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How Did Regius Become Regius? The Early Doctrinal Evolution of a Heterodox Cartesian

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Abstract

This article offers an assessment of Henricus Regius's (1598–1679) pre-Cartesian sources and their role in his appropriation of Descartes's ideas, via two main questions: 1) Who was Regius, doctrinally speaking, before his exposure to Cartesianism? And 2) how did he use Descartes's theories before his quarrel with Descartes himself in the mid-1640s? These questions are addressed by means of a textual analysis that concerns his theory of matter. In this article, I will show that 1) Regius started out with a scientific program he had found in Ramism and the medical theories of Heurnius and Santorio. 2) On this basis, he developed a physiology encompassing Descartes's theory of blood circulation and sensory perception. 3) Regius completed the resulting physiology with a theory of matter more developed than Descartes's, and which he appropriated from Santorio, Basson, and Gorlaeus.

Keywords

Henricus Regius – theory of matter – physiology – theory of qualities – Santorio Santorio –

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1. Introduction

The relations between the Dutch physician and natural philosopher Henricus Regius (1598–1679) and René Descartes (1596–1650) were, until 1645, positive, and testify to Regius's keenness to spread some of Descartes's ideas in the Netherlands. However, Regius was more than just an expositor of Descartes's theories. Regius was certainly faithful to Descartes's positions with regard to certain topics such as the explanation of blood circulation and sense perception. Moreover, during the *querelle d'Utrecht* in 1641–1642, Regius defended Descartes's philosophy – of which he was considered the foremost proponent – against the criticism of Gysbertus Voetius. Yet between 1645 and 1648 Regius entered into a quarrel with Descartes concerning the theory of mind and epistemology, which Regius interpreted from both a radically empirical and a materialist position.[1] The selective use that Regius made of Descartes's philosophy, i.e., the so-called 'Regius problem,' has led historians to seek to establish his pre-Cartesian background.[2] A century ago, Marinus Johannes de Vrijer traced Regius's specifically materialist positions on the soul back to his religious heterodoxy, which had become evident during the so-called 'Naarden affair' of 1630–1631.[3] Later Karl E.

[1] See Theo Verbeek, ed., *Descartes et Regius: Autour de l'Explication de l'esprit humain* (Amsterdam, 1993); Delphine Bellis, "Empiricism without Metaphysics: Regius' Cartesian Natural Philosophy," in Mihnea Dobre and Tammy Nyden, eds., *Cartesian Empiricism* (Dordrecht, 2013), 151–183. On the *querelle d'Utrecht*, see below, n5.

[2] The expression "il problema 'Regius'" was coined by Paolo Farina, "Sulla formazione scientifica di Henricus Regius: Santorio Santorii e il *De statica medicina*," *Rivista Critica di Storia della Filosofia*, 30 (1975), 363–399, 365.

[3] Marinus Johannes Antoinie de Vrijer, *Henricus Regius: Een 'cartesiaansch' hoogleraar aan de Utrechtsche hoogeschool* (The Hague, 1917).

Rothschuh and Paolo Farina surveyed Regius's pre-Cartesian background and education, and shed a first light on the ways in which – paraphrasing Rothschuh – 'Regius became Regius' before he became a Cartesian, as well as demonstrating Santorio Santorio's influence on his thinking.[4] More recently, attention has been paid to another of Regius's pre-Cartesian sources, David Gorlaeus, to whom Regius referred during the *querelle d'Utrecht* as a source for his characterization of man as an accidental being.[5]

Given that a more fine-tuned view of Regius's intellectual career has been developed in recent decades, my paper will revisit the 'Regius problem' by answering two questions: 1) Who was Regius, doctrinally speaking, before his exposure to Cartesianism in the late 1630s? And 2) how did he use Descartes's theories before his quarrel with Descartes himself in mid-1640s?

Answers to these questions will be sought via an analysis of extant texts by Regius dating from 1640 to 1643, in which he expounded his early physiology, and via some scattered elements of his natural philosophy.[6] These texts were written before he could have

[4] "Regius wäre also nicht (vorübergehend) zum Gefolgsmann von Descartes geworden, wenn er nicht schon vorher ein Regius gewesen wäre." Karl E. Rothschuh, "Henricus Regius und Descartes: Neue Einblicke in die frühe Physiologie (1640–1641) des Regius," *Archives internationales d'histoire des sciences*, 21 (1968), 39–66, 53. See Farina, "Sulla formazione scientifica," 366–381.

[5] Theo Verbeek, "*Ens per accidens*: Le origini della Querelle di Utrecht," *Giornale critico della filosofia italiana*, 71 (1992), 276–288; Geneviève Rodis-Lewis, "Problèmes discutés entre Descartes et Regius: L'ame et le corps," in Theo Verbeek, ed., *Descartes et Regius*, 35–46; Christoph Lüthy, *David Gorlæus (1591–1612): An Enigmatic Figure in the History of Philosophy and Science* (Amsterdam, 2012), chapter 4.2.

[6] Henricus Regius, *Disputatio medico-physiologica pro sanguinis circulatione* (Utrecht, 1640); idem, *Spongia qua eluuntur sordes Animadversionum* (Leiden, 1640); idem,

read Descartes's *Principia philosophiae* (1644) and *L'homme* (posthumously published in 1662 (in its Latin translation) and 1664). As has been demonstrated by Rothschuh, Regius did not read the manuscript of *L'homme* until 1646. These dates are important as they demonstrate the independence of Regius's physiology from Descartes's theory of man.[7] As for other works by Descartes from the 1630s and early 1640s – besides the *Discours de la méthode* and the *Essais* (1637) – Regius received a draft copy of Descartes's *Meditationes*

Physiologia (Utrecht, 1641-1643); idem, *De illustribus aliquot quaestionibus physiologicis* (Utrecht, 1641); idem, *Responsio, sive notae in Appendicem ad Corollaria theologico-philosophica… Voetii* (Utrecht, 1642). Regius's main treatises in natural philosophy (the *Fundamenta physices* of 1646, based on earlier texts) and medicine (*Fundamenta medica*, 1647) later appeared in two enlarged editions each, published in 1654, 1661, and 1657, 1668 (to which he appended his *Praxis medica*) respectively. Regius's *Fundamenta physices* also appeared in a French edition (*Philosophie naturelle*, Utrecht, 1687).

[7] Rothschuh, "Henricus Regius," 49–61. As recently argued by Erik-Jan Bos, this does not mean that Regius was completely unaware of Descartes's *L'homme*. Indeed, "[a]ccording to Descartes, he never wanted Regius to read the *Treatise on Man* out of fear he would plunder it […]. That being said, Descartes freely shared many of his physiological insights with Regius, as their correspondence testifies." Regius included two theses on sense perception in his *Physiologia* which do not appear in Descartes's *Dioptrique*, but are present in his *Traité de l'homme*: First, the idea that the pineal gland is surrounded by animal spirits, and second, that animal spirits inflate the brain cavities, like wind inflates sails (even if in his *Dioptrique* Descartes compared spirits to a "vent très subtil, qui, venant des chambres ou concavités qui sont dans le cerveau, s'écoule par ces mêmes tuyaux dans les muscles." René Descartes, *Oeuvres*, eds. Charles Adam and Paul Tannery, 11 vols. (Paris, 1897–1913 (henceforth 'AT' plus ordinal number)), vol. 6, 110; see Regius, *Physiologia*, 33–34; Erik-Jan Bos, "Descartes and Regius on the Pineal Gland and Animal Spirits, and a Letter of Regius on the True Seat

the spring of 1640, and he read Descartes's *Le monde* only in the late spring or summer of 1641, as Theo Verbeek has shown.[8]

In this article I will analyze Regius's early texts by considering specifically his theory of matter. This topic has been chosen because Regius developed his theory of matter by making use of identifiable positions of others in physiology and natural philosophy, and by rejecting others. Through this analysis I hope to show that Descartes's model of matter could not satisfy Regius's needs as a medical physiologist. After all, the building blocks of physiology were elements, mixtures, temperaments, and the organic construction of the parts of the body, and Regius could not find these notions in those of Descartes's texts that he read before 1641. Consequently, Regius 'completed' the essential physiology and theory of matter he found in Descartes's *Discours* and *Essais* with notions he appropriated from his pre-Cartesian sources.

In what follows I will first provide an assessment of Regius's education, his scientific program, and the basics of his physiology and theory of matter (section 2). I will then show that Regius came to embrace Descartes's ideas on blood circulation and sense perception in order to fulfill a scientific program whose first source can, however, be identified in the logic of Pierre de la Ramée, from which Regius adopted the idea of an abridged system of medicine which he integrated into ideas that can be traced back to Plato and Lucretius. I will further (section 3) shed light on some of Regius's other pre-Cartesian sources, notably the medical theories of Johannes Heurnius and Santorio Santorio. From them Regius appropriated the ideals of the conformation of medicine to the standards of philosophical knowledge, making medicine a non-conjectural art, and providing a new explanation of the

of the Soul," in Stephen Gaukroger and Catherine Wilson, eds., *Descartes and Cartesianism: Essays in Honour of Desmond Clarke* (Oxford, 2017), 95–111, 104–105.

[8] Theo Verbeek, "Regius's *Fundamenta Physices*," *Journal of the History of Ideas*, 55 (1994), 533–551.

traditional qualities. Finally (section 4), I wish to show how Regius moved towards a corpuscular worldview under the influence of Sébastien Basson (4.1), from whom Regius appropriated the ideas of nature and causality, and David Gorlaeus (4.2), from whom he adapted his theory of elements.

2. Regius's Early Thought

2.1 Regius's education

Born in Utrecht in 1598, Regius studied at many universities before settling in his native city, first as a town physician, and later as a professor of medicine. He first enrolled and graduated in the liberal arts at the University of Franeker (1616); thereafter, he studied medicine at the Universities of Groningen (1617–1618), Leiden (1618), Montpellier (1621), Valence (1622), and Padua (1622–1623), where he obtained his doctorate. In 1625 he became a town physician at Utrecht, and in 1631 the rector of the Latin School of Naarden.[9] In 1634 he moved back to Utrecht, where he befriended Henricus Reneri.[10] According to Regius it was Reneri who introduced him to Descartes's ideas, even before the appearance of the latter's *Discours* and *Essais*.[11] In the same year, Regius was again appointed town physician. In 1637 he lectured privately on Cartesian topics.[12] In July 1638, he was appointed extraordinary

[9] Erik-Jan Bos, *The Correspondence between Descartes and Henricus Regius* (Utrecht, 2002), 257–259 (all further references to the correspondence are to this edition, which includes several corrections to the standard Adam-Tannery edition); Johannes Graevius, *Oratio funebris in obitum… Henrici Regii* (Utrecht, 1679), 7–14.

[10] Robin Buning, *Henricus Reneri (1593–1639), Descartes' Quartermaster in Aristotelian Territory* (Utrecht, 2013), chapter 7.

[11] Regius to Descartes, 8/18 August 1638; Regius to Descartes, early February 1639, in Bos, *Correspondence*, 3–5, 12.

[12] Descartes to Mersenne, 23 August 1643, in AT II, 334.

professor of theoretical medicine and botany at the University of Utrecht, and from April 1640, he lectured at that university on the Aristotelian *Problemata*. According to Descartes's *Epistola ad Patrem Dinet* (1642), Regius completed a "whole physiology" within a few months after reading the *Dioptrique* and *Météores* (1637).[13] He continued to work on a textbook of medicine and natural philosophy until at least 1643.[14] At the same time he presided over various disputations in medical physiology, namely his *Pro circulatione sanguinis* (1640), *Physiologia* (1641–1643), and *De illustribus quaestionibus physiologicis* (1641). Other texts from these years are his *Spongia* (1640), which was written against the English physician Jacob Primerose's criticism, and the *Responsio* (1642) against the attacks of the Dutch theologian Gysbertus Voetius.[15]

In order to understand how 'Regius became Regius,' we need to look at the various figures he met during his early life. At the University of Franeker, Regius could have attended the classes on metaphysics by Johannes Maccovius, an adherent to scholastic

[13] "Doctor quidam medicinae […] legit Dioptricam meam et Meteora, cum primum edita sunt in lucem […]. Quae colligendo diligentius, et alia ex iis deducendo, ea fuit sagacitate, ut intra paucos menses integram inde physiologiam concinnarit." AT VII, 582–583. All translations are the author's except where otherwise noted. Evidence of Regius's 'earliest' physiology might actually have come from some his "notes assez courtes" on Vittore Trincavelli, sent to Descartes in August 1638, and named *Essais de médecine* (now lost). See Regius to Descartes, 8/18 August 1638, in Bos, *Correspondence*, 6.

[14] Details on the scattered references to this textbook are given in Bos, *Correspondence*, 39–40.

[15] Gysbertus Voetius, *Appendix ad Corollaria theologico philosophica nuperae disputationi de iubilaeo romano, de rerum naturis et formis substantialibus* (discussed on 23 and 24 December 1641), published in idem *et al*. *Testimonium academiae Ultraiectinae, et Narratio historica* (Utrecht, 1643), 36–51.

positions.[16] In Groningen, he was the *respondens* in a disputation *De thorace* (1618) presided over and written by Nicolaus Mulerius (the only professor of medicine in Groningen at that time).[17] In Leiden he attended the lectures of Evherardus Vorstius, Reinerus Bontius and Otto Heurnius, and he was certainly acquainted with Johannes Heurnius's (Otto's father's) *Institutiones medicinae* (1592), which he was to use in his first lectures at Utrecht; he probably also knew Gilbertus Jacchaeus's teachings in natural philosophy. In Montpellier Regius attended the private lectures of Lazare Rivière, and in Valence he studied law under Giulio Pace.[18] In Italy he graduated with Cesare Cremonini, Santorio Santorio and Adrianus Spigelius as promoters.[19] If we look at the rare references to authors other than Descartes present in his early works, Jean Fernel and Santorio occupy a prominent place, while, in addition to David Gorlaeus, Franco Burgersdijk and Sébastien Basson are more covertly referred to.[20]

In order to restrict the scope of my analysis of these sources, I will first focus on the main tenets and targets of Regius's texts of 1640–1641. This will shed light on his overall program and give a first insight into his theories and sources.

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[16] On Maccovius, see Wilhelm J. van Asselt, "On the Maccovius Affair," in Aza Goudriaan and Fred van Lieburg, eds., *Revisiting the Synod of Dort (1618–1619)* (Leiden, 2010), 217–241.

[17] Marius J. van Lieburg, "De medische faculteit te Groningen en de ontwikkeling van de medische wetenschap," in Henk Huussen jr., ed., *Onderwijs en onderzoek: Studie en wetenschap aan de academie van Groningen in de 17e en 18e eeuw* (Groningen, 2013), 31–83.

[18] Graevius, *Oratio*, 12–14, 16.

[19] Bos, *Correspondence*, 257.

[20] On Fernel and Santorio, see Regius, *Physiologia*, 2, 13–14, 29, 52–53.

2.2 Regius's program in physiology

We can gain some insight into Regius's program in medical physiology, his first field of interest, from the dedicatory letter to the authorities of the University of Utrecht that opens his *Fundamenta medica* (1647). He there declares that, when he was appointed professor in 1638, his aim was to provide an exposition of medicine which would be "short, easy, and useful." Such succinct teaching, for Regius, was possible only through an eradication of "superfluous concepts" from medical theories, and an "elucidation" of its "obscurities." Accordingly, he intended to expose such medical theories clearly (*perspicue*), follow an "accurate order" and be "methodical."[21] This program does not sound Cartesian. For indeed, Descartes did not intend his own method, as set out in the *Discours de la méthode*, to be didactic, but rather to provide a means for the solution of problems and the discovery of new truths.[22] Moreover, Regius's *perspicuitas* was not Descartes's *claritas*, the difference being that Descartes understood *claritas* in the *Discours* as indubitable, purely rational knowledge, a notion that Regius was to undermine in his own *Physiologia*, in which he availed himself of an empirical theory of the knowledge of universal notions.[23]

[21] "[C]redidi, ut brevem, facilem, et utilem, pro virili, ad artem nostram auditoribus ostenderem viam. Idque facile obtineri posse speravi, si superfluis amputatis, et obscuris dilucidatis, […] totius medicinae praecepta, accurato ordine […], perspicue proponerem […]. Ubi enim, […] sola necessaria methodice proponuntur, necessarie iusta oritur brevitas." Henricus Regius, *Fundamenta medica* (Utrecht, 1647), "Dedicatio," [i–ii].

[22] See, for instance, AT VI, 3, 21–22. On Descartes's method, see Stephen Gaukroger, *Cartesian Logic: An Essay on Descartes's Conception of Inference* (Oxford, 1989).

[23] For instance, in his *Physiologia* Regius stated that imagination is the faculty by which the mind attains universal concepts: Regius, *Physiologia*, 43. Moreover, he declared only the knowledge of immaterial substances, i.e. soul and God, as purely rational (*perceptio*

Regius's initial program reveals one of his early pre-Cartesian sources, namely the works of Pierre de la Ramée, or Petrus Ramus (1515–1572). Ramus abridged vast bodies of knowledge by following an analytic order or method consisting of the use of dichotomies, aimed at the resolution of complex notions into simpler ones – a process that he illustrated with the use of diagrams.[24] Such a Ramist order or method is also discernible in Regius's texts. In his *Physiologia* he had already followed a "compendiary method," which Schoock was to attack in his *Admiranda methodus* (1643) due to its lack of demonstrations of the proposed theses.[25] Even Descartes himself criticized Regius for his "naked" style of exposition in his manuscript textbook and in the draft version of his *Fundamenta physices*; he thought its divisions – which Descartes considered suitable for teaching – insufficiently tied together, lacking the necessary proofs.[26] Further evidence of their methodological differences

inorganica), see Regius, *Physiologia*, 33.

[24] On Ramus's method and its dissemination, see Walter J. Ong, *Ramus, Method and the Decay of Dialogue* (Cambridge, MA, 1958); Howard Hotson, *Commonplace Learning: Ramism and its German Ramifications, 1543–1630* (Oxford, 2007). The Ramist derivation of Regius's method of exposition has been noted in Theo Verbeek, "The Invention of Nature: Descartes and Regius," in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London and New York, 2000), 149–167.

[25] "Si novae philosophiae alumni principiis suis maxime intelligibilibus patronos inter omnis generis homines serio quaesitum ire cupiunt, ostendant ea quam maxime demonstrabilia esse, quod non potuerunt compendiosori methodo praestare, quam si ostendant non garriendo sed solide demonstrando." Martin Schoock, *Admiranda methodus novae philosophiae Renati des Cartes* (Utrecht, 1643), 200.

[26] "Cumque meminerim me multa legisse in tuo Compendio physico, a vulgari opinione plane aliena, quae nude ibi proponuntur, nullis additis rationibus, quibus lectori probabilia reddi possint, toleranda quidem illa esse putavi in Thesibus, ubi saepe paradoxa colliguntur, ad

is found in the third edition of the *Fundamenta physices* (1661), where Regius declared that logic consists only in teaching how to proceed in an exposition by using such an order or method, i.e., by means of definitions and divisions (or distributions), to which explanations are added. This order or method, for Regius, is the "clearest and shortest."[27]

Given Regius's biography, his adoption of this method should not surprise. As mentioned above, he had first studied in Franeker, the first center of Ramism in the Netherlands, and then in Leiden, where Ramism was very influential, as testified by Rodolphus Snellius's and his son Willebrord's commentaries on Ramus's dialectic, rhetoric and arithmetic; both were professors of mathematics at the University from 1581 to 1613 and from 1613 to 1626 respectively).[28] Moreover, at Valence, Regius attended the lectures of Giulio Pace, who was a Ramist.[29]

Ramism, thus, may have been Regius's very first source of inspiration. However, according to his 1647 dedicatory letter, he did not only aim to abridge the discipline of medicine, but also to clarify its obscure concepts. His ideal of clarity clearly went beyond Ramism, and must have had further influences. In his dedicatory letter, Regius declared that

ampliorem disputandi materiam adversariis dandam; sed in libro, quem tanquam novae philosophiae Prodromum videbaris velle proponere, plane contrarium iudico esse faciendum." Descartes to Regius, April 1641, in Bos, *Correspondence*, 57. Cf. Descartes to Regius, July 1645, in ibid., 187.

[27] "Methodus sive ordinatio […] fit per definitiones, distributiones, et additas dilucidationes, analytica methodo procedentes. Haec enim est clarissima et brevissima. Atque in his tota logica, eiusque rectus usus consistit." Regius, *Philosophia naturalis*, 476–477.

[28] See Van Berkel, "Franeker als centrum van ramisme"; Theo Verbeek, "Notes on Ramism in the Netherlands," in Mordechai Feingold, Joseph S. Freedman and Wolfgang Josef Rother, eds., *The Influence of Petrus Ramus* (Basel, 2001), 38–53.

[29] Hotson, *Commonplace Learning*, 24.

his predecessors had failed to provide the kind of exposition he aimed at because they had relied on an obscure philosophical theory. It was only thanks to the emergence of Descartes's principles that the much-needed project of a methodical exposition of medicine could be carried out. For Regius, the abridgement of medicine was only possible upon a reconsideration of its concepts, that is, by an eradication of its *abditissima*.[30] The so-called *abdita*, i.e., the hidden or occult qualities and faculties, lay at the core of most contemporary theories of matter and of physiology, with Jean Fernel's dialogue *De abditis rerum causis* (1548) as their manifesto.[31] Because of his ideas on occult qualities, Fernel was a *bête noire* for Regius and his teacher at Padua, Santorio. So, before analyzing Regius's physiological intentions and ideas further, we need to have a look at them.

2.3 Traditional ideas on physiology and matter

A large number of current secondary sources provide discussions of Renaissance and early modern, pre-Cartesian theories of matter.[32] What is worth mentioning here is that, in the

[30] "Tentarunt hoc ante me viri multi, ingenio praestantissimi. Verum […] propter obscuriorem ipsorum philosophandi ratione, non satis feliciter id hactenus praestitisse videntur. […] Cum itaque a paucis annis, maior in philosophia lux […] affulserit […] manum operi admovi. Ac universa medicinam […] methodice revocavi. […] Et ut verbo absolvam, […] abditissima et difficillima, perspicua et facilia reddere tentavi." Regius, *Fundamenta medica*, "Dedicatio," [ii–iii].

[31] Jean Fernel, *De abditis rerum causis libri duo* (Paris, 1548), also published in John Forrester and John Henry, eds. and trans., *Jean Fernel's On the Hidden Causes of Things. Forms, Souls, and Occult Diseases in Renaissance Medicine* (Leiden and Boston, MA, 2005), which is based on the editions of 1567 and 1586, which had been published alongside Fernel's *Universa medicina.*

[32] Robert Pasnau, *Metaphysical Themes: 1274–1671* (New York, 2011); Hiro Hirai, *Medical*

matter theories of Aristotelian philosophers like Franco Burgersdijk (whose definitions are present in various crypto-quotations in Regius's works), or in that of Fernel, the manifest qualities of the human body do not suffice to account for all of its functions.[33] The primary manifest qualities are hot, cold, humid, and dry, which bring about a common temperament when their carriers, the four elements, mix, and they are unified in a homogeneous body (mixture) by a substantial form which is 'educed' from the matter of the mixture itself. The 'secondary' or 'derived' qualities result from the interaction of hot and cold with the 'matter' of the mixture, i.e. with the elements of earth and water. These secondary qualities are hard, soft, dense, rare, coarse, smooth, and so on.[34] In physiology, the basic mixtures constituting the components of the human body are the 'homeomeries' or 'similar parts,' which acquire a further, last level of organization when they form 'organic parts,' i.e., in assuming a conformation, figure and internal disposition.[35] Together, similar and organic parts compose a

Humanism and Natural Philosophy (Leiden and Boston, MA, 2011); Elisabeth Moreau, *Eléments, atomes & physiologie: Le contexte médical des théories de la matière (1567–1634)* (Ph.D. dissertation, Radboud University and Université Libre de Bruxelles, 2017).

[33] As to the crypto-quotations from Burgersdijk, see below, n68. Burgersdijk's books on logic, metaphysics and natural philosophy became standard textbooks in the Netherlands after the 'School order' of 1625, see Egbert Bos and Henri A. Krop, eds., *Franco Burgersdijk (1590–1635): Neo-Aristotelianism in Leiden* (Amsterdam, 1993).

[34] Franco Burgersdijk, *Idea philosophiae naturalis* (Leiden, 1652; 1st ed. 1622), 39–41, 45–48; Jean Fernel, *Universa medicina* (Geneva, 1638; 1st ed. 1554), 101, 107–112; idem, *On the Hidden Causes*, 406 and 408. According to Burgersdijk, elements are 'broken' and their qualities are altered in the mixture. For Fernel, elements and qualities are preserved unaltered, even if they exist just potentially in the mixture.

[35] Fernel, *Universa medicina*, 95–96; idem, *On the Hidden Causes*, 474. On the levels of organization of animated bodies in the Aristotelian tradition, see Dennis Des Chene, *Life's*

body which – in Fernel's account – is unified by 1) the soul, which is the first cause or principle of bodily functions, and 2) the divine spirit, or innate, non-elementary heat that has resided in the body ever since it was pure semen, and that is directing its growth.[36] Innate heat is also the "seat" and the "vehicle" of the soul and its faculties, which come forth from the "bosom" of the soul, as "intimate accident[s]" of it.[37] Together, soul, innate heat, and the faculties of the soul constitute the "total substance," a notion that constituted the main target for Regius and several of his pre-Cartesian influences.[38] According to the theory Regius was to question, substantial forms, both of the human body and of plants and animals, not to mention certain stones, are provided with their own, occult qualities whose effects – like those of the faculties of the total substance – cannot be explained in terms of primary and secondary qualities, and fall outside the scope of natural philosophy.[39] In the case of the

Form: Late Aristotelian Conceptions of the Soul (Ithaca, NY and London, 2000), 94–102.

[36] Fernel, *Universa medicina*, 136–137, 163. The idea of an innate heat is presented also in Burgersdijk's *Idea*, 57. On innate heat in Fernel's physiology see Hirai, *Medical Humanism*, chapter 2.

[37] "Est enim facultas vis illa et potestas quam animam tanquam de sinu suo promit, et ad munerum functiones profert. Id autem perinde est atque si dixeris insitam et vernaculam animae proprietatem: quae ipsa quidem est accidens, sed animae intimum atque adeo intestinum." Fernel, *Universa medicina*, 166.

[38] "Totius vero substantiae nomine et insitum spiritum, et divinum illius calore, et facultates ipsamque formam complectimur." Ibid., 341.

[39] "Horum tamen obscurae sunt causae, et adeo occultae ut percipi a nemine possint, nullaque certa ratione comprehendi. Latent enim obscuritate involutae naturae, quae dum neque evidenter percipi neque verbis dici possunt, occultae nobis rerum proprietates appellantur […]. Haec itaque quoniam vires et naturas elementorum excesserunt, supra naturalem philosophiam (quae tota in illis versatur) constitui, nec demonstrationum cancellis coarctari

human body, the faculties of the soul do not originate from any combination of the elements and manifest qualities, but from "nature, spirit, and heat," which "are above the powers and status of the elements, and their pre-eminence cannot belong either to these transient and dirty elements or to the special character of the temperament."[40]

So, if we search in Fernel's books for the explanation of those phenomena that in Regius's texts of the 1640s (see the next section) would be explained in mechanical-corpuscular terms, like nutrition, we find a nutritive faculty at work which consists of various sub-faculties (e.g. attractive or repulsive), which are the mutual "friendship and desire" and "hate and offensiveness" between the parts of the body.[41] In the same way, elementary heat

merito iureque dicemus." Fernel, *On the Hidden Causes*, 418.

[40] "Ut quatuor simplices naturas elementa vocamus, quod in rerum omnium concretionem confluunt, illisque cedunt in materiam: ita coelum ac stellas, quod suas etiam vires adhibeant ac impertiant, elementa iure appellemus. Si in primam animantis procreationem, quae ex semine ex maternoque sanguine fit, mentem cogitationemque figes, animadvertes sanguinem ex quatuor elementis quae in cibis inerant constitui, ex eisque materiam seminis, quam purior utiliorque sanguis contulit. At naturam, spiritum, et calorem quos semen in se comprehensos continet, quum aliunde prodiisse memineris, intelliges supra elementorum vires et ordinem esse, neque posse illorum praestantiam vel ad caduca haec et sordida elementa, vel ad temperamenti proprietatem pertinere. Partium humani corporis subiectam materiam ab elementis, et a temperamentis: at facultates, spiritus, insitum calorem, et figuram, ab eo seminis spiritu, in quo tum calor, tum natura, visque divina insidebat, proficisci." Fernel, *On the Hidden Causes*, 496. Translation from page 495.

[41] "Si est facultatis attrahentis necessitas unicuique parti ingenita, necesse est simul et expultricem quandam inesse, quae quod inutile est et supervacaneum depellat. Ut enim convenientis amicitia atque desiderio res unaquaeque trahit, ita par est eandem odio et offensione contatam, quicquid sibi noxium est et infensum extrudere." Fernel, *Universa*

does not in itself explain the concoction or transformation of food into blood: Elementary heat first turns food into a "juice" (*cremor*). Its substantial transformations, however, are made possible as the concocting faculty converts juice into chyle, chyme, and then into blood.[42] Fernel's hierarchic theory of matter is even more clearly expressed in his account of the diseases of similar parts, and of the powers of medicaments. The diseases are due to three factors: 1) The immoderateness of the first qualities of the temperament, 2) the immoderateness of matter (consisting of defects in density, rarity, etc.), and 3) the "corruption of the total substance" of the body.[43]

2.4 Regius's early physiology and its internal evolution

In Regius's texts of 1640 (i.e., his disputation *Pro circulatione sanguinis* and *Spongia*) we find a theory of matter that is corpuscular and aimed at supporting a mechanical theory of physiology. The disputation had two aims. First, it served to support Descartes's account of the movement of the heart and the blood circulation, after the Louvain physician Vopiscus Plempius had attacked it in his *Fundamenta medicinae* (1638). In his disputation, Regius followed both Descartes's *Discours* and his correspondence with Plempius, which Descartes had lent him in August 1638.[44] Second, the disputation served as an example for the scientific

medicina, 173.

[42] The whole process is explained ibid., 221.

[43] Fernel, *On the Hidden Causes*, 522. Also in Fernel, *Universa medicina*, 341. On the diseases of organic parts, i.e., the defects in their conformation, figure and *situs*, see page 343.

[44] Regius presented Descartes's causes of the movements of the heart and blood thus: 1) Blood's aptitude to dilate itself, 2) its heat, 3) fermentation, and 4) the conformation of the heart; see Regius, *Pro sanguinis circulatione*, thesis 5; cf. Descartes's *Discours de la méthode*, AT VI, 45–54, and Descartes to Plempius, 15 February 1638, in AT I, 521–534; see

theories Regius taught at the University.[45] Regius's faithful presentation of Descartes's account was part of a broader explanation of concoction, according to which concoction is understood to be the "adaptation of the unobservable particles […] in order for them to acquire a conformation fitting the human body," which are then distributed to the different parts of the body "according to mechanical laws."[46] Regius's overall model is mechanical, as is also evident from his account of respiration (not found in Descartes) as due to 1) a back-

also Regius to Descartes, 8/18 August 1638, in Bos, *Correspondence*, 3–6. In this article, I do not systematically distinguish between a theory of the heartbeat and a theory of blood circulation, since Descartes's and Regius's theory of blood circulation encompasses a theory of the movement of the heart. Both topics also fall under the heading of the pulse, i.e. the theory of the movement of heart and arteries. Indeed, for Descartes and Regius the pulsation of both heart and arteries depend on the movement of the blood itself, by which they are dilated; after dilatation, they contract by means of their elasticity, but this contraction plays no role in the movement of blood itself (which is a sort of self-mover in the Cartesian account, see below, section 4.2.4). Notably, Descartes built upon William Harvey's theory of blood circulation as presented in his *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (Frankfurt, 1628). However, Descartes rejected Harvey's theory of the movement of the heart, as it took recourse to a 'pulsific faculty.' For Harvey, indeed, the heart works as an active pump, which pushes blood through the arteries. On this topic, see Annie Bitbol-Hespériès, "Cartesian Physiology," in Gaukroger, Schuster and Sutton, eds., *Descartes' Natural Philosophy*, 349–382; Lucian Petrescu, "Descartes on the Heartbeat: The Leuven Affair," *Perspectives on Science*, 21/4 (2013), 397–428. In his *Oratio funebris in obitum Henrici Regii* (Utrecht, 1679), Johannes Graevius reports that, in his first public lectures at Utrecht, Regius subscribed to Harvey's theory, as part and parcel of the "whole physiology" that Descartes had praised: "[P]redicaret Cartesius […] paucos intra menses physiologiam concinnarit. Hanc cum in publicis recitationibus pro concione explicaret Regius […].

and-forth motion of spirits moving the muscles of the thorax – like the motion of clock parts – which is rendered possible by the conformation of their vessels, and 2) the propulsion of air into the lungs by the external atmosphere: External air is compressed by the chest during inspiration, and is propelled into the lungs, as a vacuum does not exist in nature.[47]

This theory of respiration includes notions that Regius may have found in Descartes's 1637 texts: There, he may have seen the example of the clock which Descartes used in the

Vexabatur in primis opinio Harvaei, cui subscripserat noster, de fluxu et refluxu sanguinis." Graevius, *Oratio*, 26–27. This passage thus seems to testify to Regius's adherence to the idea of blood circulation, rather than Harvey's explanation of pulse. Otherwise, Descartes would not have praised him. Later in his career, however, Regius would go beyond Descartes's explanation of the heart-beat: See his *Philosophia naturalis* (Amsterdam, 1661), book 4, chapter 9 (discussed in Petrescu, "Descartes on the Heartbeat"). It is probable that Regius adhered to the theory of blood circulation before he read Descartes's 1637 texts, although there is no textual evidence for this.

[45] Regius to Descartes, 5/15 May 1640, in Bos, *Correspondence*, 38.

[46] "Consistit autem illa praeparatio […] non in generatione aut corruptione alicuius formae substantialis, sed tantum in adaptatione particularum insensibilium […] ut ea conformationem humano corpori idoneam acquirant." Regius, *Pro circulatione sanguinis*, thesis 1. Cf. Regius, *Spongia*, 17: "[S]anguinem pelli et in caput et in pedes, sed diversimode, propterea quod vasa et viae in illas partes spectent; illaeque non semper eodem modo sint constitutae; et praeterea quod sanguis in corde ebulliens magna vi expellatur, cuius variae particulae pro agitationis suae varietate in varias partes secundum leges mechanicae distribuuntur."

[47] "Aër […] in inspiratione pectus ingreditur […] quia thoracis dilatatione vicinus aër […] de loco deturbatur; qui porro alium loco movet: et cum omnia corporibus plena sint, nec vel minimum sit vacuum […] necessario aër a pectore et alio aëre sic pulsus, in thoracem […]

Discours to exemplify the process of blood circulation.[48] Moreover, in Descartes's *Dioptrique*, he would have seen an explanation of muscular movements as determined by the flow of animal spirits.[49] Regius's model of respiration was, however, also inspired by Plato's *Timaeus*, which explained respiration as a consequence of a circular thrust (περίωσις, *circumpulsio*) of air due to the fact that there can be no vacuum in nature. Plato's explanation is similar to Regius's: When we emit air during expiration, this exhalation moves the external air in a circle – a movement that moves into the lungs again, as a vacuum cannot exist in nature.[50] Regius was most likely acquainted with this explanation via Galen's *Fragmentum ex quatuor commentariis de iis quae medice dicta sunt in Platonis Timaeo*.[51]

adigitur. […] Respiratio naturalis […] fit […], a certa conformatione meatuum, qui sunt in partibus cerebri, a quibus thoracis nervi oriuntur […]. Sic in horologio particula illa, quae vulgo inquies dicitur, ob solam partium ipsius machinae conformationem, reciprocam patitur agitationem, etsi spira ferrea, vel appensum pondus, semper eodem tenore rotulas moveat." Regius, *Pro circulatione sanguinis*, theses 9-10.

[48] See AT VI, 50.

[49] Ibid., 111.

[50] "Seeing that there is no such thing as a vacuum into which any of those things which are moved can enter, and the breath is carried from us into the external air, […] [breath] pushes its neighbour out of its place, and that which is thrust out in turn drives out its neighbour; and in this way everything of necessity at last comes round to that place from whence the breath came forth, and enters in there, and following the breath, fills up the vacant space; and this goes on like the rotation of a wheel, because there can be no such thing as a vacuum." Plato, *Timaeus*, 79b–c, translation from Benjamin Jowett, ed. and trans., *The Dialogues of Plato*, vol. 3 (London, 1892; 1st ed. 1871), 501–502.

[51] This topic merits a short digression. As early as in July 1639 one of Regius's students, acting as *opponens* in the inaugural disputation of Florentius Schuyl, rebuked Schuyl's

A further, 'original' element in these texts is Regius's overt attack on substantial forms. For Regius it is not necessary to posit a substantial change in concoction. Whereas one might observe changes in perceptible bodily qualities such as their size, figure, and the disposition of parts (*situs*), one cannot observe any change in substance.[52] Although this argument relies on a principle of economy like that used by Descartes in his *Météores*, which avoids substantial forms without overtly rejecting them, Regius's explicit rejection is far

Aristotelian explanation of magnetism by following the "sententiam novae philosophiae," as is reported in the *Narratio historica*, 13–14. Hence, in the (now lost) draft of his *Physiologia*, Regius included an explanation of magnetism which Descartes did not really find convincing, and which was omitted in the printed text (see Descartes to Regius, second half of May 1641, in Bos, *Correspondence*, 72–73). Later, an explanation of magnetism surfaces in a fragment from Regius's unpublished textbook, quoted in Martin Schoock's *Admiranda methodus*: "Inter lapides opacos admirandus est magnes, cuius operationes non fiunt per attractionem, sed circumpulsione corporum magneticorum vi exhalationis magneticae e tellure versus septentrionem vel austrum exhalantis." Schoock, *Admiranda methodus*, 228. Regius's succinct explanation is based on the idea of a circular thrust, which Plato used to explain magnetism shortly after the discussion of respiration in his *Timaeus* (see 79e–80c). Later in the *Fundamenta physices* – where Regius appropriates Descartes's explanation of magnetism from the *Principia*, and based on the idea of 'screwed particles' that move through the poles and create a vortex around the Earth – Regius would establish his originality on this topic, as he states: "[E]x his [i.e. from his Cartesian explanations] patet, verum esse illud Platonis, apud Galenum nostrum in Timaeo dicentis, magnetem non per attractionem sed circumpulsionem agere, quod, ut dicam quod res est, mihi iam ante multos annos occasionem, veram magneticarum operationum causam investigandi et proponendi, primum dedit." Regius, *Fundamenta physices*, 141–142. This digression reveals Descartes's fears that Regius might anticipate him in publishing a full-blown 'new philosophy' as well as Regius's

more radical than that of Descartes, who reprimanded his Dutch ally rather sternly for his move.[53]

Eventually, Regius's theory of the human body was presented in full in his *Physiologia*. In this text, Regius unifies the heart of the matter, i.e., his 1640 physiology (which explains only concoction, pulse, and respiration), with the full body, i.e., an account of all the processes traditionally associated with the vegetative and sensitive functions.

attempt to go beyond the theories of his correspondent. Indeed, Descartes did not develop his theory of magnetism until 1643, while preparing the fourth part of his *Principia* (see Desmond M. Clarke, *Descartes: A Biography* (New York, 2006), chapter 10). Moreover, it reveals Regius's source for respiration, as well as magnetism. Indeed, Galen discusses both topics while commenting upon three *textus* from the *Timaeus*, in the mentioned *Fragmentum* (see Galen, *Opera… Prima classis naturam corporis humani… complectitur* (Venice, 1550; 1st ed. 1641), ff. 289v–290r, reporting the text from *Timaeus*, 79a–80c).

[52] "Particulae […] in coctione […] aliam induunt conformatione, quae consistit in convenienti partium magnitudine, figura et situ, in quibus omnibus nihil videmus quod substantialem mutationem redoleat." Regius, *Spongia*, 6–7. On *situs* see below, n71.

[53] "Je ne veux rien du tout nier […] leurs formes substantielles, leurs qualités réelles, et choses semblables, mais […]il me semble que mes raisons devront être d'autant plus approuvées, que je les ferai dépendre de moins de choses." AT VI, 238–239. It is worth noting here that Regius's name figures – for the first time after Mulerius's disputation *De thorace* (which is traditional in content, and in which he was only the *respondens*) – in a disputation presided over by Reneri on 17 March 1638, when Regius was not yet a professor. Regius figures in the dedication among the "promotoribus ac fautoribus" of the *respondens*'s, Antonius Mudenus's, studies. The disputation, entitled *Disputatio physica continens theses aliquot illustriores*, was recently discovered and discussed by Robin Buning, who notes the "fact that this disputation differs so much from Reneri's other disputations" and that "the

Regius provides a complete account of "natural" actions, i.e., the traditional vegetative functions, as depending only on the "temperament" and "conformation" of the body: *alitura* (i.e., nutrition and growth) and generation. Moreover, he explains "animal" actions, i.e., those performed jointly by mind (a separate, immaterial substance) and body.[54] Regius thinks of both kinds of function in terms of flows and the distribution of particles, in which the heart is the engine (or the furnace, given the fact that it is moved by boiling blood) which sustains all

medical character of the disputation and its dedication to, among others, Henricus Regius strongly suggest that the latter was involved to some extent" (Buning, *Reneri*, 163–164). Indeed, in the disputation we find 1) an essential theory of nourishment in which substantial forms are criticized, with ideas which will be typical for Regius (i.e. the recourse to a principle of economy and the rejection of the generation of forms from nothing: "I. […] nullam formam substantialem ponere est necesse, quae sit principium operationum plantae […]. V. In chyli, sanguinis, lactis, seri et spirituum generatione nulla intervenit generatio substantialis, qua nova substantia, quae ante non fuerat, producantur," Reneri, *Disputatio*, theses 1 and 5); and 2) a theory of sense perception and movement of muscles which is a summary of Descartes's theory, as given in the *Dioptrique*, and which would be present in Regius's *Physiologia* in all its parts (theses 13, 17, 19, 20, 22). What is missing from this disputation – strangely enough, as its author proves to be an attentive reader of Descartes – is an account of blood circulation. This omission might have been motivated by the highly controversial nature of the issue in the late 1630s. The relinquishment of the idea of substantial forms in this disputation does not seem to have raised any issues at Utrecht. On Descartes's reprimand to Regius, see the Descartes's letter to Regius of late January 1642 in Bos, *Correspondence*, 98.

[54] "Actiones […] naturales sunt quae a sola partium natura seu temperie et conformatione fiunt et perficiuntur." Regius, *Physiologia*, 17. Animal actions are 1) cogitative (understanding – including sense perception, memory and imagination – and will) and 2)

physiological processes. For vegetative functions, blood circulation serves the distribution of particles that restore the "substance of the body" according to their fit for the different pores of the organs.[55] For the sensitive functions, the rarefaction of blood in the heart enables the production of the 'animal spirits' necessary to communicate movement through the nerves.[56]

2.5 Regius's cunctarum exordia rerum

In sum, while Regius gradually appropriated from Descartes the 'mechanisms' of the functioning of the body (above all the models of blood circulation, sense perception, and muscular movement), he cooked them up, as it were, into a complete physiology, which he could not find in Descartes's texts. After all, according to Regius – and all the physiologists of his time – the human body does not only show a visible conformation, i.e., a 'quantitative' organization of its parts, but also a temperament, a concept that is entirely absent from Descartes's *Essais*. By the same token, another key ingredient of medical physiology, a theory of mixture, was also missing. Generally speaking, Regius needed a more complete theory of matter, which was capable of explaining medical notions like mixture, temperament, health and disease.

The fundamental notions of Regius's physiology may then be summarized as follows:

1) 'Matter': A three-dimensionally extended substance, of which quantity is not an accident.[57]

automatic or sensitive, i.e. simple perception and appetites; see ibid., 33. On the mind, see ibid, 5, and on *alitura*, 18.

[55] Ibid., 29.

[56] Ibid., 4.

[57] "Substantia in longum latum et profundum se extendens," ibid., 16; cf. Regius, *De illustribus quaestionibus*, *secunda*, thesis 7: "[M]ateria a magnitudine realiter non differt:

2) 'Form': Regius uses this term to denote the "comprehension" (*comprehensio*) or combination of movement, rest, dimension, position or disposition (*positura* or *situs*), as well as the figure of any parts of matter constituting a body.[58] For him, forms are the real, primary qualities (henceforth 'PQs') of matter, which in a much-quoted distich he defines, together with matter and mind, as the "beginnings of all things" (*cunctarum exordia rerum*).[59] The forms are, however, only "accidental or rather modal qualities" of matter.[60]

3) 'Temperament' (*temperies*): A composition of the PQs of the particles

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atque ideo nemo recte dixerit quantitatem esse accidens."

[58] For the quotation on "comprehension" see below, n60. According to Goclenius's *Lexicon*, 'comprehensio' refers to the containment of many things in one; see Rudolph Goclenius, *Lexicon philosophicum* (Frankfurt, 1613), 425. 'Situs' and 'positura' were synonyms; see Stephanus's *Dictionarium seu Latinae linguae thesaurus*, vol. 2 (Paris, 1543; 1st ed. 1532), 1121.

[59] "[N]ec […] ullas […] qualitates imaginamur, quae proprie loquendo primae sint, et omnium corporum differentias constituant, praeter illas […]: Mens, mensura, quies, motus positura, figura, / Sunt cum materia cunctarum exordia rerum." Regius, *Physiologia*, 5.

[60] "Omnes enim […] sunt tantum accidentariae, vel potius modales quaedam qualitates […] forma nihil aliud revera sit, quam comprehensio motus vel quietis, item magnitudinis, situs et figurae partium materiae." Ibid., 18. See also Regius, *De illustribus quaestionibus, secunda*, thesis 16. In the scholastic tradition, figure, *situs* and movement were considered modes (i.e. modifications of substance not amounting to accidents, yet positive beings), quantity an accident, and rest as a privation of movement; see Franco Burgersdijk, *Institutionum metaphysicarum libri duo* (Leiden, 1640), 44–47, 362; idem, *Institutionum logicarum libri duo* (Leiden, 1626), 22, 133.

constituting visible bodies and allowing them to perform actions.[61] 'Temperament' and 'form' – that is, the 'comprehension' of PQs – are overlapping concepts in Regius's theory.

As for his sources, Regius may have found his first inspiration for some of these ideas in Lucretius's *De rerum natura*. Lucretius used the phrase 'cunctarum exordia rerum' three times to describe atoms which, provided with figure, shape, and movement, are the source of all variety among the visible bodies.[62] Lucretius was generally a prominent source in the seventeenth-century's 'atomist revival.' He influenced – among others – Francis Bacon who, in turn, exerted a notable influence on Regius's friend Henricus Reneri, and who used the expression *exordia rerum* in his *Descriptio globi intellectualis* (not published until 1653) to distinguish between the Aristotelian elements, which he took to be the visible masses of bodies (*collegia rerum*) produced by the moveable 'texture' of matter.[63] In his *Sylva sylvarum* (1626), a text that Regius may have read, Bacon furthermore ascribed the processes of "concoction, maturation, putrefaction, vivification" to the "motions of the minute parts of bodies," exploiting – as Guido Giglioni has recently emphasized – the dynamical aspects of Lucretius's poem: "Bacon moved from an understanding of atoms in terms of actual

[61] "Bona temperies a nobis definitur: situs, figura, quantitas, et motus vel quies particularum insensibilium partes sensibiles constituentium, actionibus perficiendis conveniens." Regius, *Physiologia*, 5.

[62] See Lucretius, *De rerum natura*, II, vv. 333–341: "Nunc age, iam deinceps cunctarum exordia rerum / qualia sint et quam longe distantia formis / percipe, multigenis quam sint variata figuris […]"; see also III, vv. 31–40 and IV, vv. 26–36.

[63] Francis Bacon, "Descriptio globi intellectualis," in *Scripta in naturali et universali philosophia* (Amsterdam, 1653), 75–154, 89. On Reneri and Bacon see Buning, *Reneri*, chapter 4.3.

substances to one […] in that the dynamic aspect of matter became more important […]. Bacon had certainly read of this kind of dynamic atomism in Lucretius's […] *cunctarum exordia rerum eterno percita motu*."[64]

But there may also have been a more direct Baconian influence on Regius himself, as Paolo Farina has recently argued, as they both endorsed a non-atomist but corpuscular worldview, in which "real particles", composed by a *fluxa materia*, can change.[65] Traces of Bacon's idea of a flexible, 'pliant' matter are not actually found in the final versions of Regius's early texts, but Descartes's textual interventions suggest their initial presence. For

[64] See Francis Bacon, *Sylva sylvarum or A Naturall History in Ten Centuries* (London, 1626), Century 1, § 98; Guido Giglioni, "Lists of Motions: Francis Bacon on Material Disquietude," in idem, James A.T. Lancaster, Sorana Corneanu and Dana Jalobeanu, eds., *Francis Bacon on Motion and Power* (Cham, 2016), 61–82, 63. On the reception of Lucretius in Bacon and in the seventeenth century, see Benedino Gemelli, *Aspetti dell'atomismo classico nella filosofia di Francis Bacon e nel Seicento* (Florence, 1996).

[65] "Neque propterea res deducetur ad atomum, quae praesupponit vacuum et materiam non fluxam […] sed ad particulas veras, quales inveniuntur." Francis Bacon, *Novum organum scientiarum* (London, 1620), book 2, aphorism 8. Cf. Regius, *De illustribus quaestionibus*, *secunda*, theses 10–11: "Partes insensibiles […] non sunt atomi, […] nec semper eiusdem sunt magnitudinis aut figurae." See Paolo Farina, "Il corpuscolarismo di Henricus Regius," in Ugo Baldini, Paolo Farina, Francesco Trevisani and Giancarlo Zanier, eds., *Ricerche sull'atomismo del seicento* (Florence, 1977), 119–178,139–140. The article explores the Baconian climate in the Dutch scientific context of the early seventeenth century and the relations between Gassendi and Regius, mostly through an analysis of the various editions of Regius's *Fundamenta physices* (Amsterdam, 1646; 2nd ed. as *Philosophia naturalis, editio secunda* (Amsterdam, 1654); 3rd ed. as *Philosophia naturalis, in qua tota rerum universitas, per clara et facilia principia, explanatur* (Amsterdam, 1661)).

instance, commenting upon a draft version (now lost) of Regius's *Physiologia*, Descartes suggested a change that may reveal such an early Baconian influence on Regius. In the relevant letter, Descartes suggests to Regius that he correct his claim that condensation of air is due to the condensation of its singular particles: For Descartes, this process is due to a condensation of the whole mass instead.[66] For Bacon, the phenomenon of condensation can be explained in terms of such a *plica materiae*, which he opposes to Leucippus's and Democritus's atomist explanation, in which rarefaction is explained with the introduction of a vacuum between the atoms.[67] This correction shows that Regius originally had a more 'dynamic' view than Descartes of the changes that singular particles underwent, one that strongly resembled Bacon's 'pliant' matter.

This notwithstanding, Descartes's influence on Regius's *exordia rerum* is, of course, undeniable, even though it was certainly tempered by other sources. For instance, *exordium* 1) ('matter') is clearly a trademark of Cartesian philosophy.[68] Moreover, in his *Essais*, Descartes had replaced the notion of mixture with those of "size, figure, arrangement and movement of parts of bodies," all of which were integrated into Regius's *exordia rerum* (to

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[66] "Ubi habes: *vicinus aër cuius particulae*, etc., mallem: *vicinus aër* qui, etc. *potest*; neque enim singulae particulae condensantur, sed totus aër, per hoc quod eius particulae magis ad invicem accedant." Descartes to Regius, June 1641, in Bos, *Correspondence*, 74.

[67] Cf. Bacon, *Novum organum*, book 2, aphorism 48.

[68] See Descartes's *Discours*, AT VI, 36. Notably, by providing this idea of matter, Regius quotes and rejects definitions given in Burgersdijk's works, for instance, "materia enim eorum non est aliquid, nedum corpus, sed tantum *ens in potentia*, imo *pura potentia*." Regius, *Physiologia*, 50; italics by Regius (marking the text present in Burgersdijk's textbook); cf. Burgersdijk, *Idea*, 12–13; see also Regius, *De illustribus quaestionibus*, *secunda*, thesis 6, cf. Burgersdijk, *Idea*, 12.

which Regius added the state of rest).[69] At the same time, there were also precedents for such ideas. Regius's Cartesian idea of matter can partially be traced back to Philoponus and the notion that 'indeterminate dimensions' pertain to the essence of matter.[70] This position, as will be shown below, was also assumed by Santorio. What this amounts to is that Regius fundamentally was a 'Cartesian,' but one who relied more on the Descartes *pour les honnêtes hommes*, i.e., the Descartes of *Le monde* and the *Essais*, rather than the more professional philosopher of the *res extensa*, i.e., the author of the *Meditationes* and the *Principia*, two works that aimed to provide his scientific theories with a metaphysical foundation.

We must indeed exclude Descartes's *Meditationes* (which he received in the spring of 1640) from Regius's sources for two reasons. First, Regius did not adopt the definition of local motion that Descartes provides in this text, i.e. local motion as a change of *situs*, but he relied on the customary definition of local motion as change of place (*locus*).[71] It is to this

[69] See Descartes's *Dioptrique*: "[S]elon l'opinion de plusieurs Philosophes, tous ces corps ne sont faits que des parties des éléments diversement mêlées ensemble; et selon la mienne, toute leur […] essence, […] ne consiste qu'en la grosseur, la figure, l'arrangement et les mouvements de leurs parties." AT VI, 227.

[70] See Jacopo Zabarella, *De prima rerum materia*, II, 12, in idem, *De rebus naturalibus libri XXX* (Venice, 1590), 205; cf. Philoponus, *De aeternitate mundi contra Proclum*, ed. Hugo Rabe, vol. 2 (Leipzig, 1899), 412–415.

[71] "[D]e loco in locum progressionem: itaque per hunc intelligo solum motum localem." Regius, *De illustribus quaestionibus*, *secunda*, thesis 18; cf. Descartes's *Meditationes*, AT VII, 43: "Situm, quem diversa figurata inter se obtinent, et motum, sive mutationem istius situs;" and Burgersdijk, *Institutiones logicae*, 46: "[S]itus est ordo partium inter se. […] Etsi autem situs mutari non possit sine motu locali, qui est motus ad ubi, non est tamen situs cum ubi confundemus." As to the other PQs, Regius only provides a definition of *mensura*, intended to encompass every kind of quantity; see Regius, *Physiologia*, 5.

change that Regius reduces all other traditional kinds of change, such as generation, corruption, accretion, diminution and alteration.[72] Second, Regius, even though he considers matter an extended substance, admits the possibility of a vacuum in a corollary to his *De illustribus quaestionibus*.[73] By contrast, in his *Meditationes*, Descartes famously distinguished between a *res extensa*, or matter, and a *res cogitans* that was *non extensa*, i.e., mind: A position that logically excludes the existence of any extension deprived of matter.[74]

In sum, Lucretius, Plato, and then Descartes provided Regius with some of the fundamentals that helped him develop an abridged and clearer physiology. Obviously, the sources cited so far are not sufficient to explain his entire program. In what follows, I will analyze other pre-Cartesian sources for Regius to shed further light on the reasons for his appropriation of Descartes's theory of blood circulation and sense perception on one hand, and to integrate these elements into a broader physiology on the other. This will allow me to provide an answer to my first question (i.e. who was Regius, doctrinally speaking, before his exposure to Cartesianism?), by shedding light on Regius before his encounter with Descartes. This analysis will also provide an additional insight into Regius as Descartes's cooperator, which is the object of the second research question of this article.

3. Regius's Medical Sources: Heurnius and Santorio

In this section I analyze Regius's foremost pre-Cartesian medical sources, which I have identified in Johannes Heurnius (1543–1601) and Santorio Santorio (1561–1536). As reported by Graevius in his *Oratio funebris Henrici Regii*, Regius had used Heurnius's

[72] "[M]otus generationis, corruptionis item accretionis et decretionis, nec non alterationis, sunt tantum varii motus locales particularum insensibilium." Ibid., 5.

[73] "II. An sublata subtili materia detur vacuum? Aff." Regius, *De illustribus quaestionibus*, *secunda*, "Corollaria."

[74] AT VII, 44.

Institutiones medicinae (1592) in his first university lectures.[75] We may therefore assume that the *Institutiones* partially conformed to the ideal of a clear system of medicine that Regius mentioned in the dedicatory letter to his *Fundamenta medica*. As for Santorio, he was one of the very few medical authorities explicitly mentioned by Regius, who referred to him as his preceptor.[76]

3.1 The 'erosion' of total substance and occult qualities as medical concepts

First and foremost, Heurnius, Santorio and Regius all rejected Fernel's idea of total substance and its related concepts, i.e., occult qualities and faculties. For Heurnius, this rejection follows from the effort to "make medicine conform to philosophy," or to "philosophize more highly," that is, according to Aristotelian philosophy. Since, for Aristotle, the soul is the first act of the organic body and is numerically one, it acts, according to Heurnius, by using the temperament and the structure of the body (which are accidental forms) as its only instruments.[77] If one supposes the existence of faculties "flowing" from the "bosom" of the

[75] Graevius, *Oratio*, 16.

[76] Regius, *Physiologia*, 29.

[77] "Qui philosophiae vestigia sequi volet, et medicinam conformem reddere philosophiae, ille definiet facultatem esse: actionum quas res quaeque edit proximam et praecipua causam, vel, ut brevius dicam: rei cuiusque formam. Sed quemadmodum duplex forma a philosophis statuitur, ita quoque duplex statuenda facultas. Accidentalis quidem, ex quatuor elementorum proportione nata temperies: essentialis vero peculiari nomine caret, et in rebus viventibus dicitur anima; […] a medicis totius rei substantia, unde apud medicos orta fuerunt occultas rerum proprietates. Animam autem definit Aristoteles esse actum primum corporis organicis, viventis potentia: primam, praecipuam et moventem actionum causam. Hanc quidem philosophi ex variis operibus qua exercet varia natura esse existimaverunt. Sed si qui altius philosophari volet, non sine magna ratione, animae formam unam statuere possit, quaeque

soul, this would imply that the soul has parts which are from time to time annihilated.[78] Therefore, the diseases Fernel attributed to the "total substance" and to the matter of the body itself are reduced either to temperament (which is an accidental form), or to external causes. And those qualities traditionally called "occult qualities," then, are reduced to an unknown combination of manifest qualities rather than to the corruption of the total substance of the body.[79] According to Fernel, by contrast, occult qualities could not be reduced to a combination (known or unknown) of 'elementary' qualities, which is why he postulated their origin in the soul and in celestial heat.[80]

dividi in varias partes et formas nequeat; unicam suapte natura possidens facultatem, qua varia munera exerceat: quod instrumenta quibus utitur sunt diversa temperie et structura." Johannes Heurnius, *Institutiones medicinae*, in idem, *Opera omnia* ([s.l.], 1609; 1st ed. of the *Institutiones* 1592), 21.

[78] "Alii […] dixere facultatem esse vim atque potentiam vernaculam, maximeque propriam animae, quam anima suo veluti de sinu profert ad munerum functiones. Sed haec opinio absurdi […] aliquid continet […]. Verbi gratia: facultatem auctricem in vigore corporis aboleri." Ibid., 20–21.

[79] "[Q]ui medicinam cum philosophia conformem reddere conabitur, morbos formae vel totius substantiae eos duntaxat agnoscent, qui ex incerto, seu nobis incognito intemperies gradu, dependent. […] Quos autem ponit materia morbos, materiae intemperiem, eiusve puritatem, vel propriam formam sequuntur, aut occasionem externam, ut callus a corpore duro." Ibid., 58.

[80] Heurnius's ideas can be put into the context of the gradual evolution of the idea of 'occult qualities' which has been analyzed by Keith Hutchison. According to Hutchison, if occult qualities were intended as not manifest in the Renaissance, or not perceivable by senses, and for this reason excluded from the realm of natural philosophy, in seventeenth century they were increasingly included in scientific theories: "[M]any leaders of the Scientific Revolution

Santorio adopts the same view in his *Methodi vitandorum errorum omnium, qui in arte medica contingunt libri* (1603), but he is far more radical. Beyond the programmatic aspect of his theories his case is interesting in that he offered Regius further elements to compose his own physiology. First, he provided Regius with additional arguments against total substance. In book 8 he criticized "innovators of diseases" such as Fernel, for whom "substance brings about that potency of acting and operating without the work of heat, cold, humid, and dry, but […] by itself, […] without any interposed instrument."[81] Santorio does so by means of two clock analogies which were uniquely used by himself and in Regius's

can be seen to be explicitly urging the acceptability of occult qualities. When they appear to be recommending the abandonment of occult qualities, close examination reveals that they are instead objecting to the earlier […] use of substantial forms as causal explanations […]. With the acceptance of insensible agencies into the scope of natural philosophy, the word 'occult' lost its connotation of 'insensible' and henceforth referred solely to unintelligible." Keith Hutchison, "What Happened to Occult Qualities in the Scientific Revolution?" *Isis: A Journal of the History of Science*, 73 (1982), 233-253, 233.

[81] "Qui vero admittunt qualitates totius substantiae, quas alio nomine vocant occultas, inter quos est Fernelius, […] et alii plures medici, eas non putant referri posse ad primas, vel ad alias manifestas, […] ratio vero cur ab illis qualitas, quae a primis non pendet, vocetur occulta, est, quia putant, hanc esse substantiam operantem, quae sua natura est occulta, et incognoscibilis, dicuntque substantiam non opificio calidi, frigidi, humid, vel sicci, sed primo, per se, et immediate nullo interposito strumento illam agendi, seu operandi potentiam sortiri, et has qualitates occultas dici totius, et solius substantiae. […]. Morborum innovatores conantur probare […] quod dentur qualitates occultae a substantia emanantes, quaeque nullam communionem habeant cum calido, frigido, humido, et sicco, et aliis has primas insequentibus." Santorio Santorio, *Methodi vitandorum errorum omnium qui in arte medica contingunt libri quindecim* (Venice, 1603), ff. 151v–152r.

Physiologia. First, the mechanical clock serves him to show that the idea of substance is useless in physiology. As in the case of mechanical clocks, he argues, what is required for the formerly so-called 'potencies of the soul' to act are merely the figure, placement (*situs*) and measures of the body, which are "conditions [that] do not pertain to the substance" and can be changed outwardly while "substance remains the same"; change can thus be explained without invoking a substantial "transmutation."[82] Regius would later adopt the same ideas. In his *Spongia* he claimed that features such as *situs* and figure can change in concoction "without any substantial mutation."[83] In the *Physiologia*, after having presented the *vis vegetativa* and *sensitiva* as consisting only in the "apt temperament of the well conformed human body," and as the "nature" of the body itself, he claims that substantial forms are not required in the explanation of vegetative and sensitive operations, as invoking them entails a multiplication of entities beyond necessity. Again, just as in the case of mechanical clocks, one can explain their function by considering bodily conformation alone.[84]

[82] "[P]otentias, vel aptitudines immediate pendere non a substantia […], ratio est, quia posse agere requirit talem figuram, talem situm, et talem numerum, quae conditiones non pertinent ad substantiam; nisi enim in horologio esset talis orbiculorum vel rotarum situs, numerus, et figura, […] nihil ad usum magis […] conferret […]. Possem hic plura exempla afferre, […] canto res canendi potentiam non a substantia, sed ab optima constitutione pectoris […]. Signum, quod res ita sit, est quia tollitur canendi potentia si larinx obstruitur […] eadem semper manente substantia. […]. Patet ergo, potentias non pendere immediate a substantia […] per transmutationes." Ibid., f. 155r–v.

[83] See above, n52.

[84] "Hae duae itaque [i.e., *vis vegetativa* and *sensitiva*] (quae natura corporis appellari possunt) nihil aliud sunt, quam corporis humani apte conformati apta temperies: quandoquidem omnes illarum operationes ab hac ita fieri queunt, ut in horologio et aliis automatis plurimae actiones admirandae a sola partium conformatione peraguntur: ita ut non opus sit aliquam

Santorio's influence on Regius is confirmed by a second use of the analogy of the clock, which Regius invokes in relation to the occult qualities. In his *Physiologia*, when he quotes Fernel's definition of the 'total substance', he criticizes his attribution of the intemperateness of the so-called 'occult qualities' to the corruption of this total substance. Given that, for Regius, all (material) forms are reduced to comprehensions of PQs, and that matter is mere extension, it is obvious that for him Fernel's so-called 'intemperateness of occult qualities' and the whole concept of the 'intemperateness of matter' are, in fact, due to a "usually […] unknown" combination of the "often recalled five principles," that is, Regius's abovementioned PQs.[85] However, for Regius, such combinations are only temporarily unknown. To elucidate his viewpoint he uses an anecdote concerning a mechanical clock that Santorio had used for exactly the same purposes. According to the anecdote Girolamo Cardano once presented to Pope Clement VII a stone with a spot that completed a circle around the stone in 24 hours. In his *Commentaria* (1554) on Ptolemy's *Tetrabiblos* Cardano

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substantialem incognitamque formam hic vel alibi in similibus fingere, entiaque contra verissimum philosophiae dictatum, multiplicare absque necessitate." Regius, *Physiologia*, 15–16. On Santorio's use of forms, see below, n91 and n110.

[85] "Occultarum qualitatum intemperiem […] ex manifestioribus rationibus communiter nequeunt explicari. […] Haec intemperies a Fernelio morbus formae et totius substantiae corruptela vocatur […]. Sed cum praeter mentem et materiam corpoream, quae oppugnari a morbis non possunt, in nobis nihil substantiale contineatur, reliquaque omnia, quae in nostro corpore inveniuntur, tantum sint accidentariae, quaedam qualitates, quae ex quinque principiis antehac saepe commemoratis originem ducunt, nullus morbus substantiae vel formae substantialis corruptela est dicendus. Tum autem occultae qualitates et formae substantiales rebus attribui solent, cum accidentarias istas qualitates ex claris istis principiis explicare non possumus." Ibid., 53.

had used this example as evidence for the existence of occult qualities.[86] Santorio, in book 8 of his *Methodi vitandorum errorum libri*, and then again in his *Commentaria in primam fen primi libri Canonis Avicennae* (1625), reports that after the death of Cardano the stone was opened, and a clock (equipped with a spring) was found inside it.[87] Regius reports this story to reinforce his argument that occult qualities can be reduced to manifest qualities.[88]

3.2 Santorio's theory of matter and heat

The clock analogy – especially the case of Cardano's clock-driven occult stone – establishes a clear connection between Regius and Santorio. Santorio had used this anecdote to criticize the traditional hierarchy of physiological qualities. While Regius does not follow the same argument, he does appropriate Santoro's conclusion, the formulation of a new concept of

[86] Girolamo Cardano, *In Cl. Ptolemaei… De astrorum iudiciis, aut, ut vulgo vocant, Quadripartitae constructionis, libros commentaria* (Basel, 1554), 10–11.

[87] "Audias quomodo Hieronymus Cardanus […] hallucinatur: refert […] se lapillum vidisse, qui ob eius excellentia aderat in potestate Pontificis Clementis Septimi, in cuius superficie erat […] macula, quae in orbem tractu 24 horarum ad instar solis movebatur. […] [E]am statim in cathalogo reconditarum a substantia prodeuntium recensuit. Vel maxime fuit deceptus, quia maculae circularis motus (sicuti deinde auditum fuit) a situ, numero et figuris internis prodierat; quoniam […] lapillus […] poterat aperiri, et in eius cavitate erat spira chalibaea." Santorio, *Methodi libri*, f. 160r–v; cf. Santorio Santorio, *Commentaria in primam fen primi libri Canonis Avicennae* (Venice, 1660; 1st ed. 1625), cols. 127–128.

[88] "Huius rei exemplum aliquatenus nobis suppeditat gemma illa tempore Cardani Clementi septimo Pontifici Romano donata, quae habebat naeuum spatio 24 horarum circulum percurrentem. Hic enim a spira chalibea circumrotabatur, quod quamdiu non innotuerat, gemmae ab istius saeculi philosophis adscribebatur qualitas occulta vel forma substantialis, circularis istius motus autor." Regius, *Physiologia*, 53.

matter and a new theory of heat.

Santorio claimed that Cardano and Fernel had reverted to occult qualities because they could not reduce the so-called 'moving faculty' to the temperature of primary qualities. Santorio turns the evidence around by claiming that the movements of animals may be explained in the same way as the movements of clocks, just by considering the qualities of the number, *situs*, figure and size of its parts (traditionally counted among the organic or derived qualities), which can change even if the temperature of the first qualities is unchanged. In Santoro's eyes, the case of the clock – and by extension that of animal movements – showed that mechanical features provided a sufficient explanation for the movements of animals, and consequently that "the four qualities [are] not the first of all [qualities]," because a change in the supposedly derived qualities can be independent from a change in the temperature of the primary qualities.[89] A substantial trace of this argument can

[89] "Ostenditur horologii exemplo quatuor qualitates non omnium primas. […] Nemo sane mentis dicet horologii potentiam a temperatura prodire, sed a numero, situ et figura rotarum, orbiculorum et spirae chalibeae, […]; quare, si in artefactis dentur potentiae motrices non pendentes a temperatura, cur plurimi sunt adeo audaces ut ignorantiae crimen illis inurant, qui a situ, et a caeteris differentiis positionum sine ulla alteratione quatuor qualitatum putant plurimas virtutes prodire posse? Eademque de causa nimis audax fuit Fernelius, dum omnes motrices potentias animatorum retulit in substantiam: habet enim haec verba lib. de abditis rerum causis, stupidi homini est credere animalis motum fieri a quatuor qualitatibus, quam revera omnis potentia movendi debat referri ad substantiam. Quo pacto vir lepidissime ad substantiam vis referre, si humanus artifex varias dat virtutes motrices metallo mutando figura, situm, et numerum rotarum: quanto facilius alma parens natura, quae rotas, et (ut ita dicam) spiras viventes diviniori artificio efficere potest, potentias motrices in iis collocabit? […] Cardanus itaque et Fernelius in hoc praecipue sint decepti, quia dum videbant, motrices potentias non posse referri ad quatuor vocatas primas, putabant aliud non posse referri quam

be found in Regius's *Physiologia* where, besides invoking the abovementioned principle of economy, Regius claims that experience often shows that, when secondary qualities (such as weight, density, acidity, etc.) change, the temperament of first qualities (hot, cold, dry and humid) may nevertheless remain unchanged. Therefore, he claims that the consideration of only the first four qualities is insufficient in physiology.[90]

This 'detachment' of primary from secondary qualities led Santorio also to rethink the entire "series of accidents," seeking a way to account for those occult potencies that Fernel, unable to reduce them to the traditional order of primary and secondary qualities, needed to attribute to total substance. Santorio looks for an alternative explanation in Aristotle's texts. Among others, he appeals to the eighth book of Aristotle's *Physica*, according to which all celestial and sub-celestial changes depend on the different *situs* assumed by the First Moveable. From this changing *situs*, other qualities follow: First come rarity and density; then rarity and density and density produce hot, cold, humid and dry; hardness and softness follow in turn, and finally, figure. This new chain of qualities or accidents provides the source

ad substantiam." Santorio, *Methodi libri*, f. 160r–v. Santorio may have been referring to this sentence in Fernel: "Quid dici potest obtusius, quid perversius, quid intolerabilius, quid inscitius, quam temperaturam causam motionis haberi, quae nihil sola, ne eius principium quidem efficere possit?" Fernel, *On the Hidden Causes*, 508.

[90] "Et quidem ii qui temperiem moderatam in aequalitate quatuor qualitatum quas primas vocant, consistere imaginantur, temperiem etiam omnem immoderatam ad illis reducunt […]. Quod non sufficere perspicuum est ex eo, quod facile possit contingere, ut manentibus istis quatuor qualitatibus in eodem gradu, temperies compositi mutetur." Regius, *Physiologia*, 9. The *temperies compositi* is nothing but the combination of (old) derived or secondary qualities, as clarified in Regius's *Fundamenta physices*, as he adds (at page 108) "dum scilicet illud [corpus] sit vel asperius, vel laevius, vel acrius, vel tenius, vel rarius, vel densius."

of all assumed occult potencies and faculties, which can be ultimately reduced to quantitative features of matter, "or threefold dimension," because the changes in *situs* of the first moveable are nothing but the spatial changes of the reciprocal positions of the parts of matter. To those objecting that quantity is an accident, Santorio answers that he agrees with Philoponus on the concept of three-dimensional extension as the essence of matter, which becomes the "first root of all the accidents," once it is "determined" by substantial forms (whose existence is assumed by Santorio both here and in his *Commentaria in primam fen*).[91] Regius, then, may have appropriated this idea of matter from a tradition that preceded his acquaintance with Descartes's thought; conversely, this tradition may have positively disposed him towards Cartesianism.

Finally, Santorio is aware that this theory contradicts the standard hierarchy of qualities as given in *De generatione et corruptione*, but he points out that Aristotle himself had not been very clear on the order of such qualities as heat and rarity.[92] Moreover,

[91] "Aristoteles 8 Phys. […] varietatem […] refert […] ad primum corpus, quod octo differentiis positionis […] faciet tam varium situm: a situ orietur raritas, et densitas, a raritate et densitate calidum, et frigidum, durum, molle: ab iis tertia species qualitatis, quae est passio, et passibilis qualitas, et quarta, quae est figura: a tertia et quarta specie oriuntur potentiae, ut a primo ad postremum corpus, vel trina dimensio, quae est ipsamet materia, quaeque causare potest omnes differentias positionis est prima omnium accidentium radix. Neque obiiciat trinam dimensionem esse accidens: quia cum Philoponus sustinebimus corpus, vel trinam dimensionem esse ipsammet materiam prima, quae statim dum terminatur a forma differentias positionis efficit, unde situs, unde raritates […] et demum potentiae, quae ab accidentium serie, per inde ac ab una cathena omnes tam manifestae, quam occultae oriantur." Santorio, *Methodi libri*, f. 157v. Cf. Aristotle, *Physica*, VIII, 260a25–261b16. On the *Commentaria in primam fen*, see below, n110.

[92] Santorio, *Methodi libri*, f. 158r.

empirical evidence is contradictory, as in some cases rarity precedes heat, while in other cases heat rarifies matter, and from this other qualities follow: For instance, heated urine becomes transparent as heat changes the *situs* of its "minimal particles." Santorio attempts to solve this problem by seeking a common cause for both rarity and heat, and finds it in the fast movement of the particles of bodies. According to him experience shows that, when a rarefied and hot body is destroyed, a very fast motion occurs. Moreover, according to Aristotle himself, elementary fire is maintained by "a very rapid motion," which first rarefies bodies, and then renders them hot.[93] The idea that heat derives from rarefaction and that rarefaction is due to rapid movement is important once we compare, as we are going to do below, Santoro's explanation of heat with those of Descartes and Regius.

3.3 … and Regius's 'Santorian' explanation of hot and cold

In his *Météores*, Descartes maintains that heat and cold result from the movement of the particles making up the visible bodies we touch: If this movement is strong, we feel heat; if weak, we feel coldness. The main cause of the movement of the particles in bodies is due to the presence of subtle matter in their pores. If a body has pores large enough to be filled with the bigger particles of such matter, which – in accordance with Descartes's dynamics – are more forceful in motion, such a body will be hotter, because its parts will be moved more

[93] "[V]aria igitur consideratione modo raritas, modo caliditas erit prior. Quod caliditas sit quoque prior, exemplum est lotium torbidum, quod ab igne rarefaciente crassas partes, et mutante particularum minimarum situm reddi potest splendidum, et perspicuum. Sed revera, si consideraverimus prima initia caliditatis, semper raritas prius enasci videbitur, quam caliditas: quia prius a motu rarefit materia, deinde incalescit. Inter caetera exempla […] unicum debet afferri ab Aristotele desumptum, quod est de motu diurno rapidissimo, qui alio modo non generat, et conservat elementum ignis, nisi prius rarefaciendo materiam contentam sub orbe Lunae." Ibid., f. 158r–v.

forcefully. If it has small pores, by contrast, it will be colder.[94] Regius's account is different. Actual heat is the "movement in all directions" (*motus varius* or *varia agitatio*) of a body; actual cold, by contrast, is the state of rest in the particles of such a body.[95] In turn, potential heat consists of bodies' aptitude to warm up other bodies easily, or to be warmed up, while potentially cold bodies cannot easily be moved by other bodies, or impede the agitation of other bodies.[96] For Regius, "stable" or "solid" bodies can be hot or cold only in potency. For instance, a hand, which is considered a stable part (in accordance with its "permanent temperament"), cannot be considered hot or cold – *contra* Descartes.[97] True to his style,

[94] "[J]e suppose que les petites parties, dont l'eau est composée, sont longues, unies et glissantes, ainsi que de petites anguilles, qui, quoiqu'elles se joignent et s'entrelacent, […] puissent aisément être séparées; et […] que presque toutes celles tant de la terre que même de l'air et de la plupart des autres corps ont des figures fort irrégulières et inégales, en sorte qu'elles […] se lient les unes aux autres, ainsi que font les diverses branches des arbrisseaux […]. Et lorsqu'elles se lient en cette sorte, elles composent des corps durs, comme de la terre, du bois, ou autres semblables; au lieu que, si elles sont simplement posées l'une sur l'autre, sans être que fort peu ou point du tout entrelacées, […], elles doivent […] composer des corps liquides fort rares et fort légers, comme des huiles ou de l'air." AT VI, 234–235.

[95] "Tota caloris natura in solo motu consistat, quippe qui nihil aliud est quam motus varius particularum insensibilium." Regius, *Spongia*, 10. "Calor actualis est varia agitatio insensibilium particularum." Idem, *Physiologia*, 6. A summary of Regius's explanations of sensory qualities is provided in the appendix to this article.

[96] "Calor potentialis est aptitudo ad incalescendum, vel ad calefaciendum […]. Contra vero omnia corpora, quorum particulae non facile agitantur, itemque omnis, quae agitationem particularum alterius corporis apta sunt impedire, potentia frigida dici possunt." Ibid., 7.

[97] "Temperies permanens est, quae ex sola partium stabilium constitutione dependet; […]. In hac considerari quidem possunt […] calor […] et frigus non nisi ut sunt potentia, […]; neque

Regius does not provide an explanation for this claim, but it is consistent with his explanation of solidity (or stability) and fluidity, as "every kind of adhesion" and "disjunction" or "reciprocal movement" of parts respectively.[98] Since heat, for Regius, does not consist in every kind of movement of a body, but only in "various movement," i.e. movement in all directions, it follows that a solid body can never be actually hot, because if it were, it would lose its solidity.

At the same time, Regius must also explain why a solid body cannot actually be cold, given that coldness is the result of a state of rest of the particles, as opposed to their fluidity intended as the movement in all directions of its parts. To explain this we need to look at his Cartesian theory of perception. In the *Physiologia* Regius refers to the *Dioptrique*, in which Descartes had explained such "sacred things," claiming that all sensations are the result of movements transmitted via the nerves to the brain.[99] Regius integrates this theory – according to which, in principle, cold cannot be perceived as a 'positive' sensation, because nothing moves – with Santorio's idea that external coldness hinders insensible transpiration.[100] Regius's conclusion is that we perceive cold when external bodies, at rest, hinder insensible transpiration, which is equivalent to a flow of particles through our pores and results in a

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enim secundum hanc temperiem permanentem manus frigida differre putatur a calida." Ibid., 12.

[98] "Stabilitas oritur ex quacunque adhaesione particularum insensibilium. […] Fluiditas fit ex disiunctione et motu particularum insensibilium." Ibid., 8.

[99] "Ut autem intelligatur, quomodo motus fibrillis nervorum impressus cerebro, ac denique glandulae pineali possit communicari, sciendum est (uti optime docet horum sacrorum mystagogus in gallica Dioptrica)." Ibid., 34; cf. AT VI, 109–111.

[100] "Frigus externum prohibet perspirationem in debili, quia eius calor dissipatur." Santorio Santorio, *De statica medicina* (Venice, 1634; 1st ed. 1614), aphorism 67.

"certain disordered movement" of particles in our body.[101]

It is thus obvious that Regius's theory of coldness leans more on Santorio than on Descartes. Equally, his idea of heat as *motus varius*, which does not actually affect solid bodies unless they are turned into fluids, is closer to Santorio's "very fast motion," which rarefies bodies and only makes them hot afterwards, rather to Descartes's generic idea of the movement of parts.[102] As a matter of fact, Regius's idea of heat is also quite distinct from both the Platonic idea that heat derives from the acute triangular shape of the particles of fire (which others, including Basson, were to copy), as well as from that according to which heat derives from the attrition of 'gross' bodies (a notion embraced by Gorlaeus) – which I will consider in section 4 below.

3.4 Santorio's mathematical medicine and his appropriation by Regius

One last observation on Regius's debt to Santorio must regard the latter's quantitative approach to medicine. In his *Physiologia* Regius praises Santorio's measurement of insensible transpiration from the *Ars de statica medicina* (1614).[103] Santorio's aim in developing this *mathematica medica* was to turn medicine into a non-conjectural discipline, and is presented in his *Commentaria in primam fen*.[104] Out of the various causes for which

[101] "Sensitur autem frigus dum ex quiete partium exteriorum corporis nostri effluvia insensibilis transpirationis, ob poros a frigore clausos, impediuntur: unde inordinatus quidam motus oritur, qui certam quandam sensationem producit, quam nos frigoris perceptionem appellamus." Regius, *Physiologia*, 6.

[102] Descartes would not connect the rarefaction of bodies to heat until his *Principia philosophiae* (II, § 6; IV, § 31).

[103] Regius, *Physiologia*, 29; cf. Santorio, *De statica medicina*, aphorism 58.

[104] The phrase 'mathematica medica' was used by Santorio in a letter to Senatore Settala of 27 December 1625. This letter is discussed in Fabrizio Bigotti, "*Mathematica medica*: Santorio

medicine was traditionally labelled a conjectural art, Santorio focused on the difficulties in quantifying disease, i.e., the measure in which a body diverges from its natural state, and in quantifying the remedies and their powers. In order to render medicine non-conjectural Santorio used instruments such as the thermometer, hygrometer, the *pulsilogium* and scales, with which he measured variations in the weight of the body, in the hope of finding ways to keep the body healthy by adding what it lacked.[105] In addition to a direct reference to Santorio's quantification of transpiration Regius's *Physiologia* also contains traces of Santorio's medical program, for instance, in Regius's endorsemet of Santorio's criticism of Fernel's theory of mixture, according to which qualities are retained unchanged in temperament, which is a sort of "concert" (*concentus*) or harmony of different qualities. For Fernel qualities are retained in their original degree in the temperament, i.e., as *summae qualitates*, without being destroyed or altered. Their reciprocal tempering, in fact, is nothing other than their diffusion in the body of the mixture. Only in this way, according to Fernel, could qualities be restored in their original proportion once the mixture was dissolved.[106] For

and the Quest for Certainty in Medicine," *Journal of Healthcare Communications* I, 4/39 (2016), 1–8.

[105] See Santorio, *In primam fen*, cols. 28 and 299, and idem, *De statica medicina*, aphorism 1.

[106] "Mistio […] est diversorum in unum atque idem concretio. […] Elementorum substantias mistio totis totas non inserit, sed qualitates duntaxat miscet atque confundit, ut per totius compositi molem aequabiliter sint fusae. […] Quae porro in hoc genito simplici corpore manent exiguae elementorum portiones, suis quidem formis integrae subsistunt, non tamen liberae aut sui iuris, sed implicitae, vinctae, et quasi interceptae mutua qualitatum pugnantia, etque etiam dignioris formae praesentiae. […]. Atque sic ut cum temperamento per obitum dissoluto ad se redibunt, partesque propriis elementis reddentur atque restituentur universitatis, nullius imperio obstrictae in libertatem vindicentur resumantque pristinas vires. […] Est […] temperamentum, non ipsa mixtio, sed mistionis ratio. Poterit et id earum quae in

Santorio, this contradicts experience: Qualities are always changed in a mixture, as shown, for instance, by the cooling of heated iron in water, or in the case of fevers which are mitigated by drinking and then vomiting water.[107] The same kind of criticism as the one put forward by Santorio is present in Regius's *Physiologia*, as he reprimands those who maintain the primacy of the four Aristotelian qualities and reduce all other qualities to them: "[E]specially those," he adds, "who, by considering those qualities always absolutely, even if

mistis elementis sunt principum qualitatum harmonia et concentus definiri, […] ut neque mistio citra efficientium qualitatum opem, neque sine elementorum omnium substantia temperamentum induci possit. […] Nam si elementorum summae qualitates ut et substantiae in permistione non pereunt, sed asservatae temperamentum constitutuunt, nihil prohibet aequis illas portionibus mistas, exquisite temperatum proferre, quod in portionis situm est aequabilitate. Licet etenim in illa aequabilitate non tanta sit mutua qualitatum actio, quae vel abolitionem vel repressionem contrariorum moliatur: tanta tamen est ut paria contraria possit confundere ac vere permiscere in unum temperamentum. Minus enim virium et inaequalitatis contrariorum temperatio desiderat, quam illorum dissolutio atque occasus." Fernel, *Universa medicina*, 107-112, 120.

[107] "Fernelius putat in omni temperatura summas vigere qualitates, id est summam caliditatem, summam frigiditatem, summam siccitatem, et summam humiditatem, additque has qualitates nihil agere: quia una aliam impedit. Hinc dicit temperaturam esse concentum, proportionem, seu rationem mixtionis quatuor primarum qualitatum. […] Hac ratione reiicitur Fernelius: primo, quia si qualitates in mixto essent summae ergo essent incorruptibiles: quia summae a sua qualitate contraria non patientur, si a sua contraria non patientur; ergo a nulla causa destrui potuerunt. Secundo, si temperatura esse concentus, seu harmonia summarum qualitatum quae nihil agunt, quia ut vult Fernelius una impedit aliam: quid aget iste Fernelii concentus? Nihil certe. […] Quod vero qualitatum excessus agant, patet experientia […] Demum his experimentis refellitur Fernelii sententia: febris ardens aliquando tollitur largo

have to be considered almost only comparatively, and not distinguishing between actual and potential qualities, have attributed determined degrees of them to singular bodies."[108] Regius, as so often, does not overtly declare his sources and his targets. However, we may suppose that in this case, too, Santorio might have directly influenced Regius when he studied at Padua, for, besides criticizing Fernel's theory of the preservation of qualities in their original degrees, Santorio in fact addressed all the points in his *Commentaria in primam fen* that are also mentioned by Regius: He provided a medical program focusing on 1) the measuring of the variations in the intensity of qualities (both hot-cold and humid-dry, by means of thermometers and hygrometers); 2) a comparison of the different qualities in different parts of one body; and 3) the assessment of potential and actual qualities.[109]

Thus far, even though the *Physiologia* does not describe any measurements of the

potu aquae frigidae, et paulo post sequitur aquae vomiti, et caloris remissio. Per Fernelium adhuc summus aestus, et summa frigiditas perseverant in membris: quia constanter tenet in quacunque temperatura vigere summas qualitates: sed quomodo erunt summae post frigidae potum? […] Praeterea iniicias ferrum candens in aquam gelidam, et statim educas, invenies aquam quendam teporem acquisivisse, et ferrum multim de calore deposuisse: quare nemo negabit ferrum egisse in aquae frigiditatem, et eam retudisse, et aquam in fervorem ferri. Ergo neque in ferro neque in aqua qualitates reliquentur summae, sed remissae." Santorio, *In primam fen*, cols. 251–253.

[108] "[P]raecipueque illi, qui istas qualitates semper absolute considerantes, quamvis fere tantum comparate debeant sumi, et potentiales ab actualibus non distinguentes, certos earum gradus singulis corporibus tribuerunt, dicentes hoc esse calidum ut duo, siccum ut tria, humidum ut duo; et sic de caeteris, quorum ea in re decretis non sine accurato examine est fidendum." Regius, *Physiologia*, 8.

[109] On point 1), see Santorio, *In primam fen*, cols. 305-313, on 2) cols. 289-290, and on 3) cols. 398-400.

temperature, weight or pulse of patients, it retains Santorio's program of making medicine a non-conjectural discipline. However, Regius seems to focus less on quantification than on the ontological premises of medicine, that is, on providing a corpuscular and mechanical theory of matter on which it can be erected. Santorio had not developed a 'mechanical' physiology: His rethinking of traditional qualities did not result in the full mechanization of the human body. As seen above, his ideas certainly contributed to the dismissal of the traditional theory of qualities and to the assumption of corpuscular explanations in medicine. Yet he still maintained the existence of substantial forms. In his *Commentaria in primam fen*, for instance, he explicitly rejected a corpuscular view of matter, as he dealt with the question "whether the forms of the elements and their qualities remain in the mixture." According to him, if elements and their qualities were preserved unaltered in the mixture – as Avicenna and Fernel had maintained – the mixture would be a mere heap, and the form of the mixture a mere accident.[110] Santorio's ideas actually seem to pre-date those of Daniel Sennert, who developed an atomist theory of matter encompassing the idea of the substantial form in the first half of seventeenth century. Thus far, we may claim that Regius interpreted Santorio's theory of transpiration from a more overtly corpuscular position, which he had acquired not only from Santorio's own criticism of the traditional theory on qualities, but also from other sources, such as Plato, Lucretius, Descartes, and – as I am going to show in the next section – Sébastien Basson and David Gorlaeus.[111]

[110] "Nos sequemur Divuum Thomam, Scotum, et alios credentes elementa, neque quoad formas, neque quoad qualitates manere in mixto. […] Fernelius, […] et Avicennas reiiciuntur: quia si elementa servarentur integra in mixto, mixtio esset iuxtapositio, et non mixtio. […] Praeterea si formae elementorum actu manerent in mixto, forma mixti esset accidens." Ibid., cols. 255–256; this is discussed in Farina, "Sulla formazione scientifica," 368–371.

[111] Fabrizio Bigotti has recently analyzed Santorio's own marginalia to his *Commentaria in*

4. Regius's Pre-Cartesian Natural-Philosophical Sources

The analyses carried out in the previous sections have shown that Regius must have been positively disposed towards some of Descartes's ideas when he first encountered them, because – roughly speaking – they matched ideas he had previously acquired from Ramus, Heurnius, and Santorio. However, this very background also made him diverge from Descartes's theory on important questions such as the explanation of hot and cold. Nevertheless, there are still a number of missing pieces in our retracing of Regius's path from his pre-Cartesian program and ideas to his appropriation of Descartes. What we are still missing are (1) his reasons for totally rejecting substantial forms and their replacement by distinctive features of matter, which he elevated to an even more radical level than Descartes; (2) the sources for his notions of natural change and causality; (3) the peculiarities of his treatment of the traditional qualities of humid and dry, and the nature of 'visible' elements.

4.1 Sébastien Basson

I wish to argue here that points (1) and (2) were appropriated by Regius mostly from the

prima fen, including a hitherto unnoticed use of corpuscular ideas by Santorio to clarify the main text, see Fabrizio Bigotti, "A Previously Unknown Path to Corpuscularism in the Seventeenth Century: Santorio's *Marginalia* to the *Commentaria in primam fen primi libri Canonis Avicennae* (1625)," *Ambix*, 64/1 (2017), 29–42. Bigotti has also drawn attention to some of Joachim Jungius's student notes (he graduated under Regius at Padua in 1618), testifying that Santorio taught corpuscular theories to his students. Regius himself, thus, may have been acquainted with Santorio's corpuscular ideas from the latter's lectures, alongside reading his published works. In other words, the impact of Santorio's corpuscularism on Regius might have been bigger than suggested in Santorio's published texts. Bigotti has also noted the possible influence of Santorio on Sennert.

Philosophia naturalis adversus Aristotelem (1621) by Sébastien Basson (ca. 1573– after 1625).[112] In particular, Regius took from Basson a) a particular definition of nature; b) his main argument against substantial forms; and c) a particular theory of natural causation.

4.1.1 The definition of nature of Basson and Regius

As for Regius's use of Santorio's anecdote of Cardano's clock, we can establish an equally secure connection between Regius and Basson by looking at their definitions of nature: The wording is identical, and cannot be found in any other early-seventeenth-century source, with the exception of Daniel Sennert's *Epitome naturalis scientiae* (in the 1633 edition) where, however, it is discussed in a way that sheds additional light on the definition itself.

Regius defines 'nature' as an "internal principle of acting, undergoing passion, and ceasing."[113] This definition is given in *De illustribus quaestionibus*, where Regius aimed to shed light on the philosophical underpinnings of his medical notions. In his *Physiologia* he had labelled the *vis vegetativa* and *sensitiva* as the nature of the human body, without clarifying the meaning of 'nature' itself.[114] The very same definition, as shown by Theo Verbeek, was given for the first time at the beginning of Basson's *Philosophia naturalis*, as the principle of any (traditional) change, that is, generation, corruption, accretion, diminution, alteration according to quality, and local movement.[115] This definition cannot be traced back

[112] On Basson see Christoph Lüthy, "Thoughts and Circumstances of Sébastien Basson: Analysis, Micro-History, Questions," *Early Science and Medicine*, 2 (1997), 1–73.

[113] "I. Quandoquidem in re medica quotidie de natura fit mentio, et apud philosophos non parva de ea re est disceptatio, idcirco etiam meam sententiam hic breviter interponere libet. II. Natura proprie est internum agendi, patiendi et cessandi principium." Regius, *De illustribus quaestionibus*, *secunda*, theses 1-2.

[114] See above, n84.

[115] "Per naturam intelligimus illud principium […] tum agendi, patiendique, item ab iisdem

to Aristotle, but has its roots in scholastic discussions of Aristotle's concept of nature (although the wording of the definition given above originated with Basson). Aristotle's own definition was of nature as the "principle and cause of movement and rest in which it exists primarily, by itself, and not by accident."[116] This definition was scorned by Regius, who in his *De illustribus quaestionibus* called it "tautological," probably because Aristotle defines nature first as the principle of motion and rest of the thing in which it is, and then as something not accidental or external to it.[117] Regius proposes the aforementioned definition, identifying nature with matter (that is, three-dimensional extension) and a material or "general" form (i.e., the previously mentioned "comprehension" of PQs).[118] In Burgersdijk

cessandi habet potentiam. […]. Quippe, prout naturalis, nulla res est sublunaris quae non multiplices mutationes patiatur: vel enim sit, cum non esset, […] dicitur […] generatio; aut desinit esse […]: quod ipsius corruptio […]. Vel iam producta in mole crescit maiorem, aut decrescit […]. Vel secundum qualitatem, […] vel mutat locum." Sébastien Basson, *Philosophia naturalis adversus Aristotelem libri XII* (Geneva, 1621), 1–3. See Theo Verbeek, *Descartes and the Dutch: Early Reactions to Cartesian Philosophy, 1637–1650* (Carbondale, IL, 1992), 104; idem, "The Invention of Nature," 158.

[116] "Natura est principium et causa motus, et quietis, eius, in quo est, primo, per se, et non per accidens," quoted from Burgersdijk, *Idea*, 15–16; cf. Aristotle, *Physica*, 192b 20–23.

[117] "IV. Hallucinantur, mea quidem opinione, qui Aristotelis de natura definitionem […] defendere student: praeterquam enim quod obscura sit, […] tautologiam etiam continet." Regius, *De illustribus quaestionibus*, *secunda*, thesis 4. Aristotle used this 'tautological' definition to exclude external causes of change.

[118] "V. Natura duplex est: materia rerum naturalium, earumque forma. VI. Materia est substantia corporea […]. XV. [Forma] est, vel generalis, vel specialis. XVI. Forma generalis […] consistit in comprehensione motus, quietis, situs, et figurae partium." Regius, *De illustribus quaestionibus*, *secunda*, theses 5, 6, 15, 16. Like Descartes, Regius rejects the

(who, in turn, followed the Conimbricenses, Toletus, and Pereira) we find the idea that nature is an "active and passive principle of motion." This definition arose in the commentaries to Aristotle to make sense of Aristotle's claim, given in the *Physica*, that matter (which is passive) also is nature.[119] Burgersdijk identifies this "active and passive principle of motion" with both matter and form, because passive matter is "disposed to receive […] movement" by the substantial form.[120] Eventually, in the definition given by Regius and Basson – which Basson uses interchangeably with Aristotle's first part of the definition of nature (the "internal principle of moving and of resting oneself") – the idea of *cessatio* is added to the

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distinction between natural and artificial forms in the third disputation, thesis 12.

[119] Cf. Aristotle, *Physica*, 193a 28–19b 6. For an extensive treatment of the Aristotelian concepts of nature, see Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca, NY and London, 1995), 229–237.

[120] "Natura est principium motus activum et passivum. […] In quibus rebus, et quorum motuum, natura principium activum est, in iisdem rebus, et eorundem motuum, est etiam principium passivum: sed non vice versa. Itaque motus non solum naturalis dicitur, qui a forma rei mobilis, ut a causa efficiente, proficiscitur; sed etiam ad quem recipiendum materia apte disposita est. Licet ergo formae, peculiari prerogativa, naturae vocabulum tribuatur, non est tamen negandum, quin etiam materiae tribuenda sit appellatio naturae. Conimbr. 2 Ph. c. 1, quaest. 3. Tol. ibid. quaest. 2. Perer. lib. 7 cap. 17," Burgersdijk, *Idea*, 16. See Collegium Conimbricense, *Commentarii... in octo libros Physicorum Aristotelis Stagiritae* (Coimbra, 1592), 224-227; Franciscus Toletus, *Commentaria una cum quaestionibus in octo libros Aristotelis de Physica auscultatione* (Venice, 1573), ff. 47v-49r; Benedictus Pereira, *De communibus omnium rerum naturalium principiis et affectionibus, libri quindecim: Qui plurimum conferunt ad eos octo libros Aristotelis, qui de Physico auditu inscribuntur intelligendos* (Rome, 1576), 263-264.

'scholastic' definition, according to which nature is the principle of action and passion.[121] Basson's addition to one of the traditional definitions of nature, then, is the idea of cessation.

For Basson, *cessatio* was the ceasing of local motion in Aristotle's sense, to which Basson reduced all other kinds of change. This limitation was noted by Daniel Sennert. In his discussion of Aristotle's own definition of nature in the 1633 edition of his *Epitome naturalis scientiae*, Sennert adds a clarification that had not been included in the previous edition (1618). In that edition, Sennert had used the term 'cessation' in the context of arguing that 'rest' did not imply a 'cessation' of motion, but rather the finish of a local movement when a body reached ins natural place.[122] In the 1633 edition this observation was replaced by the observation that 'rest' was not just the 'cessation' of local motion, but of any kind of action, "unless we want to throw ourselves into great difficulties." Only based on this understanding of 'rest,' Sennert argues, Aristotle's definition of nature may be explained. The definition Sennert offers is, however, that of nature as the "internal principle of acting, undergoing passion, and ceasing" – a definition that, as mentioned before, had previously only been used by Basson and (subsequently) Regius.[123]

[121] Indeed, Basson also reverts to the more traditional definition of nature in the first article of his *Philosophia naturalis*. For instance: "De rebus igitur […] agimus […] quatenus internum habent illud se movendi quiescendique principium." Basson, *Philosophia naturalis*, 2.

[122] "Non incommode natura definitur, quod sit principium motis et quietis in eo, in quo primum est, per se, et non ex accidenti. […] Per quietem vero non denotatur quaevis a motu cessatio, eiusque privatio: sed quiescere est in suo naturali loco manere." Daniel Sennert, *Epitome naturalis scientiae* (Wittenberg, 1618; 1st ed. 1599-1600 as a collection of disputations, 2nd ed. 1600, 3rd ed. 1618; 4th ed. 1633), 47–48. The second part of the quotation is absent from the 1633 edition.

[123] The parts not present in the 1618 edition of Sennert's *Epitome* are given in italics: "Non incommode natura definitur, quod sit principium motus et quietis in eo, in quo primum est,

In sum, Regius's definition of nature was not just a 'Cartesian rendering' of a scholastic idea; rather, it was a definition used by proponents of alternative matter theories in the first third of the seventeenth century, and in the debates between them. It should be noted here that Sennert, despite his emerging atomism, remained a defender of substantial forms, so that his theory of natural change did not involve only the local movement of parts of matter, but also changes in substantial forms.[124] By contrast, Basson – like Regius – was an overt opponent of substantial forms and a proponent of corpuscular explanations.

But apart from the definition of nature, Regius's debt to Basson involved other key elements, which we can retrace in his early texts. As stated above, I identify them in an argument against substantial forms, to which he relates a new theory of concoction (see the next sub-section of this article), and a general theory of nature (see the sub-section thereafter).

4.1.2 Basson's rejection of substantial forms and his corpuscular theory of concoction

per se, et non ex accidenti. *Cum autem ab Aristotele natura definitur, quod sit principium motus et quietis, non solum (nisi in magnas difficultates nos coniicere velimus) accipiendus est solum motus localis.* […] *Et si, ut modo dictum, definitio Aristotelis ita explicetur, quod natura sit internum principium, a quo res quaevis agendi, patiendique, et ab iisdem cessandi potentiam habet, omnia ista, quae difficultatem habere videntur, plana fiunt*." Daniel Sennert, *Epitome naturalis scientiae* (Wittenberg, 1633), 65–67.

[124] Sennert is mostly famous for his adoption of an atomist worldview that was compatible with the continued existence of substantial forms. See Christoph Lüthy, "Daniel Sennert's Slow Conversion from Hylemorphism to Atomism," *Graduate Faculty Philosophy Journal*, 26/2 (2005), 99–121; Emily Michael, "Daniel Sennert on Matter and Form: At the Juncture of the Old and the New," *Early Science and Medicine,* 2 (1997), 272–299.

Contrary to Sennert, but like Regius, Basson rejected substantial forms. His main argument against the adoption of such forms – which his later antagonist Voetius would call the argument *ab ortu formarum* – is as follows.[125] The theories of the eduction of forms from matter in Aristotle's *De generatione et corruptione*, and by Durandus of Saint-Pourçain, Albert the Great, Franciscus Toletus, or the Conimbricenses, presuppose that the substantial forms are new (*de novo*) and come about (*fieri*) from nothing, so that they are in reality rather created than educed from matter. In order to explain them as a true eduction from matter, one would need to presuppose that parts of the forms had already inhered in the elements before they mixed; however, this is impossible. Logically, this explanation forces one to take recourse to a creation or generation from nothing – a solution that obviously violates the principle *ex nihilo nihil fit*. Basson gets out of this impasse by redefining 'substantial' change in terms of a "continuous flux […] [of] particles," by which new forms are composed – which therefore can no longer be considered 'substantial.'[126] For him, mixtures are therefore accidents, formally speaking.[127] As a consequence, generation and corruption, but also accretion, diminution and alteration are to be understood purely in terms of local motions. Basson's foremost example is the case of concoction, the process by which food becomes aliment due to the resolution and copulation of corpuscles, but in which "nothing is newly

[125] Gysbertus Voetius traced the argument *ab ortu formarum* back to Basson and Gorlaeus, and rejected it in thesis 4 of his *Appendix ad Corollaria*, in which he provides specific references to Regius and Gorlaeus, and to which Regius responded in his *Responsio* (1642). In his rebuttal Regius included, without changing it, an argument that Descartes had suggested and which was built upon the earlier arguments *ab ortu formarum*. This episode is discussed in more detail in Helen Hattab, *Descartes on Forms and Mechanisms* (Cambridge, 2009), chapter 1.

[126] Basson, *Philosophia naturalis*, 148–149,158–159

[127] Ibid., 246–247.

generated."[128]

These ideas are all at work in Regius's early texts: The reduction of all changes to local motions and the idea that the theory of eduction presupposes a generation *ex nihilo*, as well as a theory of concoction that was presented as an alternative to Fernel's, but which – importantly – cannot be found in any of Descartes's texts that were available to Regius.[129] In fact, it was precisely in the context of proposing his account of concoction (i.e., in his 1640 disputation on blood circulation) that Regius rejected substantial forms for the first time. I wish to claim here that this is the last essential piece missing from Regius's 1640 physiology, for which he appropriated the theory of the pulse from Descartes and the theory of respiration from Plato.

We now have a rough picture of Regius, who found it easy to be well-disposed towards Descartes's ideas thanks to the pre-Cartesian sources that had informed his earlier physiological ideas. This predisposition is, however, also the reason behind the divergence between Regius's and Descartes's ideas. Such a divergence is found, for example, in Regius's

[128] The example of concoction is given – with a textual repetition – at the beginning of his treatise, where Basson deals with the notions of matter and mixture (ibid., 9–11), and in the third book (242–243), where he proposes his own account of form: "[C]ibus enim varius in stomachum ingestus, sed prius diligenter tritus, calore ventriculi in suas partes resolvitur, cuius partibus inutilibus excretis, quaecunque ad nutritionem prosunt retentae in chylum coalescunt: nihil de novo accedente.] […] Hinc monstrant quomodo et ex corruptione nihil de novo generetur: sed tantum earundem partium, quarum facta erat copulatio, fiat resolutio; […] sic generatio, sic nutritio, sic accretio compleatur, rursusque decretio atque corruptio."

[129] Cf. the previous note and Regius, *Physiologia*, 5, 18-19: "[M]otus generationis, corruptionis item accretionis et decretionis, nec non alterationis, sunt tantum varii motus locales particularum insensibilium. […] [Q]uod absurdum putent, illas, quae ipsis sunt substantiae vel substantiales, in generatione e nihilo fieri, et in corruptione in nihilum redigi."

general theory of nature, which he appropriated, together with the wording of its definition, from Basson.

4.1.3 The theory of nature of Basson and Regius (and Descartes)

Basson's general theory of nature may be summarized in a few key points. On the one hand, Basson defines 'nature' through the abovementioned internal principles of action, passion and cessation; on the other hand, he also identifies it with God, and the order of things established by God.[130] In his explaination of how this natural order acts, Basson relies on three main notions: a) God himself, who is the source of all movements; b) an 'aptitude' and 'propensity to movement' of bodies (both elements and their compositions), and c) a spirit, or world-soul that acts as an intermediary between the two. The natural order is goal-oriented: Elementary particles are provided with a figure and a movement befitting this order; for instance, fire is provided with a sharp angular figure and very fast motion which allows it, among other things, to dissolve food.[131] In composites, elements join together in complex structures by means of an internal "impetus" or "aptitude" towards specific compositions.[132] In both cases the ultimate cause of their movement is God, while the intermediate cause or "universal […]

[130] Basson, *Philosophia naturalis*, 309–310.

[131] Ibid., 311–312.

[132] "Neque enim aliter Deus per ea agit, quam si ipsammet in finem quodque proprium impetum suum innata sibi virtute dirigeret, neque magis cessat ea movere, quam ipsa cessarent si per se moverentur. […] Atque, uno verbo dicam, non aliter illorum actione in compositis naturalibus utitur, quam si singula per se agendo. […] Quem enim singulis dedit impetum a principio, seu potius quam unicuique dedit ad certum finem sibi proprium, aptitudinem, eandem semper servat; eademque […] finem huic elemento debitum prosequitur. […]. Perinde enim est, se ea dicas se ipsis agere, quandoquidem Deus per illa agit, haud aliter ac si se ipsis illa moverentur." Ibid., 315–317.

instrument" is spirit.[133] The spirit or world-soul has two specific functions: First, it allows for rarefaction and for the movement of parts in relation to each other, for otherwise it would be necessary to postulate a vacuum to explain their spatial separation.[134] Second, the enlivening spirit also explains how corpuscles are able to move without being self-movers, as the spirit "excites" them to motion.[135] This threefold scheme (God as the prime mover; the bodies' internal impetus and propensity to movement; and subtle matter as a universal instrument) can also be found in Regius's texts. Their presence obviously indicates important differences in comparison with Descartes's ideas.

If we look at Regius's *De illustribus quaestionibus* and at his *Responsio*, we find two rivalling models at work. On the one hand, Regius follows (and restates) Descartes's principle of the conservation of the quantity of motion as given in *Le monde*, maintaining that all movement is originally produced by an external mover and then preserved and exchanged in the same total quantity among all parts of matter.[136] As a consequence, we must not assume that there exist any substantial forms as individual movers in the material world.[137] This position, as Han van Ruler has put it, entails a "diffusion of causality" in which one cannot

[133] Ibid., 333–334.

[134] Ibid., 324, 333. In a letter to Constantijn Huygens of 8 October 1629 Descartes declared his agreement with Basson's explanation of rarefaction by the idea of ether; see AT I, 25.

[135] "[A]b illo spiritu ineunte res cunctas moveri prout ipsarum fert aptitudo. Si enim materiam ignis subeat, illos inquam minutissimos aculeos, eos motu quam citissimo diducit movetque, prout petit eorum naturae conditio. […] Hinc clarum est, quomodo elementa sint in mixto, insunt scilicet secundum propriam cuique materiam, propriamque eius aptitudinem. Quae quod ibi non agat, non mirum, si ab hoc spiritu non cieatur." Basson, *Philosophia naturalis*, 334.

[136] Regius, *De illustribus quaestionibus*, *secunda*, theses 22–25; cf. AT XI, 43.

[137] Ibid., thesis 26.

find individual entities endowed with causal powers. By contrast, Regius also posits internal, individual causal principles, a kind of "concentration of causality."[138] There exist, first, individual natures such as the noted internal principles of action, passion and the cessation that bodies exercise. This second view plainly contradicts the Cartesian principle of the overall conservation of motion, as it allows for a movement to come to a cessation 'internally,' without the intervention of an external cause.[139] This idea is also contrary to Descartes's general idea of nature as proposed in *Le monde*, according to which nature is the "matter itself […] with all the qualities […] considered all together." For Descartes the regularities observable in such qualities and expressed by his three laws of nature are granted by the constant action of God, who conserves the world and the total amount of motion in each instant just as it had been in the previous instant. Change is due to the contingent diversity among the parts of matter.[140] In short, Descartes's idea of nature served primarily to grant a regulated physical system, one of continuity within diversity. Regius's idea, which served above all to describe the nature of human bodies, undermined the premises of such a system. In fact, in the second disputation *De illustribus quaestionibus*, the first corollary

[138] Han van Ruler, *The Crisis of Causality, Voetius and Descartes on God, Nature and Change* (Leiden, 1995), 203.

[139] The topic is discussed in Verbeek, "The Invention of Nature," 158-159.

[140] "[J]e me sers de ce mot [i.e. nature] pour signifier la matière même, en tant que je la considère avec toutes les qualités que je lui ai attribuées, comprises toutes ensemble, et sous cette condition que Dieu continue de la conserver en la même façon qu'il l'a créée. Car, de cela seul qu'il continue ainsi de la conserver, il suit de nécessité qu'il doit y avoir plusieurs changements en ses parties, lesquels ne pouvant, ce me semble, être proprement attribués à l'action de Dieu, parce qu'elle ne change point, je les attribue à la Nature; et les règles suivant lesquelles se font ces changements, je les nomme les lois de la Nature." AT XI, 36–38.

states: "Is, whatever is moved, moved by its own force? I affirm."[141] In the main text of the disputation Regius distinguishes between "active" and "passive" motions.[142] These ideas are clearly at odds with Descartes's idea that all movement is communicated externally, from one body to another, so that all motions must be characterized as passive, excluding the idea of a self-mover.

Regius's admittedly inconsistent model of causality also complicates his answer to Voetius in the *Responsio*. Voetius argued that the rejection of substantial forms must lead to notions such as that of an animated world-soul (as is the case, in fact, in Basson) or of "celestial globules" (as in Regius himself) so as to account for the operations of bodies.[143] In his rebuttal, Regius distinguishes between an external cause of the motion of what moves, which is God, the "common cause," and an internal "efficacy" or "activity" of bodies, which operates both by means of external, divine aid and by an internal "disposition to movement," depending on the quantity, figure and *situs* of the parts of matter (which in his previous text define their nature i.e. internal principle of acting, undergoing passion, and ceasing).[144] The external aid or mover is the "ethereal matter," which Basson had previously postulated. In

[141] "I. An quicquid movetur, moveatur sua vi? Aff." Regius, *De illustribus quaestionibus*, *secunda*, "Corollaria."

[142] "Omnes actiones et passiones corporum naturalium tantum esse motiones locales, tum activas, tum passivas." Ibid., thesis 21.

[143] Voetius, *Appendix ad Corollaria*, thesis 2.

[144] "Habent enim illae propriam efficaciam, qua concurrente divino auxilio operantur. […] Nam ipse motus, quae est in mobili, item dispositio mobilis ad motum, quae a quantitate, figura et positura oritur, est ipsa activitas causae efficientis, non autem conditio tantum requisita, et causa sine qua non dicenda. Motus vero quatenus a causa aliqua externa ipsi mobili imprimitur, est causa minus principalis, utpote universalis seu communis." Regius, *Responsio*, 17.

rebutting Voetius's objection – according to which Regius had not correctly distinguished between natural and artificial things, which he had equally provided with an internal principle of motion – Regius pointed to the functioning of clocks that was due to the movements of their parts, which are "internal moving causes." This movement, however, has an external source, because, "as a matter of fact," all bodies are moved by subtle matter.[145] So, for Regius subtle matter works as a constant mover of any visible parts of matter, as in the case of components of mechanical clocks. When speaking of clocks, Regius had in mind timekeepers driven by a "hanging weight," (*pondus appensum*), a "twisted coil" (*spira contorta*), and a "restless part" (*particula inquies* – which transmits movement – components that he mentioned in *Pro circulatione sanguinis* and in the *Physiologia*, before his *Responsio*.[146] There, he states that "[an] iron coil [the balance spring], or [a] hanging weight always move the small wheels with the same rhythm."[147] In his *Responsio* he refers to the "hanging weight and twisted coil" as the "internal moving causes, being essential, that is, integral parts of the

[145] "Neque hanc validam rationem solvit responsio, quae dicit horologium ab externo motore moveri, quae est manus artificis […] proinde hoc exemplum esse dissimile: nam primo pondus appensum et spira contorta sunt causae moventes internae, cum sint horologii partes essentiales seu integrales; his enim sublatis horologium non est integrum. Et deinde etiamsi horologium ab externo motore moveretur (uti revera movetur ab aetherea materia […]), illud […] omnibus rebus naturalibus […] esset simile, utpote quae eodem modo per auxilium externi motoris agant." Ibid., 26–27. In his commentary on Regius's *Responsio* Descartes does not touch upon the cause of the movement of clocks (see his letter to Regius of 3 or 4 February 1642, in Bos, *Correspondence*, 113-118).

[146] See above, n47; cf. Regius, *Physiologia*, 27.

[147] "[S]pira ferrea, vel appensum pondus, semper eodem tenore rotulas moveat." Regius, *Pro circulatione sanguinis*, thesis 10; the sentence is repeated in idem, *Physiologia*, 27.

clock."[148] Given that he was speaking of weight-driven clocks, he could claim that they are ultimately moved by subtle matter, on the basis of Descartes's theory of weight and gravity given in chapter 11 of *Le monde*. According to Descartes, bodies become heavy because they are continuously pressed downwards by subtle matter, and are moving in circles around the Earth.

In 1642 Regius was well aware of this theory, as he seems to have read Descartes's *Le monde*: Its theory of elements is presented in his *De illustribus aliquot quaestionibus physiologicis*, and its theory of tides – based on the idea of the circular movement of subtle matter – features in his unpublished textbook on natural philosophy.[149] With regard to the

[148] See above, n145.

[149] According to Descartes's explanation of weight (given in chapter 12 of his *Le monde*), the subtle matter rotating around the Earth goes through the narrowing passage between the Earth and the Moon once, presses on the liquid surfaces of the planet and makes such liquid surfaces rise or descend. Regius appropriated this explanation, as testified to by a fragment of his *dictata* reported by Schoock: "*[Q]uantum ad aestum maris attinet, hic oritur ex eo, quod coelum nostrum peculiare (clauso illo circulo quem luna singulis mensibus peramit) circumraptu suo circum terram et interfluxu inter terram et lunam ipsam terram ad aliquot pedes extra centrum sui caeli deturbat. Hinc enim oriuntur duae angustiae in illo caelo sibi mutuo diametraliter oppositae, una inter lunam et terram, altera inter terram et illam peculiaris caeli extremitatis partem, versus quam ipsa terra ab interfluxu subtilis materiae sive caeli fuit propulsa. Dum itaque torrens perculiaris nostri caeli istas angustias interfluit, aquas maris in istis partibus premit et versus littora attollit. Cum autem ob diurnum terrae motum illa pars maris, quae lunae erat obversa, a luna paulatim avertatur, sensim etiam cessat in illis partibus aëris et maris pressio, quo a littoribus versus altum relabentes refluxum maris efficiunt*." Schoock, *Admiranda methodus*, 234-235. Italics by Schoock, marking his own quotation of Regius's text. On Regius's adoption of Descartes's theory of

explanation of the functioning of clocks, therefore, Regius's theory of matter was generally consistent with Descartes's. However, he did not clarify here how subtle matter actually 'pushes' the parts of a clock. He would later provide a mechanical theory of weight in his *Fundamenta physices*. So, in his earlier use of the idea of subtle matter, Regius seems to have leaned not only on Descartes's cosmology, but also on Basson's theory of a 'universal mover.' At least, we may say, Basson prepared Regius for accepting Descartes's theory of weight.

However, Descartes disagreed with Regius concerning the way in which particles propelled each other in the abovementioned letter of 3 or 4 February 1642. Commenting upon a passage (now lost) from a previous letter by Regius, Descartes criticizes him for 1) maintaining that the globules of celestial matter (i.e., the "second matter") are moved by the most subtle matter, when they had been put in motion in the very beginning of the world; and for 2) proposing that the bigger the globules were, the easier it would be for them to be moved. As to the latter point (2), according to Descartes this is "absolutely contrary" to what he had stated in the *Météores*.[150] As to point (1), is worth noting that Descartes's cosmogony

the three elements, which he read in Descartes's *Le monde*, see Regius, *De illustribus quaestionibus*, *tertia*, thesis 14: "[E]lementa appellari possunt: subtilissima, subtilis, et crassa."

[150] "Quae habes in fine tuae Epistolae de globulis aethereis, non intelligo; quia non censeo illos a materia subtilissima moveri, sed a se ipsis, cum motum habeant ab exordio mundi sibi inditum. Nec etiam maiores vehementius moveri quam minores, sed absolute contrarium puto: dixi quidem in Meteoris, maiores, cum magis sunt agitati, maiorem calorem efficere, sed non ideo facilius moveri." Descartes to Regius, 3 or 4 February 1642, in Bos, *Correspondence*, 113. Descartes, indeed, states in the *Météores* (*Discours première*) that the bigger parts of matter have more force of motion; hence, he relates the resistance to motion to the size of a body; see AT VI, 236–238. The letter, according to Bos, is a reply to the letter of

as presented in his *Le monde* (at that time unpublished) is based on the idea that the continuum of matter had been set in motion by God after the act of creation, in such a way that subtlest particles were progressively 'scratched' from bigger particles (which became globular in this process) – so that such bigger particles were not moved by smaller ones.[151] Descartes found that Regius did not understand, or ignored, key ideas of his own dynamics and cosmology. As for Regius, he clearly favored a model of natural change that presents striking similarities with Basson's for certain aspects of his physiology and physics.

4.2 David Gorlaeus

One final figure to be considered as an integral part of Regius's pre-Cartesian background is David Gorlaeus (1591–1612). In the existing literature he has usually been related to Regius due to the fact that Regius overtly appropriated the idea that man is an "accidental being" from Gorlaeus's *Exercitationes philosophicae* (1620), as Regius declared to Voetius.[152] Since this specific intellectual debt has been exhaustively addressed by historians, I may focus here on a neglected aspect of their connections: Gorlaeus's theory of matter.[153]

4.2.1 Gorlaeus and Regius on matter and modes

Specific themes that link Regius's and Gorlaeus's respective theories of matter are found in the ideas that quantity cannot be regarded as an accident of substance, that the recourse to substantial forms multiplies entities without necessity, and the argument *ab ortu formarum*.[154]

Regius to Descartes of 23 January/2 February 1642; see Bos, *Correspondence*, 107–109.

[151] AT XI, 49-51.

[152] See *Narratio historica*, 23; cf. Regius, *De illustribus quaestionibus*, *tertia*, theses 8–10.

[153] The connection between Gorlaeus's and Regius's matter theories has only been addressed in Lüthy, *Gorlæus*, chapter 4.2; this work also contains a full discussion of Gorlaeus's ideas.

[154] On the idea of quantity, see above, n57. On the argument based on the principle of

In Gorlaeus's *Exercitationes* we also find a theory according to which the spatial organization of atoms (which gather into compounds, while "real accidents," such as the visible species of darkness and light, merely "fly" around them) constitutes the positive "modes of beings." These modes consist of the *situs*, rest, place, and duration of atoms, which bring about the hardness, softness, rarity, and density of visible bodies.[155] This particular theory of matter has recently received some attention. In 2007 Helen Hattab proposed that "the substance/mode ontology Descartes adopts from the *Meditations* onwards resembles Gorlaeus' metaphysics in key respects," while in 2012 Christoph Lüthy pointed out that "while the *modi* thus defined seem useful for the description of a complete atomistic system […], it is hard to deny that […] [the] theory of 'real accidents' disturbs the coherence of Gorlaeus' atomistic explanations."[156] It should be stressed here that Regius's idea that all perceptible qualities depend on "modal qualities," which are absent from Descartes's catalogue of primary qualities given in the *Essais* (where, moreover, Descartes, contrary to Regius, does not mention rest), is a sort of *via media* between Gorlaeus and Descartes. As noted above, Regius did not endorse the ontology of pure extension/modes that Descartes presented in his *Meditationes*. Instead, he had already adopted a theory of modes on his own previously.[157]

economy see David Gorlaeus, *Exercitationes philosophicae quibus universa fere discutitur philosophia theoretica* (Leiden, 1620), 251. For the argument that, as the elementary atoms are not provided with forms, the form of the mixture would have to come from nothing, see Gorlaeus, *Exercitationes*, 267–268. Voetius convincingly ascribed Regius's argument *ab ortu formarum* not just to Basson but also to Gorlaeus, see his *Appendix ad Corollaria*, thesis 4.

[155] On real accidents see Gorlaeus, *Exercitationes,* 114. On mixtures see ibid., 222–223, 248. See also his *Idea physicae* (Utrecht, 1651), 42–43. On modes, see Gorlaeus, *Exercitationes*, 28–31, 139–140. The topic is discussed in Lüthy, *Gorlæus*, chapter 2.4

[156] Hattab, *Descartes*, 159; Lüthy, *Gorlæus*, 42.

[157] See above, n60, n69 and n71.

A more conspicuous use of Gorlaeus's theories by Regius is the latter's treatment of the qualities of humid and dry, and his understanding of mixture and the issue of adhesion in solids and fluids. In these cases – as with his 'Santorian' explanation of hot and cold – we once again find him offering a much more developed theory than Descartes, who was silent on these topics in his early work. Let us, therefore, look at the common points between the two, and examine Regius's specific synthesis.

4.2.2 Descartes and Regius on elements

Descartes's and Regius's ideas on the corpuscular nature of the traditional elements are quite similar. In his *Météores* Descartes describes water particles as oblong and slippery, comparable to eels and therefore, even when connected to each other, easily separated. Earth, air and oils are constituted from irregular particles of different dimensions and display branching shapes. But while particles of earth connect like branches of trees, the particles of air and oils are merely juxtaposed.[158] This model is roughly reflected in Regius's *Physiologia*, where the only well-defined particle is that of "ethereal globules" (which transmit light), which is the only type of particle that Regius explicitly calls "corpuscles." For other kinds of visible bodies he does not mention the particular shapes of their particles. We are told, for

[158] "[J]e suppose que les petites parties, dont l'eau est composée, sont longues, unies et glissantes, ainsi que de petites anguilles, qui, quoiqu'elles se joignent et s'entrelacent, […] puissent aisément être séparées; et […] que presque toutes celles tant de la terre que même de l'air et de la plupart des autres corps ont des figures fort irrégulières et inégales, en sorte qu'elles […] se lient les unes aux autres, ainsi que font les diverses branches des arbrisseaux […]. Et lorsqu'elles se lient en cette sorte, elles composent des corps durs, comme de la terre, du bois, ou autres semblables; au lieu que, si elles sont simplement posées l'une sur l'autre, sans être que fort peu ou point du tout entrelacées, […], elles doivent […] composer des corps liquides fort rares et fort légers, comme des huiles ou de l'air." AT VI, 233–234, 236.

instance, that the matter of stars does not differ from that of terrestrial fires, but its nature is left unexplained.[159] All "gross" bodies are kept together in principle by the figure of their particles; so, just as for Descartes, for Regius the particles of aqueous and oily bodies must be oblong or branching respectively.[160] Regius's silence on the traditional four elements is consistent with his claim that, in his own words,

> since the concourse of the four elements is no more required to the constitution of […] mixed things, than […] mixed things [are required] to constitute […] elements, and since from the mixture of these [four elements] the properties of mixed things cannot neither emerge nor be explained, other people seem to us […] as tormenting themselves in examining the nature of […] elements.[161]

[159] "Corpora lucida sunt corpora luce praedita: vel (ut magis me explicem) sunt corpora, quorum minimae particulae celerrimo motu agitatae, globulos aethereos ad lineam rectam propellunt, tale est ferrum candens, carbo ignitus, candela ardens, Sol, etc. Globuli aetherei sunt subtilissima quaedam corpuscula, aëre multo subtiliora, quibus spaciola illa, quae sunt inter particulas aquae, terrae et aëris, et spatium illud ingens, quod est a supremo aëre ad solem isque sine ulla interruptione sunt replete." Regius, *Physiologia*, 35. Also, in his *Essais* Descartes did not distinguish between the particles of 'terrestrial' fires and the matter of celestial luminous bodies, nor did he provide any detail about the composition of luminous bodies, either terrestrial or celestial. The matter is treated only in his *Le monde*, where he presents his views on the three kinds of particles in chapter 5. See AT VI, 84, 86–87, 103, 118 (on his *Dioptrique*), 233–234, 331 (on his *Météores*).

[160] "Aquositas designat partes istas fluidas esse laeves et oblongas; oleaginositas denotat illas esse ramosas." Regius, *Physiologia*, 8.

[161] "[Q]uia ad constitutionem eorum, quae mixta dicuntur, non magis requiritur quatuor elementorum concursus, quam ipsa, quae dicuntur, mixta ad constituenda haec corpora, quae

In *Le monde* Descartes distinguishes more clearly between his own three elements: (1) The most subtle matter (which takes on indefinite shapes); (2) a less subtle matter, which transmits light and has a globular shape; and (3) gross matter (which may have any shape, but is much bigger than (1)). Descartes compares, for the sake of clarity, (1) to fire, (2) air, and (3) earth.[162] The fire, air and earth that we encounter in our daily lives are, however, composed of particles of the third matter, and are therefore not pure elements.[163] In *De illustribus quaestionibus* Regius combines this account with that of Descartes's *Essais*. He declares – against his own, earlier verdict – that earth, water and air are all composed from the third type of matter, with oblong and ramifying figures, and that fire is – *contra* Descartes – a "congeries of aether," i.e., composed from the first and second matter.[164]

4.2.3 …and Regius's 'Gorlaean' explanation of humid and dry

Regius also invokes notions which he may have found in Gorlaeus, and which are part of a corpuscular tradition that can be traced back to Girolamo Cardano and Henricus de Veno,

elementa appellantur: cumque ex horum mixtione proprietates rerum mixtarum nec oriri nec explicari possint: frustra nobis videntur alii hoc in loco se fatigare in elementorum vulgo dictorum, nempe in terrae, aquae, aëris et ignis natura examinanda." Ibid., 5. There is no precise source for these claims. They may have resulted from Santorio's and Gorlaeus's respective criticisms of traditional matter theory. Reneri had also provided a criticism of such a theory, closely following Gorlaeus in that respect; on this, see Buning, *Reneri*, chapter 5.3. See also Henricus Reneri, *Disputationum physicarum prima-septima* (Utrecht, 1635), *quarta*, *De elementis*, theses 3, 7, 11; cf. Gorlaeus, *Exercitationes*, 315–316, 320–321.

[162] This comparison is provided in chapter 5 of *Le monde*.

[163] AT XI, 27–28.

[164] Regius, *De illustribus quaestionibus*, *tertia*, theses 14, 18–20, 22.

who until 1613 had taught at the University of Franeker, where Regius had also studied.[165] We are dealing here with ideas that Reneri had also promoted in his *Disputationes physicae* and *Decas quaestionum illustrium ex philosophia naturalis* (1635). Let us take a look at the three most prominent theories of this young tradition. (1) According to Gorlaeus, the only two real elements are earth and water, which are the only ones that can actually 'mix.' Experience shows that fire disaggregates wood, and therefore it cannot in itself be a component of wood. Fire, by contrast, is an accident, as it is heat, which is generated – in an obscure way – through the attrition of gross bodies. Air, in turn, is no real element, for it is too "fluid and tenuous" to mix with other bodies.[166] (2) The traditional pairs of qualities do not inhere in each element, as air is dry rather than humid, as experience amply shows. Air can, in fact, only be said to be 'humid' in the sense that vapors – particles of water, which do not mix with air – are hovering in air itself. (3) In fact, the Aristotelian notion that a humid body is more easily contained in another body rather than in itself applies to fluids.[167] In turn, for Gorlaeus, humid bodies are no longer those that can be more easily contained in another body rather than in themselves (which for Gorlaeus constitutes the definition of fluidity,

[165] On the De Veno – Gorlaeus connection see Lüthy, *Gorlæus*, chapters 3.4–3.6

[166] Gorlaeus, *Exercitationes*, 115, 327–329; cf. Reneri, *Disputationum physicarum*, *quarta*, *De elementis*, theses 10 and 27, and idem, *Decas quaestionum illustrium ex philosophia naturali* (Utrecht, 1635), thesis 6.

[167] "Aiunt quoque aerem esse humidissimum: quod et nos negamus. Non enim humidum est, quod exsiccat. Aerem res multas exsiccare probat experientia. […]. At illi obiiciunt ipsam aliquando quoque humectare. Verum hoc tribui potest vaporibus, qui sunt in aere. […] Obiiciunt nobis quoque humidi definitionem. Humidum est quod difficile suis terminis, alienis facile terminatur: item, quod facile diffluit. Verum hae non sunt humidi definitiones, sed fluidi, cui non opponitur siccum, sed stabile," Gorlaeus, *Exercitationes*, 332–333; cf. Reneri, *Disputationum physicarum*, *quarta*, *De elementis*, thesis 29.

which can still be applied to air), but only those that have pores into which particles of water have entered. In other words: 1) Gorlaeus changes the meaning of 'humid' to signify 'aqueous' (so that for him, air is no longer humid), and 2) he uses the old definition of 'humid' (i.e., what is contained in other bodies) to signify 'fluid'. This definition can still be applied to air, which for Gorlaeus is thus a sort of 'dry fluid'. And even though particles of water thus defined have formed a composite with porous bodies (something that cannot happen with air), they do not thoroughly mix, as we still perceive the particles of water in them.[168] So much for Gorlaeus.

As for Regius, (1) when he explains traditional qualities, he maintains that actual humidity properly pertains only to solid or stable bodies, while potential humidity properly pertains to aqueous bodies (i.e., "gross" fluids). Regius considers solid bodies "potentially humid," i.e., they can become humid or make other bodies humid only "abusively."[169] The reason for this claim is that actual humidity consists of the presence of particles of aqueous bodies in the pores or cavities of solid bodies. A solid body is said to be actually humid when – notwithstanding the distinction between solids and fluids – the particles of a fluid like water adhere to it "as if they were not fluid."[170] Potential humidity relies on the possibility for particles of aqueous bodies to enter into the cavities of solid bodies.[171] In other words, actual

[168] Gorlaeus, *Exercitationes*, 145–146: "[A]qua, si siccum contingat, per poros repit, seque inter minimas partes insinuat; ut ita siccae partes adhuc quidem sint, sed ob aquae copiam appareant humidae: humidum tamen quod ibi conspicitur, est ipsa aquae […] substantia."

[169] See below, n171.

[170] "In hac [partium stabilium constitutione] considerari quidem possunt humiditas et siccitas, prout sunt actu (quia humorem particulae, solidarum partium poris impactae, ita iis adhaerent, ut pro fluidis non habeantur)." Regius, *Physiologia*, 12.

[171] "Humiditas actualis proprie tantum est stabilium corporum, cum particulae aquae, vel alterius liquoris sensibilis, eorum poris ita insunt, ut ipsis inhaereant. […] Humiditas vero

humidity is a complex quality which arises from the mutual adhesion of two different kinds of bodies; for example, water and earth may adhere to each other as if they had become one body. (2) This is not the case with air, which will not adhere to any pores, so that Regius characterizes it as a potentially dry body. Actual dryness, for Regius, pertains only to stable bodies, and consists of the presence of particles of air or of a more tenuous fluid in their pores. In potency, however, it pertains also to air and more tenuous fluids.[172] Finally (on point 3) Regius replaces the traditional notion of humidity (as that which is easily contained by a body other than itself) with that of fluidity. For Regius, air may still be seen as fluid, even if it is no longer considered by him a humid body (*pace* the Aristotelians). It may (improperly) be said to be humid only when vapors flow through it.[173] Regius makes use of this definition of fluidity in his classification of organs: He categorizes lungs and intestines as solids, but since they are contained by other bodies rather than by themselves, the label "solids" is, strictly speaking, improper.[174]

potentialis proprie tribuitur liquoribus crassiusculis, quia nempe aliorum corporum poros ingressi facile illis inhaerent. […] Sed abusive etiam humida potentia dicuntur stabilia corpora, quae quomodolibet vel humefieri, vel alia humectare: et sicca potentia, qua vel exsiccari, vel alia exsiccare apta sunt." Ibid., 7.

[172] "Siccitas actualis est eorundum [stabilium] corporum, cum ipsorum pori nullius liquoris sensibilis particulis, sed solo aëre, vel etiam corpore aëre tenuiore replentur. […] Et siccitas potentialis proprie tribuitur liquoribus tenuissimis quia aliorum corporum poros apti sunt ita pervadere, ut iis interim non adhaereant." Ibid.

[173] "Cum vero aër humidus dicitur, putandum est hoc fieri ratione particularum aquae in vaporem resolutae, quae per illum sparsae sunt […]. Et quantum ad humiditatem, quam plerique philosophi aëris elemento tribuunt, nullam eius rationem agnoscimus." Ibid., 8.

[174] "[P]ulmone, et intestinis, quae solidae partes dicuntur, etsi potius alienis, quam suis terminis contineantur." Ibid., 2.

At first sight, Regius's overall distinction between solids and fluids resembles Descartes's, which the latter developed in *Le monde* to characterize the two main states of particles of bodies, while Regius outlined his in the *Physiologia*. They also both conceived of fluidity in terms of reciprocal movement and the easy disjunction of particles, even though Regius, unlike Descartes, did not explicitly consider rest the primary glue that kept bodies together.[175] We may suppose, therefore, that Reneri might have communicated to Regius some basic ideas of Descartes on matter before Regius himself read *Le monde* in 1641. After all, Reneri had assisted Descartes while the latter was writing his *Le monde* in the early 1630s.[176] Alternatively, Descartes himself may have leaned upon Gorlaeus to the same extent as Regius. Gorlaeus's ideas, in any case, play a prominent role in Regius's theory of matter, as they provided him with a theory of traditional elements which he could put to work in his clarification of old notions for his new physiology. This is the case in a key idea of Regius's theory of blood circulation, the explanation of innate heat, which is essential for showing how blood can flow through the body, and support nourishment and the generation of spirits, and thereby to render sensitive functions possible in the first place. For this account, Regius needed a reinterpretation of the function and nature of innate heat.

[175] AT XI, 13–14; cf. Regius, *Physiologia*, 2–3; see above, n98.

[176] Even though he adopts hylomorphism, Reneri finds acceptable the position of those who trace all elementary differences to accidents, because all phenomena can be explained by considering only matter, quantity, figure, movement and rest: "[E]lementa dicuntur corpora simplicia […] ut excludatur compositio ex aliis corporibus […], non tamen ex materia et forma substantiali, quam […] cuique elemento assignant, et nos cum iis. Attamen si quis solum discrimen accidentarium inter elementa statuere vellet, solida et aperta ratione redargui non posset, cum nulla phaenomena in elementis sunt, quae plus requirant, quam materiam et eius diversam dispositionem, quoad quantitatem, figuram, motum, et quietem." Reneri, *Disputationum physicarum*, *quarta*, *De elementis*, thesis 4. See Buning, *Reneri*, chapter 5.3.

4.2.4 Regius's use of Descartes and Gorlaeus in physiology: The case of innate heat

As he addresses the notion of innate heat in his *Physiologia*, Regius explicitly quotes Fernel's definition of innate heat as a "primeval humid completely perfused by an inherent spirit and heat," and another definition (possibly taken from Descartes's adversary, Vopiscus Plempius), according to which innate heat is a "certain, primeval substance of our body, fat and oily, perfused by natural heat."[177] Regius appreciates both definitions, as they characterize innate heat as elementary and affirm its extra-elemental nature.[178] I would suggest that Regius embraces these definitions not only because, in a post-Galilean world, there is no difference between terrestrial and celestial bodies and qualities, but also for the explanation that he offers for this type of heat. Regius explains its properties by leaning on

[177] "Non male definit Fernelius *calidum innatum, quod sit humidum primigenium spiritu et calore insito perfusum*, et alii, *quod sit substantia quaedam corporis nostri primigenia pinguis et oleosa, calore naturali perfusa*." Regius, *Physiologia*, 13; italics by Regius, marking the definitions he quotes; cf. Fernel, *Universa medicina*, 150, and Vopiscus Plempius, *De fundamentis medicinae* (Leuven, 1638), 133: "[C]alidum innatum […] sic potest definiri: est substantia quaedam corporis nostri primigenia, pinguis et oleosa spiritu et calore naturali perfusa."

[178] "[E]t, sive dixerint calorem nativum esse elementarem, sive caelestem, facile assentimur, quia nullam inter utrumque agnoscimus differentiam." Regius, *Physiologia*, 15. Fernel postulated a 'divine' nature for this type of heat; among Regius's sources, Heurnius also maintained this position; see Heurnius, *Institutiones medicinae*, 19–20. For Santorio, by contrast, innate heat was not a quality of a separate body, but coinciding with the essential temperament of the body, and it can be observed also in metals: Santorio, *In primam fen*, cols. 72–73, and *Commentaria in primam sectionem Aphorismorum Hippocratis* (Venice, 1660; 1st ed. 1629), 263–264.

Cartesian concepts on the one hand, and on his 'Gorlaean' interpretation of traditional qualities on the other. For Regius, blood is constituted by three kinds of particles: 1) Oily and humid particles, of which the oily are branched (as for Descartes), and thanks to their cohesion can entrap particles of subtler fluids, so that they "may be considered humid," in accordance with his own explanation of humidity, which he appropriated from Gorlaeus. Such particles entrap 2) ethereal matter, i.e. the celestial matter postulated by Descartes and adopted by Regius. Moreover, the oily and humid particles entrap the subtler part of blood itself, i.e., 3) the spirit, by which innate heat is communicated to the body at the moment of its generation. Consequently, the ethereal matter is constricted to a small space. There it increases and keeps its own speed, and can thus maintain the innate heat, i.e. the movement of the spirit (with which this ether is entrapped by oily particles). Accordingly, for Regius innate heat can be defined both as a "primeval spirit" (of which innate heat properly consists) and as a "primeval humid" (which is the vehicle of such spirit), and it is constantly maintained by ether.[179] This explanation is very much in keeping with Descartes's theory of

[179] "Quatenus autem hic calor ope spirituum, qui sunt in sanguine, iam inde a prima genitura communicatur, dici potest spiritus primigenius; et quatenus id fit ope sanguinis, ac praecipue partium eius oleaginosarum, quae pro humidis habentur, vocari potuit humidum primigenium: et quia hic calor praecipue communicatur per sanguinis partes, tum spirituosas, quae maxime sunt mobiles, et facillime quasvis corporis partes sua subtilitate penetrant; tum oleaginosas, quae cohaesione sua impediunt, quo minus spiritus possint dissipari, et in poris suis materiam aetheream ita disponunt, ut fortius agat: quod ni fieret, calor brevissime extingueretur." Regius, *Physiologia*, 13. Please note that elsewhere in his *Physiologia* Regius clearly distinguishes between ethereal matter and animal spirits; for instance, in his discussion of voluntary movements: "[I]n motu voluntario ab anima nullus excitatur novus motus, sed tantum spirituum in hanc vel illam partem determinatio, qui a subtili seu aetherea materia agitati, quantum motus partibus communicant, tantundem ipsi perdunt." Regius,

circulation, in which – as pointed out above – blood acts as a sort of self-mover. [180]

5. Conclusion

The analysis of the evolution of Regius's thought proposed in this article would indicate that earlier authors that Regius had read and integrated into his own thinking disposed him favorably to Descartes's thinking, and allowed him to appropriate from Descartes the model of blood circulation and sense perception. This favorable disposition towards Cartesianism had multiple sources: Its primary roots were in Ramism (translated by Regius into the wish to abridge and conceptually clarify medicine) as well as Heurnius and Santorio, who in their own ways aimed to overcome Fernel's ideas on total substance and occult qualities. As far as the first research question of this article is concerned, then, we may conjure up the image of a physician who sought a shorter and clearer medicine, but had not yet found a satisfying solution to questions such as 'how to explain concoction without postulating substantial changes,' 'how to replace the deficient, Aristotelian hierarchy of qualities,' 'how to account for blood circulation,' or "how to explain perception without a theory of intentional species.' Having taken his principal cues from Ramus, Heurnius and Santorio, Regius adopted a theory of concoction from Basson, a theory of qualities from Santorio and Gorlaeus, and subsequently found a suitable theory of perception and blood circulation in Descartes.

Regarding the second research question we may now say that Regius could not have been content with Descartes's ideas alone, because the physiological theory he wished to develop required a more complete theory of matter and of the human body than Descartes could offer. This explains why he had to take recourse to bits and pieces of information that he found in the respective matter theories of Santorio, Basson, Gorlaeus, and Reneri. In some cases, such as in the theory of perception of hot and cold, the nature of humid and dry, and

Physiologia, 45.

[180] See above, n44.

the model of natural causation, however, these pre-Cartesian sources led Regius to offer solutions that differed from, and were often not compatible with, those of Descartes. As Descartes's corrections and his sometimes unsubstantiated dismissals of Regius's explanations document, he discouraged Regius from publishing his own solutions.[181] This constellation eventually led to the publication, by both Descartes and Regius, of their rivalling textbooks in natural philosophy, that is, Descartes's *Principia philosophiae* and Regius's *Fundamenta physices*.

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Appendix

Regius's explanation of sensory qualities in the *Physiologia*:

hot	"Various agitation of imperceptible particles"
hot (potential)	"Aptitude to heat up," or to "excite […] movement" of such particles

[181] This is the case, for instance, in Regius's explanation of the powers of medicaments, which is absent from the *Physiologia*, where only a catalogue of such powers is given (see Regius, *Physiologia*, 155); cf. Descartes to Regius, between June and October 1641, in Bos, *Correspondence*, 78.

cold (actual)	the state of being at rest of particles
cold (potential)	"Being not easily agitated," and "being apt to hinder" movement by particles
humid (actual)	"Inherence" of particles of "visible liquors" in "stable" bodies
humid (potential)	"Thickness" of the particles in visible liquids (water)
dry (actual)	the presence of particles of liquids "more tenuous" than those of "visible liquids" in "stable" bodies
dry (potential)	Dimension of such more tenuous particles
thickness	the "Major or minor" dimension of particles
tenuity	a lesser degree of thickness
density	dimension of "pores or interstices" between particles
rarity	a lesser degree of density
stability	"Every kind of adherence" between particles
- hard	their strong adherence
- soft	their weak adherence
fluidity	"Disjunction and movement" of particles
- aqueous	length and thickness of particles in fluids
- oily	branched figure of particles in fluids
- viscose	difficult disjunction of particles in fluids
volatility	tenuity, weak cohesion, flexibility, and pliability of particles
fixity	the opposite of volatility[182]

[182] Regius, *Pysiologia*, 6–8.