistance to penetration is due to each part of air resisting its separation from the part of air next to it. What about the other half of the equation at the beginning of the falling motion, the downward pressure exerted by the heavy stone? For Zabarella, as Basson remarks and as we have seen, the efficient cause of this downward force is

35 As we have seen in the chapter on Sennert, the Wittenberg physician agrees completely with Zabarella on the explanation of accelerated fall. Indeed, the passage quoted by Basson here describes Sennert's account exactly. Basson, *Philosophia naturalis*, 353; Zabarella, *De rebus naturalibus*, lib. 8, cap. 16. Cf. p. 43 above. Nielsen, "Seventeenth-Century Physician," 326, summarizes Basson's position on accelerated fall, but does not connect it to Zabarella's and only mentions one of the four elmentary motions.

36 The reason why parts of air are introduced into the explanations of free fall is that such air parts are involved in both the *antiperistasis* and the air layer theories of projectile motion. See p. 43 above.

37 "meminisse oportet, idcirco inferiorem aerem descensui lapidis resistere, quia refugit sui solutionem a lapide faciendam." Basson, *Philosophia naturalis*, 353.

the substantial form of the stone.[38] We have also seen that the striving of an element towards its natural place is one of the fundamental motions postulated by Basson in the book on action. In his discussion of accelerated fall, he does not explicitly make the connection to the natural motions of the elements and seems to take as a given that given constant resistance, a heavy body would move downwards at a constant velocity. It seems natural to attribute this constant downward motion to the motion of the elemental atoms towards their natural place, that is, to motion 2a. In any case, his focus in the first *intentio* is on the mechanism by which the air's resistance is gradually decreased. His explanations of this mechanism can be clearly connected to the attractive and repulsive motions that I have labeled 1a and 2b above, applied to the air parts taken from Zabarella. Here is Basson's description of what happens after the downward pressure exerted by the heavy stone has first overcome the air's resistance to separation and begun a slow initial motion:

> In the first [instance] of the cleaving stone's descent, the closest part of the air resists its division more, the second part less. The reason is that, where the first parts of air are broken up, they tend quickly upward to fill the space left behind by the stone. [...] Nothing else, therefore, urged the first parts of air to abandon one another except the weight of the stone, which is why they resisted more. But the second [parts] are moved, besides by the force of the rock, [also] by the first ones ceding, from which they are separated only reluctantly, [and so they] give way more easily to the pressing stone than the ones they are about to follow.[39]

From the moment in which the air parts are first separated from one another, a self-accelerating process takes its course. The "second part of air" is attracted to the first one that was moved upwards, which counteracts its own resistance to being separated

38 Cf. p. 39 above; Zabarella, *De rebus naturalibus*, lib. 8, cap. 4 407.

39 "In primo ergo descensu lapidis proxima pars aeris findenti magis repugnat sui ipsius divisioni, secunda pars minus. Ratio est. Quia, ubi primae partes aeris fissae sunt, ocyus sursum tendunt locum a lapide relictum occupaturae. has ergo aeris divisi partes hinc inde cedentes, secundae partes aeris aegre deferunt, ideoque prementi lapidi citius cedunt, (nedum ab invicem nolunt sejungi) ab aliis illis primis quae sursum adscendunt divellantur. Nihil igitur aliud urgebat primas aeris partes ut sese relinquerent quam pondus lapidi; idcirco magis resistebant: secundas vero, praeter vim saxi, movent primae cedentes a quibus dum gravate sejunguntur, facilius cedunt findenti lapidi, primas scilicet illas sequuturae." Basson, *Philosophia naturalis*, 353 f.

from the other (unmoving) parts of air around and below it. After the second part of air has been set in motion, the same process happens even more quickly for the third part, and so on. Since, therefore, the parts of air that remain below the falling stone are sucked upwards and to the side progressively faster, the resistance offered by the air decreases. The same self-reinforcing motion of air parts upwards also has a second effect, which works to increase the downward force exerted by the stone. The reason is that the air above the stone is compressed, or in any case more agitated, than the air below, and "it is certain that agitated air is stronger and therefore more able to drive out the troublesome rock."[40]

In sum, Basson explains the process of accelerated fall by the pushing of the stone against the air, by parts of air pulling on one another because of their resistance against separation, and by parts of air pushing out the stone. The process is initiated and kept going by the fact that the elemental atoms that constitute the stone tend downwards, following their motions of natural place 2a. The resistance that the air offers against the falling stone results from motion 1a, according to which air parts that are separated further from one another than is natural for them tend to close the gap. The ability of individual parts to displace one another is due to the minimal distance particles tend to keep from one another, that is, from motion 2b. Finally, the air atoms endeavor to push out the stone according to motion 1b. This effect occurs on all sides but is progressively stronger on top because the air becomes more compressed there. The self-accelerating fall of a heavy body therefore results from a combination of the propensity of the elements within the stone to move towards their natural place and their interaction with the parts of air outside the stone. That is why Basson writes that "the heavy and the light are moved partly by an internal principle, partly by an external one, i.e., by a surrounding body that expels them."[41]

While the first *intentio* of the book on motion gives a mechanism why the fall of any heavy object progressively accelerates, the second *intentio* discusses differences between materials. One of the questions that Basson poses is this: "Since things of equal bulk divide the air equally, why is it that some things fall faster than others?"[42] As in the previous problem, Basson takes Zabarella's account as his basis, quoting

40 "[…] constat aerem agitatum potentiorem esse ac proinde validius lapidem molestum excutere." Ibid., 354 f.

41 "Gravia & levia moventur partim ab interno principio, partim ab externo; corpore scilicet ambiente quod ea expellit." Ibid., 366 f.

42 "Cum res aequalis molis aerem aequaliter dividant, unde fit nihilominus, ut aliae aliis celeries descendant?" Ibid., 358.

extensively from book 9 of the *De rebus naturalibus*. There, Zabarelly discusses the natural motions of mixts, as opposed to those of the pure elements. As he explains, the main difficulty arises from the fact that at the beginning of *De caelo* I, Aristotle writes that the natural motion of a mixt is "according to the prevailing element." How should we understand such a motion? In particular, what exactly should we take to be the *motum* and the *motor*?[43]

Zabarella presents two types of opponent accounts that he ultimately refutes, one that is recognizable as Thomist and is attributed to certain *latini*, and another attributed to the *nominales*. As Zabarella presents it, these two accounts have in common that they view the qualities of the elements are the causes of the motion of the mixt. The difference between them is that the Thomists argue that only one quality remains, while the *nominales* (Zabarella mentions Albert of Saxony in particular) think that the qualities of all four elements remain in the mixt and are in constant contest. Zabarella's own position is that only a substantial form can be the cause of a natural motion and that therefore, since both he and his opponents agree that the substantial forms of the elements are not efficacious in the mixt, it must be the form of the mixt itself that causes its natural motion. The natural place towards which a mixt tends to move is determined by its proportion of the four elements and coincides most of the time with the natural place of the dominant element, but nevertheless it is the form of mixt alone that causes the motion.[44]

This is clearly not a solution that Basson can agree with, since he does not recognize a substantial form of the mixt. His own account is instead modeled on Zabarella's rendering of his opponents. Both the *latini* and the *nominales*, as we have seen, attribute the causal power to the qualities of the elements in the mixt. The *nominales* in particular use the mutual contest between the qualities to account for differences between the behavior of mixtures with various proportions of the four elements. They argue that if there is, for example, a "mixt that has five degrees of the quality of fire,"[45] those five degrees will be in their natural place as long as the mixt is in the sphere of fire and therefore will not contribute to the weight of the mixt in either direction. As soon as the mixt comes to another sphere (moved by the degrees of the other elemental qualities), the same five degrees of fire-quality are below their natural

43 Ibid., 358–362, 366–368; Aristotle, *De caelo* I, 2, 269a2, in *Complete Works*, I, 448; Zabarella, *De rebus naturalibus*, lib. 9, caps. 1–4, 443–452.

44 Zabarella, *De rebus naturalibus*, lib. 9, caps. 2–4, 445–450; Albert, *Quaestiones in Aristotelis De caelo*, 472–477.

45 "mixtum habens quinque gradus ignae qualitatis," Basson, *Philosophia naturalis*, 358; Cf. Zabarella, *De rebus naturalibus*, lib. 9, cap. 2, 445.

place and become light. The resulting natural motion of the mixt is the arithmetic difference of the natural motions of all the natural motions of the elements according to their proportions: The total upward tendency of all the elements that are below their natural place minus the total downward tendency of those that are above their natural place. Basson adopts this account with only two changes. The first is that he tacitly exchanges the elemental qualities for the elemental atoms. The second change, which he spends much more time on, is that those parts of a mixt which are currently in their natural place are not simply inert, but instead actively resist being moved away from there. He writes (confusing the *nominales* with the *latini*): "The *latini* therefore [argued] badly when they denied that the elements of the mixt act in their own region, and [they argued] well when they attributed motion to those elements."[46]

Having settled on this account, Basson then goes on to apply it to several examples. I shall now discuss his treatment of the first two and illustrate that, as was the case for accelerated fall, his descriptions of the behavior of the elemental atoms are in accordance with the four basic motions we have seen outlined in the book on action. The first example is the following observation: A ball or empty animal bladder will fall down to the ground whether it is filled with air or not, but it will fall more quickly when deflated.[47] That difference arises, according to Basson, as a result of two factors:

> An element also acts in the mixt as befits its location, when it delays other elements so that they move away from the place less quickly. In that way the air in a mixture, enjoying the company of the surrounding air, is loath to move away from it; but that is not the only reason why the mixture falls more slowly when it slows down its fall with its own delaying. The other [reason] is that the surrounding air acts less on the mixture, when it is less opposed to the ambient air due to the mass of internal air.[48]

46 "Male ergo Latini cum negant elementa misti in propria regione agere. Bene cum motum eius elementis attribuunt." Basson, *Philosophia naturalis*, 361.

47 The original example of the air-filled bladder is introduced by Aristotle in *De caelo* IV, 4, 311b8–14. The different falling speeds are Basson's addition, cf. *Philosophia naturalis*, 351 f.

48 "Elementum quoque in misto, quod huic loco convenit, agit, dum alia elementa moratur quominus celeriter ab eo loco recedant. Ita scilicet Aer in mixto Aeris ambientis societate gaudens gravate ab illo recedit; nec solum hac ratione causa est cur mistum segnius descendat, dum ejus lapsum sua mora tardat, sed quia circundans Aer minus agit in mistum, quod propter copiam Aeris interni, minus est Aeri ambienti adversum." Ibid., 361.

In other words, the air-filled bladder falls more slowly than the deflated one because the air around it interacts both with the air enclosed within and with the mixture as a whole. The ambient and the enclosed air are similar and therefore attract each other – an application of motion 1a, the motion of elemental attraction. The bladder as a whole, however, mainly consists of atoms of types other than air, and is therefore ejected from the ambient air according to motion 1b. At the same time, the water and earth atoms in the hull of the bladder tend to move downwards, according to motion 2a. In the deflated bladder, this latter factor remains the same, but the first two are different: 1a is not active at all, since there is hardly any internal air present, while 1b is stronger, since the deflated bladder contains a higher proportion of non-air than the inflated one.

The second example concerns the behavior of different materials at the surface of a body of water. Imagine, says Basson, two objects falling from some height through the air into water, namely a piece of meat and a piece of fat or lard. What happens is that the fat reaches the water first and then floats, while the meat falls more slowly through the air and then sinks. Basson argues that accounts like Zabarella's cannot explain this behavior, because they are forced to commit to a single natural place for the entire mixt. That the fat falls faster in the air than the meat means that it is heavier, so why does it float in the water?[49] Basson's own solution leverages the idea that each type of atom behaves differently in air than in water. It is the following: The two dominant elements in the meat are earth and air, while the fat is composed chiefly of water and fire. As long as both are in the air, both are heavy because the earth and the water are both above their natural place, but like the inflated bladder, the meat is not ejected from the ambient air because it contains a significant proportion of air itself. When they both arrive in the water, however, the air evaporates from the meat through very small pores, so that the earth in the meat is unopposed and drags it down. The fat, on the other hand, is kept afloat by the fire atoms contained in it, which strive to move upwards to their own sphere, while the water atoms strive to remain in the water. Assuming the same basic account of falling motion in both, the differences are again explained through the motions 2a and 1a in elemental atoms of different types. One added twist is that in this example, Basson also postulates an exchange of material as an additional tool of explanation: The air atoms in the piece of meat not only interact differently with the surrounding air and water than the water, earth and fire atoms, but in the last phase of the process, they are also expelled from their pores entirely.

49 Ibid., 360.

2.3. *Projectile motion*

In *intentio* four of the book on motion, Basson discusses projectile motion. His procedure remains the same as in the previous two problems: First he discusses some Aristotelian accounts, then he points to an observation that is difficult to explain with these accounts as he understands them, then he explains the phenomenon using the elemental atoms and their motions. In the case of projectile motion, Basson summarizes and quotes Scaliger in addition to Zabarella. The positions here are straightforward: Zabarella summarizes the air layer theory, while Scaliger defends a *vis impressa*.[50] Basson does not spend a lot of time discussing these positions themselves but moves on rather quickly to an example that in his opinion can be explained much better by his own theory than by either of the Aristotelian ones. The observation that he starts out with is that heavy bodies seem easier to throw far than light ones. He explains it by once again making a distinction between factors external to the moving body and those internal to it. The description of the external cause is familiar from the discussion of accelerated fall:

> You ask for the cause of this diversity [between light and heavy bodies]? It seems to be twofold, external and internal. The external [cause] is the air behind, which pushes the thing that cedes, just as we said of the natural motion of the heavy. But the traversed air being torn apart, the air following the stone pulls it so that the ceding [of air] becomes easier. But the more whatever thing is alien to the air, the more it is pushed out by it.[51]

Basson here lists the same two factors in the interaction between the projectile and the surrounding air that he also listed in the interactions of the falling body with the air. The first factor is the decreasing air resistance, because air in front of the stone is displaced and moves behind it, pulling more air along with it. The second factor is that the same flow of air leads to an increase in air pressure behind the projectile,

50 Ibid., 370–372; Zabarella, *De rebus naturalibus*, lib. 8, cap. 16, 438; Scaliger, *Exotericae Exercitationes*, Ex. 28, 101.

51 "Hujus diversitatis causam petis? Duplex ea videtur. Externa & interna. Externa est Aer sequens qui qua res cedit, eam expellit, ut de motu naturali gravium diximus. Rupto autem Aere transverso Aer qui lapidem sequitur, eum illac pellit quà facilior fit cessio. Quo vero res quaeque magis aeri aliena est, eo magis ab illo extruditur." Basson, *Philosophia naturalis*, 374.

which increases the air's power to eject it. Both factors make it easier for the projectile to move forward, but the difference between heavy and light projectiles lies only in the second factor: Since heavy bodies contain proportionally more water and earth than light ones, they are also more alien to the surrounding air and are therefore propelled forward with more force.

Because Basson draws such strong parallels between free fall and projectile motion, it seems all the more difficult for him to explain an obvious asymmetry between them: Free fall is generally taken to accelerate over time, whereas projectile motion is taken to be fastest in the beginning. Why would the same interactions between surrounding air and moving body that lead to a self-accelerating motion downward not also lead to an ever faster forward motion? This objection is not answered explicitly by Basson, and it is not clear that he has an answer to it. However, if he can make a meaningful distinction between the two cases, the difference must lie in the second type of cause that he lists for both motions, the internal one. Here is how he describes the internal cause of projectile motion:

> The other cause is internal, namely the internal spiritus which moves the thing. This motion moves the matter in so far as it is moveable. But the elements of the mixed, as we have said, are minimally moveable in their natural place, because they want to stay there and be at rest.[52]

We have already seen that it is the ether that moves the elemental atoms, and also that each type of atom is moved according to its own pattern.[53] Since all motions are therefore caused by *spiritus*, the contrast between internal and external causes is a contrast between the influence of internal and external *spiritus* – that is, spirit that inheres in the moving object itself *versus* spirit that inheres in external things like the ambient air. What Basson therefore says in the quoted passage is that in projectile motion, there is an action of the spirit within the projectile that moves it forward. This internal action takes place in addition to any external reaction with the surrounding air, but nevertheless it is weaker in lighter projectiles that contain more air than heavy ones. The difference is due to the fact that it is simply in the nature of

52 "Altera causa est interna. *Spiritus* nempe ille internus qui rem movet. Is motus materiam movet prout est mobilis. Elementa autem misti, ut diximus, in loco naturali minime sunt mobilia, cum appetant illic stare & quiescere." Ibid.

53 See p. 110 above.

each element to be less moveable when it is in its natural place, and the spirit realizes that inner nature. In other words, the same motion 2a that drives things towards their natural place also makes them reluctant to move away from it.

If this is his view of internal motion, how might Basson articulate the difference between free accelerated fall and projectile motion? As we have seen, the internal tendency to move towards the natural place is what starts the self-reinforcing motion of air and falling stone. In lateral projectile motion, the internal tendency of most of the atoms in the mixt contribute nothing at all, since fire tends upwards, water and earth downwards. The air atoms, however, actively slow the lateral motion, because they resist all motion as long as they remain in their natural place. Consequently, there is no constant pressure being applied to the external air atoms in front of the projectile. Basson would be able to point to this difference when pressed as to why falling bodies behave differently from projectiles. In any case, his account of projectile motion ends up being quite similar to the *antiperistasis*-theory: The initial motion of the projectile sets the air in motion, which carries it forward for a certain distance before it loses its moving power.[54]

The analysis has shown, I hope, that the four rules for the motions of the elemental atoms that Basson formulates in the book on action are already at work in his treatment of local motion in the preceding book. In both of the example cases, accelerated fall of heavy bodies as well as the flight of projectiles, the motions of the elemental atoms are consistently invoked to explain both the basic process itself and the fact that different materials behave differently. What is more, Basson's explanations always appeal to motions of the elements; he is never tempted to ascribe a motion or power to the composite that is different from the motions of its constituent atoms. Furthermore, we have seen that the distinction between external and internal causes of motion is at work in many of the examples, meaning that the motion of an individual particle is determined by its interactions with other particles (according to motions 1a, 1b and 2b), as well as according to its internal tendency toward its natural place (according to motion 2a). Taken together, this constitutes a serviceable frame of explanation for the kind of phenomena that have been discussed in this section, namely the local motions of sensible bodies and masses of elements. What remains almost entirely unexplained, however, is Basson's claim that the *spiritus* moves the atoms, as well as how the same explanatory mechanisms could be used to explain more complex phenomena. I will use the next section to illustrate that these are

54 See p. 54 above.

indeed central questions for the interpretation of Basson's natural philosophy as a whole, and one that modern commentators of Basson have found different answers for. I will then endeavor to throw some light on the question in the sections following that.

3. Spirit, God and atoms

3.1. *Is the substantial form replaced by the spirit or by God's action?*

As mentioned before, the overall structure of the *Philosophia naturalis* is that Basson uses the first five books of his work to criticize the fundamental Aristotelian notions of prime matter and substantial form. In the three books on form in particular, he examines all the explanatory functions that the notion of substantial form is taken to fulfill and shows that it cannot do so. The third book on form, for instance, focuses on the functions generally ascribed to vegetative and sentient souls. To take just one example, towards the end of the third book on form, Basson counters an Aristotelian argument for the form as that which provides physical coherence to living substances. The argument of his fictional opponents is this: Living plants and animals have heterogeneous parts that are nevertheless organized in such a way that they form a stable unity over time, and even work together to fulfill the functions of the whole. Such a unity would not be possible without a substantial form of the whole organism. Basson answers that if a substantial form is required to explain a stable connection of unequal parts, there are a multitude of examples that would seem to require substantial forms as well, even though no Aristotelian could accept them as substances. The examples include a piece of metal and a piece of stone held together by glue, an oak tree and the mistletoe growing on it, and a fetus in the womb. In each case, two dissimilar objects are closely connected. Basson concludes:

> If the conjunction and communion of parts of different genera do not require the regime and force of the form, how much less is that form necessary for the joining of parts that have the same genus, as the parts of bones, or nerves, or flesh?[55]

55 "Quod si diversi generis partium conjunctio, atque communio formae regimen vimque non requirit, quanto minus ad partium quae ejusdem generis habentur (quales sunt partes ossis, vel nervi, vel carnis) coitum, ea forma necessaria est?" Basson, *Philosophia naturalis*, 265, the conclusion of an

With this and other arguments, Basson proves that a substantial form is not necessary, approaching the issue from multiple different sides over the course of the three books on form. But if there are no substantial forms to provide unity to natural bodies and to act as the causes of natural processes, how are we to explain the unity and regularity in the world around us? Basson answers that we must assume that God constantly and directly intervenes. The core argument for this claim is articulated in the second book on form. The book starts with the observation that there seems to be teleological organization everywhere in nature, the most striking example of course being the growth of animals and plants out of seeds: "It is certain that the nature of every thing whatsoever acts towards an aim towards which it determines its actions."[56] From there, the argument has three main steps: Firstly, Basson argues that any process that takes place for a purpose presupposes cognition in its efficient cause. Since the world as a whole is purposefully organized, this condition is fulfilled for all physical processes, so a thinking cause must be involved in everything. Secondly, Basson argues that there is only one alternative to identifying God or the universal cause as this thinking principle in every single case, namely, to assume that nature is full of intelligences. That is impossible, so it must be God who directs each thing towards its aim:

> And there are no single Natures which, through their own intelligence, produce things in this way; therefore, they come to be by some universal nature, which can hardly be anything except God himself. Therefore, it is shown by manifest reasons that the best and greatest God produces everything continually, moves things himself and leads each to its proper end.[57]

In a final step, Basson argues that it is impossible that both God and the individual things have causal power, refuting the theory of secondary causation.[58] In other

argument stretching over pp. 260–265. The most detailed summary of Basson's arguments against the substantial form is given by Nielsen, "Seventeenth-Century Physician," 309–315.

56 "[…] extra dubium sit, uniuscujusque rei naturam propter finem agere." Basson, *Philosophia naturalis*, 182. A summary of the argument is found in Nielsen, ibid., 330.

57 "At non dantur Naturae singulares quae intelligentia propria res ejusmodi fabricentur, ergo fiunt à Natura quadam universali, quae sane alia quam Deus ipse esse nequit. Manifestis igitur rationibus convincitur Deum Opt. Max. omnia continue facere, eaque seipso movere, atque ad proprium cujusque finem perducere." Basson, *Philosophia naturalis*, 197.

58 Ibid., 221–239. A detailed analysis of this section of Basson's work can be found in Hattab, "Modern View of Causation," 178–188. See also Nielsen, "Seventeenth-Century Physician," 330.

words, natural things have no causal power at all according to Basson, neither those that an Aristotelian would count as substances nor any other. Assuming that one accepts these arguments, the obvious follow-up question is by what mechanism God's acts in the world. Basson's answer is the *spiritus*, which is why that is a central concept in his system. We have encountered the *spiritus* above and seen that Basson initially introduces it as a means of explaining rarefaction, but later goes on to say that it is the *spiritus* which imparts the four basic motions upon the elemental atoms.[59] The *spiritus* therefore plays a mediating role between God as the universal cause and natural things, which have no active power on their own at all.

The question of how exactly this mediation is envisioned by Basson has divided the opinion of past commentators. Lasswitz solves the exegetical puzzle by claiming that Basson is a pantheist who identifies God with nature. This interpretation is taken up by Gregory, who claims that Basson's God does not intervene in nature from without. Rather, the actions of the *spiritus* are entirely immanent to nature and no direct action on God's part is required: "La causalità divina si identifica di fatto con la 'vis' che muove gli elementi."[60] Brugger, thirty years before Gregory, views the relationship in the exact opposite way: He emphasizes against Lasswitz that Basson does make a distinction between God and nature or the world. His conclusion is that Basson is not a pantheist, but rather an occasionalist *avant la lettre* who anticipates arguments made by Arnold Geulincx later in the seventeenth century.[61] All in all, Basson can probably be said to consistently defend neither pantheism nor occasionalism. Instead, he hints at both without making a consistent decision. However, the choice between them has no impact on his physics: Whether God moves the elemental particles around directly or whether He invests the *spiritus* with the power to move them just as He would, the atoms are passive bits of matter moved according to certain rules by an intelligent, ever-present cause. Nielsen's interpretation offers a way to split the difference between the occasionalist and the pantheist Basson, namely by claiming that the spirit is itself a kind of atom. When Basson claims that the *spiritus* is the instrument by which God effects the motions of the elements, what he means is that God moves the subtle spirit atoms, which in turn push the larger atoms. This does not change the relationship of God and *spiritus*, but it does mean that the elements are only indirectly moved by God.[62] Ultimately, however, Nielsen's as well as Brugger's and Lasswitz'

59 Basson, *Philosophia naturalis*, 333 f., 434. See above, ns. 30 and 31.
60 Lasswitz, *Geschichte*, I, 474; Gregory, "Sebastiano Basso," 61.
61 Brugger, "Sebastiano Basso Occasionalismo," 535, 537.
62 Nielsen, "Seventeenth-Century Physician," 319, 336.

reading are attempts on the part of interpreters to supply a consistent ontological foundation to a doctrine that is left vague by its author.

3.2. *Two aptitudes of the elemental atoms*

As we have just seen, how exactly the spirit moves the elements is an important topic in Basson's system for a number of reasons. I will now try to throw some light on it. Most of the passages that I base myself on are taken from book 6 of the *Philosophia naturalis*, the book on nature. This book is particularly interesting for the question at hand, because it is the first purely constructive book after the more polemical first five books, which focus on criticizing Aristotelian matter and form. Consequently, Basson views the book on nature as taking up the natural order of exposition that was interrupted by the need to refute the doctrine of Aristotle.[63] What is most important for our purposes is that whereas Basson has proven in previous books that God is the only cause of all physical changes and that He does this by means of the *spiritus*, in the book on nature he can simply assume this basic fact and begin explaining it in more detail.

A key term that Basson uses often when he writes about spirit as the cause of the motions of the elemental atoms is their *aptitudo* or "aptitude." At the beginning of the book on nature, he rephrases the doctrine of God's pancausality by claiming that the difference between the systems of Aristotle and the other ancients is that Aristotle's matter is purely passive, while the *veteres* posited material principles that are the instruments of God. The perspective of the book on nature consists in elaborating this instrumental aspect of the atoms, and their aptitude is the key to understanding it: "The first thing to draw attention to is their aptitude to the use to which they are ordained."[64] This aptitude is specific to each type of elemental atom and is the reason why their motions follow different rules:

> In that way, if [the *spiritus*] goes into the matter of air, of water, of earth, it gives each its fitting measure, moving the parts away from each other as they require it, and moves each as ordained. And so that same spiritus forms fire with fire-matter, air with air-matter, and so with the rest.[65]

63 Basson, *Philosophia naturalis*, 309.

64 "Primum quod in illis venit advertendum, est eorum aptitudo, ad usum in quem sunt ordinata." Ibid., 311.

65 "Hunc in modum si aeris, si aquae, si terrae materiam ineat, cuique mensuram dat congruam,

In other words, Basson makes a distinction between the matter of the elementary atoms, on the one hand, and the complete elemental atoms consisting of that matter combined with some amount of ether, on the other. The spiritus is the direct cause of motions, but it causes different motions when it combines with different kinds of matter. There is fire-matter, and when it combines with spiritus (or, in the words of the quotation above, when the spiritus "goes into" the matter), fire is formed. Of course, the distinction remains mostly theoretical, since elemental atoms are initially created as such by God and never perish naturally. Nevertheless, Basson speculates that spiritus and elemental matter are separable entities in principle:

> For if the *spiritus* were to leave, what would fire be? It will contract quickly and undergo the form of earth or of dust, and no power would be left in it, except the instrumental aptitude by which it is ordered to another motion and aim than the matter of air or water or earth. Of these, the same is true as of fire, in their way.[66]

Fire-matter without any spirit would therefore have all the passivity of earth and be indistinguishable from it, but nevertheless it would still retain its instrumental aptitude, so that if any spirit were to enter it again, it would become fire once again. In sum, the relation of the spirit to the four elements very much resembles that between substantial form and prime matter in Aristotelian theories. One difference is that whereas elemental matter without any spirit is a speculation, there is in fact spirit that is not bound to any element: As we have seen, Basson introduces it originally as that tenuous substance which fills the gaps in between atoms that would otherwise contain a vacuum.[67]

That the spirit is able to "go into" matter and act as its active principle is a common idea in renaissance philosophy. It is often paired with a verse from Virgil's *Aeneid* "spiritus intus alit" or "spirit nourishes within," which Basson also quotes. The originator of this renaissance line of thought is Marsilio Ficino, but it is also prominent in the

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partes quoad requirunt, alias removens ab aliis: atque movet unumquodque prout ordinatum est. Itaque idem ille *spiritus* cum ignis materia ignem, cum aeris aerem efficit; & ita de reliquis." Ibid., 333 f.

66 "Excedat enim ille *spiritus*, quid erit ignis? contrahet se ocyus, formamque terrae, vel pulveris subibit: nihilque virtutis in eo supererit, nisi illa instrumentalis aptitudo, qua in, alium motum finemque ordinatus est, quam sit aut aëris aut aquae aut terrae materia. De quibus idem pro modulo suo, quod de igne, censendum est." Ibid., 334.

67 Ibid., 333. Cf. n. 30.

work of Jean Fernel, who is among Basson's direct sources.[68] Despite these historical connections, it never becomes quite clear how the union of spirit and matter should be understood in the context of Basson's system. The main difficulty is that the *spiritus* is introduced as a type of body, but that at the same time, its role in directing and forming matter seems to require it to be immaterial or at least penetrable. Basson insists on the bodily dimension when he deflects the accusation that the union of spirit and matter would require two bodies to be in the same place at once: "[I]t is false that this spirit passes through bodies, so that there are two bodies simultaneously; rather, it places itself in between the particles of bodies by means of its incredible subtlety."[69] This is meant to apply first of all to the spirit entering visible bodies, but should we understand its relation to elemental matter in the same way?

If Nielsen's suggestion that the spirit is exclusively the fifth type of atom is correct, the spirit's going into the elemental matter means that the elemental matter itself has pores which are filled by the spirit. The specific aptitudes that distinguish the four types of matter might then consist in different size and structure of these pores: Fire particles are not only smaller than earth particles, but they also contain more internal room for the even smaller spirit particles to inhabit. Nielsen seems to prefer a model on which the elemental atoms are solid pieces of matter and are moved by spirit atoms from without.[70] This, however, is difficult to reconcile with the passages in which Basson describes the ether as internal to the active elements and as intimately connected with them. The same goes for passages that seem to suggest that God acts on the atoms directly and gives them something like a specific nature – for example, in describing God's operation in the world, Basson claims that God is thereby "impressing upon the material principles the impulse to which they are apt."[71] Despite his denial that the *spiritus* is a body competing for space with other

68 Virgil, *Aeneid* 6.726; Basson, *Philosophia naturalis*, 225 for the Virgil quote and ibid., 199, for Fernel as an authority on *spiritus*; Hirai, "The World Soul in the Renaissance," 155 and 161.

69 "Falsum est hunc spiritum per corpora meare, ita ut duo corpora sint simul¸ sed inter corporum particulas sese sua subtilitate incredibili insinuat." Ibid., 337. Basson has the Stoic ether in particular in mind here; Plato's *Timaeus* is also often quoted, though Basson sees his spirit in analogy with what Plato calls fire rather than his world soul. See ibid., 340; Nielsen, "Seventeenth-Century Physician," 356 n. 87.

70 "Basso's concept of causation is purely mechanistic inasmuch as in the material world of atoms he recognizes no other means of transmitting movement than by way of atoms exerting pressure on other atoms." Ibid., 335.

71 "[…] principiis materialibus imprimens impetum ad quem apta sunt." Basson, *Philosophia naturalis*, 269.

bodies, in the union with elemental matter, Basson envisages the spirit not as another type of impenetrable atom, but rather as an amorphous principle of activity.

In sum, the spirit occupies a somewhat uncomfortable middle ground between material atom and immaterial principle. What is clear, however, is that the union of the spirit with the four types of elemental matter gives rise to the atoms corresponding to the four elements and their regular motions. This brings us to the next issue, namely what it means for an elemental atom to be moved according to its aptitude. The four basic motions that we have already discussed as a part of Basson's explanations of accelerated fall and projectile motions are only one type of regular motion caused by the spirit in the atoms, namely their aptitude outside the compositum. When he introduces the term "aptitude," he immediately distinguishes this sense of the term from the aptitude inside the compositum and remarks that he is about to discuss the first one only:

> But for the moment, we do not treat of [the material principles'] aptitude in so far as the Creator of things uses them for the natural compositum, not only as matter but as suitable instruments. We speak of their aptitude outside the compositum.[72]

Basson goes on to talk about the specific properties of the four elements and ascribes a certain particle size, degree of mobility and velocity and distance from other particles to each element. The rules of motion that are specific to each type of elemental atom therefore describe their aptitude outside the compositum. This includes the four basic motions described in the book on action, which are after all introduced to explain the primary qualities of the four elements.[73] The four basic motions 1a–2b are therefore best thought of as Basson's attempt at a more systematic description of the motions that result from the nature of the elemental particles in isolation, disregarding any complications that might arise from their being part of composite bodies. As we have discussed, the same four motions can also be seen at work in Basson's accounts of the classical examples of the local motions of sensible bodies. The parts of air that are invoked to explain the accelerated fall, for example, interact with each other and with the particles of the falling stone, and their behavior follows from a combination of

72 "Neque tamen in praesentiarum agimus de eorum aptitudine quatenus ad compositum naturale rerum Conditor iis utitur non tantum ut materia sed ut instrumentis idoneis. Loquimur de eorum aptitudine extra compositum." Ibid., 312, continuing the text from n. 64.

73 Cf. the discussion of the text in ns. 31–34 above.

their tendencies to keep certain minimum and maximum distances from one another. Even the heaviness of the stone itself is simply the sum of the upward and downward tendencies of its constituent particles.

All the motions of the elemental atoms discussed so far are therefore expressions of their aptitudes outside the compositum. The fact that Basson distinguishes a separate aptitude inside the compositum is his way to grapple with a weakness of a reductive approach like his: Even if all motions of the elements are sufficiently explained as the results of God's action, regularities like those described in the four basic motions seem far too simple to explain the complex phenomena in composite bodies. The descriptions of falling and thrown bodies, as we have seen, may be coherent, but even these are by no means very precise or evident. It is quite implausible that the same simple motions would suffice to explain all the complex properties and behaviors of visible bodies, and especially of living ones. Basson is aware of this difficulty and approaches it in the following way:

> The author of nature, therefore, set forth a double end in these elements: One that is the elements' own, which we have treated, and another that is the construction of the natural composite out of them and through them, to which He directs the proper actions of the elements. [...] [He] by their concourse and mutual action brings about manifold species of things; for God acts no differently through them than if each one of them itself directed its own impetus towards its aim through its innate force.[74]

It is only because of God's foresight, in other words, that the complex properties of sensible bodies emerge from the simple motions of the atoms. Whether an individual particle seems to strive for its aim outside the composite (that is, it tends to move towards its natural place and to keep a fixed distance from particles around it) or whether it seems to follow some other aim dictated by the needs of a compositum, it is God who brings the final result about. The two aptitudes of the elemental atoms should therefore not be taken to mean that God moves an atom that is part of a

74 "Ergo naturae author duplicem finem in his elementis proposuit: alterum qui est elementorum proprius de quo egimus, alterum qui est compositi naturalis ex ipsis & per ipsa constructio, in quam proprias illas elementorum dirigit actiones. [...] multiplicesque illorum concursu mutuaque actione rerum species perficiat; Neque enim aliter Deus per ea agit, quam si ipsamet in finem quodque proprium impetum suum innata sibi virtute dirigeret." Basson, *Philosophia naturalis*, 315.

composite according to different laws than one that is outside. Rather, the kinds of properties of complex bodies that an Aristotelian would describe as qualities flowing from their substantial forms result from interactions of the same motions in the elemental atoms which they also follow when outside any compositum, but prearranged by God. Basson drives the point home when he claims that the actions of the elements contribute to complex processes (e.g., the growth of plants) in the same way in which Judas Iscariot and Pontius Pilate made the passion of Christ possible and thereby contributed to the redemption of humankind.[75]

3.3. *Conclusion*

In the introduction of this chapter, I have remarked that Basson's exposition of his own system is in many ways dependent on the scholastic philosophy that he attacks so vigorously. One expression of this influence is that he treats many of the topics that would have been covered in a scholastic *cursus*. As was illustrated in section 2.2 above, his treatment of local motion is a good example of this general tendency. The comparison to Sennert's hylomorphic account is especially illuminating in this respect: Both use Zabarella as their author of reference on the subject, and Sennert adopts Zabarella's account of falling motion with very few changes. On the topic of projectile motion, however, Sennert is almost entirely silent. Basson has much more to say on that topic, apparently convinced of its importance by the very fact that it is a frequent topic in scholastic philosophy textbooks. However, while he is clearly influenced by the accounts that he finds in his copy of Zabarella's *De rebus naturalibus*, he never simply adopts them without change. That is made impossible by the fact that he denies that any sensible body is a substance. What he does instead is to reinterpret the scholastic accounts in terms of the local motions of particles.

Basson's denial of substantial form also means that some of the standard scholastic topics around the notion of *motus* find no mention at all by him. In particular, we search in vain for a treatment of the ontological status of motion itself in the *Philosophia naturalis*. In a hylomorphic context, it is an open question whether change itself can be reduced to a more basic entity, for example by describing it as a gradual realization of the form associated with the *terminus ad quem*. For Basson, in contrast, the local motions of *spiritus* and the elemental atoms are ontologically basic.

75 Ibid., 317. Cf. Nielsen, "Seventeenth-Century Physician," 323.

While the existence of the particle motions is simply assumed as basic, the ontology of the particles themselves is discussed at length by Basson. In the material universe, the four types of elemental atoms and the *spiritus* are the only things that truly exist. Outside the elements, the spirit can be identified as the fifth type of atom, though much finer than the other types. The elemental atoms, however, are not absolutely simple entities, but themselves contain some amount of *spiritus*, which acts as the principle of activity animating otherwise passive elementary matter. On its own, that matter is all equally inert, but each piece of it has a specific instrumental aptitude, which means that it can only become one among the four types of elemental atoms when it is united with the required amount of spirit. The spirit, for its part, loses its material character when it is united with elementary matter.

Both inside and outside the elements, the spirit is the source of all motion in the physical universe. At the same time, it is only the manifestation of God's continuous action in the world. It is not God's passive *instrument*, because Basson reserves that expression for the elemental atoms. The difference between a pantheist and an occasionalist interpretation of this system lies in a semantic detail: If it is correct to say that God acts in the *spiritus* and is Himself the active principle in the elemental atoms, then He is physically present everywhere in the world; if, on the other hand, He moves the spirit-atoms from without and the motions of the atoms result from their interactions with the spirit, then He remains outside the world.

God, the *spiritus* and elementary matter are important parts of Basson's metaphysical picture of the world. When it comes to physical explanations, however, the regular local motions of the elemental atoms do all the heavy lifting. As we have seen, Basson ascribes two aptitudes to the elemental atoms, an external one that is expressed in their motions outside any fixed body and an internal one that describes their behavior inside composite bodies. That the spiritus moves the atoms according to their aptitude means that it produces certain regular local motions in them; the result is the same as if each elemental particle had an inner nature and a motive power that moved it according to certain simple rules.

The four motions described by the aptitude outside the compositum are 1a) *attraction*, 1b) *ejection*, 2a) *natural motion* and 2b) *minimal distance*.[76] These four motions are the result of two appetites inherent in each particle, namely appetite one for conjunction with the similar and appetite 2 for a specific space as well as place. Each appetite formulates criteria for the ideal state of the particle. If all criteria are fulfilled, the

76 See above, p. 112.

particle remains at rest; if not, it tends to move in such a way as to fulfill them. What makes this model capable of explaining not only the motions of individual particles, but of complex interactions between them is that three of the four motions depend on the presence of and distance to other particles. Since, metaphysically speaking, it is the spirit or God that is the cause of the motions and their regularities, this implies neither perception of other particles nor knowledge of their aims in the atoms. Nevertheless, they not only act as if they had an inner motive force, but also as if they were aware both of other particles in their proximity and of the aims they themselves strive to fulfill.

As an explanatory mechanism, the four motions that result from the aptitude outside the compositum work reasonably well for a certain set of phenomena. Basson's accounts of the local motions of composites contain some of the more successful applications, at least as far as his explanations of multiple different phenomena are coherent with each other and tell a story that is at least as plausible as the competing hylomorphist accounts. In these cases, it is an obvious advantage that Basson can appeal to the interactions of many separate particles instead of having to assign one single nature and principle of action to each sensible body. For example, the doctrine that the air atoms contained in a falling body slow down the fall because they are reluctant to part with the surrounding air could not have been proposed by someone who believes that the air atoms as such are either destroyed or diminished when they become part of a mixt.

A very common use of Basson's corpuscles is one that we have seen in before in Sennert, namely the transportation of a quality from one place to another. Given the assumption that atoms of fire, air, water and earth exist and that their presence is what causes the sensations of the associated qualities in an observer, it is possible to explain the presence, disappearance and reappearance of a quality by postulating that the carrying atom is temporarily obscured or captured by other atoms. Basson uses this kind of explanation for instance in his discussion of a piece of meat falling into water: Air atoms leave the meat and are replaced by water atoms, leading it to sink. Overall, however, his favorite example is fire and its heat: For example, he explains the sudden heating of limestone when water is poured on it by the expulsion of fire particles, repeating the same example from Scaliger respectively Vitruvius that we have seen being used by Sennert.[77]

77 Sennert, *Hypomnemata* III, 2, SO 122b; Scaliger, *Exotericae Exercitationes*, Ex. 5, arts. 8–9; Vitruvius, *Architectura*, I, 5; cf. Lasswitz, *Geschichte*, I, 217. Cf. p. 91 above.

Although the elemental atoms are used by both authors to explain the migration of qualities, their accounts of the primary qualities themselves are different. Whereas according to Sennert, heat is an accident that flows from the substantial form of an individual fire atom, Basson identifies heat with a certain pattern of motion. The quality of heat in particular is also associated with a certain geometrical shape of the corresponding atoms, which is not the case for the other three primary qualities.

From the aptitude that the elements have as far as they are outside any compositum, Basson distinguishes their aptitude inside the compositum. He uses this second type of aptitude to explain the fact that it is composite bodies and not invisible particles that provide the most striking examples of regular behavior in nature. In other words, the specific natures of bodies are explained by Basson as certain patterns of local motion that the elemental particles exhibit when they compose them. The natures of bodies are therefore explained by Basson in precisely the same way in which he identifies the natures of the four types of elemental atoms with the patterns of motion that they exhibit when outside the compositum.

In other words, Basson identifies both the natures of composite bodies and the natures of the four types of atoms with certain regular patterns of motion of the elemental atoms. In addition to that, he also holds that both are *the same patterns*. The expression that the elemental atoms' aptitude to be moved by the *spiritus* is a different one when they are part of a compositum than when they are not is nothing but a shorthand for the claim that from the interaction of all the motions of all the individual atoms, each strictly following its program as described by the four basic motions, an ordered whole emerges. Although this seems impossible from the human perspective, God achieves it through foresight. It is emblematic for Basson's style and project that it is this most ambitious of all his claims that he projects back into Democritus:

> When he said that individual things come about by the fortuitous concourse of elements, [he meant that] it is certainly fortuitous with regards to these very elements, which intend nothing less than the structure of such a thing by their acting. It is not fortuitous with regards to the first cause, however, nor with respect to the best and most wise order constituted by it, according to which the very elements concur and act.[78]

78 "Cum dixit concursu elementorum fortuito singula fieri: fortuito profecto ipsis elementis quae agendo nihil minus quam talis rei structuram intendunt. Non autem fortuito primae causae, neque respectu optimis ac sapientissimi ordinis ab ipsa constituti, secundum quem elementa ipsa concurrunt, atque agunt." Basson, *Philosophia naturalis*, 318.

The concourse of atoms, Basson says, seems fortuitous from the perspective of the elemental atoms and from the perspective of a human understanding that starts its analysis with them and their regular motions. The stable natures of complex bodies arise from the interactions of these motions according to some kind of regularity as well, but it is not the kind of regularity that is accessible to human understanding. What is remarkable is not that Basson believes in providence, but that he appeals to it at as a substitute for a physical explanation: It is one thing to claim, as was the standard view since the time of Boethius, that God directs the world as a whole in ways that sometimes seem disconnected and fortuitous from the human perspective; it is quite another to claim that most of the basic properties and changes of sensible bodies arise from a few simple rules in the local motions of atoms without even offering a plausible story of how that might be possible.

CHAPTER 3

David Gorlaeus

1. Gorlaeus' conception of motion

1.1. *David Gorlaeus*

The grave of David Gorlaeus in the village church of Cornjum, which is one of the few traces left of him, tells us that he was born in 1590 and died in 1612, at a mere 21 years of age. Two philosophical treatises were eventually published under his name. The longer of the two, entitled *Exercitationes Philosophicae*, was printed in 1620, the shorter *Idea Physicae* only in 1651. Both works are for the most part identical in doctrine, although the longer *Exercitationes* contain a much better worked out metaphysics, while the *Idea* treat only natural philosophy. The last chapters of the *Exercitationes*, on the human soul, are starkly different in style from the rest of the work and end very abruptly. From that and other circumstantial evidence, it seems likely that the *Idea* were written first, when Gorlaeus had just finished his basic *Artes* studies, and that the *Exercitationes* were to provide a better metaphysical foundation for the physical doctrine, an endeavor that was cut short by the author's premature death.[1]

The event that made Gorlaeus' name known more broadly during some time in his own century took place many years after his death: In the course of the public quarrel between anti-Cartesians and Cartesians at the University of Utrecht in the 1640s, Gisbert Voetius, the dean of the faculty of theology and leader of the anti-Cartesian fraction, alleged that Descartes had taken a dangerous doctrine from Gorlaeus. Descartes denied that he had ever maintained the doctrine in question, namely that "man is an *ens per accidens*," but Gorlaeus did in fact maintain it. Regius, Descartes' friend and representative in the disputation that triggered the *querelle d'Utrecht*, also maintained it, and we know that Regius, at least, read Gorlaeus directly.[2]

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1 See Lüthy, *David Gorlæus*, 12 f. on Gorlaeus' biography. See also ibid., 25–34 on the dating, authorship and structure of the *Exercitationes philosophicae* and the *Idea physicae*. Since there is only one edition for each, references to the two treatises will be simply by short title and page number.

2 According to Lüthy, *David Gorlæus*, 146–150, the public disputation by Henricus Regius which set off the Utrecht crisis is in fact influenced by Gorlaeus. On the scandalon of the doctrine that the union

However, outside the very specific context of the *querelle*, Gorlaeus' footprint remained small. His work was first shunned because of his opposition to Aristotelianism (e.g. by Mersenne in the 1620s) and then celebrated as an influence on Descartes and Cartesians (by later historians like Morhoff and Reimmann in the early 18th century).[3] Like many other corpuscularist figures of the early modern period, Gorlaeus was rediscovered for modern scholarship by Lasswitz.[4] For most of the 20th century, he was increasingly seen as an atomist and a proto-scientist, while he was almost entirely forgotten among historians of philosophy.[5]

In the last 20 years, there has been some renewed interest in Gorlaeus as an independent figure, rather than a stepping stone on the way to "modern science." The only monograph entirely dedicated to him so far is Lüthy's, which explores our young author's intellectual environment and formation and gives a general account of his theses.[6] Gorlaeus also figures in a number of different metaphysical contexts within Pasnau's *Metaphysical Themes*.[7] The only other recent commentator on Gorlaeus in English is Hattab, who has claimed that Descartes' use of the concept of *modes* originates with Gorlaeus, and linked the young Frisian student's account of universals to that of Francisco Suàrez.[8] In 2014, a number of the journal *It Beaken* was dedicated to Gorlaeus, containing five original articles on him.[9]

Gorlaeus' general project can be described as a conjunction of Italian natural philosophy with the German metaphysical tradition.[10] There are, as it were, two parts to his philosophy: On the topics of elements, qualities and mixture, he works

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of body and soul is accidental in this context, see also Ruler, *Crisis of Causality*, 206. On the Utrecht crisis more generally, see Verbeek, *La Querelle d'Utrecht*; *Descartes and the Dutch*.

3 Lüthy, *David Gorlæus*, 15–17.

4 Lasswitz, *Geschichte*, I, 333–335, 455–473.

5 For an overview of Gorlaeus' reception in the history of philosophy and in that of science, see Lüthy, *David Gorlæus*, 12 f. and the references in the notes there. Notable twentieth-century contributions on Gorlaeus are Jaeger, "David van Goorle als Atomist", who researched some of the biographical information, as well as van Melsen, *From Atomos to Atom*; Dijksterhuis, *De mechanisering van het wereldbeeld*; Gregory, "David van Goorle e Daniel Sennert", all of whom treat him in the context of the history of Atomism.

6 Lüthy, *David Gorlæus*; Lüthy, "David Gorleus' Atomism."

7 Pasnau, *Metaphysical Themes*.

8 Hattab, *Descartes on Forms and Mechanisms*, especially 159 and 168–172. Hattab, "Gorlaeus on Universals."

9 It Beaken 76, 2//3 (2014). The article by van Ruler is closest in perspective to my own endeavor, since it asks for Gorlaeus' ontology and its Aristotelian influences: "Entiteiten zonder vorm," 197–228.

10 Lüthy, "David Gorleus' Atomism," 246.

with a theory of two rather than the traditional four elements and replaces the element of fire with the real quality of heat. In this, he follows his erstwhile teacher Henricus de Veno, as well as Girolamo Cardano and Julius Caesar Scaliger. On issues pertaining to metaphysics, however, Gorlaeus maintains an austere conception of metaphysics as the science of being. Because of this, he is keenly interested in the division of all things into real and fictitious ones. He also insists that any real being must be one, actual and unchanging. This leads him to conclude that any change at all must have an indivisible being as its substrate and that therefore, all real material beings are atoms. This kind of ontological reasoning is not found in the Italian natural philosophers that inspire other parts of his theory. Neither is the nominalist principle that "beings must not be multiplied unnecessarily," which Gorlaeus constantly invokes.[11]

Since we are concerned here with local motion, I will begin this chapter with a discussion of the passages in which Gorlaeus discusses motion explicitly. What local motion is, in the opinion of Gorlaeus, might at first appear a simple question to answer: Among the few hundred 8° pages of his oeuvre, there are about twenty or so that are directly concerned with local motion.[12] The are some passages on other topics of natural philosophy that are traditionally related to local motion, in particular some remarks on cosmological topics, on the circular motions of the stars and on the elemental nature of the spheres, and one mention of Galilei's discovery of the stars in the milky way. There is also a very short discussion of the dynamics of throw and fall, and a sketch of a distinction between natural and violent motion, to which we will turn in a moment. But generally, none of these treatments is very long and they do not have much interconnection among them. A treatment of most of Gorlaeus' philosophy is therefore not directly relevant to his views on motion. In fact, these views can be established for the most part without reference to his views on the rest of natural philosophy or metaphysics.

Although Gorlaeus' treatment of local motion is short, it is not without difficulties. The aim of the first part of this chapter is therefore to establish not just the

11 The most common phrasing is "non enim entia sunt multiplicanda absque necessitate." The first instance in the *Exercitationes* is on page 45, and it is repeated at least ten more times, for example on pages 99, 140, 159, 178. 228, 299. In the *Idea*, it occurs on pages 13, 19, 32, 34, 53, 67.

12 Dispersed across the *Exercitationes* and the *Idea*, the directly relevant passages are the following: *Exercitationes* XVI, 2, 303–311 and *Idea* VI, 3, 33 f. on cosmology, *Idea* VIII, 9, 47 on Galilei, *Exercitationes* II, 1, 32, IX, 2, 192–195 and *Idea* V, 1–2, 27 f. on definitions and discussions of local motion, *Idea* III, 5, 13 ff. on magnetism.

content of Gorlaeus' treatment of local motion, but also its problems. What remains unclear at the end of section one is for what reasons he defends such a problematic position. The second section will then attempt to answer that further question by taking into account other aspects of his philosophy, in particular the concept of a *modus entis*.

1.2. *Gorlaeus' definitions of motion*

Gorlaeus defines local motion as follows:[13]

> Local motion is not the same as the very existence of a thing in varying place, although it includes that, but it is properly the migration from place to place, or rather the continuous flow of the being's existence through various places. That flow of the moved thing is a passion.[14]

The sentence just quoted has three parts. First, an opposing position is sketched, according to which local motion is nothing over and above the existence of the moving thing. Then follows the definition proper: motion is a "continuous flow of existence through various places," which, as we can infer from the opposition to the first part of the sentence, must be something over and above the fact that an object is now here, now there. Lastly, we get the additional information that this flow or *fluxus* of existence is a *passio* or being-acted-upon on the part of the moving thing. Since he says that local motion is a passion, what are action and passion, for Gorlaeus?

> Passion can be defined more clearly than action. For it is in fact threefold: Either becoming and perishing, or receiving, or being moved.[15]

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13 In the following, I will use references from three different places in Gorlaeus' work: From exercise II in the *Exercitationes*, which gives a condensed overview of his ontology and introduces many of his concepts; from exercise IX, which is explicitly about motion, action and passion; and from a roughly two-page passage in *Idea* V. All three treatments are similar in content and structure.

14 "Motus localis non est idem, quod ipsa rei existentia in vario loco, quamvis hunc includat, sed est proprie migratio de loco ad locum, seu potius entis existentiae per varia loca continuus fluxus: qui fluxus rei motae est passio." *Exercitationes*, 35.

15 "Passio manifestius declarari potest quàm actio. Est autem triplex: aut fieri vel interire, aut recipere, aut moveri." *Exercitationes*, 33 f.

Local motion is therefore not the same thing as passion, but rather one of three subspecies of it. We might suspect that there are three corresponding subspecies of action, but Gorlaeus does not mention any. In fact, he seems quite uncertain about his own definition of action:

> [A]ction is that mode by which the entirety of a thing finds itself, when it exercises its efficacy. It is, as it were, a certain advancement of the thing, when it, as it were, impresses a certain force on the patient.[16]

This is less a definition and more a collection of metaphors, most of which are nowhere unpacked by Gorlaeus. The repeated use of *quasi* further reinforces the sense that the author is grasping for words. And although we know that local motion is a specific type of passion and may suspect at least some connection to a corresponding action, both of them are defined far too vaguely to be of help in understanding local motion. However, Gorlaeus' further arguments bear out that there is a more thoroughgoing correspondence than just between the passion of being-moved and local motion. The force (*vis*) in the mover corresponds to the passion in the moved, as we learn from an example of local motion that has the purpose of illustrating the general definition of action. In the example, the continued motion of the stone is explained by the fact that the throwing hand "impresses a certain force" into the stone. The idea that local motions are caused by a *vis impressa* is of course nothing new. What is uncommon is that Gorlaeus then *identifies* this force with the action of the hand. What is more, he attempts to generalize this identification of force and motion to other types of natural change, including coming-to-be, although he inserts another qualifying *quasi*:

> And so this force is that action itself. Similarly, we ought to think that a similar force, as it were, and efficacy is impressed into things that come to be, which cannot be comprehended by us in any other way.[17]

There is therefore one kind of action that corresponds to local motion and to the passion of being-moved, and a second kind that corresponds in the same way to generation and being-generated. Gorlaeus never mentions a third kind of action that

16 "Actio est modus ille, quo se habet tota rei entitas, quando exercet suam efficaciam. Est autem quasi rei quaedam promotio, dum quasi vim quandam imprimit patienti." *Exercitationes*, 32.

17 "Atque ita haec vis est illa ipsa actio. Simili modo putandum est, similem quasi vim & efficaciam rebus imprimi, quae fiunt, quod à nobis aliter comprehendi nequit." Ibid., 33.

would correspond to the third kind of passion, the passion of receiving a property, so we are left with an incomplete scheme of concepts that the author himself seems unsure how to explain.

The argumentative strategy is clearly not that of defining action and passion and then deriving the nature of local motion from these general notions. Rather, local motion is the well-understood case that the other types of natural change are derived from. Action and passion themselves are never explained with examples taken from natural philosophy, so if anything, they too are explained by the examples rather than the other way around. This is confirmed in the later exercise nine, where Gorlaeus gives another definition of motion in the wider sense of "natural change." Again, he claims that local motion is better known to the senses than generation and corruption:

> Let us now furthermore see, what [motion] is. This is quite difficult, since it is not very well-known to the senses. For who ever could inspect the production and corruption of a thing, or how it came to be? It is only local motion that we see. And from it, we come to know the others, namely generation and corruption, which is why we understand them like certain local motions as well and attribute two terms to them, one from which and one to which, because these are truly there in local motion.[18]

What point is Gorlaeus making here? The passage might seem like a general appeal to sense experience against the unobservable substantial form, and it is of course an atomist trope to claim that local motion is obvious to the senses and therefore explains all other kinds of change. But I do not believe that this is what Gorlaeus wants to imply here, because in order to appeal to sense experience, Gorlaeus must be writing about changes in everyday objects and not the metaphysical structures that underlie them (whether they are substantial forms or atoms). Therefore, the point here cannot be that the mere fact of local motion is better supported by the senses, since in everyday experience, it is just as obvious that things come into and go out of existence as that they change place. Although Gorlaeus uses a variety of visual

18 "Videamus nunc porro, quid sit [motus]. Illud admodum difficile, quoniam non ita bene sensibus notus est. Productionem enim rei & corruptionem, quis unquam inspexit? Vel quomodo fieret, observavit? Solus motus localis est, quem videmus. Et ex hoc venimus in cognitionem aliorum, nempe generationis & corruptionis. Unde has quoque ut motus quosdam locales concipimus, & duos terminos, a quo, & ad quem, iis tribuimus, quoniam ii in motu locali revera dantur." Ibid., 192.

metaphors, the central claim that production and corruption are inaccessible in a way that local motion is not uses the verb *inspicere* (inspect, see into), which suggests that it is the inner workings of the process that are inaccessible. Furthermore, what is "truly there" in local motion, but not in generation, are two distinct terms, one "from which" and one "to which." As we have seen in chapter one, the Latin words *terminus a quo* and *terminus ad quem* are technical terms of Aristotelian philosophy designating the substantial forms that are the endpoints of a natural change. In this parlance, the term "from which" is the substantial form that the change begins from, and that is the efficient cause of the change as well as the form of the subject that is being changed. Therefore, to claim that in local motion the two terms are "truly there" is to say that cause and effect are separate. That local motion is more accessible to the senses than other types of change in terms of the causal relations it manifests will turn out to be a critical feature of Gorlaeus' theory of motion.

1.3. *Natural & violent motion*

In the passages following the one that was just discussed, Gorlaeus begins to examine local motion in particular, true to his previous claim that it is more accessible to the senses and can serve to illustrate the more obscure process of generation. The paradigmatic cases of a natural and a violent motion discussed by Gorlaeus are the same as those treated by Basson and Sennert, namely that of a heavy body falling down to the earth and that of a stone being thrown by hand. Despite his insistence that it is more accessible to the senses than the other types of change, Gorlaeus finds the precise nature of local motion difficult to explain:

> Every local motion comes from a certain impressed force. That force is, after a fashion, a weight and a heaviness given to the thing by the mover, pushing the thing and moving it where it pushes. This cannot be described more clearly in other words. That force is indeed a mode of being, as has been discussed above. However, what and of what sort this mode is, I frankly confess is hidden to me. Neither do I think it is possible to explain it.[19]

19 "Omnis motus localis fit ab impressa quadam vi. Vis haec est pondus quoddam & gravitas rei indita a movente, premens rem & movens eo, quo premit. Aliis verbis describi commodius haud potest. Est autem haec vis modus entis, quemadmodum in superioribus disputatum est. Qualis autem sit ille modus, & quid, latere me fateor ingenue. Nec puto explicari posse." Ibid.

That it is a "certain impressed force," a *vis impressa*, that causes each local motion is a repetition of what we have heard before, since Gorlaeus has already identified the action of the mover with such a force. That it is a "mode of being" is also not new. Other than in these familiar claims, Gorlaeus is unable to say what local motion is or what causes it. He makes another attempt, however, again claiming that the *vis impressa* is particularly accessible to the senses:

> Meanwhile, that such a force exists is more certain than certain. For it can be sensed. A stone that falls down strikes with force that which it touches. But it possesses this force naturally. However, if you throw the same stone violently downwards, it pierces that which it touches with a much greater force. That greater force is not natural to it, for it was not there before. Since it has [that greater force] now, it is necessary that it has it from something, and it has it as something distinct, since it did not have it before. It is also moved much more quickly when it is thrown with force than when it falls with its own motion. It is therefore moved more quickly by an impressed force. Therefore, it is also moved by the same.[20]

The experience appealed to in the first half of the paragraph is the difference between two imaginary scenarios: In one, a stone is let go, falls straight down and lands with some impact. In a second scenario, a stone is actively tossed down. Gorlaeus claims that the thrown stone will "pierce with greater force" when it lands and that the force in this second case is not natural to the stone, while in the first case it is natural. Some quibbles could be made with the setup of this thought experiment, but what matters for the argument is the next step: The difference in impact and motion between the two scenarios must be due to the only factor that changes, and that is the throwing hand. The violent motion is different from the natural one in that the motion itself is quicker and in that the impact has more force. Gorlaeus concludes that he is justified in identifying three things: the added force of the impact, the force of the throwing

20 "Interim dari hanc vim certo certius. Sentiri enim potest. Lapillus, si deorsum cadat, vi ferit illum, quem tangit. Sed haec vis ei est naturalis. Quodsi eunde lapillum violente dejicias, multò majore vi percutiet illum, quem tanget. Haec major vis ipsi non est naturalis. Non enim antea aderat. Quum ergo eam nunc habeat, ab aliquo necesse est ut habeat, & quidem distinctam, quum eam antea non habuerit. Movetur quoque multo celerius, quando vi projicitur; quam si proprio motu cadat. A vi ergo impressa celerius movetur. Quare ab eadem quoque movetur." Ibid., 193.

hand, and the ontological surplus which the stone in the violent case has over the one in the natural case. Furthermore, since it is established that a naturally falling stone and one that is moved violently are distinguished by the presence of a force, a resting stone and a naturally falling one are also distinguished by such a force.

Introducing another variation into his example, Gorlaeus then claims that a stone that is thrown straight upward is moved entirely by the impressed force of the throwing hand, while when it was thrown downwards, it is moved both by the hand and by the natural force that moves the free-falling stone, and then draws conclusions for natural change in general:

> On the contrary, if it is thrown upwards, it is moved entirely by the impressed force, a force which stands in a relation to weight and to the heaviness of what presses it. We believe the remaining actions to come about in a similar way, namely, that there is some similar force which proceeds, as it were, from the agent, and by which the thing is produced, and that this very being-produced is the passion itself of the thing. This cannot be understood and explained by me in more detail.[21]

That the violent force in this third case "stands in a relation to weight" I take to mean simply that heavier things need a greater force imparted to them in order for them to move upwards. Gorlaeus then claims that the analysis of motion just given applies not just to local motion, but to generation and corruption as well.

The next part of exercise nine discusses the motions of spirits and angels, the planets, and the elements. Having said what he wanted to about the definition of motion and natural change, Gorlaeus turns to the question in what sense various types of beings are capable of self-movement. Since natural motion is simply motion caused by the moved thing, this is at the same time about the delineation of violent and natural motion. Gorlaus begins his discussion of self-movement with spirits: Spiritual substances, he claims, move themselves in the sense that they impress their own force onto themselves.[22] The (human) soul is such a spirit and can cause its own

21 "Imo si sursum projiciatur, totus movetur a vi impressa, quae vis habet rationem ponderis; & gravitatis cujusdam prementis. Reliquas actiones simili modo fieri remur. Nempe esse vim quandam similem, quae procedat, quasi ab agente, & per quam producatur res: & hoc ipsum produci esse ipsam rei passionem. Latius haec a me intelligi & explicari nequeunt." Ibid., 193 f.

22 Ibid., 194.

motions when it is outside the body. Within the body, the weakness of its force does not allow it to overcome the resistance of the body, although it can direct the body's movements. The angels are the other main type of spirit, moving functionally in the same way as disembodied human souls, except with a greater force. By contrast, Gorlaeus argues, inanimate bodies do not have any ability to move themselves, since they lack intelligence and so would not know when and where to move. Therefore, they are indifferent to motion in themselves, and it is God who impresses and conserves in them the force towards the center of the earth:

> God Himself, therefore, impressed that force into them, and still conserves it in them. This force cannot be taken away from the bodies, except by the one who imposed it. And it can be impeded for a while by a greater force, which can be imprinted into a body. Besides, this adventitious force is not perpetual, because that force to the center resists it and eventually wins over.[23]

Because the conservation of the force that causes natural motion is an action of God, the force cannot be taken away from the bodies by natural causes. If a greater force comes from outside, natural motion can be impeded for a time, but the adventitious outside force will eventually be overcome by the natural force, which is perpetual due to God's conserving it. The stars also have a natural motion, caused by the same kind of perpetual impressed force, but in their case, it compels them to a circular motion. Bodies in general can have only one natural motion because if there were more than one, the necessary forces would be in conflict:

> And so this is the reason why the thing is moved to only one motion naturally. For it cannot be moved towards two terms at the same time, so neither can a force be impressed into it by which it is moved towards them. For a force that is naturally inserted acts always, except if it is impeded. Therefore, one force would impede the other if multiple were inserted into the thing.[24]

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23 "Ipse ergo Deus vim hanc ijs impressit, qua ad centrum moventur: eamque adhuc in ijs conservat. Vis haec a corporibus tolli nequit, nisi ab eo, qui illam imposuit. At impediri potest interim a vi majore, quae corpori alicui imprimi potest. Caeterum haec vis adventitia non est perpetua, quia haec vis ad centrum resistit illi, & tandem vincit illam." Ibid., 194 f.

24 "Atque haec caussa est, quod unico motu res moveatur naturaliter. Non enim ad duos diversos

Gorlaeus finishes his discussion of natural and violent motion in solid bodies by introducing another variation of the thought experiment using falling rocks he had already used in exercise two. Again, two rocks are compared, but this time, they both fall naturally, the difference being the height of the fall. A greater height leads to a stronger impact, and that is because of a force that is gradually impressed during the fall:

> Because the weight of a stone is felt much more when it falls from a high place than from a low one. Where does this stronger force come from? Another force is impressed into the *motum*, apart from the one it had before. When I throw a stone, I move the hand and by this motion impress a force into it, by which it is moved; and in the same way, when it is moved naturally, by its own motion its force increases, because there is no resistance to this motion in it. Indeed, such a force can be impressed by motion.[25]

Just as the throwing hand in the case of violent motion, there is something that impresses into the moving body the force that is felt by the eventual impact. Since the only difference between the two natural motions in the thought experiment is the duration and height of the fall, Gorlaeus concludes that natural motion itself serves to accumulate force. But here, the two senses of "force" that Gorlaeus had identified begin to drift apart: The force that is acquired by the motion itself is an output force which can be felt on impact, whereas the cause of motion is an input force, provided in the natural case by God. Gorlaeus identifies both of these forces and hence gives no explanation of how the same conserving action of God, providing a constant force to natural motion, could result in different forces on impact.

In the remainder of *Exercitationes* 9, section two, Gorlaeus moves on to the motions of the elements and mixts. In most Aristotelian theories, the four elements in the sublunar sphere have two natural motions among them: Water and earth move naturally

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terminos simul moveri potest. Quare nec vis ei imprimi, qua ad eos moventur. Vis enim naturaliter indita semper agit, nisi impediatur. Una ergo vis impediret aliam, si plures rei indita forent." Ibid., 195.

25 "Nam multo magis sentietur lapidis pondus, si cadat ex loco alto, quam si ex humili. Unde vero haec major vis? Motu priore paulatim imprimitur aliqua vis praeter istam, quam antea habebat. Sicut enim, quando lapidem projicio, manum moveo, & illo motu vim ei imprimo, qua movetur: ita quando naturaliter movetur, per suum ipsius motum auget suam vim, quia in ipso nulla est resistentia huic motui. Potest enim per motum vis ejusmodi imprimi." Ibid., 198.

down, air and fire move naturally up. Whether a mixt moves up or down depends on the surroundings and on the proportions in which it contains the four elements. Gorlaeus, on the other hand, eliminates the natural upwards motion and instead argues that water, earth and air all move naturally downwards.[26] In the case of water expanding into vapor the change in volume (the so-called rarification) cannot be the cause of the motion, because the essence of water has not changed: "The motion belongs to it by its essence, not by the aggregation of atoms."[27] Instead, the heat itself "imprints" the upwards motion on the vapor:

> For just as the hand imprints a power to move into the stone, by which it is moved when it is not in contact with the hand, so also into the vapors a power to move is impressed by the heat, by which they are moved in absence of the heat.[28]

The upwards motion of water vapors, in other words, is a type of violent motion, with heat taking the role of the throwing hand as the efficient cause. Gorlaeus defines heat as a "real accident," which replaces the element of fire, since fire is not a real being according to him. The rest of the section uses this principle to show that the motions of earth and water, fuelled by a combination of heat and the natural heaviness, can account for earthquakes, sea-storms, rain and underground water currents.

Among the assertions that Gorlaeus makes in connection with local motion, one in particular is difficult to understand, namely his identification of the *vis impressa* or force with the action. This seems to conflate two things that have good reason to be separate, as the *vis impressa* is something within the moving thing, while action is a property of the agent. What Gorlaeus therefore seems to be saying is that the cause is somehow present in the effect. Since he says so little about the matter, it is difficult to see how exactly this can be articulated in any coherent way.

Most of what Gorlaeus does say about the nature of the impressed force occurs in his discussions of natural and violent motion and the traditional test cases of falling and projectile motion, as discussed in section 1.3. Firstly, the concept of *vis* is used

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26 Gorlaeus discusses these issues at more length in other places of the *Exercitationes*. Some passages are at VII, 7, 146, where he claims that levity is the absence of gravity, and at XVII, 5, 332, where he reiterates that the upwards motion of air is finite and not a natural motion.

27 "motus ei competit per essentiam, non per aggregationem atomorum." *Exercitationes*, 199.

28 "Nam sicut manus motu suo imprimit lapidi vim, qua movetur, quando non contingitur a manu: ita & vaporibus hoc motu imprimitur vis à calore, qua moventur absente calore." Ibid., 200.

by Gorlaeus to draw the distinction between natural and violent motion in general. According to him, both natural and violent motion are caused by an impressed force. The difference is that in natural motion, God immediately induces the moving force into the *motum*, while in the violent case, it is the result of the interaction with another natural substance. The main difference of this account from the theory of *vis impressa* as it is found for example in Toletus or Scaliger is that for these latter authors, the *vis* that is responsible for natural motion stems from the substantial form of the moved body.[29] Since Gorlaeus denies the substantial form, a direct intervention by God is necessary. Secondly, Gorlaeus also invokes the *vis impressa* when he discusses particular examples of falling and thrown heavy bodies. His strategy is to use local motion, which he claims can be "seen into,"[30] as a model to explain the relation of action to *vis* in general. This does not seem to be very successful, however, since the role of force in the various examples of local motion turns out to offer little additional information. The claim that the action causing any natural change is a force is no better founded by Gorlaeus' physical examples than by the dogmatic identification of action and force in his definition of natural change, where he had simply claimed that "a similar force, as it were, and efficacy is impressed into things that come to be."[31] In effect, the claim that the producing agent has a force to generate the patient is no more informative than simply saying that one thing produces another.

2. What is a "mode"?

2.1. *Beings, accidents, modes*

The first part of this chapter explored Gorlaeus's definitions of natural change, local motion, and his account of natural and violent motion. The result was that Gorlaeus has difficulties articulating a coherent account of natural causation in general and local motion in particular. Both to see whether there is a way to rescue Gorlaeus from himself and to understand what internal reasons there might have been for him to maintain his peculiar account of motion, the next section will consist in an investigation into his understanding of the term *modus*. Starting with the concept of *modus* makes sense because it is the part of the definition of motion that Gorlaeus says the

29 See p. 56 above; on Scaliger, cf. Maier, *Zwei Grundprobleme*, 297–299.
30 Ibid., 192, quoted above in n. 18.
31 *Exercitationes*, 33, quoted above in n. 17.

most about in the rest of the *Exercitationes*: As discussed in the first section, the three types of natural change are introduced as three types of passion, and both passions and actions are modes. However, precisely because it is so central, an explanation of what Gorlaeus means by *modus* must also involve some of his other basic notions. That is why I will first explain what Gorlaeus understands by an *ens reale*, an *ens rationis* and an *ens per accidens* before moving on to modes.

As mentioned at the outset of this chapter, Gorlaeus identifies theoretical philosophy with the science of being. Accordingly, the most fundamental distinction in his philosophy is that between the real being or *ens reale* and the fictional being or *ens rationis*. An *ens reale* is

> that the essence of which exists through itself. Wherefore it is neither invented by the intellect (but rather remains even when the intellect is not thinking), nor is its entire essence toward something or in something, but rather it has its own existence proper to itself, through which it exists and not through another. But the being of reason is that which is invented by the intellect.[32]

Real things, in other words, are those that are sensible and actual, whereas fictional things have no being at all and are mere figures of speech. Gorlaeus consistently calls the former *ens reale* (real being) but interchangeably calls the latter *ens rationis* and *ens fictum* (being of reason and fictional being). The status of being invented, as he explains further, is defined by a certain relation of the intellect to the sensations:

> The concepts in a single mind have been brought to it by the senses and are real things. They have a disposition among each other and are connected in reality. But the thing that is signified by them, if it is nowhere outside [the mind], and nevertheless is signified as being, that is a fictional being. This is why we said in the definition that the being of the being [of reason] itself is invented.[33]

32 "Ens reale est, cuius essentia per se existit. Quare neque ab intellectu fingitur; sed eo etiam non cogitante datur: neque tota ejus essentia est esse ad aliud, aut in alio, sed suam sibi propriam habet existentiam, per quam existit, non per alienam. Sed ens rationis est, quod ab intellectu esse fingitur." Ibid., 22 f.

33 "Conceptus singuli mentis per sensus ad ipsam fuere delati, & rerum sunt realium: ii inter se disponuntur, & realiter conjuncti sunt. Sed res per eos significata, si nuspiam extra sit, & tamen esse

Fictional things, therefore, result when concepts or combinations of concepts refer to a thing that does not exist in the world. There is not enough material in the *Exercitationes* to say precisely how Gorlaeus thinks this relationship comes to be. But as far as I can see, any way of filling in the blanks would quickly run into problems. For instance, the fact that Gorlaeus speaks of concepts as "brought to the mind by the senses" suggests that in the case of real, sensible objects, the concepts in the mind are linked to the objects in the world by the sensation itself. So imaginary things result from the combination of concepts gained by experience, creating new concepts that are not self-contradictory, but also do not have a corresponding thing in the world. As long as we speak about non-existing imaginary things, the relation of signification is not a problem, because we can just deny that there is such a relation. Gorlaeus gives the following example: I have the concept of a donkey, given to my mind by the senses. Likewise, I have the concept of a flying thing, also from the senses. Because of this, I can imagine a flying donkey, which is a thing in my mind without any referent in the world. But what if we modify the example given by Gorlaeus and imagine something that *does* exist? Instead of "flying," take "white." White donkeys do actually exist, although I personally have never seen one. My concept of "white donkey" signifies the set of existing white donkeys – otherwise the donkeys would be fictional things, merely because of my lack of experience of them. But what connects the animals in the world to the conjunction of concepts in my mind? Gorlaeus gives no indication what his stance on this would be. In any case, though Gorlaeus' conception of fictional entities might provoke some questions, it is fairly clearly defined.

Gorlaeus then discusses being by accident or by aggregation. In one sense, the aggregate is real and not fictional, but that is only insofar as the aggregated beings are real – the aggregate is "properly speaking not a being, but beings."[34] However, the aggregate taken as a unity is a fictional entity. Summing up, Gorlaeus quips that the aggregate is "not a true being, but nevertheless it is true that it is."[35] This notion of a being by aggregate is the core of his metaphysical argument for atomism, since it disqualifies any divisible body from the status of real being. At least among material things, only the indivisible atoms are truly real beings. The atoms are created by God but are unchanging as far as the course of nature is concerned.[36] Most of the

significetur, haec est ens fictum. Idcirco in definitione diximus: ipsum entis esse fingi." *Exercitationes*, 23.

34 "proprie non est ens, sed entia" *Exercitationes*, 25.

35 "ens per aggregationem non sit verum ens, & tamen vere dicatur esse" *Exercitationes*, 26.

36 "Nego plane ullum corpus factum esse, nisi per solam creationem, quum Deus Optimus Maximus

properties of sensible bodies are then explained in terms of the atoms and their spatial arrangements. The austerity of this conception is somewhat diminished by the fact that Gorlaeus also introduces a category of beings that have a lesser degree of being than the atoms: A select few accidents, heat chiefly among them, are *real* accidents. Like most late scholastics, Gorlaeus takes a real accident to be an accident that is able to migrate from subject to subject, although it usually inheres in one. The fact that he admits the existence of such accidents as "little substances" is rather surprising in the context of an atomism as strict as his.[37]

After defining accidental union in general, Gorlaeus distinguishes multiple kinds of it. All of them share the central characteristic that they cannot produce one being out of many. The most unusual entry on the list of accidental unions is that of soul and body. The union of body and soul is one "where one is in the other intimately and penetrates it and acts through it."[38] Nevertheless, both halves of the union remain numerically distinct, since the human mind is a spiritual substance and is therefore an *ens per se* as well.[39] This account of accidental union was picked out by some of the later readers as the most outrageous part of Gorlaeus' philosophy, because that the unity of body and soul is an essential one was not just a philosophical tenet, but also a theological one. To claim, as Gorlaeus does, that both are distinct entities, is quite radical indeed.[40]

Next, Gorlaeus introduces one last sense of "being": modes. Modes answer a question that might be seen to arise from his previous claim that accidental union is nothing over and above the real beings involved: If accidental union is a mere fiction, how are real beings within an accidental union distinguished from those outside it? The answer is that their union is a mode of the united beings themselves: The soul's being united with the body is a mode of the soul and vice versa.[41]

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mundum hunc crearet: nego ullum interijsse, aut interire posse, nisi ab eodem in nihilum redigatur: nego unum corpus in aliud transmutatum esse, et transmutari posse." Gorlaeus, *Exercitationes*, 256; Lüthy, *David Gorlæus*, 41; Pasnau, *Metaphysical Themes*, 705.

37 Gorlaeus, *Exercitationes*, 110–114; Hattab, "Gorlaeus on Universals," 288; Lüthy, *David Gorlæus*, 42; Pasnau, *Metaphysical Themes*, 259.

38 "[…] ubi unum est in alio intime, illudque penetrat, & per illud agit." Gorlaeus, *Exercitationes*, 25.

39 Gorlaeus, *Idea*, 71.

40 The claim that the union of body and soul is accidental was first made by Nicolas Taurellus, who is a definite influence for much of the metaphysics of the *Exercitationes*. See Lüthy, *David Gorlæus*, 126–129.

41 That these are modes can be gathered from the fact that Gorlaeus uses the union of body and soul as an example to show that modes are mind-independent and therefore not fictional: "Differt autem modus entis ab ente rationis: quoniam hoc, intellectu non cogitante, non est. At etiamsi nemo

Modes are defined as "a certain habitude accidental to a being, whose entire being is inhering in the *ens* and belonging to it externally."[42] A mode is a "habitude"; that can either mean "disposition," "state," which is intransitive, and in the sense that each mode is the property of a single being, this is what is implied. Or it can mean "relationship," and then it is transitive from the perspective of the being underlying the mode: The mode of being-united-with-body is a state or property of the soul, but it is a state which consists in a relationship with another being, the body. In fact, both of these meanings of the word are present in Gorlaeus, which is clear from the fact that some of the categories that are later listed as modes are properties of single atoms (like their shape), while others are clearly relationships (like their spatial arrangement). Compare also this passage:

> And a mode of a being is that habitude itself, by which the being to which it belongs is referred either to place or to time or to other beings that coexist with it, a habitude that can change in the subject thing, because what is being referred to can change.[43]

The definition calls modes not just a habitude, but an *accidental* habitude "whose entire being is inhering in the *ens* and belonging to it externally."[44] That seems contradictory, since a mode is both internal and external to the thing it is a mode of. But the point here is to emphasize that modes do not have being in the sense that real beings do. However, since they are neither fictions nor accidents, they must have being in *some* sense. Gorlaeus expresses this by saying that modes do have existence, but only by the existence of their substrates:

> For to be a real mode is to have real being, yet not an own being, but a borrowed one, not through itself, but through something else, through the existence of which [the mode] also exists. So the figure of

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intelligat animam corpori unitam esse, tamen hac unio nihilominus datur. Atque idem de reliquis modis statuendum est: nempe competere rebus per earum existentiam; non per sui intellectionem." *Exercitationes*, 27.

42 "habitudo quaedam entis accidentaria, cujus totum esse est inhaerere enti, eique extrinsecus accedere." *Exercitationes*, 26 f.

43 "At modus entis est illa ipsa habitudo, qua ens, cujus est, refertur aut ad locum, aut ad tempus, aut ad alia entia, qua ipsi coexistunt, quae habitudo in re subjecta mutari potest, quia haec mutari possunt, ad quae refertur." *Exercitationes*, 28.

44 *Exercitationes*, 26 f., quoted above n. 42.

> the wax, that is, its length, is a mode of it. It is distinct from [the wax], because it can be separated from it, namely when the wax becomes round. Nevertheless, as distinct, it does not have any being of its own, but itself inheres entirely in the wax, in which, while it inheres in it, by the existence of the wax and of its parts, that is, because they are extended in length, this length also exists.[45]

Modes, so to speak, share in the existential force of their substrate and live in a middle ground between fictions and independent being.

2.2. *Two types of modes*

There are, according to Gorlaeus, two main types of modes: The first group of modes belongs to their subject *ratione solius existentiae*, by existence alone, while the modes in the second group are affected by the essence of the subject in addition to its existence. Essence and existence are defined in section two of exercise two. Although they are defined differently, both terms are the same in reality:

> We do not really distinguish essence from existence, but assign to the very essence also its existence, not distinct from it except in reason. For essence is that called by which a being is *what* it is and is placed under a genus or species and distinguished from all other [beings]. Existence, on the other hand, is that by which a thing is actually not nothing and distinct from the non-being.[46]

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45 "Nam esse realem modum, est habere reale esse: verum non proprium, sed alienum, nec per se, sed per aliud: per cujus existentiam & ille existit. Sic cerae figura, nempe longitudo, est modus quidam ejus. Haec ab ipsa distinguitur: quia potest separari: nempe si cera fiat rotunda. Interim ut distincta non habet ullum proprium esse: sed inhaeret tantum ipsi cerae, cui dum inhaeret, per existentiam ejus, & partium ejus, scilicet quod ista in longum extensae sint, haec quoque existit longitudo" *Exercitationes*, 28.

46 "[E]ssentiam ab existentia re ipsa non distinguamus; sed ipsi essentiae tribuamus suam quoque existentiam haud ab ipsa distinctam, nisi sola ratione. Nam essentia dicitur, per quam ens est id, quod est, & sub genere aut specie constituitur, atque ab omnibus aliis distinguitur. Existentia vero est, qua res est actu extra nihil, & distincta à non ente." *Exercitationes*, 40. Van Ruler remarks about the very similar definition of essence in exercise 14 (p. 262) that this conception of essence fulfills precisely the same role as the Aristotelian form that Gorlaeus denies. Ruler, "Entiteiten zonder vorm," 202.

The reasoning for this non-distinction is particularly nominalistic:

> For because universals do not exist in singulars but are rather abstracted from them by force of the intellect, it follows necessarily that that by which something is *this* being is also that by which it is *a* being.[47]

A distinction of essence and existence that is more than merely in reason would imply the existence of universals (facts about the worlds whose truth is not decided by the existence of a single thing). Since there are no universals, the distinction is merely in reason. With this in mind, here is the passage that introduces modes of existence:

> But the mode that belongs to the being solely by its existence is another than [the mode which belongs to it] by essence and existence simultaneously. Because, although these are the same, they can still be distinguished by reason in a way that makes it possible that reason attributes something to one and not to the other. The first mode is that the existence of which exists either in space, or in time, or together with other beings. So here belong rest, location, duration and situation. The latter of these is the position of one being in relation to another and the coordination, so to speak, and disposition among each other of multiple [beings].[48]

Since the essence of a thing includes all that distinguishes it from any other thing, modes of existence are those that could be attributed to any real being. Gorlaeus goes on to say that modes of existence ("prior modus") are related to time, space or to coexisting things, which is to say, all real beings necessarily have relations to time and space, and those relations do not concern the essence of the being in question. Gorlaeus then discusses what predicates he understands to fall under the label "exis-

47 "Quum enim universalia in singularibus non existant, sed ab iis vi intellectus abstrahantur, necessario consequitur, per quod aliquid est hoc ens, per illud idem quoque esse ens." *Exercitationes*, 40 f.

48 "Est autem modus alius, qui enti competit ratione solius existentiae, alius, qui ratione essentiae, & existentiae utriusque simul. Nam quamvis hae sint eaedem, tamen ita ratione distingui possunt, ut ratio nostra uni aliquid tribuat, quod non alteri. Prior modus est, quo ipsa existentia existit aut in loco, aut in tempore, aut cum aliis entibus. Huc ergo pertinent quies, locatio, duratio, situs. Quorum postremus est unius entis ad aliud positio, pluriumque quasi coordinatio, & inter se dispositio." Ibid., 28 f., directly after the passage on the modes as relations just discussed.

tential mode." They could be summarized as "static designations in time and space": Location is glossed a little later as "the existence of a thing in place,"[49] and duration is the same as existence in multiple instants or over an interval of time.[50] *Situs* or situation, as the passage above makes clear, is the relative position of an atom versus other atoms existing at the same time, its position in relative space in contrast to the absolute *locatio*. The list of properties that are explained as instances of *situs* is quite extensive, including the properties of figure, rarity and density and the Aristotelian *habitus*. Gorlaeus further explains that duration has two associated modes: It can either be interpreted as existence in multiple instants, or as existence over an interval. A similar distinction would seem to obtain with location, as a thing can either be located in a point or extended over a volume of space. But extension in space is actually just the location of multiple atoms in various points of space: "For that a body is now extended in length, now in breadth, that comes to pass insofar as atoms acquire a different place."[51] However, there are nevertheless some existential modes that belong to location, namely "when a thing is in the same place in varying ways."[52] These are the extension of the soul and of the visible species in different sizes of body and "the figure of the simple thing,"[53] that is, the shape of individual atoms. Rest, finally, is simply the absence of local motion or "the remaining of the thing in place."[54] After this discussion of the modes of existence, Gorlaeus remarks that the same predicates cannot be said to be modes in the case of God, not because God has no location, but rather because He is necessarily everywhere and always, so that no modal distinction is possible.[55]

After that, the modes of the "essential" type are introduced. There are just three: action, passion, and rest (in the sense of non-action). The definitions of action and passion that are introduced here were discussed at the beginning of this chapter, as was the fact that local motion is included here as one of three kinds of passion. The other two modes of passion introduced along with it correspond to two other types of

49 "Locatio est rei existentia in loco." Ibid., 39.

50 "Duratio est entis continuatio." Ibid., 29. Cf. also ibid., 30: "Neque enim haec duratio idem est, quod ipsa rei existentia, quoniam possunt separari. Nam in primo momento res habet existentiam: non tamen habet omnem suam durationem."

51 "Nam quod corpus jam in longum sit extensum, jam in latum, id fit, quatenus atomi varium acquirunt locum." Ibid., 31.

52 "quando res in eodem loco est diversimode" Ibid.

53 "rei simplicis figura" Ibid.

54 "Quies est rei permansio in loco." Ibid.

55 Ibid., 32.

natural change, namely change in substance and change in quality. *Fieri*, coming-to-be, is the beginning of the existence of one thing insofar as it is the result of the action of another: "To have this origin and to begin by the action of another is properly a passion."[56] Likewise, *recipere* is the union of a thing with a new property that is introduced into it by an action. This passion, like the passion of being produced, lasts only during an instant and is only there insofar as there is a corresponding action on its subject. The properties that are received seem to be those that can be reduced to *situs*, since "this very union, considered in itself and as already attained, is not a passion anymore [...], but is a kind of *situs*."[57]

2.3. *Conclusion*

In the first part of this chapter, I discussed how Gorlaeus defines motion in general and local motion in particular, as well as his account of natural and violent motions. The main takeaway was that this part of his theory alludes both to motion as a *flux* and a passion, and to a *vis* that can be impressed into moveable bodies either by other bodies or by God. The problem was that all three of these notions seemed too thin to give a useful explanation of how genuine change of any kind is possible on Gorlaeus' otherwise static ontology. After having discussed *modus* and the other core concepts specific to Gorlaeus' metaphysics, let me now attempt an evaluation of his claims about the nature of motion and the force that causes it.

Modes are central for Gorlaeus, because they are the only type of dependent real entity which he admits – the only other real entities are the *ens reale* itself and the real accidents, which are both independent *res*. This means that whenever Gorlaeus tries to explain a property or phenomenon that is not heat and that he cannot identify with either an atom or a spiritual substance – for these are the only two types of *ens reale* he admits – the property or phenomenon in question must be explained by a mode. Therefore, when Gorlaeus claims that motion is a passion and that passion is a mode, he is making a compromise between a reductionist and a realist stance on motion, since modes are real in a very specific, limited sense. The claim that motion is specifically a mode of essence and existence further implies that motion is not reducible to the *situs* or relative position of atoms, because being reducible to *situs* in this way is the mark of modes of existence. The obvious question is what other properties these

56 "Hoc initium habere, & incipere per alius actionem est proprie passio." Ibid., 34.

57 "At ipsa unio in se considerata, ut iam facta, non est amplius passio [...] sed ad situm pertinet." Ibid., 34 f.

modes describe, if not spatial ones. What I will argue in this concluding section of the chapter is that Gorlaeus' claim that motion is a mode of essence and existence points to the causal aspect of local motions. Recall the definition of local motion:

> Local motion is not the same as the very existence of a thing in varying place, although it includes that, but it is properly the migration from place to place, or rather the continuous flow of the being's existence through various places. That flow of the moved thing is a passion.[58]

The context of this definition, as we have seen in section 2.2, is that local motion is one of three types of passion. As discussed towards the end of the that section, Gorlaeus distinguishes two other types of passion besides local motion, namely the generation of a new composite and the receiving of a new property. What he emphasizes about these latter processes is the fact that only what happens in the very moment of interaction is properly called a passion: The instant after generation, the existence of the newly generated thing does not depend on the influence of the generating cause anymore, and similarly in the case of alteration. That is not so in the case of local motion: It extends over a period of time, which is why Gorlaeus says in the definition that the "continuous flow" is a passion. The definition comes directly after the discussion of the other two types of passion in the text, so it is not plausible that this asymmetry in the treatment of the three types of passion is accidental. From the cases of substantive and qualitative change, then, we learn that change is a passion only insofar as the cause of the change is considered along with it and as long as the causal factor is actively at work. But that means that the cause of the local motion is active through all of the "continuous flow of the being's existence" – in other words, the reason why local motion is not just "the very existence of a thing in varying place" is the fact that this change of place has a cause that remains active through the entire motion.[59]

The presence of the cause within the *motum* is concentrated in the *vis impressa*, as Gorlaeus argues using variations of the traditional thought experiment of a heavy stone falling down to the earth. That motion is a passion of the moved body and therefore must be related to its cause in some general way was already clear from the

58 "Motus localis non est idem, quod ipsa rei existentia in vario loco, quamvis hunc includat, sed est proprie migratio de loco ad locum, seu potius entis existentiae per varia loca continuus fluxus: qui fluxus rei motae est passio." Ibid., 35.

59 Cf. n. 14 above.

definitions, but the physical examples convince Gorlaeus to make two more specific commitments regarding the *vis*. Firstly, because there is such a clear difference in velocity and power of impact between a stone that falls down naturally and one that is thrown downwards with additional effort must mean that motions can also differ in intensity and be added to one another. Secondly, the relation of physical cause and effect can only be understood if one and the same *vis* is brought over from the mover to the moved – as he puts it, "this force [in the moved] is that action [of the mover] itself."[60]

Gorlaeus is forced to admit that the causal influence of one natural body on another is a real, mind-independent property of both the moving and the moved body, not reducible to their spatial and temporal relations. Compared to many contemporary natural philosophies, this is of course still a very modest commitment, but in the context of the sparse ontology of the *Exercitationes*, it becomes difficult to find a place for a notion such as this *vis impressa*. Gorlaeus himself recognizes this difficulty, since he reacts by denying that it can be further explained in any way.[61] The moving force impressed into a body by another (or by God), in other words, is explanatorily primitive.

Situating Gorlaeus' notion of *vis* within the scholastic context will help us understand why his general ontology leaves him no other option than to leave the mode of passion unexplained. Although there is not much evidence as to Gorlaeus' sources for this conception, the tension between the *vis impressa* and the conception of motion as a mode is borne out by the original context of the vocabulary.[62] It stems from two distinct scholastic debates: As we have seen in chapter one, the phrases "motion is a flux" and "motion is a passion" were coined in context of scholastic theories of the ontological status of motion. The central issue in this specific scholastic debate was whether to assign to motion itself an independent reality, in addition to that of the substantial forms involved. The term *vis impressa*, on the other hand, was coined in the context of a theory of the causation of motion.[63] Within the former debate, the claim that motion is a passion seems to put Gorlaeus on the realist side: If change is one or multiple species of passion, then it is, on the Aristotelian view, in one of the

60 "Atque ita haec vis est illa ipsa actio." Ibid., 33. Cf. n. 17 and p. 141 f. above.

61 Cf. e.g. *Exercitationes*, 194, quoted in n. 21 above.

62 The disputation "On the first affections of body" by Henricus de Veno, Gorlaeus' mentor, which could have offered more specific sources, has unfortunately not been preserved. See Lüthy, *David Gorlæus*, 84.

63 See p. pp. 20 and 56 above.

categories, which means that it is a being in its own right. However, since Gorlaeus does not subscribe to the Aristotelian view that passion is one of the fundamental categories of being, he is not bound by this inference.

The claim that "motion is a flux" better explains why Gorlaeus ends up with a relatively realist stance: It suggests that Gorlaeus subscribes to a theory of *fluxus formae*, according to which change is categorically distinct from both its endpoint and its subject (the two substantial forms that it could be identified with under the alternative theory of *forma fluens*). This must however be qualified again: *Fluxus formae* had become the standard scholastic position in the 14th century, so naturally a number of different versions of the theory were developed over the centuries, some of which attributing only a relatively small degree of reality to motion. With respect to the question of independent reality, Gorlaeus' stance on the ontology of motion might therefore be compared to a moderate realism such as that of Nicolas Oresme.[64]

It is surprising at first that Gorlaeus is not more minimalist in his description of change, given that he is so reluctant to admit reality to anything but single substances otherwise and given that there were scholastic theories which were prepared to deny any independent reality to natural change. In fact, the description of change as "the very existence of a thing in varying place" that Gorlaeus uses to delineate his own definition describes Ockham's position on motion quite well.[65] What is more, the only reason why the ontological status of change is a difficult problem for scholastic philosophers is that they generally need to explain it in terms of a transition from one static (substantial or accidental) form to another. And indeed, Gorlaeus does not seem to see any need to give an explanation of how change itself is possible. What seems difficult to him, as we have seen, is the presence of the cause in the effect. From a hylomorphist point of view, even when it is that of an extreme anti-realist about motion like Ockham, there is an obvious way to articulate the relation of cause and effect, namely in terms of substantial and accidental forms. The efficient cause of any motion or change, according to Ockham, is simply "a thing that has the power to produce the effect sufficiently and without which such an effect cannot be produced."[66] A cause and its effect are related to one another by two corresponding accidents in the categories of action and passion. It is true that as a category nominalist, Ockham claims that most categories describe manners of speaking and not distinct entities,

64 See p. 26 above and Caroti, "Oresme on Motion," 24.

65 "ipsa rei existentia in vario loco" *Exercitationes*, 35. On Ockham, see Shapiro, *Motion, Time and Place*, 38–40.

66 Goddu, "Ockham's Philosophy of Nature," 155.

but the real foundation of these manners of speaking include both substantial forms and real qualities.[67] This road is closed to Gorlaeus, who denies the substantial form entirely and accepts real qualities only in a few special cases. The only way out that is left for him is to gesture at the modes of passion and action as something that might replace the causal functions of forms, without being able to explain how that might work.

67 Pasnau, *Metaphysical Themes*, 226.

CHAPTER 4

Francis Bacon

1. Introduction

1.1. *Introduction*

The accounts of Sennert, Basson and Gorlaeus which have occupied us in this study so far share a common feature: Though they all have an important place for motion, that place remains mostly implicit. Sennert discusses his two sorts of atoms almost exclusively in the context of matter theory and does not make any attempt to conceptualize their motions. Such motions are clearly implied in many of his arguments, for example when he proves the existence of particles using the dissolution of metals in acids. A further difficulty is that what conceptualization of atomic motion there is in Sennert does not fit with the Aristotelian scheme of potentiality and actuality which otherwise forms the basis of his explanations. In contrast to Sennert's view, Basson's atomism is characterized in principle by a thoroughgoing reduction of all qualities to the motion of atoms. What is missing almost entirely is a causal connection between the purely geometrical, mechanical level of the atoms and the qualitative level of everyday objects. As a consequence, the cause of atomic motion remains ambiguously suspended between God, Nature, the spirit and the nature of individual atoms. Gorlaeus, for his part, is far less interested and knowledgeable in physical questions than either Sennert or Basson but engages in similar problems in his own more sparse and metaphysical way. His ontology of real beings and modes has the potential to do for the atoms what the substantial form does for the Aristotelians. What is missing in Gorlaeus, however, is a theory of action and causality. None of these authors uses the word "motus" very often, and when it does occur, that is mostly in the context either of a discussion of the Aristotelian conception or of the traditional examples of gravitational and projectile motion.

Bacon is quite different in this respect: He writes about motion frequently and has an original and elaborate conception of how it is fundamental to other aspects of nature. In particular, he postulates so-called "simple motions" out of which all others are composed. At the end of aphorism 48 of the second book of the *Novum organum*, a text which will be discussed in more detail below, he writes that in "set[ting] out the species or simple elements of the motions, appetites and active virtues," he has

"outlined a fair portion of natural philosophy."[1] It therefore seems very worthwhile to find out what exactly Bacon's conception of motion is, and in particular what the nature and role of the simple motions are. However, this turns out to be a difficult task, as Bacon gives no explicit definitions and as a perplexing range of different things seem to count as (simple) motions. Whereas Sennert, Basson and Gorlaeus often stay very close to the traditional examples, Bacon discusses, in various texts, a great range of phenomena and experiments that either are themselves simple motions or are explained by them. Some of the descriptions read as patterns in the local motions of visible bodies or invisible particles, while others describe qualitative changes or transformations of one kind of matter into another; often, but not always, the language is teleological and seems to attribute appetites and desires to bodies. The list in the *Novum organum* contains nineteen different simple motions.

In addition to their broad range, some of the examples also do not seem to express any coherent conception of motion at all, at least at a first glance. For instance, the motion of Trepidation describes a kind of dynamic balance between two opposite appetites, found in "all bodies whose lot it is to waver between states of convenience and inconvenience."[2] What Bacon therefore describes as trepidations are oscillations, periodic local motions between two extreme states. His only example for this simple motion are the heart beats of animals. He mentions the periodic change in the precession of the equinoxes postulated by some astronomers as a second example but does not believe in this astronomical instance of *motus trepidationis*. From Bacon's brief discussion and the single example that he offers, basic questions about this supposedly fundamental motion seem impossible to answer: Is it the opposed appetites that distinguish motion of Trepidation from other simple motions, or rather the periodic change of direction? Would a cyclical change between hot and cold also be a motion of Trepidation? To cite another example, the motion of Passing Through is that "by which the virtues of bodies are to a greater or lesser extent held up or carried forward by their media,"[3] the virtues in question being such diverse things as light, sound, heat and magnetic attraction. It is clear that all the cases have in common that cause and effect are not in direct contact but only indirectly through a medium, and

1 *Novum organum*, book II, aphorism 48, in: Bacon, *Oxford Francis Bacon* XI, 413. This and other volumes of the *Oxford Francis Bacon* will hereafter be quoted as OFB, preceded by a shortened reference to the title of the work being quoted.

2 Ibid.

3 *Novum organum* II, 48, OFB XI, 409. Bacon introduces some idiosyncratic terminology. To mark when the Baconian sense of a word differs from the modern one, I will use capitalization. All the titles of the individual simple motions, for instance, will be treated as proper nouns.

that the same cause can have a stronger or weaker effect depending on the medium. However, it is far less clear what it would mean to claim that the helping or hindering of the medium is a "motion" in all these disparate cases.

Hopefully, these preliminary remarks have shown that although Bacon held the simple motions to be important for his natural philosophy, it is not immediately apparent why he did so, or what the systematic connection between his motions is. The fact that there are nineteen simple motions in the *Novum organum* shows that Bacon's account of motion is not an adaptation of the Aristotelian account. At the same time, the apparent lack of an organizing principle or of a smaller subset of more fundamental motions seems to make it difficult for him to offer an explanation of how the simple motions are foundational for the rest of his natural philosophy.

Bacon is a complex author in general, as is attested by the enormous diversity of judgments on his work and project in the four-hundred years of reception. Even if those debates were (and still are) first and foremost about the methodological parts of the project, Bacon's many facets and influences are also evident in the most speculative passages of his writing, which have often been regarded as extraneous to the method. The passages that will interest us in this chapter are among those, which is why I will endeavor first to have all the necessary pieces in place before examining the Baconian motions themselves. A consequence of this approach is that the central questions about the simple motions will not be answered until the second half of this chapter.

1.2. *Outline of this chapter*

Bacon's account of motion is important for his entire natural philosophy, and it occupies a very specific spot in it. For this reason, I will have to introduce Bacon's general vision of natural philosophy, which will be the aim of part 2. As I will explain in section 2.1, Bacon has rather a vision of a natural philosophy than a finished system. That is both because he did not have time to finish most of it and because his main philosophical project was that of a reform of natural philosophy. Consequently, much of his writing is concerned with characterizing a new way of investigating nature, and only indirectly with the concrete results of that new science. I will characterize the epistemological reform project and the famous "method of induction" in section 2.2. In the final section of the second part (2.3.), I will introduce two of the theory pieces that form the immediate context for Bacon's account of motion, namely his matter theory and ontology.

One of the main results of part two will be that Bacon's project is almost as much about fundamentally criticizing other visions of natural philosophy as it is about proving any specific claim of his own. That is why, in part three of this chapter, I will begin my investigation into Bacon's conception of motion with his critique of the Aristotelian conception. The final part of the chapter will then use the results of parts two and three to tackle the simple motions themselves, beginning with some early versions of the idea and then moving on to the two parallel lists of simple motions found at the end of the *Novum organum* and in the late fragment titled *Abecedarium novum naturae*.

Before all of this, I will use the final section of this first part to give a sketch of Bacon's biography. I hope to achieve two things in this way: The first aim is to illustrate that Bacon played multiple roles at the same time, so as to make plausible that the aims of his reform of natural philosophy were shaped by his identities as a lawyer and politician. One might object that the influence of Bacon's identity as a lawyer and politician is restricted to the methodological side of the reform project and does not extend to the speculative philosophy. If the Lord Chancellor let his views about civil life seep into his philosophy, the seepage surely occurred in matters of method and organization, not in metaphysical speculations. But in fact, it has been argued that his concept of motion itself is political in nature.[4] To evaluate such claims (which I will attempt towards the end of this chapter), it will be useful to have an idea of Bacon's politics, if not his political philosophy.

The second aim of the biographical sketch is more mundane: I will need to refer to a number of different writings by Bacon, and often it will be relevant how the passage in question relates to the entire reform project or to other writings. Bacon kept working on some of his drafts over many years and produced multiple versions of many of them, so situating the writings within his biography is a good way to organize them.

1.3. *Biographical sketch*

Francis Bacon's life was that of a lawyer, statesman and politician and was spent almost entirely in the elite circles of London. He was born in 1561 into an illustrious family: His father was Nicholas Bacon, Lord Keeper of the Great Seal of England, and his mother Anne was the second daughter of Sir Anthony Cooke. Anne Bacon was deeply religious

4 Lancaster, "The Moral and Political Character."

and highly educated and actively guided the education of her sons. Francis and his elder brother Anthony were both tutored in Trinity College. Bacon's later secretary William Rawley claimed that it was at Cambridge that "he first fell into the dislike of the philosophy of Aristotle,"[5] but it is questionable whether these two teenage years would have been enough to base the reported dislike on any substantial study.[6]

The young Bacon left Cambridge in 1575, not quite fifteen years old, and entered Gray's Inn in London to study law. Already a few months later, he left to join the ambassador to the French court, Sir Amias Paulet, where he lived for almost three years, until his father's death in 1579. He then finished his studies at Gray's Inn and was admitted to the bar in 1582.[7] He was also elected to the House of Commons in 1681. Partly through the help of his uncle, Lord Burghley, chief advisor to Queen Elisabeth, he then made quick further career steps both in law and in politics: By 1588, he had been made a bencher and a reader (senior positions within Gray's Inn), been elected to Parliament twice more, and published his first political treatises and reports.[8]

In the 1590s, he also became friends with the Earl of Essex, who unsuccessfully tried to secure the office of Attorney General for him. Bacon's career slowed down generally in that decade, and he was only able to win back the Queen's favor after 1598. That was also when he cut ties with Essex, which proved to be an opportune move, since the Earl was executed in 1601 for treason. Queen Elisabeth died in 1603 and was succeeded by King James, which changed the political geography once again. Bacon had much more success under the new ruler, being knighted in 1603 and becoming Solicitor General in 1607. In addition to his public offices, he was also an enormously productive writer in the decade from 1603 to 1612. The only published philosophical works from this period are *The Advancement of Learning* (1605) and *De sapientia veterum* (1609), but Bacon also wrote a number of fragments that were only published after his death.

The 1610s saw the culmination of Bacon's career. In 1613, he was finally named Attorney General. He also became one of the king's closest advisors, a member of the Privy Council in 1616, Lord Keeper of the Great Seal in 1617 and Lord Chancellor and Baron of Verulam in 1618. His *Novum Organum* was published in October 1620, with a dedication to the king and printed by the royal printer. In January 1621, he

5 Bacon, *Works* I, 2. The 19th century-edition by Spedding, Ellis and Heath will hereafter be quoted as SEH.

6 Gaukroger, *Francis Bacon*, 38 f.

7 Peltonen, "Introduction," 3.

8 Ibid., 4 f.

was created Viscount St. Alban and took part in his first Parliament as a peer. From that high point, his political career was brought to an abrupt end as he was charged with bribery, to which he pleaded guilty in May. He was removed from office in disgrace, briefly imprisoned, barred from holding office in the future and fined £40,000. After this sudden downfall, Bacon devoted all his energy to writing and produced an astonishing output of books and fragments. He died on 9 April 1626 of pneumonia.

Bacon was a lawyer and politician first and a philosopher second as long as he held public office. However, he always wrote and even published alongside his political career, even if he never had quite as much time for it as after his impeachment. Still, there is a remarkable consistency in his intellectual pursuits. There are two great reform projects in particular that he took up sometime in the 1590s and pursued for the rest of his life: the reform of English law and the reform of natural philosophy.[9] The former was aimed at a simplification and rationalization of the law and pursued both through political action and in writing. The latter project is what Bacon is still famous for, and he expresses many of its distinctive features and aims already in this early period. He expresses the hope and expectation that natural philosophy could be fundamentally changed by introducing a new method, and the view that the reform would have to begin by purging both the Aristotelian and the alchemical method. He also makes reference to the practical knowledge of the artisans and to the new inventions of the printing press, gunpowder and the compass. Finally, he expresses the view that the application of the new method would result in great benefit to all humankind, and even hints that this could only be achieved by a collaborative effort, not through individual genius.[10]

Although the basic vision remained constant, Bacon constantly revised and changed his drafts. Many of the works that he produced in his late years have precedents in earlier writings.[11] For example, *De augmentis scientiarum* (1623) is a translation into Latin, reworking and extension of *The Advancement of Learning* (1605); and the interpretations of the myths of Cupid and Caelum given in *De sapientia veterum* (1609) were going to be significantly extended in *De principiis atque originibus* (written c. 1612). That the latter remained a fragment is a common feature shared by many of Bacon's book projects.

9 Ibid., 5.

10 Ibid. See also SEH VIII, 109, 123–126, 334–335.

11 Bacon's process of constant revising and redrafting and of re-integrating previous ideas into new works is especially clear in the philosophical studies collected in OFB VI. See Rees' introduction on the fragment *De vijs mortis*, OFB VI, xxxi–xxxv.

The biographical situation and Bacon's way of working help explain why the late works produced from about 1620 until his death are the culmination of a lifetime of work and at the same time mere fragments. He wrote to the king that he had been working on the *Novum organum* "near thirty years," and its basic aim was indeed the same as that envisaged in the 1590s.[12] In the intervening years, Bacon had developed an elaborate structure for a great meta-book, called *Instauratio magna* or *Great Instauration*, that was going to contain both the proposal for of the new method and its execution. At the same time, only the first of the six proposed parts was finished by the time of Bacon's death.

2. Bacon's philosophical project

2.1. *Bacon's vision of natural philosophy*

If we wish to give an outline of Bacon's philosophical reform project, a good first step is to examine the structure of the *Great Instauration*. That structure is explained in the *Distributio operis*, published in 1620 together with the *Novum organum*. There, we learn that the *Instauratio magna* was envisioned in six parts. The first part was to give the "partitions of the sciences," that is, a division of all possible areas of human knowledge, and to evaluate the current state of each. Moreover, this part was to contain examples to help remedy the deficiencies of present knowledge. Bacon was able to complete part one in 1623, by publishing the *De augmentis scientiarum*, an extended Latin version of the earlier *Advancement of Learning*. If part one of the *Great Instauration* is a survey of the terrain, part two was to give Bacon's proposal on how one could transform the sciences from their present state into a better one, the "interpretation of nature."[13]

The *Novum organum* contains this second part, although it is condensed into aphorisms, and substantial parts at the end remained unwritten. It is divided into two books of aphorisms, with a complicated internal structure. Generally speaking, in the first book, Bacon makes the case that his great reform project is necessary and feasible: He stakes out his fundamental positions (preface and aphs. 1–37), motivates the need for a new method by criticizing the old one (the "Doctrine of Idols" in aphs. 38–69) and preemptively responds to pessimists and other objections (the "Doctrine of Signs" in

12 Letter to King James, October 1620, SEH XIV, 120.

13 *Descriptio*, OFB XI, 29.

aphs. 71–91 and aphs. 92–114 on grounds for hope). In book two, he begins introducing the method itself. The first ten aphorisms of the second book explain how some of the fundamental epistemological notions – form, material and efficient causes, latent process and latent schematism – fit into the system of Baconian science.[14] Aphorisms 11–20 give a preliminary account of the new method itself, including an example exercise on the form of heat called the "First Vintage." The remainder of the text consists in a discussion of the twenty-seven classes of "Instances with Special Powers," a collection of "labour-saving devices or shortcuts"[15] that can be of help in the search for form. Although the aphorisms on the ISPs take up almost half of the word-count of the *Novum organum* proper, they are only the first of nine "other aids to the intellect"[16] Bacon planned to have follow upon the First Vintage.

After the destructive and methodological efforts of the first two parts, part three of the *Instauratio magna* was to begin the rebuilding of natural philosophy by providing a new empirical foundation. As a first step, Bacon planned a series of six "specimens" of natural history, of which he managed to publish two in his final years: *The Historia ventorum* and the *Historia vitae et mortis*. A third, the *Historia densi & rari*, was published posthumously by Rawley, while the other three remained nothing but prefaces.[17]

The last three parts of the *Great Instauration* remained almost entirely unwritten. There are some fragments of part four, which was to apply the method presented in part two to the materials collected in part three. Among these is the *Abecedarium novum naturae*, which will be examined in some detail later in this chapter, because it contains Bacon's last account of the "simple motions."[18] Part five and six were to be repositories of two kinds of theories: in part six the final results of the method of induction, and in part five Bacon's "anticipations," that is, his best guess at the correct theory using ordinary reasoning.

2.2. *The inductive method*

The three most important features that distinguish Bacon's philosophical project from those of his contemporaries are arguably his method of induction, his inte-

14 OFB XI, lxvii.

15 OFB XI, lxxviii.

16 *Novum organum* II, 21, OFB XI, 273.

17 OFB XII, xix.

18 Other fragments that belong to this part of the *Instauratio magnae* are the *Historia de animato et inanimato*, the *Inquisitio de magnete* and the *Topica inquisitionis de luce*.

gration of the practical into the theoretical and his theory of matter. I shall use the remaining sections in this part to discuss these topics in order. I will begin by introducing the main idea of the inductive method and illustrating its close connection to the polemical part of Bacon's reform project. I will then compare an early and a late formulation of the idea and show that the Aristotelians were never the only target of the polemic, even if they were an important one. At the end of this section, I will turn to an aspect of Bacon's philosophy that is often confounded with the method of induction itself, namely the combination of theoretical and practical aims. In the next section, I will close out the exposition of the main lines of Bacon's natural philosophy by giving a summary of his matter theory, which is highly relevant to the topic of simple motions.

The method of induction is not identical with the project of the *Instauratio magna* or even of the *Novum organum*, but it does form the core of both.[19] In a nutshell, as Bacon explains in a famous passage, it is a new way of relating sense experience and abstract principles:

> There are and can only be two ways of investigating and discovering truth. The one rushes up from the sense and particulars to axioms of the highest generality and, from these principles and their indubitable truth, goes on to infer and discover middle axioms; and this is the way in current use. The other way draws axioms from the sense and particulars by climbing steadily and by degrees so that it reaches the ones of highest generality last of all; and this is the true but still untrodden way.[20]

Bacon here presents his more cautious and systematic way of proceeding from the empirical and particular to the abstract and general as the untried alternative to another, less systematic way of doing the same. Since introducing the new way necessarily means replacing the old one, the project of a wholesale reform of natural philosophy has an important polemical component. Bacon was acutely aware of this fact, saying that "[i]t is useless to expect great growth in the sciences from the

19 I take the basics of Bacon's method from Malherbe, "Bacon's Method of Science"; Peltonen, "Introduction"; Jardine, "Experientia Literata or Novum Organum?"; Gaukroger, *Francis Bacon*, 6–20.

20 *Novum organum* I, 18, OFB XI, 71. When available, I quote the modern translation from the *Oxford Francis Bacon* directly. When quoting from the Spedding edition, I give both the Latin and a translation.

superinduction and grafting of new things on old."[21] Bacon is convinced that the old, unsystematic way is common to most natural philosophies except his own and uses it to criticize a broad range of opponents. Already in a 1592 letter to Lord Burghley, one of the earliest documents of his program, the first step towards the new science is to remove old misconceptions:

> I confess that I have taken all knowledge to be my province; and if I could purge it of two sorts of rovers, whereof the one with frivolous disputations, confutations, and verbosities, the other with blind experiments, and auricular traditions and impostures, hath committed so many spoils, I hope I should bring in industrious observations, grounded conclusions, and profitable inventions and discoveries; the best state of that province.[22]

Neither "frivolous disputations" nor "blind experiments" can produce the kind of beneficial knowledge envisioned by Bacon. Although Bacon later made much more detailed analyses of the ways in which the human understanding has lost its way, the "two sorts of rovers" mentioned here remained two of the most important foils against which he articulated his own vision of natural philosophy. That he put a great deal of effort into creating a place for systematic critique within his method of discovery is apparent in the intricate structure of the *De augmentis scientiarum* and the *Novum organum*, both of which have interlinking destructive and constructive sections.

The single most important passage for Bacon's critique of other conceptions of natural philosophy is probably in the Doctrine of Idols, in the first book of the *Novum organum*. Under the heading of "Idols of the Theatre," Bacon criticizes three types of wrongheaded philosophical theory, to wit, the dialectical, the empirical and the superstitious type. Each of the three Idols stands for a misguided way of doing natural philosophy. The fault of the empirical family is that they get too fixated on a small number of experiments and derive all their principles from them. Their experiments are "blind," in the sense that they are not guided by a method which ensures both that all possible phenomena are integrated and that the results are sufficiently screened and systematized. The problem with the dialectical type of philosophy (of which Aristotle is the main example) is not that they have no place for observation, but that their interpretations are clouded by an overemphasis on logic and abstract categories. They,

21 *Novum organum* I, 31, OFB XI, 77.

22 SEH VIII, 109.

too, do not investigate their empirical data enough, but whereas the chymists and Gilbert are too focused on the experiments, the dialectical philosophers rely too much on "meditation and intellectual agitation."[23] In other words, the two sorts of rovers from the letter to Burghley correspond to the "dialectical" and the "empirical" type of Idol of the Theatre as presented in the *Novum organum*, while the "superstitious" type is a later addition. All three of them have in common that they lack a good method for founding their general principles in particulars. What both these philosophical traditions and the unaided intellect generate are mere *anticipations* of nature, whereas the goal of a methodical investigation should be the *interpretation* of nature. The goal of the new organon is to produce interpretations of nature, which will also function as a method of invention, that is, a way to generate new truths in a reliable way.[24]

Bacon's method is not simply an emphasis of the empirical over the theoretical, but an elaborate integration of the two. That comes out clearly in the fact that he criticizes the "empirics" just as harshly as he does the "rationalists," comparing the latter to spiders who spin their webs from their own entrails and the former to ants who merely collect materials without transforming them in any way.[25] That the method does not consist in a mere emphasis on empirical facts is also apparent in the way in which Bacon transforms the genre of natural history by writing "functional" histories subordinated under the bigger reform project. The first two parts of the *Great Instauration*, as we have seen, are dedicated to articulating the need for a new method as well as the method itself. The implementation of the project itself begins in part three with the natural histories, but these are not the same type of writing as one finds in other writers of natural history.

The experiences collected in the specimen histories written by Bacon in his last years are far from the collections of curiosities one finds in Pliny, Scaliger or Della Porta.[26] All of these writers are important sources for Bacon, but the claims he cites from them are embedded into a frame given by the *Instauratio*. Natural history in Bacon's vision is merely the first step in the inductive method. On the one hand, this means that any observation or fact recorded in it is subject to revision, but on the other, the requirement of openness to results that cannot be foreseen from the start means that the range of experiences recorded should be as broad as possible. In fact, the main critique directed at both the empirics and the rationalists is that

23 *Novum organum* I, 62, OFB XI, 99.
24 Malherbe, "Bacon's Method of Science."
25 *Novum organum* I, 95, OFB XI, 153.
26 OFB XIII, xxviii.

their data base is too narrow. While the rationalist sect jumps to abstract principles without any method, the empirics do focus on experience, but repeat one kind of experiment endlessly and build their entire worldview around it. Neither properly integrates natural history with the rest of natural philosophy. What is more, Bacon's natural history also extends its domain to include not just "the variety of natural species" but also "the experiments of the mechanical arts."[27] He explains that natural history should treat not just generations, i.e., nature in its ordinary course, but also pretergenerations and arts.[28]

The presence of a history of arts within natural history points towards the other famous feature of Bacon's vision for natural philosophy: Its interventionism. The history of arts is nature in a state of "vexation," and the reason why it is not only part of natural history, but even exalted over the histories of generations and pretergenerations, is Bacon's conviction that the behavior of things under intentional manipulation will result in more and deeper information about the physical world than simple observation. One of his favorite analogies is that nature, like Proteus, will reveal its secrets only under duress.[29] On top of being an essential part of the inductive method, the manipulation of nature is also one of its main aims. In this sense, the famous slogan that "knowledge is power" cuts both ways.[30] Antonio Pérez-Ramos has seen the reason why art is so important for Bacon in his underwriting of "maker's knowledge," meaning that "the capacity of (re)producing Nature's 'effects' was perceived as the epistemological guarantee of man's knowledge of the natural processes in the external world."[31] That does not mean that Bacon identifies truth and utility; his claim is rather that what is true is also fruitful and vice versa.[32]

Before moving on to an exposition of the main tenets of Bacon's matter theory and cosmology, let me make two remarks about the possible implications of an interpretation that puts the manipulation of nature at the center of Bacon's philosophy. The first remark is that Bacon's vision of philosophy can also be said to be practical in other senses, all of which are in the end derived from the assimilation of knowledge and power. The three main practical dimensions of Baconian science are the following: Firstly, its ultimate aim is to improve the living conditions of humanity;

27 *Novum organum* I, 98, OFB XI, 157.

28 *De augmentis scientiarum*, SEH I, 496.

29 *Parasceve*, SEH IV, 257, *De sapientia veterum*, SEH VI, 651 f.

30 "[F]or what is most useful in operating, is most true in knowing." *Novum organum* II, 4, OFB XI, 205.

31 Pérez-Ramos, *Francis Bacon's Idea of Science*, 59.

32 Rossi, "Bacon's Idea of Science," 37.

secondly, it takes inspiration from practical endeavors and trades that have no place in Aristotelian *scientia*; and thirdly, Bacon envisioned science as a collective effort, since the pure breadth of his project meant that it would be impossible for one person to finish it in their lifetime. This last aspect is why Bacon tried to enlist the support of the king and, through him, of the state. It is also why his writings are not only theoretical tracts, but also rhetorical pieces aimed at gaining such support.

The second remark is more directly relevant to our main topic: Art and the manipulation of nature are not only important for Bacon's philosophy as a whole, but also for the simple motions in particular. If the "maker's knowledge"-interpretation of Bacon's overall philosophical project is correct, the fundamentality of the simple motions over other parts of nature must be spelled out in terms of the possibility of manipulation. Whether such an articulation is plausible, however, cannot be assessed until some other pieces of the puzzle are in place. One of these pieces is the place of the simple motions within Bacon's system of philosophical disciplines, which we will have reason to discuss in the course of the next few sections; another is the character of the spirit, the material substrate which, according to Bacon, is responsible for all motions in the universe. Considerations of matter theory, cosmology and spirit were very important to Bacon himself, but have traditionally been all but ignored by his readers because they seemed to be readily separable from the inductive method. More importantly for our purposes, spirit is one of the central notions within Bacon's matter theory, as the next section will show.

2.3. *Speculative philosophy*

Bacon's matter theory is probably the area of his philosophy with the most egregious mismatch between the importance assigned to it by the author on the one hand and that assigned by his later commentators on the other, at least until the end of the 20th century. For Bacon himself, matter theory and cosmology were the paradigmatic subject matter his new method ought to be applied to, and he spent much time and ink in trying to do so. Both his critics and his admirers, however, tended to ignore his contributions in this area. Even in the seventeenth century, we find only few references to his cosmology.[33] Different readers of Bacon with very different evaluations of his philosophy as a whole, like the members of the early Royal Society, the *Encyclopédistes* in enlightenment-era France, or mid-20th-century Popperians,

33 Rees, "The Fate of Bacon's Cosmology in the Seventeenth Century."

have shown little interest in Bacon's system of claims about the material structure of the universe. Each of these groups had their own reasons for this neglect, but while they were each able to see continuities between Bacon's reform project and their own, his intuitions about the content of natural philosophy were so far from the basic convictions of even his immediate heirs that they became an embarrassment that was discussed as little as possible.[34]

The interpretative strategy of separating the project and method of reform from its results was also made relatively easy by the structure of the *Great Instauration*. After all, Bacon himself had claimed that everything but the method were mere anticipations of nature, so it was tempting to argue that it could be safely put aside. This reasoning, however, misses the fact that the anticipations are not simply the preliminary results of the method, but rather an important part of it. The entire fifth part of the *Great Instauration* was to consist of the provisional system of anticipations. It would have contained Bacon's definitive statement of what Graham Rees has called his "speculative philosophy," "an elaborate guess at the kind of science the method was expected to generate."[35] Substantive "speculative" passages can also be found in the written parts of the *Instauration*, which is good evidence that the inductive method as it was understood by Bacon is not as easy to separate from his views on matter and cosmology as it has seemed to so many for such a long time. In any case, if one is interested not in the method alone, but in Bacon's philosophy as a whole, the speculative philosophy is important.

Much of the speculative part of Bacon's work consists in his theories about matter. These discussions relate directly to the simple motions, because for Bacon, all motions are a result of active tendencies in one or another piece of matter. Specifically, it is only the pneumatic parts of matter – so-called *spirits* – that can be the source of motions. The distinction between tangible and pneumatic matter is the most fundamental one within Bacon's matter theory. Tangible matter is dense and passive, while pneumatic matter is weightless, active, and invisible. The basic cosmology is that the core of the Earth consists of pure tangible matter and the outer heavens consist of pure pneumatic matter, with a transitional region between them where both kinds of matter mix. This middle region is the terrestrial region accessible to us.[36] This means that various kinds of spirit permeate everything in this realm: Even the most solid bodies carry so-called "attached spirits" within them, which is why none of them is

34 OFB XI, xxii–xxxiv.

35 Rees, "Bacon's Speculative Philosophy," 121.

36 *Descriptio globi intellectualis*, SEH III, 756.

as absolutely passive as pure tangible matter. There are also four "free spirits" which exist outside any tangible body: air, terrestrial fire, ether and sidereal fire.[37] The latter two exist only in the superlunary regions where the celestial bodies move around the stationary Earth, balls of sidereal fire in a medium of ether.

The second main distinction is that between the two quaternions of sulphur and mercury, named after the two basic types of stable matter. The groups associated with them are opposed in their qualities: Sulphur, oily and flammable substances, terrestrial fire, and sidereal fire on one side, and mercury, watery substances, air and ether on the other. With increasing distance from the center of the universe, the balance shifts from the mercury quaternion towards their fiery counterparts: Fire on the ground can only exist for a short time and with a constant supply of fuel, while the stars burn forever and independently.[38]

While it does not strictly belong to matter theory, Bacon's view of the motions of the celestial bodies is closely integrated with his views on their matter. His preferred system of celestial motion is neither the Copernican nor the Ptolemaic one, but one similar to that of Al-Bitruji (Alpetragius.) In this system, the Earth is stationary, and the stars rotate from east to west, but in contrast to the Ptolemaic account, the retrograde motions of the planets are not caused by a west-to-east motion of their respective inner spheres, but are a result of their slightly slower east-to-west motions. Whereas Al-Bitruji claims that each of the planets sits on its own sphere, which is given its rotational motion by the outer spheres, Bacon attributes the motion to the planets themselves and claims that the closer to the earth one gets, the weaker the sidereal fire in them becomes.[39] He learned about both the Alpetragian doctrine of celestial motion and the idea that the terrestrial world is a frontier zone between the region of pure spirit and the region of pure tangible matter from Tommaso Campanella's *Philosophia sensibus demonstrata* sometime in the 1590s.[40] Presumably, his motivation for adopting such an uncommon view was that although he recognized the arguments in favor of the Copernican view, he could not abide by what he saw as an undue meddling of mathematical abstraction with physics.[41] With his quaternion theory, he provides a single physical explanation of both superlunary and sublunary phenomena.

37 *Thema coeli*, SEH III, 769, Rees, "Bacon's Speculative Philosophy," 125.

38 *Thema coeli*, SEH III, 770, Ibid., 127.

39 On Al-Bitruji, see Grant, "Celestial Motions in the Late Middle Ages," 133–135; Gaukroger, *Francis Bacon*, 175.

40 Rees, "Bacon's Speculative Philosophy," 123.

41 *Descriptio globi intellectualis*, OFB VI, 121. Cf. Ibid., 143.

The claim that sulphur and mercury are two of the basic types of matter is Bacon's adaptation of the Paracelsian *tria prima*, although he disagrees with the alchemists about the status of their third principle, salt. According to Bacon, salt is merely an intermediate nature between mercury and sulphur and can be reduced to them. Also, unlike the Paracelsians, he sees mercury and sulphur themselves not as principles, but merely as the eponymous examples of the two groups of bodies which each share a certain set of qualities. One could also call the two groups oily and watery, fat and crude, or inflammable and non-inflammable.[42] As salts are intermediaries between sulphur and mercury, there are also corresponding intermediaries between the other stages of the two quaternions: The juices of animals and plants are fine mixtures of oil and water, and the attached spirits are intermediates between fire and air.

In this way, by explaining spirits as intermediates of air and fire, Bacon connects his views on spirits with his quaternion theory of the types of matter. Together, the tangible intermediates and the attached spirits serve as the basis of most phenomena in the terrestrial region.[43] In particular, they provide an explanation for organic life. The attached spirits are of two kinds: inanimate and vital. Inanimate spirit is dominated by its airy component and is present in all matter. Because of its appetite to be united with the free air outside its container, this spirit has a destructive tendency. The bodies of plants and animals consist of the same sort of matter as non-living things, but also contain vital spirit in addition to that. The latter is predominantly fiery and so has no desire to leave the body and unite with the air, which is why it is able to restrain the destructive inanimate spirit for a while. Living bodies are by necessity inhomogeneous, since they consist of inanimate parts regulated by vital spirits distributed according to a certain structure. In plants, that means "slender passageways and tiny channels," but in animals, the channels form into a central "cell" to which they "resort as if to a university."[44]

The combination of an active, material spirit with a system based partly on the Paracelsian *tria prima* is the defining feature of Bacon's matter theory. With respect to motion, spirit is the more important part of the equation, but it is also the more difficult one. The overview of his matter theory provided in this section has hopefully

42 *Abecedarium*, OFB XIII, 191. Cf. Ibid., 130. On Bacon's matter theory and its sources, see Gaukroger, *Francis Bacon*, 175–181.

43 OFB VI, liv.

44 *De vijs mortis*, OFB VI, 319. For the theory of inanimate and living bodies, see *Historia vitae et mortis*, OFB XII, 350–353, and *Sylva sylvarum* cent. 7, SEH II, 528. Cf. OFB VI, liv. Cf. Gemelli, "History of Life and Death"; Jalobeanu, "Bacon's Apples," 2016.

shown the broad range of the roles of the spirit in the main types of matter in the Baconian universe, but it not yet clear what all these roles have in common. Spirits are active, pneumatic matter, but what kind of activity is it that distinguishes spirits from non-spirits? I would argue that the fundamental type of activity in Bacon's universe is the simple motion, and that it is therefore also the defining feature of spirit to produce simple motions. For this reason, it makes sense not to speculate too much about the nature of spirit here, but to wait until we have properly introduced the simple motions.

3. Bacon as a critic of Aristotelianism

3.1. *Appetites and processes*

After this overview of Bacon's project and system, it is time to begin our approach to his account of motion. I shall do that by analyzing some of his critical remarks on Aristotelian motion, since they are significant for the place he envisages for his own conception of motion. This first section consists mainly of a reading of aphorism 66 in book one of the *Novum organum*. We have already encountered Bacon's principal objections against the Aristotelian way of doing natural philosophy in aphorism 63. In aphorism 66, he specifically criticizes the Aristotelian division of motions. I will argue that a careful reading of Bacon's polemic on this point allows us to infer what he thinks a good conception of motion should provide. This first section focuses on what Bacon writes about the Aristotelian division of motions along the categories of substance, quality, quantity and place. The following two sections then explore his critique of natural and violent motions, first of the natural-violent distinction itself (3.2) and then of the categorization of specific motions as natural and violent (3.3.)

We saw above (in section 2.2) that Bacon sees Aristotelian natural philosophy as the outgrowth of a misguided dialectical method which leads its exponents to jump from a narrow empirical basis to abstract principles too quickly. The notion that "motion in particular bodies was singular and particular to them, and that if they shared in any other motion that circumstance came from an extrinsic cause"[45] is among those recklessly introduced by Aristotle without a sufficient empirical basis. It is clear from this terse remark alone that Bacon disagrees with the distinction between natural

45 *Novum organum* I, 63, OFB XI, 99.

and violent motion, even if, in the context of aphorism 63, it is merely an example of the undue influence of logic on Aristotle's natural philosophy.

Bacon gives a more detailed critique of Aristotelian natural philosophy in an aphorism that is not about Aristotelianism at all. After having diagnosed the three basic types of philosophy, Bacon says something more general about "the depraved subject-matter of speculation, especially in natural philosophy."[46] Although that would suggest that the ideas being criticized are common currency among natural philosophers of all kinds, they target some of the core Aristotelian concepts. In the first part of the aphorism, Bacon takes aim at conceptions of primary and secondary qualities, and especially at those that use the substantial form, that is, at the foundations of Aristotelian matter theory. The second topic he takes up is the Aristotelian conception of motion:[47]

> But a far worse evil is that as yet they reflect on and seek out static principles – *whence* [*ex quibus*] – and not the moving ones – *whereby* [*per quae*] – things occur. For the former tend to words, the latter to works. For those commonplace differences of motion – *of generation, corruption, increase, decrease, alteration, and local motion* – recognized by the received natural philosophy are worthless. So what they mean is this: if a body changed in no other way nevertheless changes its place, that is *Local Motion*; if staying in place and species, it changes in quality, that is *Alteration*; [etc.]

And a little later:

> But there is no more to these notions than their popular appeal, and they do not penetrate into nature in any way; and they are just the measures and periods of motion, and not its species. For they suggest *how far* and not *by what means*, or *from what source*. [*Hucusque*, & non, *Quomodò*, vel E*x quo fonte*.][48]

46 *Novum organum* I, 66, OFB XI, 103.

47 The project of this part of the chapter is close to that of a paper by Manzo, from which I take important clues both to the relevant passages in Bacon and to their interpretation. Manzo, "Francis Bacon y la concepción aristotélica."

48 *Novum organum* I, 66, OFB XI, 105.

Bacon's criticism here is not that the Aristotelian use of "motion" as a general label for natural change is too wide, or even that the definition of change as the actualization of a potential is inadequate. He actually seems to agree that natural change, taken in approximately the same breadth as in Aristotle, is an appropriate subject for natural philosophy. What he disagrees about is rather the Aristotelian categorization of natural change into change of place, of quality, of quantity and of substance. The problem with that division, he claims, is that it does not distinguish the motions according to their true causes.

In order to see whether this critique hits its mark, let us examine what options an Aristotelian would have had in responding to it. In a sense, Bacon's point would readily be granted: Generation, corruption, alteration and so forth are not distinguished from each other by having a different cause. Rather, an alteration is a change from one quality to another, a locomotion a change from place to place – in technical terms, the type of change is determined by the category of the *terminus a quo* and the *terminus ad quem*. That the cause is irrelevant for the typology can also be seen by the fact that there are many cases where two motions of different types have the same efficient cause. For example, the Coimbrans explain that rarefaction of air is itself a qualitative change, but one which is typically preceded by a change in temperature (i.e., another qualitative change) and accompanied by a change in place, since the same body comes to occupy a larger volume. The heat of fire is the efficient cause of all these changes in the air next to it.[49] Therefore, if Bacon's critique merely consists in claiming that motions ought to be categorized according to their causes, it remains unclear what the problem with the opposing Aristotelian model is.

Might it be that Bacon's point is not that the Aristotelian typology is wrong, but more generally that the Aristotelian notion of natural change is not sufficiently connected to causation? But that claim would be rather surprising as well, since far from being indifferent to causes, Aristotelian change is only conceptually distinct from the causal link between agent and patient. Change itself is the actualization of a passive potential to be changed in the *mobile*, but it is always implied that there is a *movens* that is the efficient cause. Indeed, one and the same change can also be analyzed as the actualization of an active potential in the *movens*.[50]

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49 Conimbricenses, *In Libros De Gen & Corr* [Mainz: Albin, 1615] lib. 1 cap. 5 quest. 17 art. 5, pp. 270–272. The authors argue against the view that a new quantity is acquired and see rarefaction proper rather in a "motus tendens ad raritatem, prout est qualitas quaedam subiecta sensibus, pertinens ad tertium speciem qualitatis" (ibid., 272).

50 Des Chene, *Physiologia*, 41–43, argues that the primary model for causation in Aristotelian theories includes both an agent and a patient.

It is true that this characterization of motion and change is somewhat schematic in that it does not contain any information about which changes have which efficient causes. But that is by design: An Aristotelian efficient cause is not a property that some changes have and others do not, but an analytical tool that is so general that it can be used on any change at all. The same is true of the other three types of cause, the material, the formal and the final ones, which is why one and the same effect can in principle be assigned causes of all four types.[51]

In sum, Bacon's critique of the Aristotelian division of motions seems to be purely external, since what he points to as problems are basic features of the Aristotelian conception. In the light of his more general accusation that Aristotelian science makes too many deductions from general principles unfounded in experience, it makes sense that he would strive for a conception that However, it is not sufficient in and of itself to explain what it would mean to find "moving principles" instead of "static" ones, and neither does it become clear why to seek out the proper division of change into its species would need to be directly linked to seeking out the causes of each individual motion.

The vocabulary that Bacon uses to draw the contrast between his standard for principles of motion is not very helpful either, since it merely points to his methodological disagreements with the Aristotelians. His stipulation that the proper principles would include "by what means, or from what source," rather than merely "how far," is reminiscent of the traditional distinction of *demonstratio quia* (demonstration from the fact) and *demonstratio propter quid* (demonstration from the reasoned fact).[52] How to integrate this with the possibility of finding new facts by induction is a classical problem of Aristotelian scientific theory. In the Paduan context in particular, complex theories of method were developed that also integrated empirical sciences like medicine. For a Paduan Aristotelian such as Zabarella, physics is a theoretical science based on first principles, so it must be possible to defend any true fact in it by a demonstration *propter quid*. As a result, both sorts of demonstrations must be used, the *demonstratio quia* in the service of the *demonstratio propter quid*.[53] As such,

51 See Ibid., chap. 6 on some debates among late scholastics over whether there must always be a final cause.

52 The distinction is based on a remark in Aristotle, *Posterior Analytics* I, 13, 78a23–78b4.

53 Risse, "Zabarellas Methodenlehre," 165. Risse quotes Paul of Venice: "Causa habet duplicem cognitionem: unam in processu quia, et aliam in processu propter quid; quarum secunda dependet a prima, et prima est causa secundae; sicut etiam processus quia est causa processus propter quid …." *Expositio Super Octo Libros Physicorum* lib. 1, text. 2, dub. 4.

the distinction is therefore not directly linked to the physical science of motions but is rather a part of the general theory of scientific demonstration and concerned with logical inferences. Trying to link Bacon's terminology with the Aristotelian one only leads us back to his general critique of the relation of inductive and deductive reasoning.

However, if the point of the passage from aphorism 66 is to prove that the Aristotelian method produces results that do not measure up to their own standard of causal science, it is all the more important to find out how, in Bacon's view, motions should be defined in order to become connected to their causes. The following remark hints at what kind of entity would have to be taken into account in order to do that:

> Nor do they [i.e., the Aristotelians] signify anything to do with the appetites of bodies or the process of their parts; but only when the motion presents the thing to our sense in the crudest way as something different from what it was do they begin to establish a division.[54]

The second clause of this quote makes an epistemological point: A further problem with the Aristotelian categorization of motions is that it only extends to changes that can be detected by the unaided human senses. As Bacon tells us elsewhere, the way to get around the limitations of the senses is to construct experiments and let the experiment judge nature, while the senses judge only the experiment.[55] The first clause tells us what the Aristotelians missed by relying on the unaided senses only. What they *should* have paid attention to, and what a conception and classification of motions that pays attention to their causes must make reference to, are the "appetites of bodies or the process of their parts." These are therefore the sorts of entities which are discoverable through experiment and induction and which are the moving principles and the causes missing from the Aristotelian analysis.

It is not clear from this passage alone what either of these supposed moving principles are. It is however possible to say some general things about them by clothing the epistemological point about experimentation in an ontological habit: Changes in the visible world cannot be assumed to form an understandable system of interactions unless one assumes the existence of other changes that are imperceptible, either because they inhibit one another or because they take place at too small a scale. To understand how the perceptible emerges out of the imperceptible is the ultimate aim

54 *Novum organum* I, 66, OFB XI, 105.
55 *Distributio operis*, SEH I, 26.

of natural philosophy and can only be achieved by carrying out the entire program of the *Instauratio*, but the two aspects the Aristotelians are accused of neglecting here are excellent starting points for a reconstruction of Bacon's own anticipations of the imperceptible.

The contrast between the "appetites of bodies" and the "process of their parts" I take to be about the subject in which they inhere: The former generally occur in bodies large enough to be perceived, while the latter is invisibly small. In addition, the word "appetite" carries a connotation of teleology that "process" does not. This does not necessarily mean that Bacon makes a strict distinction between appetites (as the unrealized strivings of perceptible bodies driven by certain aims) and processes (as actual changes among invisibly small particles without an inherent purpose). It does, however, mean that motions, as they should be described according to Bacon, may fall on either side of each of the dichotomies implied by that distinction. They can be inherently teleological or not, can involve qualitative change or merely local, and can take place either in large bodies or in insensibly small ones. Part four of this chapter will be dedicated to reconstructing how the simple motions are supposed to fulfill the requirements that emerge from Bacon's critique of the Aristotelian account, so I will not say anything more about it here. However, from what was said in part two about the basics of Bacon's matter theory as well as from what was just said about the role of motions, it is clear that the spirit will play an important role in articulating them.

3.2. *The natural-violent distinction*

Let me first, however, discuss another aspect of Bacon's attack on Aristotelian motion, namely his answer to the possible counter-example constituted by the distinction between natural and violent motion. As we have seen, the main thrust of Bacon's attack on the Aristotelian conception is that the four types of natural change do not involve causation, at least not in the sense that certain motions could only have certain causes. To this, an Aristotelian might object that, while it is true that such a connection between an individual motion and its cause is indeed not the purpose of the four categories of motion, there is in fact another important distinction that is drawn in precisely this way: the distinction of natural and violent motion. In the chapter on Sennert, we have seen that although the questions of what changes in nature fulfill this definition and what kind of causation was needed were hotly debated, there is something like a minimal Aristotelian theory of natural motions: The difference between natural and violent motions is that natural motions are caused by the nature

of the moving subject, while violent motions are caused by an *agens* that is a distinct substance from the moved thing. There is also agreement about the basic extension of the definitions: Uncontroversial examples of natural motions are the rising of light fiery bodies and the falling of heavy earthy ones, and most instances of local motion caused by a human or animal in an inanimate object would count as a violent motion.

Bacon offers his own, harsh opinion on the natural-violent distinction in the continuation of the passage quoted last, still in aphorism *66*:

> And even when they want to point to anything to do with the causes of motions, and to draw distinctions between them, they very lazily introduce the distinction between natural and violent motion, which is a stock notion if ever there was one, since all violent motion is in reality natural, but with an external efficient setting nature working in a way different from the one it was working in before.[56]

In other words, he acknowledges that the distinction of natural and violent motion constitutes an attempt at dividing motions according to their cause, but it is no more than a step in the right direction. It cannot actually be implemented, because even the apparently violent motions turn out to be natural ones: They are fundamentally due to an inner nature, even if there might be an "external efficient" with the power to influence the workings of that nature. The critique is therefore not, as one might expect from an author who denies the substantial form, that the very conception of a natural motion is incoherent. There is room in Bacon's view for changes that are "natural" with regard to the body in which they occur. At the same time, it is very un-Aristotelian to claim, as Bacon does here, that a "nature" can be changed in its actions by an external efficient cause.

We should not forget that in the context in which these remarks occur, they are in the service of the attack on the overly "dialectical" style of philosophy. The claim that the violent//natural distinction breaks down is brought up by Bacon in order to show that it is a "stock notion," that is, that it is too simple and general a rule to be usefully applicable to all of nature. This aspect is even more salient in some earlier versions of the same argument. In the early *Cogitationes de natura rerum* (1604,) the Aristotelian conception of motion is the final example in a list of "dead principles." The other examples include matter's appetite for form, matter's imitation of a (Platonic) idea,

56 *Novum organum* I, *66*, OFB XI, 105 f.

the attraction of like particles to like, celestial influence, and others. Bacon claims that "such generalities, which are nothing but apparitions and likenesses on the surface of things"[57] do nothing to further power over bodies, and adds that to "argue and capture subtleties"[58] using the notions of violent and natural motion, motion from within or without, or the *termini* of motion, is just as useless as the other examples. In *Valerius Terminus of the Interpretation of Nature* (1603,) we encounter a parallel version of the same list of "mere nugations," which leads to the conclusion that "the calculating and ordination of the true degrees, moments, limits, and laws of motions and alterations (by means whereof all works and effects are produced), is a matter of a far other nature than to consist in such easy and wild generalities."[59]

Manzo points out that there are Aristotelian contemporaries of Bacon who made more detailed divisions than merely natural *versus* violent motion. One example is Johannes Magirus, who distinguished counternatural, preternatural and supernatural motions; another is Jacopo Zabarella, who acknowledged preternatural motions in the celestial bodies.[60] But these comparisons with specific Aristotelians are not helpful for understanding Bacon's position, and that for two reasons. Firstly, as Manzo also remarks, there is no common Aristotelian doctrine on this point. Aristotle himself never explicitly makes any subclassifications of violent motion, which is why there is a wide range of them to be found in the interpretations of different scholastics. Secondly, Bacon's attack is directed against the base distinction between natural and non-natural motions, not against any of the subclasses, so the introduction of any more fine-grained distinctions is not helpful for understanding his view of simple motions. Admittedly, three of Magirus' four types of motion correspond to the three branches of natural history according to Bacon: History of generations studies "natural" processes, history of pretergenerations studies the same processes when they do not reach their aim (i.e., *monstra*, which also fall under preternatural motions in Magirus' sense), and history of arts investigates nature as a result of human intervention. The latter is not quite the same thing as violent motion, but in practice, the possible examples are almost identical. We have already seen that natural history as Bacon envisions it to form part three of the *Great Instauration* is broader than the

57 "Huiusmodi generalia, quae nil aliud sunt quam spectra et simulachra in superficie rerum …" *Cogitationes de natura rerum*, SEH III, 20.

58 "argutari et subtilitates captare" *Cogitationes de natura rerum*, SEH III, 20.

59 *Valerius Terminus*, SEH III, 243 f. Manzo, "Francis Bacon y la concepción aristotélica," 80, paraphrases the passages from both the *Cogitationes* and from *Valerius Terminus*, although she does not give an evaluation of what Bacon's criticism means for his positive account.

60 Ibid., 83 f.; Magirus, *Physiologiae Peripateticae Libri Sex*; Zabarella, *De rebus naturalibus*, 384 lib. 7, cap. 3.

traditional version of that discipline, but what the correspondence with Magirus' distinction shows is that Bacon's broadening of the purview of natural history takes place on the basis of a distinction that was at least sometimes present in Aristotelian physics. This is further evidence that Bacon integrates the two disciplines more closely than the Aristotelians do.

Within Bacon's system, however, the relevance of the distinction between natural, preternatural and artificial changes is restricted to natural history and does not extend to physics or metaphysics. As we have seen in this section, he argues that the base distinction between natural and non-natural motion is a "stock notion" that is too general to serve as a principle of physics. What is more, strictly speaking the distinction is false, since "all violent motion is in reality natural."[61]

3.3. *Violent and natural motions*

The analysis so far has shown that while Bacon continues to use the expression "natural motions," he is dismissive of the claim that "violent motions" are a coherent opposite to them. In other words, he disagrees with the intension of the violent-natural distinction. But what does he think about its extension, that is, how does he conceptualize the motions traditionally held to be violent and natural? As for the violent motions, many of the classical examples are discussed under the label of the simple "motion of Liberty" in the *Abecedarium* – the flight of projectiles, the motion of a ship under sails, the moving parts of a clock, as well as others that do not fit easily into any Aristotelian mold. Bacon even explicitly says that "this motion [of Liberty] constitutes the one commonly called 'violent.'"[62] Nevertheless, I disagree with Manzo's suggestion that the category of violent motion is redefined as the simple motion of Liberty.[63] A closer look at the discussion in the *Abecedarium* and *Novum organum* reveals that motion of Liberty is simply matter's reaction to compression and stretching. Therefore, while it is true that the common examples of violent motions can be explained as the effects of motions of Liberty, the category of violent motion itself is abolished rather than redefined, in consonance with the results of section 3.2. Let me substantiate this claim by discussing Bacon's treatment of the case we have met so often already, the flight of a projectile through the air:

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61 *Novum organum* I, 66, OFB XI, 106. See note 56 above.

62 *Abecedarium*, OFB XIII, 193. Cf. also *Cogitationes de natura rerum*, SEH III, 28.

63 Manzo, "Francis Bacon y la concepción aristotélica," 85.

> For in every simple thrust or flight through the air no movement or local motion takes place before the parts of the body are preternaturally acted on and squeezed by the body impelling it. Then, indeed, when some parts push one after another, does the whole get carried forward, and not only by advancing but by turning at the same time, and in that way too the parts can free themselves or bear the strain more equally.[64]

Bacon might have the traditional stone thrower in mind here, or a cannon shot. Either way, his explanation of projectile motion is the following: Rather than directly impressing a local motion on the projectile, the moving cause at first compresses it. Because the pressure is applied on one side, the compression is stronger on that side as well. The reaction of the compressed body is to produce a motion of Liberty in each of its parts towards restoring that part's original volume. Since one side is more compressed than the other, the stronger motion of Liberty in the parts on that side overcomes the weaker one in the neighboring parts towards the other side, so that the pressure is propagated from one side to the other. The end result is that the parts all the way at the opposite end of the body acquire a motion of Liberty, even though they were never compressed by the original mover, and so the edge of the projectile extends forward into space. Bacon's main device of explanation, in other words, is a kind of elasticity in small parts of the moved body, which acts as if the parts were striving to distribute the compression as equally as possible.

What is striking when one compares this explanation of the phenomenon to those discussed in the previous chapters is that neither the air nor an impetus play any role. Bacon limits himself to the reactions of the individual parts of the moving body. This self-imposed limitation is the reason for the obvious hole in his account: He has no way to explain the basic fact that the projectile keeps on moving forward after having left contact with the mover – the very fact that the interactions of body, medium and impressed force were introduced to explain. Regardless of the efficacy of Bacon's explanation in explaining the phenomenon, it is clear that motion of Liberty is just as natural as any other simple motion. The motion itself stems from the nature of a body which is not currently taking up its natural volume, even if the body could only have become that way through compression or stretching by an external cause. That in this first phase, "parts of the body are preternaturally acted on" is precisely

64 *Novum organum* II, 48, OFB XI, 389.

because the compression or stretching is not a result of a simple motion in the body itself, but of some other motion in another body.

So much for violent motions. The paradigmatic examples of natural motion are of course the upward motion of light bodies and the falling motions of heavy ones. The place of such motions within Bacon's system is rather easy to determine, since he had planned a separate *Historia gravis & levis* among the specimen natural histories that would constitute a rudiment of part three of the *Great Instauration*. Although the full history of heavy and light was never written, a preface to it was published in 1622.[65] The fact that Bacon planned to produce such a history means that he took the falling and rising of bodies to be important phenomena, even if he was critical of the available theoretical explanations for them. In fact, the thrust of the preface to the *Historia gravis & levis* is that a natural history of falling bodies is almost entirely missing. Currently, Bacon laments, it consists in a small number of assertions invented by the ancients and not challenged or augmented since. These assertions are that motions of heavy and light are natural "since [the ancients] could discern neither an external efficient nor apparent resistance," and that "[m]oreover this motion seemed to get quicker as it progressed."[66] In the context of a natural history, the issue is that neither of these statements is supported by a sufficient empirical basis. In other words, the main fault of existing examinations of falling and rising motions is that they lack the systematic collection of facts that Bacon claims as the hallmark of his of natural histories.[67]

Of the two assertions made by the ancients, Bacon seems to have believed the second one to be basically correct: It is true that the motions of falling and rising bodies become faster as they go. The statement that the falling motion of heavy bodies has no external cause, however, he thoroughly disagreed with. He starts his critique by offering a brief explanation of why this false opinion has been so prevalent since ancient times: Because the masses of heaven and earth are always present, it was easy to assume that they play no role in the behavior of smaller bodies – it was not possible to find out what would happen if either of these two great masses disappeared. Having excluded heaven and earth, the ancients concluded that falling and rising motions are due to the nature of the heavy or light *motum* itself. Against this, Bacon argues that it is far more likely that gravitational motion somehow depends on the celestial bodies, even though their influence cannot be tested by experiment. He then

65 *Historia gravis et levis. Aditus* in the *Historia naturalis et experimentalis*, OFB XII, 132.

66 Ibid.

67 OFB XII, 416.

gives another reason why it is wrong to dignify this specific group of phenomena with the title "natural motion," namely that it is quite weak and can easily be overruled by other motions and appetites that no less depend on the nature of the moving body. In the *Novum organum*, he adds that even if the motions of heavy and light were purely internally caused, that would not be enough to separate them out as the natural motions from all others. They could then be counted among the simple motions, but only as one type among others.[68]

If the falling and rising of bodies has an external cause, what is it? In Bacon's opinion, what is traditionally called motion of heavy and light is an example of what he calls Motions of the Greater Congregation, whereby pieces of matter have an appetite "to be united with the greater masses of their connaturals, according as they are situated in the universe."[69] In other words, the motion of the Greater Congregation is the attraction that bodies of cosmic size have on smaller bodies which share in their nature. Motions of heavy and light bodies are the main examples of this, but Bacon also mentions two examples of motions that are at least related to Major Congregation and which involve celestial bodies: The influence of the moon on the tides is due to a consent of its nature with the moist, and the Sun keeps Mercury at a fixed distance. Far from being a class of their own, motions of heavy and light are merely one instance of one of the types of simple motions. They are also not natural in the sense of being caused by the nature of the moving object alone but are rather a result of an interaction between two masses of matter.

Bacon's problem with the Aristotelian explanation of fall, as he understands it, is that it presupposes that the natural place as such is able to cause bodies to move.[70] We have seen that while there were scholastics who subscribed to such an account, it was never the majority interpretation, and Bacon's Aristotelian contemporaries were much more likely to see the substantial form of the falling body itself as the efficient cause.[71] Against the views of many mainstream Aristotelians, his argument therefore does not work. His account the motion of Greater Congregation does however serve to illustrate two ways in which Bacon disagrees with the principles of Aristotelian physics. Firstly, Bacon does not subscribe to the principle that efficient causation always needs to proceed by direct contact. As is evident in any of the Motions of Greater Congregation, he has no problem with postulating actions over distance, as long as

68 *Novum organum*, OFB XI, 393.

69 *Abecedarium*, OFB XIII, 195.

70 *Novum organum* II, 35, OFB XI, 317, *Historia gravis & levis. Aditus*, OFB XII, 132; *De principiis*, OFB VI, 267.

71 See p. 35 above.

all of those actions originate in bodies. Secondly, motion of the Greater Congregation illustrates that Bacon makes no distinction between the superlunary and the sublunary cosmos: Any appetite or motion that holds on earth holds in the entire universe. The celestial bodies, like the Moon, the Sun and Mercury, are made of a different kind of matter than sublunary bodies, but motion of the Greater Congregation affects them all, although it has different effects in each.[72]

In this part of the chapter, we have examined in some detail what Bacon has to say in his polemic of the Aristotelian conception of motion. It has turned out that the polemic is not so much against the Aristotelian ontology of motion, but rather against the ways natural changes are divided into groups. Consequently, the first section has been given over to a reconstruction of the attack on the typology of change according to the categories, while in the second and third sections, we have been occupied with the analogous attack on the natural-violent distinction. Now it is time to summarize what we have been able to learn about Bacon's own conception of motion from his criticism of the Aristotelian account. A first result is that Bacon is in fact attempting to replace the Aristotelian motions with something new, and that the simple motions are this new thing. The simple motions are designed to make obsolete both the division of changes into generation, corruption, etc. and the division into natural and violent change: For Bacon, every phenomenon that falls under one of the categories above on the Aristotelian view is actually the result of one or more simple motions. To give some evidence for these claims: After attacking the violent-natural distinction in aphorism 66, Bacon offers three examples of appetites of bodies, namely that "bodies have an appetite for mutual contact," one "for recovering their natural size or tension" and one "for getting together with the masses of their connaturals – i.e. dense bodies towards the Earth's globe, and thinner or rarer ones towards the confines of the heavens."[73] The same appetites show up among the lists of simple motions both in the Instances of Wrestling and in the *Abecedarium*, where Bacon calls them the Motions of Connection, Liberty, and of the Greater Congregation, respectively.[74] In contrasting them with the Aristotelian division of generation, corruption, alteration,

72 See the *Descriptio globi intellectualis* on the falsity of this distinction, in SEH III, 749. Cf. Manzo, "Francis Bacon y la concepción aristotélica," 92.

73 *Novum organum* I, 66, OFB XI, 107.

74 Compare the passage in aphorism I, 66 to *Novum organum* II, 48, OFB XI, 385–393, *Abecedarium*, OFB XIII, 191–195. The reason why it is precisely these three simple motions that are mentioned here is that they are the ones which are involved in the phenomena usually called violent and natural motions.

increase, decrease and local motion, he writes that "these and others like them are truly physical motions, whereas these others are simply logical and scholastic."[75]

In this sense, Bacon's simple motions can also be regarded as a transformation (rather than a simple abolition) of the Aristotelian distinctions between motions. Although he does not abolish all talk of natural motion from his anticipatory system, he does take away the special status of natural motion from the small class of traditional examples. That is so both in so far as he has an entirely un-Aristotelian explanation of them and in so far as they have no greater or lesser connection with the nature of the moving body than other instances of simple motions. In this respect, his treatment of natural and violent motion consists in transplanting the Aristotelian examples from a central place (as the paradigm cases of all motion) to a marginal one (as mere instances of some of the simple motions.)

The four Aristotelian types of motion receive a similar treatment. As we will see in the next part of this chapter, it is an important aspect of the simple motions that they can be combined, added and subtracted. In Bacon's terminology, from the simple motions there arise "Sums of Motions," which is what the processes described under the Aristotelian headings of the types of motions are according to Bacon.[76] As with gravitational and projectile motion, *latio*, generation and corruption, alteration, growth and diminution are much less central than for the Aristotelians – the sums are less fundamental than their parts, and there are many other sums of motion besides the ones derived from the Aristotelian categories. The exact nature and role of this composition will be one of the topics in part four of this chapter, but we may note here already that the very notion of a "Sum of Motions" does away with the notion that one body can only possess one inherent motion.

A second point is related to the one about the transformation of the Aristotelian typology of motion and builds on it: Since the simple motions are Bacon's replacements for Aristotelian motions of all types, what properties must they have to fulfill that role? What has emerged from the discussions in section 3.1 is that individual simple motions must be able to act as efficient causes. We have seen in that section that Bacon's main objection against the Aristotelian division is that it does not take causation into account adequately. In the main, this is simply the application of his general attack on the "dialectical method" to the domain of motion: Aristotelians put too much stock in abstract divisions and not enough in the real foundation of those divisions. Since Bacon subsumes all kinds of natural change under the term "motion,"

75 *Novum organum* I, 66, OFB XI, 107. Cf. OFB XI, 385, 393.

76 *Abecedarium*, OFB XIII, 205–211.

just as the Aristotelians do, the claim that the simple motions are the efficient causes of all other motions is quite a strong one. It means that any given process in the natural world can be explained by reference to one or more simple motions. What is more, the list of simple motions is finite (even if Bacon never finished it), so not only can any natural process be explained by simple motions, but the analysis will also always return to the same explanatory elements.

4. Simple motions

4.1. *Simple motions in the early fragments*

In the previous sections, we have examined Bacon's objections against what he sees as unproductive ways of treating the phenomena of motion. The result was that what an Aristotelian would explain as a single change from one accidental or substantial form to another, Bacon explains as a conjunction of simple motions. We have also seen that in the process, Bacon does not so much eliminate important Aristotelian divisions as transform them and integrate them into his own categories.

Sections 3.1 to 3.3 have provided a sketch of how Bacon conceptualizes the explanation of natural change, but there are open questions about his account. I shall try to answer what I think are the two most important ones in the upcoming sections. The first question is the following: What exactly does Bacon mean by saying that the simple motions are the efficient causes of other motions? The second is even simpler than the first: What *are* simple motions? It is not possible to answer both questions separately from each other, which is why I will have to go back and forth between the two. I shall begin in the present section with a part of the first question, by examining what Bacon's language suggests about the relation between simple motions and composite ones (4.1 and 4.2). Section 4.3 will then approach the simple motions through their disciplinary context in abstract physics. This will yield an ontological description of the simple motions, albeit a very general one, and also serve to distinguish simple motions from schematisms. The last two sections before the conclusion are going to engage more closely with the lists of motion. Section 4.4. will take some cues from the secondary literature about ways in which one might make more ambitious statements about either ontology or causative power of the simple motions. The hypotheses gained from that will be tested against the text of the *Abecedarium* in section 4.5. The final section 4.6 will bring the discussion back to the relation between the Aristotelian picture of natural change and the Baconian one.

In this section and the next one, I shall argue that the sense in which the simple motions cause the other natural changes is by composition. In other words, the explanatory relation between the simple motions and the composite ones is not one of causation at all, but one of ontological reduction: A composite motion is simply a number of simple motions, so-and-so combined. Such a composition is suggested already by the very term "simple motion," but as we will see, it can be further explicated by the central metaphor of the alphabet, which Bacon took great care to elaborate upon in various writings.

Bacon's most systematic thought about motion takes the form of lists of the fundamental appetites or simple motions of matter. The longest and most detailed of these can be found in aphorism 48 of the second book of the *Novum organum*, as part of one of the "Instances with special powers." Another, very similar list is contained in the *Abecedarium novum naturae*, a fragment whose contents should have formed part of the introduction to part four of the Great Instauration. The *Abecedarium* and aphorism 48 will form the basis of my discussion of Baconian motion in this chapter. Although my focus here is on the late texts of the *Great Instauration*, it would be an oversight not to begin with the fact that Bacon thought and wrote about motion throughout most of his philosophical career. I will use some early texts to illustrate how the idea of simple motions evolved, and to disentangle some of the threads within this idea, before moving on to its final version in the late texts.

Above, I have quoted passages from the *Cogitationes* that display an early version of the opposition which Bacon conjures up between the "dead" principles used by various rival accounts of motion, on the one hand, and the "living" ones he claims for his own account, on the other. In the subsequent section of the *Cogitationes*, Bacon goes on to attack the Aristotelian division of natural change according to the categories, in an early version of what was to become the same attack in NO I, 66. The conclusions at the end of the same paragraph outline very well what kind of work the "living principles" are supposed to do. Since this is the earliest text in which Bacon mentions the simple motions, I shall discuss it here. Bacon first declares the aim of the project:

> But the business is, by proper methods and a course of application suitable to nature, to acquire the power of exciting, restraining, increasing, remitting, multiplying, and calming and stopping any motion whatever in a matter susceptible of it; and thereby to preserve, change, and transform bodies.[77]

77 "Sed id agendum, ut modis debitis, et ministerio naturae convenienti, motum quemcunque in

In other words, Bacon's goal is to be able to bring about any natural change in any matter in which that change is physically possible, that is, to obtain the power of manipulating motion in the wide sense. It is remarkable in and of itself that the aim of the reform project, the amplification of human power, is tied so directly to motion. As we will see shortly, Bacon's views on this point evolved over time, because in the late works he no longer claims that the amplification of human power over nature is exclusively a business of understanding and manipulating motions. One thing that the passage from the *Cogitationes* makes very clear is that the connection of knowledge and power that is so important for Bacon's mature project depends on a distinction between two types of motions, simple ones and composite ones. In fact, the above quote continues as follows:

> Now those motions are to be chiefly inquired that are simple, primitive, and fundamental, whereof the rest are composed. For it is most certain that the more simple the motions are that are discovered, the more will the power of man be increased and made independent of materials special and prepared, and strengthened for the production of new works.[78]

The key to acquiring increased power over all motions, Bacon says, is to gain knowledge of a specific type of motions, namely the simple ones. But what does it mean for one motion to be composed of multiple others? Bacon concludes the paragraph by introducing a metaphor meant to make such a composition plausible, namely the metaphor of the alphabet:

> And surely, just as the words and terms of all languages, in their immense variety, are composed of a few simple letters, in the same manner all actions and powers of things are constituted by a few natures and origins of simple motions. And it would be shameful for men to have so accurately investigated the wind-chimes of their

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materia susceptibili excitare, cohibere, intendere, remittere, multiplicare, ac sopire et sistere possimus; atque inde corporum conservationes, mutationes, et transformationes praestare." *Cogitationes de natura rerum*, SEH III, 22.

78 "Maxime autem ii motus sunt inquirendi, qui simplices, primitivi, et fundamentales sunt, ex quibus reliqui conflantur. Certissimum enim est, quanto simpliciores motus invenientur, tanto magis humanam potestatem amplificari, et a specialibus et praeparatis materiis liberari, et in nova opera invalescere." *Cogitationes de natura rerum*, SEH III, 22.

> own voice, but to be so illiterate when it comes to the voice of nature, and in the manner of the first ages, before letters had been invented, to discern only composite sounds and voices without distinguishing the elements and letters.[79]

In the *Cogitationes de natura rerum*, the connection between the alphabet-metaphor and motion is quite explicit. It crops up in many other texts throughout Bacon's writing career as well, but there the connection is not always as strong. Probably the earliest instance is found in the *Valerius Terminus* (1603), where Bacon evokes the alphabet metaphor to explain the relation of "abstract natures" to "concrete things." *Valerius Terminus* is a collection of fragments rather than a complete text, which is why the following passage simply lists topics and theses without explaining them.

> Cap. 13. Of the error in propounding chiefly the search of causes and productions of things concrete, which are infinite and transitory, and not of abstract natures, which are few and permanent. That these natures are as the alphabet or simple letters, whereof the variety of things consisteth; or as the colours mingled in the painter's shell, wherewith he is able to make infinite variety of faces or shapes. An enumeration of them according to popular note.[80]

The purpose of the metaphor in both passages is to motivate the claim that the phenomena, which are many, inconstant and therefore difficult to systematize, should be viewed as composites of simpler elements, which are few in number and permanent in nature. The association of material elements and letters is well-worn: The term *elementum* translates *στοιχεῖον*, which can mean "sound," "letter" or "constituent part." Plato exploits this ambiguity often, for example in the *Philebus*.[81] It is used

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79 "Et certe quemadmodum verba sive vocabula omnium linguarum, immensa varietate, e paucis literis simplicibus componuntur; pari ratione universae rerum actiones et virtutes a paucis motuum simplicium naturis et originibus constituuntur. Turpe autem fuerit hominibus, propriae vocis tintinnabula tam accurate explorasse, ad naturae autem vocem tam illiteratos esse; et more prisci seculi (antequam literae inventae essent) sonos tantum compositos et voces dignoscere, elementa et literas non distinguere." *Cogitationes de natura rerum*, SEH I, 22.

80 *Valerius Terminus*, SEH III, 243. For other instances of the alphabet metaphor, see the introduction at OFB XIII, XXXIX.

81 *Philebus*, 16b5–18d2. Spedding conjectures that Bacon alludes to this passage in particular in the *De Augmentis*, SEH I, 565, where he makes a very similar point as the one just discussed in the early texts. For an analysis of the Plato passage, see Menn, "Collecting the Letters," 291–305.

this way multiple times in Lucretius' poem, but seems to have been common atomist currency, since Aristotle already evokes it in connection with the atomist position.[82]

In adopting the metaphor, Bacon emphasizes its epistemological aspect, as is typical for him. The consequences that neglect of the simple elements will have for human knowledge are prominently named in both of the above-quoted passages. The chapter summary from the *Valerius Terminus* just quoted presents it as one of the fundamental errors in human science. In the passage from the *Cogitationes* quoted before that, meanwhile, it is insinuated that ignoring the simple elements of nature is akin to being illiterate. In both cases, the problem with focusing on the words instead of the letters is not that it produces falsehoods, but rather that it is unnecessarily difficult and not conducive to the conjunct aims of discovering truths and gaining the power to manipulate nature.

4.2. *From alphabet to* abecedarium

While the metaphor of the "alphabet of the universe" is already used in Bacon's earlier works, the *Abecedarium*, true to its title, promotes it to the leading image structuring the entire text. In the main, it simply lists a total of eighty "inquiries" (*inquisitiones*) with a short commentary on each of them. They fall under different headings, although Bacon regards those as provisional, writing that "the titles by which the order of the Abecedarium has been laid out should by no means be accorded the authority of true and fixed division of things. For this would be to claim that we know the things we are inquiring into."[83] Rather than a definitive list of the fundamental elements of nature, it is a collection of Bacon's best guesses at them. In accordance with this more careful attitude, Bacon also modifies the metaphor and adds another layer to it: The image is now that of the *abecedarium*, the children's spelling book, rather than of the alphabet of nature. In addition to the idea of a composition from simple parts, this new image points to the provisional status of the *Abecedarium* itself, as well as to the activity of learning to read. What is implied is that

82 The point of the metaphor in Lucretius is that many different properties can arise from combinations of the same elements (DRN I 814–826 and 907–914). When Aristotle summarizes the views of Democritus and Leucippus in *Metaphysics* A (985b13–19), he uses letters to illustrate how on their account things come about by the shape, arrangement and position of the atoms. At the end of book Z (1041b11–16), he argues, without mentioning the atomists, that the syllable "ba" is not the same thing as the letters "b" and "a" taken separately. For Lucretius as a source of Bacon, see Gemelli, *Aspetti dell'atomismo classico*; Giglioni, "Lists of Motions," 63.

83 *Abecedarium*, OFB XIII, 221.

humans must start at the very beginning and, like children, first learn the letters before they move on to try and form words and sentences.[84] Bacon makes this part of the metaphor explicit in the opening paragraph of the fragment:

> [The *Abecedarium* is] like some child's copybook exercise but at least one wholly fit for what it teaches, for it carries us forward into the kingdom of man which, in relation to the sciences, is like the Kingdom of Heaven: none enters it except in the likeness of a little child.[85]

The investigation of the simple motions in the *Abecedarium* could also be seen as the result of another strand of Bacon's thinking, which can be found in a different set of earlier texts than those that contain his early alphabet metaphors. He did not only think about what simple motions might be, but also began looking for a list of them. In July of 1608, he noted down – in a notebook now known as the *Commentarius solutus* – an outline of a possible investigation of motion (an "Inquisitio legitima de motu"). Part of this fragment is a long list of types and subtypes of motion which includes many of the later simple motions, although ordered differently.[86] There is also another fragment from the same time called *Filum labyrinthi sive inquisitio legitima de motu* which builds on the outline of the *Commentarius solutus*. At this point in time, Bacon seems to have nurtured the idea that there had to be three parallel investigations as examples for his new method, namely into motion, heat and sound.[87] All three of those topics remained important all the way up to the texts of the *Great Instauration*, although their place in the overall architecture changed. For motion in particular, the period around 1608 marks the beginning of Bacon's systematic analysis of all possible different types and classes of motion.[88]

Comparisons with the earlier texts show, I think, that the list of simple motions contained in the *Abecedarium* is the culmination of at least two distinct ideas about the fundamental motions, namely first the image of the simple motion as a letter in the alphabet of nature, and second the structured list as a methodical device. The comparison illustrates furthermore that the late Bacon's investigations of motion

84 OFB XIII, xl.

85 *Abecedarium*, OFB XIII, 173. The allusion is to Matthew 18,3. Cf. also *Historia naturalis et experimentalis*, OFB XII, 11.

86 *Commentarius solutus*, SEH XI, 68–73.

87 As Spedding remarks at SEH III, 623, Bacon lists "The finishing the [sic] 3 Tables de Motu, de Calore et frigore, de sono" as one of the items on his to-do-list (in the *Commentarius*, at SEH XI, 64.)

88 Giglioni, "Lists of Motions," 62.

are more cautious and hedged when it comes to metaphysical assertions than the early drafts made during the 1610s. This more cautious approach is apparent in the transformation of the alphabet metaphor into the *abecedarium* metaphor.

On the other hand, one fundamental idea remained, namely the idea that the simple motions are like the letters of the alphabet. From the *Cogitationes de natura rerum* all the way to the *Abecedarium*, the core of the analogy is the claim that natural changes can be analyzed into primitive parts which are themselves changes, and that only a finite number of such primitive motions will be found. In other words, the simple motions are what the composite motions or Sums of Motions are composed of. This might not be particularly surprising, but it has consequences for the overarching question of this chapter. In section 3.3, we have seen that in contrast to the Aristotelian division of motions, Bacon's simple motions are supposed to be able to act as efficient causes. But in sections 4.1 and 4.2, we have seen that the relation between the simple motions and other, less fundamental types of change is one of composition, not of causation. It remains therefore an open question how the phrase that the simple motions act as efficient causes can be filled with content.

4.3. *Abstract physics*

In this section, I shall put the question of how the composition of the simple motions works aside in order to investigate the ontology of the simple motions more closely. I shall do so in a rather circumspect way, namely through a reflection on the philosophical discipline to which the simple motions belong according to Bacon, namely abstract physics.

Such a circumspect approach is necessary because of how closely the late Bacon's vision of the simple motions is integrated with his vision of philosophical method. As discussed in section 4.2, the late Bacon is careful to make as few ontological commitments about the simple motions as possible. Although the idea of the simple motions does not change in principle, the bold statements from early writings like the *Cogitationes de natura rerum* cannot without qualification be applied to the texts of the *Great Instauration*. In the *Cogitationes*, the discovery of motions is all but identified with the increase of power over nature, which cannot be strictly speaking true from the perspective of the *Novum organum*.[89]

89 *Cogitationes de natura rerum*, SEH III, 22, discussed in section 4.1.

Let me illustrate this problem with the question of the subject of the simple motions. There would seem to be an easy way to explain what the simple motions are: The various local motions of invisibly small corpuscles or portions of matter. If the properties of these corpuscles are left sufficiently vague, such an interpretation is not necessarily at odds with Bacon's matter theory. Furthermore, it would provide an ontological foundation for the role of the simple motions within Bacon's general vision for natural philosophy, since that role requires the simple motions not to be directly accessible to the senses.

However, to conclude that all simple motions can be identified with the motions of invisibly small particles or corpuscles would be to put the cart before the horse. In the context of the Great Instauration, simple motions are first and foremost general principles or "forms of the first class," that is, precisely the kind of thing that Bacon always insists can only be extracted from experience after a long and gradual process. It is not that simple motions are imperceptible because their subjects are too small to be seen, but rather that particle motions are viable candidates for simple motions because they cannot be directly perceived. While in some cases, a perceptible change is best explained as the result of many simple motions in insensibly small parts of matter, in other cases the subject might be a perceptible body, but the inner necessity of the perceptible change is not perceptible. It is this line of reasoning that leads Bacon to claim that a "truly physical" division of motions needs to involve the "appetites of bodies" *or* "the process of their parts." From the way in which the two halves of the phrase are contrasted, it is clear that the "bodies" in the first half are not invisible particles, but larger pieces of matter recognizable to the senses. In other words, the piece of matter in which a simple motion takes place need not itself be imperceptible for the motion to be imperceptible. The most plausible interpretation of how that is possible is that an "appetite" is a tendency to move or change under certain circumstances, so that the senses are not able to perceive a given change as the result of a simple motion. For example, the beating of a heart can be sensed, but the fact that it is a motion of Trepidation cannot.[90]

To summarize what I have just argued, it is impossible to define simple motions by describing the type of bodies they inhere in, because Bacon has systematic reasons not to make any commitments on this question. For this reason, the most promising approach to the ontology of the simple motions is to examine their place within Bacon's system of philosophical disciplines, which is what the rest of the present

90 *Novum organum* I, 66, OFB XI, 105, discussed above in section 3.1. See OFB XI, 413 for the Motion of Trepidation.

section will be devoted to. As a side effect, this examination will also shed some light on the relation of physics and metaphysics in Bacon, as well as on the distinction between the simple motions and their sister concept, the schematisms of matter.

So, which philosophical discipline treats the simple motions, according to Bacon? One would be hard pressed to answer this question from the text of the two main lists of motions alone, since these lists themselves are difficult to situate. The *Abecedarium* is a fragmentary work: It was planned as an introduction to part four of the *Instauratio*, and as such, it was to form a bridge from the natural histories to the collected anticipations of nature. As for aphorism 48, even though the simple motions are discussed there in more detail than anywhere else in the extant writings, the exposition is in service of the discussion of the Instances of Wrestling, an obscure and unfinished section of part two. The fact that both of the texts that discuss the simple motions in detail seem difficult to place within the Great Instauration is no coincidence: The motions themselves belong to a bridge discipline, called "abstract physics" by Bacon. As he explains in the *De augmentis scientiarum*, there are three disciplines that need to work together in order to produce knowledge of nature: natural history, physics and metaphysics.

> For sciences are as pyramids, whereof history and experience are the basis. And so of natural philosophy the basis is natural history; the first stage after the basis is physics; the stage closest to the top is metaphysics.[91]

Natural history does not belong to philosophy, even if it is vital for the progress of knowledge. Physics and metaphysics do, however, and together they constitute theoretical or speculative philosophy of nature. They are distinguished by the causes which they investigate: Physics investigates the efficient and material causes, metaphysics the formal and final ones.[92] Physics as a whole is therefore already an intermediary between the data-collecting of natural history and the pure speculation of metaphysics. Within the discipline, the main distinction is that between concrete and abstract physics, of which "the former, if you consider it rightly, is closer to natu-

91 "Sunt enim Scientiae instar pyramidum, quibus Historia et Experientia tanquam basis unica substernuntur; ac proinde basis Naturalis Philosophiae est Historia Naturalis. Tabulatum primum a basi est Physica; vertici proximum Metaphysica." SEH I, 567, translation adapted from SEH IV, 361.

92 *De augmentis scientiarum*, SEH I, 550.

ral history, the latter to metaphysics."[93] Bacon characterizes the difference as one between a "physics of creatures" and a "physics of natures," and uses Aristotelian vocabulary to explain what he means by that:

> The one (to use the vocabulary of the logicians) examines substances, with all the variety of their accidents, the other examines accidents, through all the variety of substances. For example, if one examines a lion or an oak, they support many different accidents; on the other hand, if one examines heat or heaviness, they inhere in many different substances.[94]

Clearly, the term "substance" does not refer to any strictly defined metaphysical entity here but is rather a term for the sorts of bodies about which information is collected in the natural histories – things like lions and oaks. Concrete physics investigates the efficient and material causes of such bodies and their properties, while abstract physics is occupied with properties *abstracted* from the bodies in which they inhere. The two causal investigations therefore differ neither in their aims nor in their data, but merely in how they group the phenomena. However, as a consequence, they also differ greatly in their structure. Concrete physics, close as it is to natural history, is divided according to generations, pretergenerations and art. This part of physics investigates the same things as natural history, but in different ways:

> But concrete physics is subject to the same divisions as natural history [...]. For in all these [i.e., the various generations, pretergenerations and art] natural history scrutinizes and concerns the fact itself, and physics does the same with the causes – I mean the variable causes, that is, the material and efficient ones.[95]

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93 "[P]rior pars (si recte advertas) Historiae Naturali propior est; posterior Metaphysicae." SEH I 551, translation adapted from SEH IV, 347.

94 "Physicam de Concretis, et Physicam de Abstractis; sive Physicam de Creaturis et Physicam de Naturis. Altera (ut logicis vocabulis utamur) inquirit de substantiis, cum omni varietate suorum accidentium; altera de accidentibus, per omnem varietatem substantiarum. Veluti, si inquiratur de leone aut quercu, illa complura diversa accidentia suffulciunt: contra, si inquiratur de calore aut gravitate, illa plurimis distinctis substantiis insunt." SEH 551, translation adapted from SEH IV, 347.

95 "Physica autem Concreta eandem subit divisionem, quam Historia Naturalis; ut sit vel circa Caelestia, vel circa Meteora, vel circa Globum Terrae et Maris, vel circa Collegia Majora quae Elementa vocant, vel circa Collegia Minora sive Species; etiam circa Praetergenerationes, et circa Mechanica.

There ought therefore to be a part of concrete physics for each domain of natural history. For example, one part of natural history is "a history of the celestial bodies, exhibiting the actual phenomena simply and apart from theories."[96] There is a corresponding part of concrete physics, namely physical astronomy. It takes the historical record of the motions of the heavenly bodies and investigates their causes.[97]

So much for concrete physics. However, the domain of the simple motions, which after all are our focus of interest here, is abstract physics. As we have seen, Bacon claims that this type of physics is akin to metaphysics, and in fact, the similarities seem so great that it becomes difficult to see how abstract physics and metaphysics are distinct at all. Whereas concrete physics is divided along the same lines as natural history – one kind of investigation for each of the main groups of bodies in the universe – abstract physics is organized in a completely different way. There are only two parts to it: the "schematisms of matter" and the "appetites and motions." Bacon uses "appetite" and "motion" here almost as synonyms, using one or both alternately. He also still abides by the distinction made in the *Cogitationes* almost twenty years earlier: motions are either simple or composite. The only addition is that composite motions can now also be called "certain weights or sums of the simple motions."[98]

The objects of abstract physics are therefore schematisms, simple motions and Sums of Motion. A glance at the titles in the *Abecedarium* reveals that this enumeration corresponds neatly to the material treated in that work. Does that mean that the *Abecedarium* is a document of abstract physics and therefore engages in a search for material and efficient causes? The answer to this question turns out to be "no," because schematisms and simple motions have a place in both metaphysics *and* physics.[99] The respective roles of these two basic notions do not become very clear in the *De augmentis*, since we merely learn that the schematisms act as a kind of boundary

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Etenim in hisce omnibus Historia Naturalis factum ipsum perscrutatur et refert, at Physica itidem causas: sed intellige hoc de causis fluxis, Materia scilicet et Efficiente." SEH I, 551, translation adapted from SEH IV, 347.

96 "Prima [historia] Coelestium, quae phaenomena ipsa sincera complectitur, atque separata a dogmatibus." SEH I 501, translation SEH IV, 299.

97 *De augmentis scientiarum*, SEH I, 552. The aim of astronomy, as of all physics, is therefore to discover material and efficient causes. In light of this, it is unsurprising that Bacon has a low opinion of the traditional view that astronomy is a mathematical science that should only be concerned to save the phenomena. Cf. SEH I, 553, *Descriptio globi intellectualis*, OFB VI, 153.

98 "[P]ensis quibusdam aut Summis Motuum Simplicium," SEH I, 560.

99 I take this point about the relation between metaphysics and physics, as well as the related point about the relations of these disciplines to form and process, from Rusu, "From Natural History to Natural Magic," 190–192.

conditions: "There are simple motions, in which lies the root of all natural actions, subject to the conditions of the schematisms of matter."[100] For a more instructive picture of the two disciplines as well as the two notions, we have to turn to the *Novum organum*.

In a well-known section at the beginning of book two of that work, Bacon describes the connection between the operative and the theoretical sides of his proposed new method. As discussed, the view that these two sides are intimately connected is not new, but rather one that he had held for many years before. In a passage from the *Cogitationes de natura rerum*, quoted above, he all but identifies power over nature with power over motions and transformations of bodies. The first aphorisms of *Novum organum* II can be viewed as an elaborated and refined version of this thought, cast in a different and more differentiated vocabulary.

The original idea from the *Cogitationes*, the idea that to have power over nature is equivalent to having the power of creating and controlling motions, is now differentiated along two separate axes. Firstly, the late Bacon distinguishes between a specific version of knowledge//power and a general one. This yields the two theoretical disciplines of physics and metaphysics and their practical counterparts, mechanics and magic. Secondly, Bacon introduces a distinction between static properties and dynamic processes in both physics and metaphysics. In metaphysics, the static properties are called the "schematisms of matter," while the simple motions are the "processes." Static properties that are not fundamental enough to be schematisms are simply natures, and changes that do not qualify as simple motions are latent processes. The goal of magic is to obtain the power to create and combine the schematisms of matter in new ways, by exploiting their interactions with the simple motions. The transformations of bodies that can be effected by magic are total, as is epitomized by Bacon's favorite example, the transformation of gold.[101] This is precisely because schematisms and simple motions are the universal properties and processes that lie at the bottom of all bodies.

How can this interpretation be squared with the fact that it is abstract physics, not metaphysics, that treats simple motions and schematisms? After all, the proper object of metaphysics are forms, as Bacon often insists. The solution to this conundrum is simply that abstract physics collects the simple motions and schematisms, while metaphysics investigates their connections. The objection arises because Bacon's

100 "Sunt enim [...] Motus Simplices, in quibus radix omnium naturalium actionum continetur, pro ratione tamen Schematismorum Materiae." SEH I 560.

101 *Novum organum* II, 5, OFB XI, 205–209.

forms are relative terms and not another type of entity in addition to motions and schematisms. What the inductive method is supposed to do is to enable us to find the form of a given nature. Bacon's most elaborate example of the search for forms illustrates this: The "First Vintage of Heat" begins from a common nature and proceeds to explain it as the interaction of several simple motions.[102]

It is now reasonably well-defined what kind of thing a simple motion is, despite Bacon's cautious attitude towards ontological commitments. At its core, a simple motion is a process that takes place in some piece of matter. It can interact with other simple motions either in the same or in different matter, leading to different results depending on what schematisms are present in both pieces.

So far, we have discussed the simple motions generally and in their relation to Bacon's system. Unsurprisingly, the resulting characterization is quite general. It is natural to ask, then, if there might be a way to come to a more substantial characterization by examining what Bacon says about each of the individual motions in detail. That is what the next two sections will be about. Section 4.4 will discuss some scholarly interpretations which depend on both the textual structure of the lists of motions and the metaphysical structure of the simple motions themselves. One question that turns out to be important for many of these interpretations is whether the simple motions, collectively or individually, strive towards certain aims, and specifically whether they exhibit an appetite towards the greater good.

In Section 4.5, I will argue that in the final analysis, there is no further principle to be found beyond the simple motions themselves. That section will consist of a detailed analysis of the groupings of the simple motions in the two lists. One of the aims of this endeavor is to show that the groupings within the lists follow a logic that is incompatible with the thesis that either one or two among the motions are fundamental to all the others, namely one in which there are four groups with different characteristics. A second aim of section 4.5. is to prepare the work of the concluding section 4.6, which will tie the ontological question back to the causal one. It will do so in two ways. Firstly, by demonstrating that the four groups of simple motions diverge in fundamental respects, the range of ontological differences that still count as simple motions for Bacon is delimited. Secondly, section 4.5 will also provide material for the causal question, so that in the conclusion, we will be able to say in what sense it is true that the simple motions are the causes of other natural changes.

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102 A concise explanation of the First Vintage in terms of a reduction of heat to simple motions is given by Rusu, "From Natural History to Natural Magic," 194 f.

4.4. *Motions, teleology, and self-preservation*

As just announced, the topic of section 4.5 will be the character of the four groups into which the simple motions can be divided. The division of the sixteen motions into four groups might seem to be a consideration of text structure without any metaphysical significance. But in fact, a number of interpretative theses have been brought forward which turn on what one takes groupings within the list to be and which lead to quite different assessments of the character of the simple motions. As is often the case, seemingly superficial questions about the proper divisions of a text and of the concepts used in it turn out to depend on deeper interpretative issues.

In the case at hand, the deeper issue is the question of teleology in Bacon's natural philosophy. The backdrop of this issue is the proposal that the appetite of self-preservation is the structuring element not only of the simple motions, but of Bacon's entire vision of nature. This implies that the universe as a whole is directed towards its own preservation, and so is each of its parts. This is obviously quite a strong thesis, which has possible ramifications for the interpretation of other parts of Bacon's philosophy, in particular of the connection between the natural and the moral spheres. The specialized literature is divided over how much one ought to emphasize the element of self-preservation in Bacon. In particular, in a recent volume entitled *Francis Bacon on Motion and Power*, three separate articles attempt to re-define the notion of self-preservation in Bacon.[103] All of them make some appeal to the simple motions, but as far as I can tell, they all evaluate the relationships of self-preservation, teleology and the simple motions differently. A summary of some of the points which are relevant for our discussion will show what is at stake in our own examination of the lists of simple motions.

James A.T. Lancaster argues that Bacon's natural philosophy has a moral dimension, in the sense that it can be judged by moral standards. According to Lancaster, Bacon adopted the Calvinist conviction that original sin corrupted not just human nature, but all of nature. The specific form that this belief takes in Bacon is that the appetites of matter, which were without conflict in the prelapsarian state, are now out of balance – in Lancaster's words, "after Adam and Eve broke the moral law, matter reverted in part to its original state of chaos."[104] The original balance was achieved by God, according to Lancaster, when He introduced the "summary law

103 Giglioni et al., *Francis Bacon on Motion and Power*.
104 Lancaster, "The Moral and Political Character," 235.

of nature,"[105] which is not a balance between the existing appetites of matter, but an additional appetite. Although the summary law was not entirely broken in the fall, the individual appetites of matter are now in conflict more often than not. Since this conflict, just like the conflicts between the actions of individual humans which characterize the political sphere, is a perversion of God's original plan, it is legitimate to say that Bacon's nature is defective in a moral sense.

According to this view, the inherent morality of nature is directly connected to the self-preservation of the world: The "summary law of nature" can be identified with the principle that the good and the preservation of the whole take precedence over the good of its parts.[106] This is a plausible suggestion, since both the summary law and the precedence of the whole are important principles for Bacon, and both seem to straddle the border between the physical and the moral. They are also similar in that Bacon seems to believe that the precedence of the whole over the parts is only partly implemented in nature, which fits with the story that the summary law was partly rescinded by the Fall. Bacon often writes that natural things follow the "double nature of the good," meaning that there is a tendency in all things to preserve themselves as well as the whole to which they belong. He furthermore claims that when the two are in conflict, the appetite towards the preservation of the whole is generally stronger.

> There is fourmed in euery thing a double Nature of Good; the one, as euery thing is, a Totall or substantiue in it selfe; the other, as it is a parte or Member of a greater Bodye; whereof the later is in degree the greater and the worthier, because it tendeth to the conseruation of a more generall fourme.[107]

He illustrates this general principle with the example of the magnet:

> Therefore we see, the Iron in particuler simpathye mooueth to the Loadstone; But yet if it exceede a certayne quantity, it forsaketh the affection to the Loadstone and like a good patriot mooueth to the Earth which is the Region and Countrye of Massie Bodies.[108]

105 *De sapientia veterum* ESH VI, 655, translation at VI, 730. Cf. Ibid., 236.
106 Ibid., 237.
107 *Advancement of Learning*, OFB IV, 136.
108 Ibid.

This and similar examples show Bacon's opinion that motions and processes which work towards the preservation of a larger whole are often or even generally stronger than those which strive to preserve a smaller one. At the same time, it is clear that it cannot hold without any restrictions whatsoever, since Bacon also introduces examples in which it depends on the relative sizes of the bodies involved which appetite predominates, as he does in the loadstone example above. A quantitative relationship between two conflicting rules of motion seems therefore to be implied, without a clear way to resolve the conflict. The interpretation offered by Lancaster is one way to explain the presence of a conflict, namely by assuming that the imperfect realization of the double good in the actual world is a consequence of the disharmony caused by the Fall. He also hints at a further connection to the simple motions by identifying the first two motions (resistance and connection) with the appetites towards self-preservation and towards the good of the universe, respectively.[109]

Self-preservation and the double nature of the good also play important roles in the contributions by Guido Giglioni and Silvia Manzo, both of whom provide detailed readings of the lists of motions in the *Abecedarium* and the *Novum organum*.[110] Both also take up most of the themes discussed above with reference to Lancaster, but in the final analysis provide different evaluations of the big picture regarding the simple motions.

The core of Manzo's argument is a thesis about the relations between ethical and physical appetites in Bacon. In the *Advancement of Learning*, after introducing the priority of the common over the particular good in the passage quoted above, Bacon goes on to describe how this division applies to ethics. He distinguishes three kinds of particular good and ranks them according to their nobility, mixing examples from ethics, nature and holy writ to argue which of a given pair of goods is or ought to be stronger.[111] In Manzo's reconstruction, we end up with four basic types of moral good, ranked from noblest to most ignoble: The universal good (the preservation of the whole) ranks at the top, then follow three types of particular good: Self-multiplication, self-perfection and, finally, self-preservation of the individual.[112]

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109 Lancaster, "The Moral and Political Character," *236–237*.

110 See mainly Manzo, "The Ethics of Motion"; Giglioni, "Lists of Motions" in the same volume. Parts of the respective positions are also developed in Manzo, "The Preservation of the Whole"; "Francis Bacon and Atomism"; Giglioni, "Cupido, Sive Atomus"; "Mastering the Appetites of Matter"; "The First of the Moderns."

111 *Advancement of Learning*, OFB IV, 139. Cf. *De augmentatio scientiarum*, ESH I, 722.

112 Manzo, "The Ethics of Motion," 180.

In other words, the priority of the common good over the good of the individual serves as a structuring principle in the moral sphere. The idea that the simple appetites in the physical sphere might be ordered in the same way is not far off. Indeed, Johann Mouton had already argued in an older article that the simple motions are "embedded in a moral theory of goods," meaning that for each of the four types of good in the moral sphere, there are some corresponding simple motions in the physical sphere.[113] Mouton had concluded that the ethical and the physical appetites both "obey the 'law' of individual and communicative good," so that what Lancaster sees as the ideal pre-lapsarian state is viewed by Mouton as the foundation of the present state.[114]

Manzo, in contrast to Mouton, argues that "moral philosophy and natural philosophy [are] parallel orders that reflect each other."[115] This conclusion is based on a classification of the physical simple motions in a number of Bacon's texts, but most important is her investigation into the possible structural correspondences between the types of moral good on the one hand and the simple motions in the *Abecedarium* and the *Novum organum* on the other. The result is that while there are indeed correspondences, they do not support the conclusion that the simple motions are organized according to fundamentally moral principles. Rather, the moral and the physical realm are equally fundamental, and the correspondences between them are due to the fact that they are both God's work.[116]

Lancaster and Manzo support their respective interpretations with explorations of the historical roots of Bacon's concept of self-preservation. Lancaster strengthens his case for the moral character of Bacon's universe by showing that Bacon was influenced in his views on self-preservation in nature by political theorists, in particular Niccolò Machiavelli (1469–1527), Francesco Guicciardini (1483–1540) and Justus Lipsius (1547–1606).[117] Manzo focuses the historical part of her investigation on the connection between self-preservation as an organizing principle and the resistance of matter as a principle in natural philosophy. In Bacon's view, the cause of matter's resistance against penetration is the first item in the late lists of simple motions. That there is a connection between self-preservation and the simple motion of Resistance is immediately plausible, because what Bacon describes under this heading is the active power each piece of matter has to defend itself from annihilation. Bacon's Latin term

113 Mouton, "The Summary Law of Motion," 142.
114 Ibid., 150.
115 Manzo, "The Ethics of Motion," 197.
116 Ibid.
117 Lancaster, "The Moral and Political Character," 238.

is *antitypia*; as Manzo notes, the concept has its origins in Stoic and Epicurean physical theories, although the direct source for Bacon is more probably either Francesco Patrizi (1529–1597) or Bernardino Telesio (1509–1588).[118]

What renders such historical discussions fragile, however, is the fact that there is a bifurcation in the genealogy of the terms involved: The Greek term on which the concept of *antitypia* is based is *οἰκείωσις*, which means both "resistance" and "self-preservation."[119] In the Stoic theories in which this concept originates, it is primarily a property of living beings: The first instinct of every living thing is to preserve itself.[120] Telesio is in this respect particularly interesting as a possible source for Bacon, because he extends the principle of self-preservation to the inanimate realm and sees a continuity between matter's resistance and the instincts of living beings. However, in contrast to Bacon, Telesio views the resistance of matter as a passive property, rather than an active power. Furthermore, although Telesio posits individual self-preservation in all things, he does not make the further connection to the preservation of the world as a whole.[121]

The fact that Bacon does make that connection, by affirming that the preservation of the universe has priority and is stronger than the self-preservation of any of its parts, makes it tempting for us to conjecture that the universal drive towards self-preservation is also what structures his lists of simple motions. Using such a conjecture, one might elegantly bridge the "summary law of nature" on the one hand and self-preservation on the other. This is in effect what both Mouton and Lancaster do: As we have just mentioned, they theorize that the "summary law" is the same thing as the precedence of the whole over the parts, and that this is what determines the relative strengths of the simple motions, just as it determines the relative nobility of the moral appetites. They differ about whether this system is in place in the actual world or merely in the idealized state before the fall. In support of this general type of interpretation, one might point to the evidence that self-preservation is more important than most of the other simple motions: Motion of Resistance, that is, the refusal of a small part of matter to be annihilated, is the first simple motion listed in both the *Abecedarium* and the *Novum organum* and is the only one called "rock solid and

118 Manzo, "Francis Bacon and Atomism," 225; Manzo, "The Ethics of Motion," 185, 188. Cf. von Arnim, SVF, III, 315; Epicurus, *Opere*, 29; Patrizi, *Nova de Universis*, fol. 78r.

119 Jammer, *Concepts of Mass*, 23 f.

120 Cicero, *De Finibus Bonorum et Malorum*, V, 24; Mulsow, *Frühneuzeitliche Selbsterhaltung*, 193; Manzo, "The Ethics of Motion," 190.

121 Manzo, "The Ethics of Motion," 191.

invincible" by Bacon.[122] Furthermore, an entire group of simple motions is described as motions of Conservation or Preservation, although the two texts seem to contradict each other when it comes to the exact extension of this group.[123] Therefore, if Bacon views preservation of the whole as simply another form of self-preservation, that means that the extent to which the summary law is implemented can be identified with the extent to which self-preservation rules. This not only explains why self-preservation and the precedence of the good of the universe were so important to him, but it also gives structure to the lists of simple motions.

However, to adequately support this interpretation, it is not enough to prove that self-preservation is more important than the other simple motions. If the size of the whole that is being preserved is to determine the strength of a given simple motion, that requires that it is possible to interpret *all* of the simple motions as forms of self-preservation. It is far from clear that this condition is fulfilled, and one's stance on this question will depend on which of the lists one takes as the textual basis. As Manzo points out, the list in the *Novum organum* seems to assign a more extensive role to self-preservation than the *Abecedarium*. For instance, the simple motions of trepidation and repose are said to "tend to the conservation and good [...] of greater wholes" in the former, whereas they are assigned to the motions of fruition in the latter. Nevertheless, Manzo concludes that "it might be said that all motions both blend with matter's tendency to preservation and are instances of it."[124]

According to all the interpretations discussed so far, the simple motions are ordered, if they are ordered at all, by their degree of association with self-preservation. By contrast, Giglioni has quite a different evaluation of the place of self-preservation in the lists of motions, and a different view of the simple motions themselves: In addition to the motion of Resistance, he emphasizes the importance of the motion of Repose or inherent tendency to rest. In Giglioni's reading, motion of Repose, which is the last motion on the list in aphorism 48, is even more basic than motion of Resistance. The resulting picture is one on which all changes in the universe are a tenacious, but ultimately finite struggle against the tendency to non-motion. According to Giglioni, the other eighteen motions depend on the motion of Repose in the sense that beyond the competition between opposed appetites, there is a general

122 OFB XI, 415.

123 In the *Abecedarium*, it consists of the first four motions, compared to the first nine in the *Novum organum*. Cf. OFB XI, 403 and OFB XIII, 193.

124 OFB XI, 413, Manzo, "The Ethics of Motion," 184.

resistance to any kind of activity at all which is presupposed by the active appetites. He argues, with reference to Bacon's eschatological views, that the motion of Repose must be read as both the original and the ultimate condition of the world, the state in which God has no need to act.[125] For Giglioni, the ultimate aim of (Baconian) human intervention in nature is not to reverse the effects of the Fall and to re-harmonize the discordant appetites of things, but merely to halt the inevitable dissolution of order as long as possible. Indeed, preventing the natural corruption of living and non-living bodies is something which Bacon was keenly interested in pursuing and which he obsessively experimented on.[126] Instead of interpreting all the motions as forms of self-preservation, Giglioni emphasizes their common appetitive nature and he places Bacon in an early modern history of *conatus* theories from Machiavelli and Telesio to Hobbes and Spinoza.[127]

This excursion into the secondary literature has hopefully shown that far from being a formal issue irrelevant to substantial questions, the question of the ordering principles of the lists of motions is in fact closely connected to an entire cluster of problems. What is ultimately at stake is the character of the simple motions, and *a fortiori* of the foundations of Bacon's physics. Are they extensions of the appetites of living beings? Are they expressions of the universal desire for self-preservation? Are they dominated by matter's resistance, by the preservation of the universe as a whole, or rather by the ultimate motion-towards-rest? As our glance at the secondary literature has shown, scholars are divided in their evaluations of these questions, as well as in the groupings among the simple motions they propose. Lancaster and Mouton only make reference to a small subset of the motions; Giglioni views them as a distribution between the two poles of self-preservation on the one hand and motion of Repose on the other; Manzo is reluctant to assign a single structure to all of Bacon's different versions of his list of motions, but tends to emphasize that the drive towards the good of the universe is stronger than the individual drives, which entails an emphasis on the various forms of self-preservation within the groups of motion.

In the next section, I shall put the various interpretations which were discussed in the present section to the test by examining the structure of the lists of motions. With regards to the textual structure, I will follow Manzo and affirm that the simple motions ought to be sorted into the four groups of the *Abecedarium*. As mentioned

125 Giglioni, "Lists of Motions," 77.
126 Jalobeanu, "Bacon's Apples," 2016, 83–113.
127 Giglioni, "Introduction," 18–23.

earlier, the account in the *Novum organum* has a different agenda and is less informative for finding out what the simple motions have in common with one another than for determining which of two given motions is stronger.

As I shall argue, the four groups of motions each have a distinct character, definable by a combination of the changeable properties and types of bodies involved. With regards to the interpretations discussed in the present section, the four groups are so different that there is no reason to believe that they are ruled by one overarching principle or even by a pair of principles. That is not to say that Bacon had purely physical motivations to posit the striving towards the good of the greater whole, the drive of self-preservation, or the motion towards non-motion – it is merely to say that these are not the organizing principles on the basis of which the other simple motions ought to be understood.

4.5. *Structure of the late lists*

Aphorism II, 48 in the *Novum organum* mostly consists of a commented list of the simple motions that discusses much of the same material as the similar list found in the *Abecedarium*. In some ways, it would seem that the treatment in the *Novum organum* is the definitive one: Not only are the comments about most of the individual motions longer and contain more examples, but there are also three simple motions on this second list that are not found in the *Abecedarium*. Conversely, every one of the sixteen motions in the *Abecedarium*-list has a corresponding motion in the *Novum organum*. For this reason, the latter is often the more useful source of information on individual simple motions. At the same time, the ultimate purpose of aphorism 48 is to investigate the relative power of simple motions over one another rather than to introduce the simple motions themselves, so one should not draw too many conclusions from the order in which they are presented. The topic of aphorism 48 are the so-called "Instances of Wrestling," that is, the rules by which one motion or appetite gains control over another. The *Abecedarium*, by contrast, lists the motions in a much more coherent order and relates them to other basic notions in a systematic way. The different contexts of the two works therefore mean that it is the *Abecedarium* that should be viewed as the more important textual basis, at least for judgments about the simple motions as a whole.

Within the *Abecedarium*, the simple motions are discussed in just one section, making up the inquiries with the numbers 25 to 40. They are preceded by the inquiries into the Great Determinants of Bulk and the Schematisms of Matter and followed by the Sums of Motions. The sixteen inquiries on the simple motions, in turn, are

divided into four groups of four.[128] Each of them serves a different aim for the body in which they inhere: In group one, nature gives bodies "an appetite or impulse for preserving themselves"; the second one gives an appetite "for raising or bettering their condition," the third "for multiplying themselves and propagating their form, and for imposing themselves upon other bodies which are adapted and susceptible to this": and the fourth "to enjoy and to exercise their nature."[129] Bacon also mentions the four basic appetites in aphorism 48, if only to say that it is an "abstract division" that is not directly relevant to the task of finding Instances of Wrestling.[130] The same passage also provides us with titles for the four groups, since Bacon there associates each with an action of the body: "Bodies [seek] the conservation, heightening, propagation or fruition of their nature."[131] Because of this quote, I will refer to the four groups as those of *conservatio*, *exaltatio*, *propagatio*, and *fruitio*.

As is apparent from the tabulated comparison, the order and naming of some of the motions in aphorism 48 deviate from those in the *Abecedarium*, but none of the differences impact the basic four-way partition. The three simple motions which are not in the *Abecedarium* can be integrated into the structure of that list without much difficulty: All three belong to the second of the four groups, the group of motions of Improvement, which therefore contains seven motions in the N*ovum organum* instead of the four in the *Abecedarium*. The other differences between the two lists, mostly concerning the order of presentation or the titles of some of the motions, also take place within the same group. The simple motions, as they appear in Bacon's late works, can therefore consistently be grouped according to the four basic appetites of Self-Preservation, Improvement, Assimilation and Fruition. What I will argue for in this section is that it is these four groups in the *Abecedarium* which give us the basic types of simple motions, rather than a single appetite (whether that may be the appetite of self-preservation, of the good of the universe, or a binary conflict between Preservation and motion of Repose, as has been variously argued). It is presupposed in this argument that the *Abecedarium* and the N*ovum organum* do not make competing divisions of the motions, but that rather the *Abecedarium* gives the true structure and the N*ovum organum* deviates from it for the purpose of a more convenient discussion of the Instances of Wrestling. I hope to show that the four groups of motions each have their inner logic by which they are distinguished from the other groups.

128 Manzo "The Ethics of Motion," 181.

129 OFB XIII, 197, 201.

130 OFB XI, 413.

131 Ibid.

Groups according to OFB XI 412	Simple motion	Number in the *Abecediarium*	Number in the *Novum Organum*
conservatio	Resistance	25	1
	Connection	26	2
	Liberty	27	3
	Continuity	28	5
exaltatio	Hyle	29	4
	Gain//Lack	–	6
	Greater Congregation	30	7
	Lesser Congregation	31	8
	Magnetic	–	9
	Flight	–	10
	Configuration	32	14
propagatio	Assimilation	33	11
	Excitation	34	12
	Impression	35	13
	Passing Through	36	15
fruitio	Royal	37	16
	Spontaneous Rotation	38	17
	Repose	39	19
	Trepidation	40	18

The first four motions – the motions of Resistance, Connection, Liberty and Continuity – are those explicitly associated with self-preservation (*conservatio*). Bacon likens them to defensive weapons, since through them, matter protects itself against "annihilation, a vacuum, torment, and separation," respectively.[132] The motion of Resistance "inheres in [matter's] every single portion, and through which [matter] utterly refuses to be annihilated."[133] The *Abecedarium* defines this same motion as a force:

132 *Abecedarium*, OFB XIII, 193.
133 *Novum organum*, OFB XI, 385.

> For a force and resistance inheres in every portion of matter, be it ever so small, with which it can defend itself against entire armies of things, and will not let itself be annihilated since it both stands firm and takes up some space.[134]

Rather than as a passive property, resistance is here being characterized as an active impulse of matter against its own destruction. Bacon takes this to imply that no force

> can reduce any amount or the smallest portion of matter to nothing, but it stays something and occupies some space [...] and things never get to the point of being nothing or nowhere.[135]

Resistance to annihilation is therefore a basic property of all matter. Bacon holds that this resistance is absolutely invincible and present in all matter, which is why he also believes that the "vexation" applied to it in experiments will only produce transformations of matter, never its destruction.[136] It is worthy of note that matter itself is active in character, in the sense that it always expresses a tendency to move and change even when the expression of that tendency is suppressed. This claim, which comes out clearly in these passages about the motion of Resistance, is one of Bacon's clearest and most fundamental disagreements with the Aristotelians. In the earlier *De principiis*, he emphasizes this point especially against Telesio, with whom he otherwise has a lot of common ground.[137]

Motions three to four are also quite straightforwardly related to the self-preservation of bodies. Through motion of Connection, a body defends itself against the creation of a vacuum, since "complete and absolute severing of one body (at any point) from another is like a step towards the impossible, namely annihilation."[138] As discussed in the sections on violent and natural motion, Bacon claims that motion of Liberty is the true explanation of what is usually called violent motion. Generally put, it is the tendency of bodies to reacquire their former extension after they have been stretched or condensed. The self-conservation of matter therefore consists here in a defense against the "torment" of stretching or condensation. On top of the traditional

134 *Abecedarium*, OFB XIII, 191. Rees translates *portio* as "particle" in this instance.
135 *Novum organum*, OFB XI, 285.
136 *Parasceve*, ESH I, 399.
137 See *De principiis atque originibus*, OFB VI, 259.
138 *Abecedarium*, OFB XIII, 191.

examples of violent motions, it can also be found in pneumatic bodies, especially in compressed and stretched air. Bacon gives the examples of "children's pop-guns" and "the air left in glass eggs after they have been sucked out" for this phenomenon.[139] He also remarks that motion of Liberty it is not the same in all bodies: Although both water and air resist compression and tend to regain their size as soon as the compressing force is not present anymore, water puts up a much stronger resistance than air, in the sense that a stronger force is required to compress water than to compress a similar mass of air by a similar amount.[140] This remark also serves to delineate motion of Liberty from the desires to avoid a vacuum and annihilation, since these are equally present in all matter.

Finally, motion of Continuity is the appetite of a piece of matter to remain connected not just to other matter in general, but specifically to matter of the same body. As such, it is a special case of the motion of Connection.[141] The difference between solids and liquids consists in a different degree of inner connection: A body is called liquid because its parts can easily be separated.[142] Although it is generally weaker in liquids than in solids, motion of Continuity manifests itself in all bodies as a resistance against being separated into parts below a certain size. Bacon sees evidence for this claim in the fact that water and air cannot get through very fine pores and cracks. But motion of Continuity is also present "in bubbles, the roundness of droplets, in the finer threads of water running off roofs, in the stickiness of glutinous bodies and so forth."[143]

What is remarkable is that the four motions which appear under the heading of self-preservation are all reactions to a very specific kind of external influence, namely either stretching or compression. The distinctions within the group can be expressed in terms of each motion's relation to pushes and pulls: Motion of Resistance provides an absolute limit to any compression, securing that no body can ever be entirely annihilated. The motions of connection and continuity provide rules for the resistance which various pieces of matter put up against being pulled apart from each other. Finally, motion of Liberty strives to return a body to its original volume.

After the first group of motions towards *conservatio*, there is a second group "by which bodies seem to strive for an improvement of their condition, and to be brought

139 *Novum organum*, OFB XI, 387 f.

140 *Novum organum*, OFB XI, 387.

141 *Abecedarium*, OFB XIII, 193.

142 Cf. the corresponding schematism in the *Abecedarium*, OFB XIII, 177.

143 *Novum organum*, OFB XI, 319.

to a better state and so be happier."[144] This second group of motions towards *exaltatio* shows the biggest differences in the two accounts: The *Novum organum* adds three motions which are not in the *Abecedarium*. It also lists motion of Configuration out of order, under number 14 instead of 11, as would be expected. However, as mentioned, the differences all take place within the motions of *exaltatio*: The three additional motions are clearly labeled by Bacon as special cases of other motions in the same group, and a comparison of the descriptions shows that motion of Configuration is another name for motion of Disposition.

What do the simple motions of Heightening have in common? In its longer form, the group consists of the following motions: Motion of Hyle, of Gain and Lack, of the Greater and the Lesser Congregation, the Magnet, of Flight, and of Situation. This looks at first like a grab-bag of rather different processes, but what unites them is that one body acts on another in a way that is not physical pressure, and thereby causes the receiving body to change either in place or in volume.

This structure is most obvious with the group of attractions and repulsions, that is, the Greater and Lesser Congregation as well as the Magnetic motion and the motion of Flight derived from them. Under these titles, Bacon adapts the idea of a motion of the similar to the similar: If body A has a nature x and is close enough to a body B which also has that nature, A will tend to move towards B. This idea is applied to different types of bodies and properties in the two types of Congregation. As for the motion of Greater Congregation, we have already seen that Bacon views gravitational motion as an example of it, and in fact he puts forward no other examples for it except the fall of heavy bodies and the rise of light ones. we have also already seen that the key difference to an Aristotelian view of the same motions is that in Bacon's view, the falling and rising motions are not directed towards places, but towards bodies. The same is true also for the motions of the lesser congregation, which are defined in the following way:

> [T]he homogeneous parts in a body separate themselves from the heterogeneous and come together with each other, and also by which whole bodies by similitude of substance embrace and hug each other, and sometimes congregate, draw together and assemble themselves from some distance away.[145]

144 *Abecedarium*, OFB XIII, 193.

145 *Novum organum* II, 48, OFB XI, 393.

It is apparent from this definition that the motion of Lesser Congregation is based on the same idea as the greater congregation, but that it constitutes a much broader category: Motion of the Greater Congregation contains only those actions between the Greater Colleges (that is, ether and fire in the heavens and the tangible bodies on the Earth) and bodies that share with them the nature of light or heavy, respectively. The category of motion of the Lesser Congregation, on the other hand, contains all the attractive actions among any two bodies that are similar, and attractions between similar parts of bodies in addition to that.

Bacon's discussion of lesser congregation in the *Novum organum* is one of the longest passages about a single simple motion in his entire corpus. That is not because lesser congregation is more important than the other simple motions, but simply because it is of particular relevance for the Instances of Wrestling: As Bacon explains, it is one of the motions that is most often overcome and, as it were, deactivated by other motions. For example, two bodies that are both made of wood usually do not tend to attract each other in any noticeable way, even though the fact that they share a nature should have that effect. The reason why that usually does not happen, Bacon argues, is that the attraction of wood to wood cannot overcome the general "sluggishness of bodies," that is, the action of the simple motion of Repose.[146] But swift motion can remove that sluggishness in turn, which is why wood-tipped arrows penetrate deeper into wooden targets than arrows with iron tips.[147]

Turning back to the question of what unifies the various motions of Heightening, the reasoning from the motions of congregation straightforwardly extends to magnetic motion and the motion of Flight. The former is simply another case of attraction between bodies (in this case the attraction between the moon and the tides and between Sun and the planets), while the latter is the name for the repulsion that occurs between bodies which are very unlike each other. Motion of Gain and Lack also fits the scheme, since it denotes the tendency to adhere to a body that is not very similar in order to evade one that is very dissimilar – in other words, a motion that resembles lesser congregation in its results, but is ultimately due to flight.

After taking away all the forms of attraction and repulsion, there are still two simple motions left in the group, both which do not seem to quite fit with the others. Motion of Hyle can be thought of as the opposite of motion of Liberty: It is a change in volume, but whereas motion of Liberty is the tendency to restore a previous volume after external compression, motion of Hyle is the tendency to actively change volume.

146 Ibid., 395.

147 Ibid. See also e.g. *Sylva sylvarum* cent. VIII, 704, ESH II, 564 f. for the arrow-head example.

The change in volume that the motion of Hyle involves does not happen without any external occasion triggering it, but it is occasioned by some qualitative change that is not a compression or stretching – Bacon's main example is the way air extends when heated. The last motion in the group is motion of Configuration (or Situation or Disposition).[148] Through this motion, bodies strive to achieve a certain spatial configuration. Bacon is very terse about what the cause for this motion could be and in fact seems unsure about it himself. About one of the examples, the direction of the rotation of the night sky, he says that "this arises from a certain harmony and consent of the world not so far noticed."[149] In the *Abecedarium*, the reasoning is rather that bodies' striving for a certain configuration "springs either from their earliest beginnings or from habit."[150] I would argue that (insofar as he has an opinion on this point at all), Bacon sees motion of Situation in analogy to the attractions between the parts of bodies due to lesser congregation.

Summing up, the motions of Heightening consist of a main group (the two types of Congregation and the associated motions) and two special cases, the motions of Hyle and of Configuration. From the core group alone, it would seem like motions of Heightening are mostly local motions of visible bodies. With the addition of motion of Hyle, it becomes clear that this first impression cannot be true, since motion of Hyle is a kind of expansion or contraction, that is, a change in volume and not in place. And in fact, even some of the examples in the group of motions of Congregation describe processes within bodies. In Lesser Congregation in particular, it is often small body parts or particles that change place, rather than entire bodies. In other words, it is legitimate to say the effects of motions of Heightening are local motions, as long as that is understood to include motions of the parts of bodies as well as changes in volume. The comparison between the motions of Hyle and Congregation also suggests a similarity in terms of the causes: Both kinds of simple motions are activated by the presence of certain qualities or natures. As explained, the principle of the congregations is that bodies move towards other bodies that are alike to them in nature. Similarly, when a body B expands after being heated, that is a reaction to the nature of heat within it, given to it by the presence of another hot body A. However, the motions of Configuration do not conform to this pattern, since there are no qualities involved, only spatial configurations between particles that have persisted for a long time. Then again, Bacon himself does not seem to have a clear model of what causes

148 *Abecedarium*, OFB XIII, 197, *Novum organum* II, 48, OFB XI, 407.
149 *Novum organum*, OFB XI, 407.
150 *Abecedarium*, OFB XIII, 197.

motions of Configuration. One explanation for the inclusion of configuration with the motions of Heightening might simply be that, like the Minor Congregation, it causes the parts of bodies to take certain positions relative to one another.

In sum, most but not all of the simple motions of Heightening are activated by certain natures or qualities. The one exception is the motion of Configuration, which does not seem to involve any qualities either in the whole body or in its parts. However, even after integrating motion of Configuration, motions of Heightening can still be distinguished from motions of Conservation: The first four motions in the lists all describe the reactions of bodies to compression or stretching, and these factors play no role in the motions of the second group. With this contrast in mind, it also makes more sense that the second group of motions is that of Heightening: Against outside forces that try to squash them or tear them apart, bodies react by preserving their integrity, whereas they react in more diverse ways to other, less destructive outside influence. By entitling these diverse reactions a heightening or improvement of a body's condition, Bacon implies that they all take place for the good of that particular body, even if they do not serve to protect it from annihilation.

Whereas the first two groups of motions describe changes that take place within one body (although they might be triggered by outside events,) the four motions of Propagation denote processes in which a nature spreads from one body to another. The motion of Assimilation is the tendency of some bodies to turn other bits of matter into themselves. In Aristotelian terms, such a process would be described as a change in substance, and a typical example would be the assimilation of a small amount of one element into a bigger mass of another. Motion of Assimilation is Bacon's adaptation of this Aristotelian commonplace, although he calls it "simple generation" and adapts it to his matter theory: Oily vapors can be assimilated by fire, as can watery vapors by air. In animals and plants, the pneumatic parts (i.e., the animate spirit) assimilate the thin parts of the food, the tangible body parts the thicker ones.[151]

While motion of Assimilation changes a body's entire nature, in motion of Excitation "only virtues are transferred, to produce more heat, more magnetism, more putrefaction."[152] It is like assimilation in that a nature inherent in one body is transferred into another, so that the nature in question seems to multiply itself, but at the same time there are enough other differences to distinguish the two bodies. Here, too, the Aristotelian parallel is close to hand: What Bacon describes is the active character traditionally ascribed to the primary qualities of hot and cold. Unsurprisingly, Bacon

151 *Novum organum*, OFB XI, 403.

152 *Novum organum*, OFB XI, 405.

takes these to be the most obvious examples as well, though there are others: The power of the magnet to magnetize iron, and the actions of leaven, yeast, rennet and poisons.

The last two motions in the group of Propagation are another variation on the same theme, concentrated around the phenomena of sound, light and magnetization. Motion of Impression is the power of certain things to produce the effects just named, for example of a bell to make a ringing sound. The key difference to Assimilation and excitation is that motion of Impression depends on the continued presence of the causing body. If the ringing bell is dampened, the sound stops immediately, whereas heat can be contained in a warmed body even after the original heat source is gone. Lastly, motion of Passing Through is closely associated with Impression. Since the latter's effects are different in different media, Bacon assigns a separate simple motion of Passing Through to the medium.

The motions of Propagation form a coherent group in that they are a collection of the instances in which Bacon judged that one body had the power to impress its own nature on other bodies as well. In contrast to the previous motions, the processes collected in the third group are not reactions to outside influences, but rather take place whenever the relevant nature is present and a fitting subject is nearby. For example, a hot body will actively propagate its heat to any other body (as long as that other body is capable of receiving heat and is nearby); if the same body is also heavy, its motions of greater congregation will depend on whether there is a mass of other heavy bodies to congregate with. There is also a certain continuity of the motions in the third group with the simple motions before them: When a body propagates and multiplies its own nature, that is not the same thing as self-preservation, but it is in a certain way serving its own good.[153]

The last group of four motions is constituted by the motions of Fruition, by which "bodies seem to wish to enjoy and to exercise their nature, seeing that they are neither placed under any necessity to preserve themselves nor suffer from the desire [*laborent desiderio*] to raise or multiply themselves."[154] Different degrees of contrast are drawn in this quote between motions of *fruitio* and the other three groups, making it clear

153 Bacon contrasts the first nine motion with the tenth (Assimilation) at *Novum organum* II, 48, OFB XI, 403. Giglioni, "Lists of Motions," 77 concludes from this fact that "[t]he first nine motions are closely related to the tendency to self-preservation through which bodies protect their being by deploying strategies of resistance, freedom and union." I argue in this chapter that an interpretation that is less focused on the text of the Instances of Wrestling leads to a different division of the simple motions.

154 *Abecedarium*, OFB XIII, 201.

that motions of Fruition involve the least amount of interaction of the subject body with other bodies. The motions of Self-Preservation are reactions necessitated by outside forces. The motions in the second and third group are expressions of a desire under which bodies labor or suffer, that is, they start from a condition of need and end when that need is fulfilled. Another way to put it would be to say that a body without the motions of Conservation would be destroyed, while a body without motions of Heightening or Propagation would merely not be expressing its nature to the fullest possible extent. The motions of Fruition, finally, are neither reactions to any outside necessity nor do they lead from a weaker to a stronger expression of a body's nature. Rather, two of the four motions in this group are literally cyclical: Motion of Spontaneous Rotation, which causes the rotations of the celestial bodies, and motion of Trepidation.[155] As mentioned in the introduction, the latter is Bacon's name for periodic local motions between two opposite states, exemplified by the heartbeat of animals. As puzzling as the categorization was without the proper context, it is now apparent that Trepidation has a well-defined place in the order of the simple motions, since its cyclical nature connects it to the other motions in its group.

The remaining two motions of fruition are Royal motion and motion of Repose. They are not as obviously cyclical as Rotation and Trepidation, but still fulfill Bacon's definition of *fruitio* in that they are stable expressions of a body's nature that do not interact with outside influences. Royal motion is the action through which one part of a body rules over the others, as the animal and plant spirits rule over the rest of their living bodies. As Bacon explicitly notes, the relevant conflict here takes place between body parts, not between simple motions – conflicts between simple motions are after all the topic of the Instances of Wrestling as a whole.[156] Motion of Repose, finally, is the motion "by which bodies tend to keep still, support motion grudgingly and aspire to immobility."[157] As Bacon explains, it is in a sense the correlate of the motion of Greater Congregation, since just as the heavy bodies on the Earth's periphery move towards the center, the mass of the Earth as a whole stays still. The same motion is the reason for the inertia of all heavy bodies – although none of them exhibits it to the same degree as the Earth itself, since the bodies in the terrestrial sphere all have some spirits mixed in which are the source of other motions.

Why are these last two motions placed in the group of Fruition and not in some earlier group? After all, when one body has an appetite to rule over another, that does

155 See section 3.3. above on Bacon's quasi-Alpetragian views of what motions these are.

156 *Novum organum*, OFB XI, 409.

157 *Abecedarium*, OFB XIII, 201.

not seem like a self-contained enjoyment of its own nature, but rather like the processes described under Assimilation or excitation, under which one body impresses its own nature on other bodies. In a similar vein, why is motion of Repose not in the group of heightening? The mark of that group is that the motions in it are activated by an outside interaction, and that would certainly seem to apply to the motion of Repose: An appetite towards being at rest, it would seem, can only be defined in relation to an opposed force towards motion. But Bacon sees this differently: He distinguishes two cases, one in which a heavy body is at rest and resisting attempts to move it, another in which it is already in motion and strives to come to rest again. That means that motion of Repose is always active, no matter the external conditions, and that is why it is one of the motions of fruition. As for Royal motion, the reason why it is not one of the motions of Propagation is that the influence of the ruling body over the ruled bodies does not involve a transfer of properties. Whereas the hot body transfers its heat to all other bodies around it, the animal spirit which rules over an animal body does not make that body spirit-like in any way.

Let us now draw some conclusions from our discussion of the structure of the list of motions. The four groups of simple motions, *conservatio*, *exaltatio*, *propagatio* and *fruitio*, each collect simple motions of a certain character. The aim of section 4.5 was to show that the character of each group can be expressed in terms of the qualities and bodies involved. The results are the following: Motions of Conservation are the powers which are responsible for the fact that bodies cannot be destroyed outright. What this means in practice is that they protect bodies from a very specific kind of threat, namely from physical crushing or tearing. Groups number two and three are collections of two different kinds of influences which one body can have on another: Motions of Heightening are influences which are caused by a certain quality in one body and result in a change in a different type of quality in another body – the motions of Congregation, for example, are caused by a similarity in nature, but result in a change in place. Motions of Assimilation, by contrast, take place in the same quality in both bodies, as in the diffusion of heat. Finally, motions of Fruition collect ways in which a body can undergo changes in quality or in place without any interactions with other bodies.

In section 4.4, we have discussed a series of scholarly opinions about the structure of the lists of motions. A central theme there was the question of whether there is a single ordering principle to the entire list, and what it might tell the reader of Bacon's works about the constitution of his universe. The most controversial question here was whether (and if yes, in what sense) the lists are structured by a single underlying principle or appetite, for instance the appetite towards the preservation of the greater

whole. However, the distinct characters of the four groups of motions seem to preclude any such principle. The most that can be said is that all four groups are framed by Bacon as strivings towards a certain sort of self-perfection on the part of the body or piece of matter in which they take place. The differences between the groups can be explained by the degree of interaction between bodies they involve: Motions of Conservation are mechanical reactions, completely determined by outside influence; the two middle groups are regular interactions of certain types of bodies; and motions of Fruition do not depend on any body except for the one in which they take place. In this sense, the four groups can also be seen as progressively more autonomous expressions of a body's nature or essence.

4.6. Conclusion

What are we able to conclude about the role of motion and change in Bacon's natural philosophy as a whole? Let me begin by emphasizing once more how different the simple motions are from each other. At the outset of this chapter, I have already noted that we find a big range of seemingly disparate examples in the lists of motions. At the end of this chapter, this initial impression remains, but it can be put into relief and explained by other features of Bacon's natural philosophy. Specifically, I would like to note three questions about the simple motions, each of which cannot be answered with a simple Yes or No: (1) Are the subjects of simple motions visible bodies or invisible particles? (2) Are the simple motions inherently goal-directed? (3) Can the simple motions ultimately be reduced to changes in place, or are there other, irreducible qualities involved?

On the first point, Bacon refuses to be restricted to one of the alternatives and insists that there are both simple motions that have invisible particles as their subject as well as ones which occur in composite bodies. This is probably best illustrated by the motions of the Lesser Congregation: Some of them describe local motions of large bodies, while others appeal to motions of invisibly small parts of bodies.[158] The question of the proper subject of motion has already been partly discussed at the beginning of section 4.3. As we saw there, the reasons why the subject of the simple motion is so difficult to nail down are to be found the epistemological status of the simple motions. What distinguishes simple motions from composite ones is not a specific type of subject, but rather a specific explanatory function: They are the

158 See the corresponding discussion in section 4.5 and *Novum organum* II, 48 OFB XI, 395.

invisible simple processes the composition of which explains the visible ones. This means that, while it is a central requirement of the "truly physical motions" that they are not immediately visible, their invisibility is not necessarily due to the smallness of their subjects.

What about the second point, teleology? We have seen in the previous two sections that it is not at all clear whether there is a goal that the simple motions collectively strive towards. Individually, however, at least some and probably all of the simple motions are the expressions of some sort of desire. In order to show that, we can simply remark that there are simple motions which are very difficult to explain without a reference to goal-directed action of some kind. Royal motion is probably the best example: It describes the dominance of the animate and inanimate spirits over tangible bodies, that is to say, the dominated body and its parts move according to the "well-being of the governing part."[159] A non-teleological re-description might be possible in other cases, especially in the motions of Conservation, which most resemble mechanical reactions. But Bacon sometimes even claims that the actions of inanimate bodies in general depend on a kind of perception. In the *De augmentis*, for example, he remarks that "no body when placed near another either changes it or is changed by it, unless a reciprocal perception precede the operation."[160]

Lastly, the simple motions differ widely in terms of the types of qualities they involve. As on the question of teleology, the motions of *conservatio* are closest to mechanical reactions, in the sense that they describe local motions explained in terms of other local motions. But the motions in the other three groups make reference to a wide array of qualities. For example, the basis of the motions of Congregation (in all their variety) is the affinity between two bodies that share a nature or quality. There does not seem to be any restriction on the type of property on which the affinity is based: It may be some similarity in material, as in the wooden arrowhead that is attracted by the wooden target, or a more abstract quality, as in the magnetic examples.

To be sure, the diversity of the simple motions is part of Bacon's program. As discussed, there are both simple motions with particles as their subjects and ones that take place in larger bodies, in order to be able to collect all the processes that might fulfill the functions of simple motions. A similar line of argument can to some degree

159 *Novum organum*, OFB XI, 409.

160 "Nullum [...] corpus ad aliud admotum illud immutat aut ab illo immutatur, nisi operationem praecedat Perceptio reciproca." *De augmentis*, ESH I, 610. Cf. Manzo, "Ethics of Motion," 184, *Sylva Sylvarum*, ESH II, 602.

be followed for the differences in quality and in direction towards a goal. The only restriction on a simple motion is that it is a process taking place in a single continuous piece of matter – no matter whether the properties changed in this process are sizes, shapes and places or any other type of property. Likewise, the notion of teleology at work here is thinner than it appears at first. Although Bacon does seem to believe that most or even all the motions in his list are directed towards an aim, that does not posit any significant restrictions on the processes that might qualify as simple motions. Any additional motion would need to be a process that is regularly present in some type of body, and so there is no reason why it could not be rephrased as the expression of that body's striving.

Now that we are in possession of a reasonably complete picture of what the simple motions are and how they function, it is time to come back to our overall question: Is Bacon able to articulate a coherent and convincing account of motion and change? The number of different evaluations and interpretations received by the relevant parts of Bacon's works over the course of their reception is surely a sign that there are some difficulties here. The diversity in the three aspects of teleology, quality, and size of the underlying body that has been emphasized above yields three obvious ways in which one might accuse Bacon of a lack of clarity. I have argued that within the logic of Bacon's system, such accusations would be missing the point: The simple motions are deliberately left open to diverse processes in all three aspects, because there is no need to do so in order for them to fulfill their function.

Nevertheless, the account of natural change implicit in the simple motions is at odds with the rest of Bacon's natural philosophy. The rub lies not in the ontology of the simple motions themselves, but rather the way in which they explain causation. Despite all their differences, the simple motions have the same general picture of causation as their precondition, a picture that is neither argued for nor spelled out. To see why that is, it is important to distinguish between two ways in which simple motions may act as causes. Most obviously, they act as the causes of composite motions – that is, after all, the entire reason why Bacon introduces them, and the aspect that makes them more valuable than the Aristotelian typologies of natural change. On this level, however, it is not quite right to speak of causation, since a sum of motions simply reduces to its part-motions. The best example is heat, which is explained as a certain kind of conjunction of simple motions in the First Vintage. In other words, the simple motions do not, strictly speaking, cause the sums of motion, although they do help to explain them.

However, it is much more difficult for Bacon to explain how the simple motions act as causes of each other than how they explain the sums of motion. What I will

argue in the following is that in order to formulate a natural philosophy that fulfills his own standards, Bacon would need a metaphysical account of how simple motions cause one another. This is apparent through a process of elimination: Given that there are simple motions which explain the composite motions, there are two ways in which one might argue that a metaphysics of causation is not necessary, neither of which is a plausible interpretation of Bacon. First, he might simply deny that simple motions act as causes at all. However, it is clear from his many references to the interactions between them that simple motions in fact do cause one another, and that they do so in a more substantial way than that in which they are the causes of the composite motions. For example, as was shown in section 4.5, three out of the four groups of simple motions are distinguished from each other by the typical interactions between bodies and parts of bodies.

A second way out would be to reply that while Bacon does not deny the existence of causation at the level of the simple motions, he is agnostic about its metaphysics. This interpretation is ultimately inconsistent with his other commitments about the simple motions, as we will see shortly. The reason why Bacon gives only hints of how the simple motions interact, the reply goes, is not that such interactions do not find a place in the system at all, but that the system remained unfinished. Although he assumes that simple motions act as causes *somehow*, a metaphysical account of this causation is not necessary for the interpretation of nature. To reach the twin goals of knowledge of and power over nature, it is enough to discover which motions act as causes for which others. Such a case-by-case investigation is certainly an important part of the project: As we have seen in section 4.3, the aim of metaphysics in Bacon's sense is not only to find all the true schematisms of matter and the definitive list of simple motions, but also to provide a comprehensive map of their connections and interactions. For instance, the rules presented in the Instances of Wrestling might be read as preliminary results of such an examination, since they discuss what happens when two simple motions are in conflict with each other. Another example would be the appetite for the preservation of the greater whole that was discussed in section 4.4. The question there was whether the simple motions followed a rule like "in all interactions between simple motions, the greater whole is preserved." Although Bacon, as was discussed in the same section, refrains from actually making this particular claim, it is exactly the kind of statement that the finished interpretation of nature would have yielded.

The full result of the interpretation of nature would therefore have included rules for all the possible interactions between all the simple motions and schematisms. Some of these rules would even be have been of a quantitative nature: In many

of the Instances of Wrestling, Bacon acknowledges that which one of the simple motions overcomes the other depends on the exact size or weight of one of the bodies involved.[161] The relationships between schematisms and simple motions so discovered might therefore even be expressed as mathematical laws. Therefore, a perfected metaphysics as envisioned by this agnostic version of Bacon would not presuppose any account of what it *is* for a simple motion to take place in a piece of matter, nor why changes in the same or other pieces of matter follow. Such an account might be developed after or alongside the discovery of the interactions between simple motions and schematisms, in an inductive approach to metaphysics.[162] Alternatively, one might go further and read Bacon as eliminating the ontology and theory of causation from his philosophy entirely. The crucial point in both cases would then be that a metaphysics of causation is not necessary for the business of Baconian science.

As mentioned, I think that the position just described is ultimately incoherent, at least as an interpretation of Bacon. The reason is that the project of mapping the interactions between the simple motions and schematisms already presupposes a metaphysical account of causation. Baconian metaphysics only makes sense if there are pieces of matter, simple motions and schematisms expressed in them, and rule-like relationships between all of these elements. There is an account of causation as well as an ontology of the simple motions implied in this description: Simple motions are forces inherent in some quantity of matter, able to be activated under certain external conditions. In a word, the model of causation underlying the simple motions is that of *powers*.

The simple motions that we find in the *Novum organum* and in the *Abecedarium* can all be characterized as powers. This does not strictly speaking prove that simple motions must be powers by their very conception, but there is certainly good evidence for it. Despite the great diversity of processes described in the lists of motions, the notion of a power in matter underlies them all. To start, even though Bacon is careful to remain open about the nature of the subject in which a simple motion must inhere, it is always assumed that there is some material subject in which the process takes place. That might take the form of the local motions of particles, qualitative changes like the temperature of a body, or the acquiring of more abstract properties, as in the magnetization of a piece of metal by a loadstone. In all these cases, however, the

161 E.g., whether the attraction between a loadstone and a piece of iron will support the weight of the iron depends on the sizes of both. *Advancement of Learning*, OFB IV, 136 (quoted in section 4.4 above.)

162 This version of Bacon can be understood as a precursor to current approaches in inductive metaphysics, as presented in Engelhard et al., "Inductive Metaphysics."

simple motion is localized in a specific portion of matter. Furthermore, not all simple motions are expressed in all kinds of matter. Rather, for each of the motions, there is a well-defined range of bodies or types of matter in which the motion occurs. For some motions, this range is rather narrow: To take two examples, royal motion is typical of spirits attached to tangible matter, and motion of Spontaneous Rotation occurs chiefly in celestial bodies. Other motions are more general, the most obvious example being motion of Resistance, of which Bacon says that it "inheres in every portion of matter."[163] Finally, the analysis of section 4.5 has shown that the motions in each of the four groups are activated under a certain type of conditions characteristic for that group: Physical pressure for the first group, qualitative similarities and differences in the second and third group, and purely internal conditions for the last one.

Simple motions can therefore be characterized as powers inherent in certain kinds of matter, even if Bacon does not explicitly say so. That in itself is an interesting result when it comes to Bacon's place in the history of philosophy, because the notion of a power is typically associated with the Aristotelian position, not with the radical *novator*. That the proponents of the new science in the later seventeenth century had little regard for explanations using powers might even help explain why the texts that formed the textual basis for this chapter found so little interest among Bacon's near-contemporaries.[164]

But more important are the consequences within Bacon's system: He is subject to his own principal objection against the common philosophy, namely that of assuming general principles without an adequate basis in facts. Put in Bacon's vocabulary, the contents of the lists of motions might be mere anticipations of nature, but the very purpose of the method is to provide a sure path to produce interpretations from the anticipations. The ontology of simple motions and schematisms can therefore not itself be an anticipation but must rather be a part of the method. To give an interpretation of nature, according to Bacon, is just to examine the schematisms and simple motions, and simple motions are powers inherent in matter out of which the natures of bodies are composed. Therefore, since an investigation into the connections between simple motions is only possible if the existence of simple motions is already secure, metaphysics in Bacon's sense depends on claims that could only come from a metaphysics in an Aristotelian sense, which he does not have.

163 *Abecedarium*, OFB XIII, 191. Discussed in section 4.5 above.

164 As is often cited in this context, Molière makes a joke about the *virtus dormitiva* of opium in *Le malade imaginaire* (*Œuvres Complètes* vol. 3, 686.)

Conclusion

The analyses offered in the preceding four chapters have shown that two issues in particular are central to understanding the strengths and the weaknesses of the explanations of natural change offered by Sennert, Basson, Gorlaeus and Bacon. The first issue is the dialectic between the perceptible phenomena of natural change, on the one hand, and the imperceptible entities and changes postulated to explain them, on the other. The second issue stems from the intuition that if a natural thing, be it perceptible or imperceptible, is to explain anything, that is because it is the efficient cause of the *explanandum*. As a consequence of that intuition, an account of what it is for a natural thing to act as an efficient cause is a necessary part of any functioning natural philosophy.

The question of how to explain efficient causation becomes especially pressing when the substantial form is rejected, because it is one of the main functions of the substantial form to provide a metaphysical description of the causal powers of natural substances. The task of explaining the relations between perceptible and imperceptible changes, by contrast, is more closely connected to matter theory and ontology than to the metaphysics of causation. This discrepancy is the reason why the two problems come to the fore to different degrees in each author, since they put very different emphasis on these two aspects of natural philosophy. They would all be anti-Aristotelian *novatores*, if not for the fact that Sennert manages, with great effort and ingenuity, to reconcile his views on atoms with his hylomorphism. Likewise, they would all be corpuscularians, if not for the fact that the late Bacon takes such great care not to commit to an ontology of particles. Only Basson and Gorlaeus have both an ontology that includes corpuscles and a desire to abolish the substantial form. At the same time, the very fact that Sennert assumes persisting particles opposes him to a significant part of Aristotle's teachings, even while he manages to make the disagreement with his contemporary non-atomist hylomorphists seem not all that outrageous. And though Bacon's methodological principles forbid him to speculate about whether matter is ultimately structured into particles or not, the simple motions and schematisms have precisely the explanatory function that would otherwise be accorded to imperceptible corpuscles. In this concluding section, I will go through the results obtained in each author and note how each of them deals with both issues. To start with, however, let me explain why it is reasonable to assume that the first tension (i.e., that between the properties and apparent changes of perceptible bodies and those of the imperceptible corpuscles or principles) plays out differently in hylomorphic theories than it does in non-hylomorphic ones.

As discussed in the general introduction, there is broad agreement among early seventeenth-century natural philosophers about two basic features of natural philosophy, namely what the apparent changes in the sublunary world are and that it is the task of natural philosophy to explain them. By contrast, invisibly small corpuscles are hypothetical, unobservable entities, and not everybody would agree that it is wise to posit them. Arguments using imperceptible integral parts are not foreign to scholastic natural philosophy either, of course. Scholastics generally deny that the four elements occur in the form of unchanging particles, but in scholastic mixture theory, the elements are unobservable, theoretical substances that explain at least some of the qualities and changes in the perceptible world. That is true even on the austere Thomist account of mixture: Although for Aquinas and those who follow him on this point, neither the substantial nor the accidental forms of the elements survive the generation of a mixt, it is nevertheless the proportion of the elements going into the mixt that explains its primary and secondary qualities. A piece of gold, according to Aquinas, does not contain any fire, earth, water, or air, but it does contain a certain proportion of hot, cold, dry, and wet, according to the proportion of the four elements that were destroyed in the moment in which the form of gold came to inhere in prime matter. The proportion of primary qualities, in turn, explains the golden color. What is more, the primary qualities are also that by which the piece of gold acts. According to other scholastic theories of mixture, the story is different in some respects, but there the elements play a more important role. Even while denying that the elements are integral parts of bodies, the scholastics use them and their qualities in their natural philosophy.

Despite these continuities, however, there is a sense in which the entire project of natural philosophy shifts as soon as a theory includes unchanging material parts that are not destroyed or diminished when they become part of a larger whole. The purpose of positing such unchanging parts is that their local motions are taken to yield simpler or more plausible explanations of natural change of all kinds at the sensible level. Consequently, there are two types of local motion in a corpuscular natural philosophy, depending on whether its subject is a perceptible body or an imperceptible particle. Only one of them is accessible to experience, but both have to be integrated into the causal story. The price for the immediate advantage that positing corpuscles brings is the need to articulate what exactly they are and what causes their motions. Sennert, Basson, Gorlaeus and Bacon are conscious of this need to different degrees, but the ways in which they attempt to meet it are crucial to the success or failure of their natural philosophies in each case.

Sennert

In the case of Sennert, the dialectic of visible substance and invisible particle plays out entirely within the hylomorphic framework. That is simply because for him, both a whole and its parts can have substantial forms at the same time. He endorses, in other words, a very wide-reaching pluralism of substantial forms, which he applies to both animate and inanimate bodies. He furthermore introduces multiple levels of atoms, each of which is associated with a certain group of qualities (as discussed in part three of chapter two). The two most relevant types of particles in his system are the four elements and the *prima mista*. The former are the most fundamental bodies in Sennert's universe and produce the qualities referred to in physical explanation, while the latter are perfect mixts formed out of the primary ones and produce the secondary qualities that figure in chymical explanations. Each of these levels can have causal influence on the others, as discussed in part four of the chapter. For example, when a perfect mixt is generated, the *forma mixti* causes various local motions in the constituent atoms and acts on them as distinct substances, so that a structured body results. Conversely, atoms of all types are caused to move by their own substantial forms, namely towards one another when they are similar in quality and away from one another when they are dissimilar. These motions of consensus and dissensus are not stronger than the motions that spring from a substantial form of the whole, but they can influence the behavior of the whole body nevertheless, especially in living bodies, which contain dissimilar parts that can interact (section 4.4 of chapter two). The resulting natural philosophy has considerable explanatory power, since Sennert is able to appeal to a variety of different entities and processes to explain a given phenomenon. At the same time, his insistence that the various ontological levels are independent from each other also means that there are certain things that cannot be explained. For example, since he denies that the secondary qualities associated with the atoms of the *prima mista* arise from a certain proportion of the primary qualities of the atoms of the four elements contained within them, there is nothing more to say about the qualities of mercury than that they flow from its specific form.

There are two separate theories of motion to be found within this pluralist atomism: An orthodox one for bodies and a more vaguely defined one for the various atoms. As discussed in parts one and two of the chapter, Sennert's theory of local motion in terms of substantial form and prime matter stays entirely within the boundaries of natural philosophy as it might also be encountered in many sixteenth-century commentaries on the *Physics* or other scholastic textbooks of natural philosophy. The guiding example is always that of a visible body with properties that are determined

by its substantial form, and atoms enter the picture implicitly, if at all. In the passages discussed in part two, most of which are taken from the *Epitome*, Sennert talks about the traditional test cases of Aristotelian kinematics, gravitational and projectile motion, and makes hardly any novel claims about them at all.

In principle, it would have been possible for Sennert to account for the local motions of atoms with exactly the same conceptual apparatus that he uses so conventionally for the local motions of bodies, though he never does so. The last part of the chapter is dedicated to showing that it is possible to reconstruct how the particle motions that are so central to his multi-layered atomism are related to the various substantial forms involved. Two features of Sennert's theory in particular make it possible for his theory of atomic motions to be mostly coherent, if vaguely defined. The first is an element that his account of motion shares with those of other early modern scholastics, namely the doctrine that the substantial form of the *motum* is also the efficient cause of its motion in many cases. Since Sennert postulates substantial forms at multiple levels, this means that there is an efficient cause at every level as well, which is part of what enables him to produce the rich explanations of chymical, physical and biological phenomena that are found in his works. Secondly, Sennert is a non-reductionist when it comes to qualities and holds that the properties of the primary atoms do not necessarily need to correspond to or cause those of the secondary atoms or composite bodies. In particular, he makes very few attempts to identify a qualitative change in a superior form with series of local motions on the lower levels, which would have been difficult to reconcile with the ontology of form and matter.

Basson

While Sennert maintains the substantial form of the perceptible body, the other three authors all abolish it. Basson is in some ways comparable to Sennert: He has similar interests in medicine and chemistry, and a similar aspiration to write a textbook of natural philosophy, even if Basson wants his textbook to be explicitly anti-Aristotelian. With regards to how they relate the motions of atoms to the changes of perceptible bodies, however, the two authors are almost polar opposites. Whereas Sennert locates different types of phenomena at different ontological levels, Basson ultimately reduces all natural processes to the motions of the fundamental five types of atoms. He does sometimes appeal to secondary atoms, relatively stable clusters of the primary atoms that can in practice be treated as if they were separate entities.

However, any properties that such clusters might have are derived from the elemental atoms that constitute them. Since Basson denies both substantial and accidental forms, the *spiritus* serves as the source of all natural phenomena in his system. All that the elemental matter contributes is an aptitude that specifies it as apt for the motions that are typical of one of the four elements. The elemental atoms that arise from the combination of specific matter and animating *spiritus* can then be said to have an individual nature, which is nothing more and nothing less than a tendency to move in a certain way.

As a metaphysics, there is a certain elegance to this system, since it suggests the possibility of doing away with all forms and qualities and even with qualitative and substantial change. When the system is viewed as a natural philosophy, however, Basson's refusal to admit any explanations involving the properties of perceptible bodies limits his ability to account for the *apparent* changes that constitute the starting point for his natural philosophy just as they do for competing theories. Some phenomena can be reasonably well explained using just the four types of elemental atoms and the motions induced in them by the spirit. That is the case especially for those phenomena for which there already exist previous theories that use the four elements and their distribution in space. As discussed in part two of chapter three, Basson's discussions of accelerated fall provide an example of how this works in practice. He adapts Zabarella's usage of "parts of air," which is itself taken from the commentary tradition on Aristotle's *Physics*, and reinterprets the parts as air atoms.

Many of the other functions of the substantial form that are criticized so harshly by Basson, however, are simply not replaced by him at all. For instance, he vehemently attacks Aristotelian accounts of the generation of animals in book four of the *Philosophia naturalis*, but himself offers no explanation of the process beyond an appeal to God's intervention. In fact, he recognizes that the rules of motion that he ascribes to the four types of atoms cannot adequately substitute for one of the simplest tasks of form, its role in Aristotelian mixture theory: The aptitude that the atoms have when they are inside a compositum is produced from their aptitude outside the compositum in a way that is only transparent from God's point of view. In other words, it is impossible to understand from the human perspective how the four distinct types of atoms form stable and intimate unions even though they ought to have no mutual attraction. Ultimately, therefore, Basson admits that it is outside human understanding how behaviors of bodies arise from the postulated behaviors of atoms. He abolishes the substantial form but pays for this in terms of explanatory power.

Gorlaeus

Gorlaeus has neither the irenic disposition of Sennert nor the anti-Aristotelian fervor of Basson, and due to contingent circumstances, he makes few explicit references to the work of others. Consequently, the sources and context of his ideas are difficult to place exactly, though historical and systematic evidence points to a conjunction of northern European protestant metaphysics and Italian natural philosophy. What is clear is that in contrast to both Sennert and Basson, Gorlaeus has little interest in medicine and chymistry.

His natural philosophy is just as explicitly atomist as Basson's, but instead of resulting from a dialectical engagement with scholastic arguments, it follows from purely metaphysical considerations. Gorlaeus begins from the claim that metaphysics is concerned with real being only, which must be one and unchanging. From this starting point, he uses nominalist arguments to derive an extremely sparse ontology according to which an entity that has physical parts can at most be an *ens per accidens*, never an *ens per se*. The only things that fulfill this extremely restrictive definition of *ens per se* are the physical atoms, God, and spiritual substances. There are also real accidents, which resemble real beings in some respects, but the list of these is extremely short. Heat and cold are on it and are often invoked in Gorlaeus' physics, and the visible species, light, and darkness sometimes seem to count as real accidents as well. Using this small number of ingredients, Gorlaeus attempts to derive all the ten categories and build a solid foundation for his atomist physics.

Gorlaeus classifies motion itself neither as an independent substance nor as an accident, but as a mode of being. He introduces the category of *modus* in order to be able to discuss properties that need to be attributed to individual substances or their aggregates, but that can neither be reduced, in nominalist fashion, to the underlying substance itself so-and-so disposed nor accorded the higher degree of reality attributed to real accidents. Gorlaeus appeals extensively to modes when he is eliminating accidents in the category of quality from his ontology, but there he is specifically using modes of *existence* alone. This type of mode, as we have seen in section 2.2 of chapter three, describes either time and space or the positions in time and space of the atoms relative to each other. Motion is classified as a separate type of mode, namely that which concerns the *essence* of the underlying subject as well as its existence. In other words, the motion undergone by a real being (an atom, in most cases) can be reduced neither to the *ens reale* itself nor to its position relative to other beings over time.

In accordance with his ontology, Gorlaeus therefore has a moderately realist stance on the ontology of motion, even though he otherwise tends towards reductionism in metaphysics. The scholastic origins of the technical terms used by him turn out to be helpful for understanding his motivation, but only when the crucial difference between them is kept in mind, namely his denial of substantial form. The substantial form has a number of distinct functions in Aristotelian philosophy, many of which Gorlaeus redistributes quite ingeniously across other notions. An example of such a redistribution would be his explanations of the secondary qualities of bodies in terms of modes of existence inhering in a mere accidental union of atoms. The one function of the substantial form that he cannot replace, however, is its role as a physical cause. That he is not willing to abandon the notion that physical bodies are able to exert genuine causal influence over each other is clear both from his definition of motion in terms of action and passion and from his use of *vis impressa*. In the final analysis, however, there is simply not enough room in the ontology of atoms and modes to articulate something like a power that inheres in a subject but is distinct from it and can be the cause of certain effects and not others. That is why Gorlaeus is left to appeal to such powers in an oblique and vague way, without being able to explain them any further. In this, his successes as well as his failures illustrate the tensions between his reductionist aspiration of getting rid of the substantial form and the demands of giving plausible explanations of physical reality.

Bacon

The systems of Sennert, Basson and Gorlaeus all contain material corpuscles. Though the details change, the motivation for introducing such corpuscles is the same in every case: Their motions, though they cannot be directly perceived, can explain physical processes that seem otherwise mysterious or that require other metaphysical commitments. In other words, corpuscles and their motions are part of the ontology, but their purpose is to explain things and processes given in experience. Bacon, on the other hand, is not chiefly known as a corpuscularian natural philosopher, but rather as a theorist of experience and the experiment. Indeed, in his late writings, he carefully avoids making any definitive statement about the structure of matter at its deepest level. Instead, he appeals to simple motions and schematisms as the principles towards which an investigation into natural change must strive. In contrast both to his own earlier views and to those of other corpuscularians, he renounces corpuscles in terms of an ontological commitment, but focuses on their explanatory function.

Since the project of the *Instauratio magna* is to assume as little as possible and prove everything else from experience by the method of induction, Bacon is careful to leave as much about the schematisms and simple motions open as possible. That is the reason that there is such a confusing diversity to be found in his list of the simple motions. As is discussed in the conclusion to chapter five, some simple motions seem to inhere in the schematisms or some other invisibly small part of matter, while others seem to be expressed in entire visible bodies. There are also some simple motions that involve goal-directed action, while others do not, and the types of properties they involve differ widely. What they all have in common, however, is that they describe powers inhering in matter. This means that each individual simple motion is relevant only to certain types of matter or material things; if a specific set of conditions are fulfilled, that type of material thing will act in a specific way.

The account of natural causation implicit in Bacon's description of the simple motions is far more sophisticated than the ones offered by Basson and especially Gorlaeus, in addition to being integrated in his rightly famous account of how to apply it to the search for physical truth. Nevertheless, as I have tried to show at the end of the chapter, it is more than Bacon can reasonably assume as given, since it can never be proved by the kind of investigation envisioned in the *Instauratio*. It must remain an ungrounded premise. In Bacon's defense, however, it must be said that he is far from the only natural philosopher of his time to assume that material things inherently have certain powers of acting on one another.

Indeed, it might be the very fact that few of his contemporaries denied such powers which led him to take some sort of causal agency in natural things as a given. Hylomorphic accounts of all kinds can have recourse to the substantial form to act as the source of various powers, as Sennert does both for the forms of perfect mixts and living beings and for those of the atoms. The lack of an alternative to form as a source of powers is at the bottom of the difficulties encountered by both Basson's and Gorlaeus' accounts of change and the local motions of particles. Basson denies that created things have any causal power at all, but his account of the motions of the elemental atoms ends up being difficult to distinguish from a description of the fundamental particles in terms of matter and form. Gorlaeus does not attempt to divest created things from all their powers, but the strictness of his metaphysics forces him to leave those powers unexplained and vague.

* * *

The four case studies of this thesis exhibit a common dynamic in the attempts of our four philosophical novatores at reforming natural philosophy from the ground up. All four authors are dissatisfied with the substantial form as the main factor of physical explanation, as are many of their contemporaries. They are also drawn to the idea that the local motions of unchanging particles can account for a large subset of the substantial form's explanatory functions. Sennert, Basson, Gorlaeus and Bacon differ in how they deal with these two shared intuitions: They agree neither about what tasks remain for forms and powers nor about the subset of phenomena that should be explained through moving particles. What they do agree about, however, is that the local motions of particles cannot explain all that the substantial form is taken to explain in the scholastic framework. The reasons that drive this reluctance are complex and different in each case, but they never consist in a simple inability to imagine a more complete mechanization. It would therefore be a mistake to view these four natural philosophies merely as unfinished realizations of the mechanical philosophy. Rather, they are attempts at building a natural philosophy that relies less on the substantial forms of visible bodies, without eliminating the concept of power outright. The preceding chapters document how difficult of a problem this was and what a variety of systems it engendered.

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Summary in Dutch

Nederlandse samenvatting

Deze dissertatie richt zich op het werk van vier natuurfilosofen uit de eerste decennia van de zeventiende eeuw. De belangstelling gaat uit naar de opvattingen van de auteurs over lokale beweging, vooral in relatie tot andere soorten natuurlijke verandering en tot hun opvattingen over de natuurfilosofie als geheel.

Zoals de titel van het proefschrift aankondigt, stellen de vier auteurs niet-aristotelische theorieën voor, wat betekent dat elk van hen op ten minste één kernpunt afwijkt van Aristoteles. Tegelijkertijd verschillen hun visies op de natuurfilosofie ook sterk van de alternatieven voor Aristoteles die later in de eeuw werden voorgesteld door auteurs als Descartes of Galileo. Daarom zijn zij overgangsauteurs die niet gemakkelijk passen in de gevestigde verhalen over de filosofische en wetenschappelijke veranderingen in dit deel van de wetenschappelijke revolutie.

Het eerste hoofdstuk behandelt het werk van Daniel Sennert (1572–1637), hoogleraar geneeskunde in Wittenberg. Sennerts opvattingen over de natuurfilosofie als discipline zijn in veel opzichten die van een orthodoxe Aristotelicus. Dit geldt ook voor zijn opvattingen over lokale beweging en verandering, die vergelijkbaar zijn met die in zestiende-eeuwse handboeken. Tegelijkertijd onderschrijft Sennert echter het bestaan van atomen, iets wat Aristoteles ten stelligste ontkent. In de tweede helft van het hoofdstuk wordt onderzocht hoe Sennert zijn engagement voor Aristotelische substantiële vormen weet te rijmen met zijn engagement voor atomen. Hij doet dit aan de hand van een theorie volgens welke het geheel en zijn atomaire delen (tot op zekere hoogte) onafhankelijk van elkaar zijn en op verschillende manieren op elkaar kunnen inwerken. In het laatste deel van het hoofdstuk wordt onderzocht onder welke omstandigheden deze interacties leiden tot lokale bewegingen van atomen.

In het tweede hoofdstuk staat Sébastien Basson (ca. 1573 – post 1625) centraal. Net als Sennert is Basson een arts, hoewel de biografische informatie over hem schaars is. In tegenstelling tot Sennert is Basson niet alleen een atomist, maar ook een fel anti-Aristotelicus. Aangezien Basson ontkent dat natuurlijke dingen überhaupt enige causale kracht kunnen hebben, wordt in dit hoofdstuk betoogd dat er een klein aantal eenvoudige regels van atomaire beweging zijn die overeenkomen hoe en volgens welke regels of wetten lokale beweging van atomen tot stand komt. Volgens Basson komen alle dingen en kwaliteiten van de fysieke wereld tot stand.

Het derde hoofdstuk gaat over David Gorlaeus (1591–1612). Dit hoofdstuk begint met een interpretatie van Gorlaeus' definitie van beweging en verandering. Vervolgens worden deze definities gecontextualiseerd binnen Gorlaeus' algemene metafysica, die gebaseerd is op een zeer strikt onderscheid tussen reële en fictieve wezens. Het resultaat van het hoofdstuk is dat lokale beweging volgens Gorlaeus een "wijze van zijn" is, meer dan louter fictief, maar ook geen reëel wezen. Uiteindelijk is de wereld zoals Gorlaeus deze voorstelt te statisch om ruimte te bieden aan verandering.

Het vierde en laatste hoofdstuk gaat over Francis Bacon (1561–1626) en zijn theorie over eenvoudige bewegingen. Bacon, die beter bekend is om zijn geschriften over de zogenaamde inductieve methode, stak veel intellectuele energie in het vinden van de fundamentele soorten bewegingen of veranderingen in de natuur, die hij de eenvoudige bewegingen of appetieten noemde. Het hoofdstuk stelt eerst vast wat de plaats is van deze eenvoudige bewegingen in Bacons late geschriften en hoe deze visie verschilt van een Aristotelische. Het tweede deel van het hoofdstuk bevat een gedetailleerde lezing van de twee late teksten die de eenvoudige bewegingen opsommen, een deel van het Novum organum en het Abecedarium novum naturae. Het resultaat is dat Bacons eenvoudige bewegingen sterk afwijken van een Aristotelische opvatting van verandering, maar niettemin afhankelijk zijn van de notie van krachten die inherent zijn aan materiële dingen.

Summary

This thesis focuses on the works of four natural philosophers writing in the first decades of the seventeenth century. The chief interest lies in the authors' conceptions of local motion, especially as it relates to other types of natural change and to their conceptions of natural philosophy as a whole.

As the title of the thesis announces, the four authors in question propose non-Aristotelian theories, meaning that each of them disagrees in at least one core respect with Aristotle. At the same time, their visions for natural philosophy also differ strongly from the alternatives to Aristotle proposed later in the century by authors like Descartes or Galileo. For this reason, they are transitional authors that do not fit easily into the established narratives of the philosophical and scientific changes of this part of the Scientific Revolution.

The first chapter engages with the work of Daniel Sennert (1572–1637), professor of medicine in Wittenberg. Sennert's views of natural philosophy as a discipline are those of an orthodox Aristotelian in many ways. This also extends to his views on local motion and change, which are similar to those presented in sixteenth-century handbooks. At the same time, however, Sennert endorses the existence of atoms, something which Aristotle vehemently denies. The second half of the chapter examines the way in which Sennert manages to square his commitment to Aristotelian substantial forms with his commitment to atoms. He does so through a theory according to which the whole and its atomic parts are (to a certain degree) independent from each other and can interact in various ways. The last part of the chapter examines under what circumstances these interactions lead to the local motions of atoms.

In the second chapter, the focus lies on Sébastien Basson (ca. 1573 – post 1625). Like Sennert, Basson is a physician, though biographical information about him is sparse. In contrast to Sennert, Basson is not only an atomist, but also a vehement anti-Aristotelian. Since Basson denies that natural things can have any causal power at all, the core issue in this chapter is argued that there is a small number of simple rules of atomic motion that accord is how and according to what rules or laws local motion of atoms comes about. Iting to Basson bring about all the things and qualities of the physical world.

David Gorlaeus (1591–1612), who is the subject of the third chapter, was a Dutch student of theology who died prematurely, but who left behind two radically atomist and anti-Aristotelian treatises. The chapter begins with an interpretation of Gorlaeus' definition of motion and change. It then moves on to contextualize these defini-

tions within Gorlaeus' general metaphysics, which is built on a very strict distinction between real and fictional beings. The result of the chapter is that local motion according to Gorlaeus is a "mode of being," more than merely fictional but not a real being either. In the final analysis, the world as presented by Gorlaeus is too static to accommodate change.

The fourth and final chapter engages with Francis Bacon (1561–1626) and his theory of simple motions. Bacon, who is better known for his writings on the so-called inductive method, put a lot of intellectual energy into finding the fundamental types of motions or changes in nature, which he calls the simple motions or appetites. The chapter first establishes what the place of these simple motions in Bacon's late writings is and how this vision differs from an Aristotelian one. The second part of the chapter contains a detailed reading of the two late texts that list the simple motions, a part of the Novum organum and the Abecedarium novum naturae. The result is that Bacon's simple motions depart very far from an Aristotelian conception of change, but nevertheless depend on the notion of powers inherent in material things.

Curriculum Vitae

Gabriel Müller received his MA in philosophy and mathematics from the University of Basel in 2017. He joined the Center for the History of Philosophy and Science as a junior researcher in 2019. He works on the history of philosophy from the late middle ages to the early modern period and is particularly interested in the foundations of natural philosophy and the metaphysics of substance. His dissertation work has been supported by a doc.mobility grant of the Swiss National Science Foundation as well as by the Research Fund for Junior Researchers of the university of Basel.