NICOLAS HARTSOEKER'S SYSTÈME OF NATURE:
PHYSICS BY CONJECTURE AND OPTICS BY DESIGN IN EARLY MODERN EUROPE

Samar Catherine Abou-Nemeh

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ABSTRACT

This dissertation sets a detailed, technical history of ideas of Dutch-born lens maker and natural philosopher Nicolas Hartsoeker (1656-1725). Hartsoeker’s case exemplifies the kinds of intellectual journeys a university-educated man with technical skills undertook to navigate the chaos and uncertainty of the seventeenth-century world and nature writ large. He defined the labile position of natural philosopher and empiric. His role as practitioner and philosopher reveals the epistemic, disciplinary, and socio-political boundaries he worked within or, in some instances, sought to overcome. He capitalized on his lens-making expertise and tested his often polemical philosophical ideas in printed works and in academic journals of the time. The ways in which he advertised his optical skills, wares, and knowledge about lenses illuminate the extensive possibilities available for self-fashioning and self-advancement in this period for talented lens grinders. Hartsoeker’s lens making skills helped him gain access to the Royal Academy of Sciences in Paris (and propelled his lenses all the way to Siam) and the Palatine court in Düsseldorf, where he actively promoted his natural philosophical ideas. This dissertation centers around Hartsoeker’s turn away from Descartes’ philosophy, and his gradual reassessment of elements of the mechanical philosophy in crafting his own system of nature.

Chapter 1 explores Hartsoeker’s early formation in philosophy and medicine in Amsterdam and at the University of Leiden in the 1670s, and sets the stage for his initial passionate support for Descartes’ system of the world. In particular, I examine the nature of Dutch Cartesianism through Hartsoeker’s university teachers, among whom were Theodoor Craanen, Burchard de Volder, and Johannes de Raey. I show how Hartsoeker’s instructors made elements of Cartesian doctrine relevant to solving questions in natural philosophy as well as in medicine, thus inspiring Hartsoeker’s early admiration for the French philosopher’s ideas. In this chapter, I argue that Descartes’ model
of matter particles in motion and of the body as machine promised to yield a variety of valid interpretations of natural phenomena.

Chapter 2 examines Hartsoeker’s role as instrument maker and his use of materials and tools in launching his own natural philosophical program. I show how his expertise as instrument maker gained him access to the Parisian Academy of Sciences where hypotheses and philosophical ideas made the philosopher. I argue that, for all this empirical know-how, Hartsoeker’s philosophical convictions trumped practice and drove his ambition to become a natural philosopher who could make knowledge claims about nature.

Chapter 3 discusses the crucial period in Hartsoeker’s intellectual work when he vocally distanced himself from Descartes’ philosophy, and endeavored to promote own his system of nature (while at the court of Johann Wilhelm II in Düsseldorf). At its core, this chapter focuses on Hartsoeker’s disillusionment with the Cartesian mechanical model of explaining natural phenomena, both in his correspondence with Leibniz and in his writings on anatomy. I argue that Hartsoeker, on the one hand, was wedded to an atomist view of nature; while, on the other hand, he introduced immaterial Intelligences, or intelligent souls, to explain causally vital physiological phenomena that eluded a mechanical interpretation.

Chapter 4 investigates the ways in which Hartsoeker challenged Descartes’ mechanical model along the lines of the Cambridge Platonists—Henry More and Ralph Cudworth—in light of Réaumur’s experiments on regenerating crayfish legs at the Parisian Academy in 1712. Hartsoeker believed that regeneration of crayfish limbs could not be explained satisfactorily with the Cartesian fundamentals of matter in motion and rejection of animal soul. I argue that the crayfish experiments, as first tried by Réaumur and then repeated by Hartsoeker himself, allowed him to distance himself further from Descartes’ philosophy, and develop and assert his proposition that Intelligences mediated between inert matter and God in his system of nature.
Chapter 5 orients Hartsoeker’s work and ideas within their immediate and posthumous reception in various French, Dutch and English seventeenth- and early eighteenth-century journals, articles, essays, literary works, and personal correspondence written by his publishers, colleagues, critics, and intellectual heirs. In this chapter, I argue, on the one hand, that contemporaries’ engagement with Hartsoeker’s ideas sheds light on what they made of his natural philosophical ideas. On the other hand, contemporary reception also helps to characterize the nature and aims of natural philosophy, the procedural aspects of natural philosophical debate, and the kinds of rules that governed the different discussion fora that made up the Republic of Letters at this time.
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matri, patri, aviae, et fratri.
Introduction

Nicolas Hartsoeker (1656-1725) Steers through the Stormy Seas of Early Modern Natural Philosophy

FIG. 1 Caspar Netscher, Portrait of Nicolaes Hartsoeker (1682), Kurpfälzisches Museum, Heidelberg.
“Ubi bene, ibi patria,” thus scribbled Nicolas Hartsoeker\(^1\) on 10 June 1721 in dark brown ink on a hand-sized page in the *album amicorum* of Johan Conrad Ihring from Kassel.\(^2\) At the age of sixty-five, Hartsoeker had tested and tried the maxim, “Where it is good, there is one’s country.” With a prominent international career as *philosophe* and *physicien* (and many less successful peregrinations), he knew what it meant to be uprooted and start from scratch—and he did so time and time again. The Dutch-born natural philosopher had lived in Gouda, Rotterdam, Amsterdam, Leiden, Paris, Passy, Düsseldorf, Utrecht; and toured in England, the German lands, and possibly even in Portugal. He went bankrupt at least twice.\(^3\) This kind of broad-perspective experience also made him a very adaptable and, perhaps, impervious to strife and setbacks.

Born on 26 March 1656 in Gouda, Nicolas was the son of Anna van der Meij and the Remonstrant preacher Christiaan Hartsoeker (1626–1683). He was well educated and came from a respectable family with a long tradition of devotion and activism to the Remonstrant cause. His father Christiaan was close friends with Philip van Limborch and acquainted with the circle of Benjamin Furly, merchant in Rotterdam. And though Nicolas was shaped by more liberal strands of reformed Christian thought like Remonstrantism, he chose “to study the Book of Nature rather than

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\(^{2}\) For example, Constantijn Huygens to Christiaan Huygens, *Oeuvres complètes de Christiaan Huygens* (The Hague, 1901), 35: “Estant de retour a Rotterdam il se maria et devint marchand de vin. Un Anglois son correspondant le trompa et lui fis banqueroute de 200 mille livres; par ou estant mal dans ses affaires, il a esté obligé de quitter le pays, vertreckende bij noorder Son [‘partant sans trompette’] et s’en est allé en France ou il demeure au village de Passy près de Paris.”

\(^{3}\) For example, Constantijn Huygens to Christiaan Huygens, *Oeuvres complètes de Christiaan Huygens* (The Hague, 1901), 35: “Estant de retour a Rotterdam il se maria et devint marchand de vin. Un Anglois son correspondant le trompa et lui fist banqueroute de 200 mille livres; par ou estant mal dans ses affaires, il a esté obligé de quitter le pays, vertreckende bij noorder Son [‘partant sans trompette’] et s’en est allé en France ou il demeure au village de Passy près de Paris.”
the Holy Scripture.” Beginning in the fall of 1674, he spent about a year learning philosophy under Johannes de Raey, ancient Greek under Philip van Limborch, and literature under Petrus Francius at the Amsterdam Athenaeum Illustre, and then several years thereafter studying philosophy under Burchard de Volder, medicine under Theodoor Craanen, and anatomy under Charles Drélincourt at Leiden University. In 1678, he wrote to Christiaan Huygens and convinced him to secure him safe passage to Paris, based on his skills in lens making. Over the next twelve years, Hartsoeker gained fame as a lens-grinder for Gian Domenico Cassini at the Académie des Sciences and published two works on physics—the Essay de Dioptrique in 1694 and the Principes de physique in 1696. At the Académie he not only constructed microscopes but also fashioned telescopes for the Royal Observatory. Between 1684 and 1696, he served as Colbert’s technical advisor at the royal glassworks in Cherbourg. He also oversaw the production of telescopes for the king of Siam and the Jesuit missionaries in the Far East, and lectured on lens-making and spermatist theories at the Académie. He knew Latin, had some knowledge of ancient Greek, spoke Dutch natively, but wrote all his treatises and much of his extant correspondence in French. He wrote on topics ranging from optics, mathematics, and astronomy to medicine, navigational techniques, and magnets—all of which he and his contemporaries considered part of one common endeavor: natural philosophy. In 1699, the Royal Academy of Sciences in Paris nominated him for membership as associé étranger (foreign member).

By the end of the seventeenth century, Hartsoeker’s renown had reached international proportions, as he was sought after by powerful foreign princes. Fontenelle’s Éloge and a few Dutch sources corroborate that Hartsoeker regaled Peter the Great with sights of the moon and Jupiter in 1696. He was allegedly appointed by the magistrates of Amsterdam to teach the Czar mathematics

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4 Fokko Jan Dijksterhuis, “Constructive Thinking: A Case for Dioptrics”, in The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation, ed. by Lissa Roberts et al. (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007), 72.

and navigational techniques in 1696, when the latter was residing in Amsterdam. In 1704 Hartsoeker eventually moved to Düsseldorf, where the Elector of Palatine Johann Wilhelm II had been trying to lure him to his court for three years. His Highness appointed him court mathematician in Düsseldorf and honorary professor of philosophy at the University of Heidelberg. Although he was generously paid by the university, he never lectured there, and remained in Düsseldorf for the most part. Between 1707 and 1710, Hartsoeker met Leibniz and the latter’s patron, the Elector of Hanover; he traveled to Berlin and Kassel; and he received visitors, among whom were the illustrious Landgrave of Hesse-Kassel and the indefatigable chronicler Zacharias Conrad von Uffenbach. While in the German lands, he produced the bulk of his natural philosophical writings. Importantly, this was also a time when he was decidedly distancing himself very vocally from Descartes’ philosophy and formulating his own système of nature. His extensive correspondence with Leibniz stands perhaps as the most dynamic and dramatic illustration of the kind of philosophical ding-dong Hartsoeker waged. Its clamor unsettled some prominent

6 Fontenelle, “Éloge de Monsieur Hartsoeker,” in Éloges des Académiciens de l’Académie Royale des Sciences, mort depuis l’an 1699 (Paris, 1766, vol. II), 239-240: “Le feu Czar étant allé à Amsterdam pour ses grands desseins, dont nous admirons aujourd’hui les suites, demanda aux Magistrats de cette Ville quelqu’un qui pût l’instruire, & lui ouvrir le chemin des connoissances qu’il cherchoit. Ils firent venir de Rotterdam M. Hartsoëker, qui n’épargna rien pour se montrer digne de ce choix, & de l’honneur d’avoir un tel Disciple. Le Czar, qui prit beaucoup d’affection pour lui, voulut l’emmener en Moscovie: mais ce Pays étoit trop éloigné, & de moeurs trop différentes; l’incur- [p. 240] titude des événemens encore trop grande, une famille trop difficile à transporter. Messieurs d’Amsterdam, pour le dédommager en quelque sorte des dépenses qu’il avoit été obligé de faire pendant sa demeure auprès de Czar, lui firent dresser une petite espèce d’Observatoire sur un des bastions de leur Ville. Ils savoient bien que c’étoit-là le récompenser magnifiquement, quoiqu’à peu de frais.” Besides Fontenelle’s Éloge, Dutch historian Huib Zuidervaart has recently located a couple nineteenth-century mentions of Hartsoeker tutoring Peter the Great in the following Dutch source—“Geschiedenis,” De NAVORSCHER 11 (1861): 193: “‘M. HARTLOEKER’ - de beroemde en bekende HARTSOEKER; het schijnt toen reeds bij de Franschen eene gewoonte te zijn geweest onze hollandsche eigennamen te radbraken - M. HARTLOEKER, qui est parti d’ici pour Paris, depuis 4 ou 5 jours, et qui reviendra dans un mois ou deux, s’instruirà à fond du dessin de l’abbé de HAUTEFEUILLE, car il entend bien ce qui concerne les télescopes. Il a régéle le grand-duc de Moscovie (PETER I) à Amsterdam de la vue de la lune et de Jupiter. Il y (BAYLE schrijft hier vrij slordig) porta ses deux télescopes (waarschijnlijk naar het observatorium, dat de stad Amsterdam ten dienste van den czaar had laten bouwen) fit dresser un mât dans un jardíen...... (wat volgt is mij niet verder bekend). Ce prince a assés de génie pour les mathématiques, et goûta beaucoup l’opération astronomique de M. HARTLOEKER, mais du reste quel travers d’esprit , il ne se plait guere qu’a charpenter, et il passe des jours entiers à travailler comme un ouvrier à la construction des vaisseaux. On le voit aux ateliers comme le plus vil manoeuvre.’” See further, De NAVORSCHER 17 (1867) 94: “1699: NICOLAES HARTSOEKER, In de Brouwerij van den Helm, Prinsegracht,” as evidence for Hartsoeker’s stay (or address) in Amsterdam during Peter’s visit to The Netherlands. Finally, a second Dutch source mentions Peter the Great: [Author unknown], “Het Leven van Nikolaas Hartsoeker,” in Levensbeschryving van Eenige Voornaame meest Nederlandsche Mannen en Vrouwen, Tweede Deel (Amsterdam: Petrus Conradi, Harlingen: F. van der Plaats & Junior, 1775), 183-184.
republicans of letters, most notably Fontenelle and the Jesuits of Trévoux. After the death of his patron in 1716, he moved back to Utrecht, where he rented an residence near Marieplaets. In 1725, he died and was buried in this city that had cradled the first vitriolic battles inspired by Descartes’ philosophical ideas back in the 1640s.

In 1682 Caspar Netscher painted a portrait of the twenty-six-year-old Hartsoeker, of which several copies are extant. The pictured painting is allegedly a copy of the original that hangs in the Musée d’Art et d’Histoire in Geneva. Netcher depicts the young Hartsoeker in a lavishly embroidered red robe, with his instruments perched precariously on the corner of a pedestal on the left—a celestial globe, a beautifully ornate telescope, an equally lavish compound microscope, a compass, a protractor, and, teetering on the edge, a simple (or single-lens) microscope. The globe and telescope suggest the study of the macrocosm, while the microscope represents a natural philosopher’s tool to access the microcosm. On the pedestal, we can make out a bas relief portraying a woman reclining against an anchor and other objects while holding up what looks like an apple in her hand (at least in the Heidelberg portrait above). To the right, Hartsoeker knowingly guides the onlooker’s gaze to a maritime scene in the background: a ship on a stormy sea. The ominous dark skies and waves are furthered reinforced by the inscription on the pedestal, “...Fata ferant, ubi sistere detur.” The fragmentary quotation—from the line, “incerti quo fata ferant, ubi sistere detur” (“without knowing where our destinies will carry us, or where we will be permitted to settle”—comes from the

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7 Gemeentelijke Archiefdienst Utrecht, Inventarismr. U 139 a 6, Notaris Jacob van den Doorslagh, aktenr. 87, 8 Jan. 1717.
8 The above portrait hangs in the Kurpfälzisches Museum in Heidelberg and is considered a copy of the original in the Musée d’Art et d’Histoire in Geneva (inv. 1843-12). See Stroup, “Nicolas Hartsoeker, savant hollandais,” 204. According to art historian Marjorie Wieseman, who has hesitatingly identified the painting as “Portrait of Nicolas Hartsoeker?”, the other copies are in the Musée du Louvre in Paris, in the Kurpfälzisches Museum in Heidelberg, in the private collection of Walter Kobinger in Vienna, and possibly three more copies elsewhere. Apparently, Netscher had also painted a portrait of Nicolas Hartsoeker and his wife, which the latter mentioned in her will and bequeathed to their youngest son Jan Theodore Hartsoeker, together with a portrait of Hartsoeker by Jan Frans van Douven. See Marjorie E. Wieseman, Caspar Netscher and Late Seventeenth-century Dutch Painting (Doornspijk, The Netherlands: Davaco Publishers, 2002), 304-5; and, Peter de Clercq, “Two 17th-century Dutch Portraits with Optical and Mathematical Instruments,” Bulletin of the Scientific Instrument Society 87 (2005): 4-7, n7.
beginning of book III of Virgil’s *Aeneid*. At this point in the story, Aeneas wistfully recalls the fall of Troy and his father’s advice to set sail with destiny, before traveling to Thrace:

> When Heaven had overturned the Trojan state  
> And Priam’s throne, by too severe a fate;  
> When ruined Troy became the Grecians’ prey,  
> And Ilium’s lofty towers in ashes lay;  
> Warned by celestial omens, we retreat,  
> To seek in foreign lands a happier seat.  
> Near old Antandros, and at Ida’s foot,  
> The timber of the sacred groves we cut,  
> And build our fleet—uncertain yet to find  
> What place the gods for our repose assigned.  

Netscher’s (or Hartsoeker’s?) choice of this particular quotation was probably meant in general to symbolize the uncertainties of life and of scientific inquiry. Then again, if we take it at face value, Hartsoeker poignantly personifies Aeneas. As in Virgil’s song “of arms and the man” called Aeneas, Hartsoeker was caught in several wars in his life—political, religious, and philosophical in nature. For example, Alice Stroup has fruitfully explored his role as spy for Louis XIV against his own country. She has wonderfully analyzed how war between the Dutch Republic and the French crown taught Hartsoeker about clandestine ways of transmitting scientific knowledge between the two countries. As Wieseman points out, the motto and the relief “may also allude to the vicissitudes of Hartsoeker’s peripatetic career in the service of” the French monarch, Czar Peter the Great of Russia, and Elector of the Palatinate Johann Wilhelm II. However, this last point is true only in hindsight (since the portrait was made in 1682, well before Hartsoeker had established himself as *philosophe*). Wieseman compares Netcher’s portrait of Hartsoeker with the one he painted of

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10 Art historian Marjorie Wieseman has deciphered the partially obscured Virgil quotation on the painting. She also notes that the original copy in Geneva does not show the storm-tossed boat and rocky shore on the right, something that *is* depicted in the painting’s copies in the Louvre, Heidelberg and Vienna, as can be seen in the portrait above. See Wieseman, 304-305 and 101-102.


13 Wieseman, 101.
Christiaan Huygens. She concludes that Huygens’ choice to be depicted without scientific instruments and other paraphernalia signals that he, unlike Hartsoeker, sought to emphasize his patrician social status and “sartorial savoir faire” rather than his scientific and learned pursuits, which were “just one of his many accomplishments.” Hartsoeker, on the other hand, reminds the onlooker of his natural philosophical pursuits very clearly.

From the Early Modern Republic of Letters to the Present

This dissertation is about craft practice as philosophical practice. My choice of Nicolas Hartsoeker is motivated by what he can reveal about late seventeenth-century natural philosophy, experimental practice, and optics. He is an interesting figure for three key reasons. He illuminates how multifarious, complex and heterodox early modern natural philosophy was. Second, the philosophical debates he developed against his contemporaries reveal the salient issues at stake in natural philosophy of the late seventeenth and early eighteenth centuries. Related to this, the communities within which Hartsoeker traveled, exchanged ideas, and discussed his work are crucial to capturing the larger context in which he lived, and show the kinds of occupational and social niches that were available to him. With Hartsoeker as our guide—our articulate witness—into the world of late seventeenth and early eighteenth centuries, we can better capture and understand where knowledge, know-how, and technical expertise overlapped and where these three diverged. Much recent historical work has grappled with questions of expertise, artisanal practice, and knowledge-production. We have come a long way from a history of science that paid homage

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14 Wieseman, 100.
15 Wieseman, 102.
almost exclusively to Great Men of Science, or squeezed itself into a Kuhnian dichotomy of the “Classical Physical Sciences” versus the “Baconian Sciences.”  

(1) Denizens of the early modern period earnestly tried to merge the old with the new—ancient Greek philosophy and Hermeticism with newly invented instruments, machines, and ways of discussing God and the universe. One of the difficulties that trips historians of science when discussing the early modern period and its ingenious pursuits in knowledge-making is oppositional categories. One such example is the perennial problem with pitting theory against practice. How do we talk about artisans who participated in natural philosophy and, vice versa, how do we articulate natural philosophers who developed instruments, constructed lathes and machines, or experimented with magnets? Recent historiography has suggested several fruitful approaches for disentangling such questions and complicating seemingly clear dichotomies. In his *Power, Knowledge and Expertise in Elizabethan England*, Eric H. Ash explores how expert mediators brokered and facilitated the transmission of knowledge between their patrons and craftsmen by emphasizing their mastery of theoretical principles that underlied the practitioner’s skills. These experts, he argues, were a symptom of early modern capitalist ventures and growing royal bureaucracies. And while he concedes that his use of “expert” was not exactly an actor’s category in early modern Europe, he points to a kind of expertise that was notable and, in some respects, new because it combined the skill of managing bodies and types of knowledge with the dexterity of translating these to a variety of audiences. Closely related to this, is the problem of social and occupational, or professional and expert status and knowledge. In his review of Pamela H. Smith’s *Business of Alchemy*, Ole Peter Grell points out that merchants as well as artisans were active in manufacturing, trade, and banking to varying degree. He continues, “The period’s use of terms such as merchant and artisan had, in my

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opinion, social rather than precise occupational connotations.”¹⁸ I believe Grell has put his finger on a seemingly small but rather crucial and illuminating distinction. Often we miss the forest for the trees when focusing too much on what early moderns were doing to earn a living, and not enough on what these actions meant in relation to other social goals. By taking to heart Grell’s discriminating comment and by reconsidering the “social” and the “occupational,” we come closer to understanding that the two were not always at the same stage of development. This mindfulness allows us then also to reconstruct more effectively the ways in which the study of nature intersected with and encompassed broader social, political, religious concerns. On the whole, his critique is appropriate; and it helps to isolate the problem revisionist studies have encountered when seeking to merge and disentangle alchymical, artisanal, mercantile practices—in essence, craft-based occupations that produced tangible things and results—and humanist scholarly pursuits often concerned with knowledge gleaned from books and with less concrete or quantifiable transactions. As Lissa Roberts and Simon Schaffer remind, however, this normative, polar vision of theory and practice is still with us today.¹⁹

Going beyond practices, Grell’s point also applies to simplistic interpretations of the meanings of instruments, commodities, and objects of value. In Merchants and Marvels, Pamela H. Smith and Paula Findlen remind that princely as well as bourgeois collectors distinguished objects of value by more than simply their commercial significance:

Nobles collected the old-fashioned commodities of gold and silver, and pieces were not infrequently melted down in times of need, as the famous story of the bronze for Leonardo’s equestrian monument of Francesco Sforza reminds us on an even larger scale. Perhaps the important thing to keep in mind is the very instability of these categories since the same object could serve multiple purposes.²⁰

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¹⁹ Lissa Roberts and Simon Schaffer, preface to The Mindful Hand, xiv-xv.
Moreover, they argue, the application and dissemination of instruments “reflected the abilities of individuals in early modern society to cross boundaries that we have since installed by creating disciplines in areas which were predominantly defined by skills and techniques rather than specific kinds of knowledge.”

Disciplinary boundaries did not exist or were being redefined; communities and technical experts often prefigured the nominal occupation, as was the case for lens makers (see Chapter Two). Tracking the mercurial value, meaning, and content of objects, ideas, and people—indeed, the instability of the categories themselves—over time is always a thorny task for the historian. In this dissertation, the images and objects discussed have natural philosophical, commercial, and cultural import. Some, if not all, of them serve as clues to early modern ideas about nature and also help us access and explain the ineffable world of the popular (and individual) imagination. These artefacts tell us what their authors and creators thought was possible and impossible. A way to readdress this perennial problem of disambiguation is to use and interpret the language and terms of one’s actors, and, thus, attempt to build a solid and historically nuanced narrative. This is the tall order with which this dissertation grapples and which it ultimately hopes to achieve.

(2) Another fruitful way is to examine the spaces of exchange and networks of communication. By focusing on these intersections, instabilities, and dynamics, it becomes possible to demonstrate and explain the many ways in which bankers, merchants, miners, ship-builders, or turners partook in similar learned, literary, as well as skilled traditions. Pamela O. Long’s most recent work does this adeptly. Applying Peter Galison’s “trading zones”—a concept he borrowed from the anthropological studies—Pamela O. Long examines how fifteenth- and sixteenth-century European humanist scholars, engineers, artisans, architects, navigators, mathematicians, and many

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21 Smith and Findlen, introduction to Merchants and Marvels, 13.
others exchanged ideas and objects, and sometimes shared arenas of production. However, Long notes that her use of trading zones is different than Galison’s. She refers to groups of practitioners of various arts, crafts, and theoretical fields of knowledge who had not undergone formal professionalization. This was especially the case in areas such as architecture and engineering. Long convincingly argues that skilled artisan/practitioners valued the knowledge of classical texts and archaeology that customarily belonged to learned humanists much like the erudite scholars appreciated the kinds of technical knowledge that were to be gained from the practical arts, such as pottery, military engineering, and alchemy. As she summarizes, “Early modern trading zones consisted of arenas in which the learned taught the skilled, and the skilled taught the learned, and in which the knowledge involved in each arena was valued by both kinds of ‘traders.’” Thus, she concludes, the ‘traders’ in this period began losing “the distinguishing characteristics deriving from their particular backgrounds.”

While this framing is in many ways useful and illuminating, it nonetheless runs the danger of maintaining and operating within the dichotomy of artisan versus philosopher, or skilled versus scholarly, that it ultimately wants to distance itself from.

(3) To mitigate this conundrum, in part, this dissertation considers a historical figure like Hartsoeker who was fluent in many different kinds of knowledge and thus can offer a more holistic answer to these questions surrounding theory and practice. Hartsoeker experimented as much with ideas, schools of thought, and imagined realities, as with dissecting crayfish, building microscopes, and testing the strength and workings of magnets. Some of his knowledge and creative pursuits proved useful, lucrative, and productive in the eyes of his contemporaries. Others fell on deaf ears. In good part, this ambitious savant made use of “cunning” or practical intelligence to craft, polish, and promote his lens-making skills, his mathematical know-how (which he translated into optics and

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astronomy), and his fluency in many contemporaneous debates of learned communities. This “cunning intelligence” is often difficult to pin down because it was akin to animal instinct, evident in the successful conjectures of ship’s pilots, a set of ingenious semiotic skills proper to carpenters, politicians, physicians and midwives. Crucially for our understanding of the role of metis in the processes of knowledge production, Greek commentators reckoned that it was the very nature of things that made cunning intelligence powerful. Because citizens, diseases and seaways were multiple and shifting, their mastery required multiply shifting skills. Those epistemologists who denied shifting ontologies in favour of ideal types denounced cunning methods. Intellectual historians of technologies and sciences, much indebted to platonising philosophies of knowledge, sweepingly damned practical intelligence as a plausible source of rational science. Cunning might be involved in the recalcitrance of local circumstances and materials; but how could it ever show the value of and provide values for universal laws?

Hartsoeker definitely had his share of practical intelligence and “cunning ways of world-making”—and he was not afraid to use them. Two examples illustrate this cognitive point. The first is his soliciting Christiaan Huygens to persuade him of his optical and mathematical knowledge; and convincing him to take a stranger to Paris and introduce him at the Academy of Sciences (explored in detail in Chapter Two). The second involves the early—and anonymous—circulation of his ideas at the Academy: After taking stock of the intellectual culture of the Academy and working there for several years, Hartsoeker planned his steps to craft and publicize his own “system of the world,” in Huygens’ words. Huygens’ letter to Philippe de la Hire from 1692 reveals a facet of Hartsoeker’s cunning intelligence in world-making as well as in getting feedback from his immediate audience, the Academy. Even before Hartsoeker had authored his first treatise on lens making in 1694, he showed interest in important, unresolved contemporary questions in natural philosophy. In 1691 he

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23 Fokko Jan Dijksterhuis argues Hartsoeker was able to move from lens making to positing natural philosophical ideas thanks to his knowledge of mathematics in “Constructive Thinking,” 72-77.

24 Roberts and Schaffer, preface to The Mindful Hand, xxi-xxii.

25 Ibid., xx.

26 Christiaan Huygens to Philippe de la Hire, 9 October 1692, Oeuvres complètes de Christiaan Huygens (The Hague, 1905), vol. X, 324: “Que juge-t-on à l’academie de son [Hartsoeker’s] systeme du monde, où il attribue un estrange pouvoir aux raisons du soleil. L’Experience du ressort qui a ce qu’il dit, en est agité au foier d’un miroir concave est elle vraie? et si elle l’est, ne seroit ce pas de l’alteration ou extension que la chaleur donne à l’endroit du ressort le plus echauffe. On voit tous les jours bien de productions nouvelles mais peu de bonnes . . .”
had circulated a short, sixteen-page essay, in which he posited a causal explanation for planetary motion around the sun and for the nature of comets. Parts of the think piece were also excerpted and published in the *Journal des Scavans* of 11 February 1692. Neither publication disclosed the name of the author. Still, members of the Academy, including Huygens, clearly had an idea of who the author was. The treatise dealt only (and briefly) with cosmological problems. Hartsoeker endowed sunlight with, in Huygens’ words, “strange power,” a force that propelled and kept planets in orbit around the sun. The Dutch savant supported this idea on the basis of how a spring coil behaved under the concentrated sunrays and heat reflected by a burning mirror. Huygens asked De La Hire if Hartsoeker’s experiment with the burning mirror and coil was “trustworthy (vraie).” The zeal, with which he canvassed opinion of his contemporaries—such as Christian Huygens, Father Malebranche, or Gottfried Wilhelm Leibniz—and continued to rework his natural philosophical undertakings, betrays not only his will and desire to practice natural philosophy. It also reveals the astounding and exhausting variety of possible answers, clues, and systems of nature that abounded around him and that he could choose from, or better yet, cross-pollinate. Finally, his adaptability and his reserves of practical intelligence—even in the face of defeat—show him as someone who actively sought to improve his lot by changing his environment or the rules of the game.

27 I discovered the *Essay d’un nouveau systeme du monde* (Paris: Jean Cusson, 1691), KB 1691 80-635, in the Rare Book Division of New York Public Library, New York. The excerpted work by the same title (and the accompanying diagrams) is in the *Journal des Scavans*, 11 February 1692, 67-70. By a close reading of the text, I’ve found the language to be very similar and in some cases entirely identical to what can be found in Hartsoeker’s later *Essay de dioptrique* of 1694 and his *Principes de Physique* of 1696. The language in the introductory paragraph on p. 1 of the *Essay d’un nouveau systeme du monde* matches that in the introductory paragraph of chapter VII in the *Principes de physique*. In addition, several of the astronomical diagrams in the *Principes de Physique* can be traced back to his anonymous treatise *Essay d’un nouveau systeme du monde*. Fig. I from the *Essay* from 1691 can be found on pages 125 and 126 of his *Principes*, while Fig. II in the *Essay* is again reproduced on pages 138 and 147 of the *Principes*. Fig. III from the *Essay* is reproduced on pp. 195-196 of the *Essay de dioptrique*, although this last diagram not identical. Hartsoeker does not repeat the image or the text in the *Principes de physique*, but instead refers his reader on p. 124 (of the *Principes*) to his *Essay de dioptrique* for a close discussion of comets.

28 Hartsoeker had based this on his experiments with a burning mirror, which will be discussed in more depth in the last chapter of this dissertation. Huygens hinted at this experiment in the letter above.

29 Christiaan Huygens to Philippe de la Hire, *OC*, vol. X, 324.
In other words, this research project tells the story of Hartsoeker’s life and work in order to translate and better understand the complex cogs and wheels of early modern natural philosophy. Broadly taken, this dissertation would like to put in concert Ole Peter Grell’s constructive observation with the recent substantial, thoughtful, and richly documented scholarship by Eric H. Ash, Pamela O. Long, Pamela H. Smith, Paula Findlen, and the contributors to the important volume *The Mindful Hand*. With Hartsoeker as the central lens onto the period, the following thesis intends to build on the social, cultural, and cognitive dimensions of early modern science, and the networks and loci of exchange that these works articulate and examine.

**Conclusion**

In sum, this dissertation examines the natural philosophy of Nicolas Hartsoeker. Thanks to his expertise in optics, he was gradually able to build his own theoretical system of physics and establish himself as a natural philosopher. In the dissertation, I examine how this Dutch-born lens maker and philosopher sought to forge an intelligible comprehensive system of physics, all the while attempting to reconcile a myriad of probable natural philosophies. His case offers entry into a milieu defined by religious strife, political upheaval and ideological heterodoxy in the Dutch Republic and beyond. In many ways, Hartsoeker was an ordinary, university-educated man who had a profound interest in nature and knew how to advance himself and sell his skills. But he was also a man of the world: he had worked as a wine merchant, traveled abroad, met important men of his day, and even spied against his native country for the French crown. What made him extraordinary was his willingness and zeal to mobilize all the tools he had at hand—microscopes, telescopes, Cartesian philosophy, Cambridge Platonism, atomism, ancient Greek philosophies, chymical experiments, magnetism, animal experiments, human anatomy, personal experience—to make sense of a chaotic universe. In the dissertation, I explore the ways in which Hartsoeker and his
contemporaries struggled to develop a coherent framework of nature, negotiated between new empirical evidence and competing ideologies, and used their ideas as bargaining chips to gain authority and prestige.

Hartsoeker’s case is relevant to both the historian and the interested general reader, for it exemplifies the kinds of intellectual journeys a university-educated man with technical skills undertook to navigate the chaos and uncertainty of the seventeenth-century world and nature writ large. From the granular lenses he fashioned to the abstract theories he authored, we watch him grapple with the new language and methods of the New Science. As a natural philosopher, Hartsoeker hoped to reconcile and improve upon the existing theories that were peculiar to his period. Both Hartsoeker and his contemporaries give us access to the larger questions that were at stake, as they tried to articulate this vision of the New Science for the first time.

This dissertation proposes an alternative account to standard interpretations of how natural philosophy was practiced in the early modern period. It focus on the story of, in many ways, an ordinary thinker like Hartsoeker—not a Newton or Galileo—and considers critically the ways in which he was both a typical and extraordinary practitioner of natural philosophy in the second half on the seventeenth and early eighteenth centuries. In many ways, Hartsoeker was living out the last days of an age concerned with explaining everything from the causes to the effects of natural phenomena. His own eclectic natural philosophy exemplifies the preoccupation and frustration with constructing and defending a comprehensive system of physics. In the dissertation, I use Hartsoeker, his interlocutors, their natural philosophical works, and other documents from the period to examine broader questions in the field of history of science: What kinds of philosophical debates were happening and how did Hartsoeker’s and his contemporaries’ questions develop over time? What specific role did instruments, such as the microscope, come to play in investigations of nature? In what ways did the meaning of empirical evidence change, and what was its relationship
to building an explanatory system of nature? What was the status of natural philosophy and natural philosophers at this time? As a result, this research not only re-incorporates an important and curious figure into early modern history of science, but it also speaks to anyone who is interested in invisible microcosms and unfathomable macrocosms; religion, politics and natural philosophy; and, more generally, how knowledge, know-how, and technical expertise were defined and redefined in the later seventeenth and early eighteenth centuries.
Chapter 1

Medical Philosophers: Nicolas Hartsoeker and Cartesians at Leiden University and at the Amsterdam Athenaeum Illustre in the 1670s

“Ubi Physicus definit, ibi Medicus incipit” – Burchard de Volder

“Bastion of Liberty”

“Here are Students of all Nations of Europe, most of them Gentlemen of good Families; and often Princes, and great Lords Sons, have been seen to come hither for their education,” wrote the Englishman William Aglionby in 1669 about Leiden University. Another English traveler told the following about the university and its character:

... the Professor’s Closets are full of extraordinary curiosities. The Students have no Colleges or Halls to lodge and diet in, (as in Oxford and Cambridge,) but board in the Citizens Houses; their Tutors are very careful of them, and diligent in keeping them close to their Exercises, both at Publick Lectures, and in their Private Examinations, for which they have appointed Hours, and at which they are very punctual: ‘Tis a celebrated Academy, having continually in it about two Thousand, half Natives, and the rest Hungarians, Grecians, Germans, Polanders, French, English, Scots, and Irish; of which three last are computed about one hundred. Here they take their Degrees easier, and cheaper, and without that Pomp and extravagant Expence in practice in England.

This oldest Dutch University was not only an internationally renowned bastion of higher education in seventeenth-century Europe, but also a center of various spaces of learning and scholarly activities.

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1 I wrote this chapter as Research Fellow at the Edward Worth Library in Dublin, Ireland, in the summer of 2011. I am much indebted to the Edward Worth Library and its Trustees, and Dr Elizabethanne Boran, the Librarian, for providing me with the support, resources and, most importantly, access to Dr Edward Worth’s exquisite early modern book collection. I would also like to thank Marsh’s Library and Dr Muriel McCarthy, Sue and Anne who gave me access to Marsh’s wonderful treasure trove of early modern works.

2 I’m borrowing the title of a history of Leiden University by Willem Otterspeer (Leiden, 2008).

3 William Aglionby, The present state of the United Provinces of the Low-Countries as to the government, laws, forces, riches, manners, customs, revenue, and territory of the Dutch (London: Printed for John Starkey, at the Mitre, betwixt the Middle-Temple Gate and Temple-Bar, in Fleet Street, 1669), 247. About Leiden itself: “If this City had but running Water, a great Market-place, and some fountains of clear Water for drink, it would be the pleasantest in all Europe; but nothing can be ex omni parte beatum, accomplish’d in all points,” 249.

4 William Mountague, The delights of Holland: or, A three months travel about that and the other provinces. With Observations and Reflections on their Trade, Wealth, Strength, Beauty, Policy, &c. Together with a Catalogue of the Rarities in the Anatomical School at LEYDEN (London: Printed for John Sturton, near Serjeant’s-Inn Gate, in Chancery Lane; and B. Bosvile, at the Dial over-against St. Dunstan’s Church, in Fleet-street, 1690), 96-97.
that promoted a wide array of academic and scientific cultures. Libraries\textsuperscript{5}, a botanical garden, an anatomical theatre and a teaching hospital as well as an astronomical observatory were all part of the university experience at Leiden in the second half of the seventeenth century. The “Anatomy-House” in particular attracted foreigners who came to marvel at “Egyptian Mummiaes, Pagan Idols, Birds and Beasts brought from China, and remoter places, whole Skeletons, and an infinite number of other things . . .”\textsuperscript{6} Leiden University drew not only students from all parts of Europe but also curious visitors, who came to admire the collections of exotic \textit{naturalia} on display in the \textit{hortus botanicus} or the anatomical theatre. The university also attracted “Stars of this learn’d Firmament,”\textsuperscript{7} like “the great Scaliger”\textsuperscript{8} (1540-1609) and Franciscus de le Boë (Sylvius, 1614–1672). The latter was one of the first proponents of William Harvey’s theory of the circulation of blood.\textsuperscript{9}

The administrative identity of Leiden University from its very inception functioned on both a national and local level. On the one hand, university governance involved the administrative entities of both the States of Holland and Zeeland as well as the city of Leiden: these officials were known as the Curators and Burgomasters (\textit{Curatoren en Burgemeesteren}). The Curators were typically elected representatives from the political establishment—including former burgomasters of other cities, high-ranking officials, and nobles. Meanwhile, the Burgomasters were the four chief governors of Leiden. On the other hand, the university had its own senate, a governing body that represented the professors but had less power than the Curators and Burgomasters. Every year the

\textsuperscript{5} Fredericus Spanheim, professor of theology and head of the Leiden University library, expanded the access to and use of the library to all members of the university community from 1674. See, Christiane Berkvens-Stevelinck, \textit{Magna Commoditas: A History of Leiden University Library, 1575-2005} (Leiden: Primavera Pers, 2004), 38. In addition to the university library, “not only the Professors” of the university but also some citizens of Leiden “that are curious in Libraries” had opened their private libraries for public use (Aglionby, 151).

\textsuperscript{6} Aglionby, \textit{The present state of the United Provinces}, 251.

\textsuperscript{7} Aglionby, \textit{The present state of the United Provinces}, 245.

\textsuperscript{8} Mountague, \textit{The delights of Holland}, 102-103.

professorate chose a spokesperson who served as rector.\textsuperscript{10} Leiden’s fame spread beyond its status as a university boasting resources and eminent scholars when it took the torch from the University of Utrecht\textsuperscript{11} in the cause for Cartesianism. The Dutch Republic emerged as the first stronghold from which Cartesian physics spread to other parts of Europe.\textsuperscript{12} While the explosion of Cartesianism in the United Provinces was a uniquely Dutch phenomenon in that it confined itself primarily to the universities, it also resonated with the public outside of the academic institutions.

On the whole, there was a strong intellectual climate receptive to new philosophical ideas, including those of Descartes, Spinoza and Hobbes.\textsuperscript{13} While in the sixteenth and seventeenth centuries Aristotelian thought became largely accepted, it did not dominate. The Netherlands—unlike other European countries—lacked a Peripathetic tradition that stretched back to the Middle Ages. Ancient works of Vergil and Lucretius were taught alongside those of Renaissance humanists Desiderius Erasmus and Justus Lipsius.\textsuperscript{14} In a similar vein of eclecticism, Cartesianism in the Netherlands played itself out on every level of Dutch intellectual, political, religious and university life. Notably, most of those who adopted Descartes’ philosophy did not altogether reject Aristotelian philosophy. Some, like Adriaan Heereboord and Johannes Clauberg, translated Cartesian ideas into Scholastic terms and categories. Others, like Johannes de Raey, believed

\textsuperscript{10} Willem Otterspeer, 	extit{Bastion of Liberty: Leiden University Today and Yesterday} (Leiden: Leiden University Press, 2008), 31 ff.

\textsuperscript{11} In March 1642, while serving as rector of the University of Utrecht, Voetius persuaded the university’s academic senate to issue a formal condemnation of the Cartesian philosophy and its local defender, Henricus Regius. According to the senate’s statement, Cartesian philosophy was to be suppressed because: (1) it was opposed to ‘traditional’ (i.e. Scholastic/Aristotelian) philosophy; (2) young people taught Cartesian philosophy would be unable to understand the technical terminology of Scholasticism; and (3) it had consequences contrary to orthodox theology.


\textsuperscript{14} Leen Spruit, 	extit{Species Intelligibilis: From Perception to Knowledge}, vol. II (Leiden: Brill, 1995), 421.
Cartesian thought to have an affinity with Aristotelianism.\textsuperscript{15} Rather than a revolution, historian Paul Dibon identified Cartesianism in the Dutch Republic as a ferment; it was “certainly powerful, but difficult to isolate from the many other ferments that were agitating the spiritual life of the Golden Age and helping to usher in a new intellectual climate.” Even more crucially, he rightly reminds us that the Cartesian conversion initially was conciliatory in that it sought to synthesize the new philosophy with “a renewed Aristotelianism.”\textsuperscript{16} In other words, even staunch Aristotelians like Burgersdijck believed that a mastery of the “old,” or Aristotelian, philosophy was indispensable to the understanding of more recent developments in philosophical thought.\textsuperscript{17} In fact, even a brief examination the University of Leiden and other institutions in the Dutch Republic at this time supports the idea that there was a spirit of eclecticism not only among its faculty but also among its students. Descartes’ philosophy (as well as Bacon’s program) offered scholars like Heereboord a new and independent approach to the study and understanding of nature. Descartes along with Bacon, Gassendi, Campanella and other contemporary authors emerged as champions of a tradition that called for a skeptical method for investigating the world. The novelty of their investigative program centered on renewing the call of the ancients, like Aristotle, to examine critically both traditional and more recent sources of knowledge. Hence, as Sassen put it, Heereboord should be seen as an eclectic thinker who wanted to reconcile the old with the new. In sum, he was not a strict “Cartesian,” or proponent of Descartes’ doctrine, but more a “follower of a philosophia novantiqua,” an intellectual program that wedded modern and ancient philosophical traditions.\textsuperscript{18}

\textsuperscript{15} Leen Spruit, Species Intelligibilis, 429.
\textsuperscript{16} Paul Dibon, La Philosophie Néerlandaise au Siècle d’Or, tome I (Amsterdam: Elsevier Publishing Company, 1954), vii-viii: “Le cartésianisme n’est en définitive qu’un ferment – certes puissant, mais difficile à isoler – parmi tant d’autres ferments qui agitèrent la vie spirituelle du Siècle d’or et contribuèrent à fixer un nouveau climat de pensée.”
\textsuperscript{18} Ferd Sassen, Geschiedenis van de Wijsbegeerte in Nederland tot het Einde der Negentiende Eeuw (Amsterdam: Elzevier, 1959), 152. See also, Leen Spruit, Species Intelligibilis, 429; and, Ruestow, Physics at seventeenth and eighteenth-century Leiden.
That said, Descartes’ call to skepticism in natural inquiry encouraged and extended to “the aggressive assertion of the self, whether is intellectual matters, in the running of government or the ordering of society, or even in the pursuit of material interests.”\textsuperscript{19} In both the Dutch Republic and Paris, Cartesians wrote and debated with fervor and conviction, making and breaking alliances, in similar character to those involved in (and belonging to) a political party. Besides the Dutch Republic, Paris was the other famous center of influence where Descartes’ ideas were taken up, tried and tested by its academicians. On a large scale, Descartes’ skepticism became a “fashionable” end in itself and spawned skeptics and coteries of libertines, “among them Cyrano de Bergerac, who spoke, and cautiously wrote, against Christian orthodoxy.”\textsuperscript{20} Closer to the Academy of Sciences, Jacques Rohault led experiments, first at his house in the mid-1650s and later at the academy during the 1660s, where he popularized the Cartesian method. One way in which Rohault did this was through weekly house lectures in Paris. During these social gatherings, he lectured on and debated the major problems in Descartes’ natural philosophy with his audience. Experiments to test the weight of the air, create artificial rainbows, or illustrate magnetism according to Cartesian principles drew crowds from courtiers and bourgeois as well as foreign visitors and \textit{virtuosi}. Rohault was also instrumental in recruiting other Cartesian disciples. For example, he instructed Pierre-Sylvain Régis, whom he later sent “to spread the doctrine in Toulouse.” However, just as the Dutch Cartesians we will soon discuss, so too Rohault “did not wish to appear as a mere Cartesian partisan . . . but as a sympathetic arbiter between the systems of Aristotle and Descartes.” Cartesian explanations were often portrayed as more “complete elaborations of Aristotelian foundations.”\textsuperscript{21} Rohault took “all general notions from Aristotle” and sought to add more detail about the shape, size and motion of matter. Aristotle had only treated these concepts generally, but Descartes elaborated upon them.

\textsuperscript{19} Jacob, \textit{The Radical Enlightenment}, 15.
\textsuperscript{20} Jacob, \textit{The Radical Enlightenment}, 13.
within his scheme of matter consisting of variously shaped atoms in motion. Rohault’s approach was both conciliatory and nuanced. In negotiating the boundaries between old and new, he pointed out dissent among the Aristotelian scholars themselves, who quibbled and took the opposite side on issues on which they nominally would agree.

Descartes’ connection to the University of Leiden dates back to his matriculation as a student in mathematics on 27 June 1630. Before settling in Leiden, he matriculated from the University of Franeker in 1629. His Discourse on the method (Discours de la méthode, 1637) was published in Leiden; and for several years he lived in Endegeste (near Leiden) and had friends who taught at the university or were affiliated with it in another way. Descartes counted as his friends prominent Dutch figures, like Isaac Beeckman and Sir Constantijn Huygens, and university professors, such as Henricus Regius and Adriaan Heereboom. His work on optics, Dioptrics (Dioptrique, 1637), was not only an important and popular work in the Dutch Republic, but also inspired some of its readers to learn the art of lens grinding. Not surprisingly then, the general outlines of Descartes’ physics were known to his Dutch readers before his Principles of Philosophy (Principia philosophiae, 1644) was published.

Going beyond the circle of his immediate intellectual followers, Descartes’ complete works reached an even wider readership, when they appeared in Dutch between 1656 and 1661. In Holland, there was also a considerable history of the reception of Cartesian thought, from

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22 Jacques Rohault, preface to Traité de Physique (Paris, 1671), unpaginated: “J’ay pris d’Aristote toutes les notions generales, soit pour l’établissement des principes de choses naturelles, soit aussi pour ce qui regarde leurs principales proprietez.”

23 Rohault, Preface to Traité de physique, last page (unpaginated): “Et sans en venir à compte, il est aisé de s’en convaincre, si l’on considere qu’il n’y a point de question sur laquelle ils ne soient partagez; la moitie prenant Presque toûjours des conclusions toutes contraires à celles que les autres prennent; D’où il suit, que l’on doit necessairement trouver dans les écrits de ceux qui se proposent d’enseigner la Doctrine d’Aristote, autant d’endroits contre luy que pour luy.”


27 Ruestow, Physics at Seventeenth and Eighteenth-Century Leiden, 34.

pamphlets to later works such as *De Betoverde Wereld* (*The Enchanted World*, 1691), *Voyage du monde de Descartes* (*Descartes’ Journey around the World*, by Gabriel Daniel, 1694), and *Reize door de Wereld van Deskartes* (*A Journey through the World of Descartes*, 1700).

This chapter explores Hartsoeker’s early formation at Leiden University in the 1670s. In particular, I examine Descartes’ philosophy and how his disciples, in the form of Hartsoeker’s teachers, at the Amsterdam Athenaeum Illustre and at Leiden understood its import to the study of medicine and philosophy. Over the course of this chapter, I hope to offer a few suggestions to questions such as what it meant to be “a Cartesian” (a term used by Hartsoeker and his contemporaries), what kinds of Cartesian ideas prevailed, and what the university of Leiden offered both the professor and the student. As we move from a more general sketch of the University of Leiden and its Cartesian climate, I will focus on key instructors who shaped Hartsoeker’s ideas.

While the university of Leiden became the new center of Descartes’ followers in the 1640s, the teaching of Cartesian philosophy was not uniformly accepted. Since its inception, Descartes’ doctrine summoned as many followers as critics. Descartes’ seeming disregard for the substantial form, or what many accepted as the soul, and arguments for a moving earth were a few of the central notions that troubled both theologians and traditional philosophers. Moreover, Descartes’ method of universal doubt encouraged skepticism, on the one hand, and a proud rationalism that seemed to challenge the authority of Scripture (and of the faculty of theology, by extension), on the other. On the whole, one can easily begin to understand how instructing students to systematically doubt everything may have stirred unease at best and upheaval at worst among the institutional authorities. Finally, Descartes’ assertion of free will resulted in added tension from the orthodox Calvinists. Nonetheless, a significant fact was that from the beginning, and in large part due to student demand, Leiden university hired professors who taught traditional Aristotelian ideas and also

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those who taught the new philosophy of Descartes. This continued for quite a while, and further lends support to Dibon’s argument for a conciliatory and integrative program of the old and new philosophies. On the one hand, prominent new philosophers like Burchard de Volder, Herman Boerhaave and others began gradually moving towards a more experimental approach in teaching natural philosophy and medicine from the 1670s onwards.\(^\text{30}\) On the other hand, orthodox Aristotelians at Leiden continued to publish Peripatetic textbooks well into the eighteenth century.\(^\text{31}\) As soon as the Cartesian debates hit the university of Leiden in the late 1640s, heterodoxy among the professoriate ensured for decades to come that no one philosophical school would dominate. While such an approach kept student discontent at a minimum, hostile confrontations between the representatives of the old and the new were inevitable. We can say that at Leiden University, to borrow Wiep van Bunge’s astute observation, “dissent became institutionalized.”\(^\text{32}\)

**Medical Education in the Dutch Republic**

Institutionalized medical education in the Netherlands coincided with the founding of Leiden University in 1575, after the city had survived a dramatic, drawn-out and devastating siege by the Spanish during the Eighty Years’ War. Medical instruction in those days was predominantly theoretical. A hortus botanicus for the teaching of botany was eventually built in 1590 and an anatomical theatre for the teaching of gross anatomy followed in 1594.\(^\text{33}\) Bedside teaching and clinical instruction, in what would be termed the collegium medico-practicum, were added to the medical curriculum in 1636.\(^\text{34}\) According to Lindeboom, a medical curriculum at Leiden could be completed


\(^{32}\) Bunge, *From Stevin to Spinoza*, 154.


\(^{34}\) Lindeboom, “Medical Education in the Netherlands,” 205.
within two years. Before a student could proceed to the final examination, he had to have sustained two public disputations, which were meant to give the student practice in speaking and an opportunity to show what he had learnt. Lindeboom explains what followed in this process, which would persist for the next two centuries:

Before a student was allowed to graduate he had to pass a preliminary examination privately. Then, on a following day, he had to explain in the afternoon an aphorism of Hippocrates that had been communicated to him at 8 o’clock that morning. Finally, the candidate had to explain, against the objections of the professors, the case-history of a patient and to suggest the detailed treatment. This disputation lasted an hour. After that the candidate was entitled to have his thesis printed and to request from the Rector a date for his graduation. At the graduation ceremony the candidate had to defend his dissertation and a few additional short theses. The disputation lasted an hour, the end of which was marked by the beadle’s exclamation bora. Then the graduand received his doctor’s diploma and took an oath. Except for the teaching of botany and anatomy, all medical teaching was originally theoretical.35

This changed under the tutelage of Franciscus de la Boë Sylvius, who brought in a considerable practical side to the teaching of medicine at the University of Leiden. He was a celebrated anatomist, physician, clinical instructor and gifted teacher. Over the fifteen years he taught practical medicine, he conducted experiments in his three in-house laboratories and personally performed more than three hundred autopsies.36 He not only encouraged bedside medicine, but also incorporated chemical demonstrations and experiments into the medical curriculum. This seemed to be the case especially in the faculty of medicine, where such practice-based branches of medical instruction as anatomy and chemistry ceased to play an important role in the curriculum. With the death of the eminent Sylvius in 1671, a hands-on approach to medicine (via chemistry, anatomy and bedside teaching) and an appreciation of the experimental philosophy dissolved, the general story

35 Lindeboom, “Medical Education in the Netherlands,” 203.
goes. His brand and quality of medical instruction would not be matched until the appointment of Herman Boerhaave as lector in 1701 (and decline, once again, after his death in 1738), argues Lindeboom.\(^{37}\) Though technically Boerhaave supported the Iatrophysical – as opposed to the Iatrochemical – School at Leiden, he conducted chemical experiments and studies.\(^{38}\)

By the time Hartsoeker arrived at Leiden in 1675, Johannes de Raey had already left Leiden University for the Athenaeum Illustre in Amsterdam. It seems, therefore, that Hartsoeker entered the University of Leiden when it was experiencing an intellectual ‘low tide.’ Lindeboom’s inexorable thesis for the temporary decline in Leiden’s medical glory seems to correspond with Luyendijk-Elshout’s general conclusions. The latter argues that the period of Cartesian medicine at Leiden was one that created “an exceptionally unfavorable context for empirical research, which had enjoyed such a flourishing period in the middle of the seventeenth century.”\(^{39}\) Luyendijk-Elshout is much more nuanced in her analysis than Lindeboom. However, she, too, suggests that this period – coinciding intentionally with Craanen’s appointment at Leiden in 1671 to his move to Berlin in 1686 or 1687\(^{40}\) – was one of little advancement in medicine, and primarily in physiological and anatomical knowledge. Upon closer examination, their argument for scientific decline and lack of advancement in medicine in this period is neither entirely substantiated nor historically accurate. By looking at what Cartesians like Theodoor Craanen and Burchard de Volder were doing, we will find much intellectual ferment brewing. Later, I will show that Craanen, too, conducted dissections at times and engaged in clinical medicine. We must remember also that during the same time that Craanen

\(^{37}\) Lindeboom, “Medical Education in the Netherlands,” 207.

\(^{38}\) Lindeboom, “Medical Education in the Netherlands,” 211.


\(^{40}\) Many sources dated Craanen’s departure from Leiden to 1687; however, his position was being replaced earlier. P.C. Molhuysen, *Bronnen tot de Geschiedenis der Leidse Universiteit* (’s-Gravenhage: Martinus Nijhoff, 1920), vol. IV, 45: Paul Hermans replaced Craanen as professor of the collegium practico-medicum on 10 April 1686; and, vol. IV, 41: By 30 January 1687 Craanen was no longer at Leiden.
began teaching at the University of Leiden, he was joined on the faculty by anatomists Antonius Nuck and Lucas Schacht, as well as by the French royal physician Charles Drélinecourt and the equally famous Scotsman Archibald Pitcairn. And it is very likely that Schacht—unlike his teacher Sylvius—was less invested in solving philosophical rather than anatomical questions. Nevertheless, medical practitioners with training in philosophy at this time redefined the kinds of questions medicine and philosophy could ask and answer from 1670 onwards—and Descartes’ philosophy was crucial to this development. Moreover, the evolving distinction between medicine and anatomy incidentally highlighted the role of the (natural) philosopher. I argue that Descartes’ philosophy and the ways in which it was taken up by Leiden philosophers, like Craanen and De Volder, made possible ‘medical philosophers’. In other words, this intellectual development allowed for a fertile ground between medicine and philosophy, spawning new questions for how to interpret bodily processes and mechanical conceptions about the body and its parts.

The Amsterdam Athenaeum Illustre and Johannes de Raey

The Athenaeum Illustre in Amsterdam was part of a new educational institution in seventeenth-century Holland. The Athenaeum filled the middle ground between the Latin School and the university. Besides Amsterdam’s illustrious school, The Hague, Rotterdam, Dordrecht [and apparently also Deventer and Utrecht] each also had one. The “illustrious school” was not entirely a new concept in other parts of Europe, for its roots stretched back to the academic identity crisis of the sixteenth century. While not as popular as the Latin school or university, the illustrious school served to provide students with a curriculum that prepared them for university studies and offered general instruction in a variety of subjects. Amsterdam’s Athenaeum Illustre was founded by friends and fellow humanists Caspar Barlaeus and Gerardus Johannes Vossius in 1632. It provided

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propaedeutic instruction primarily in theology, law, and medicine and also in the “‘useful sciences’” [‘nuttige wetenschappen’]. In a city whose population and economy were experiencing a boom, it was a convenient choice for those young men who wanted a general education before going on to a job in commerce, for instance, or to one for which a university instruction was not crucial. The choice of an athenaeum was convenient for another reason as well. In times of religious and political upheaval, these local schools provided higher education to students who, for either lack of money or want of safety, could not travel and live far away from home. Of all the athenaeum, the one in Amsterdam was the most successful and prestigious, and over the subsequent decades after its inauguration grew to become a bona fide university with additional departments in preacher instruction [predikantenopleiding], surgery and navigation. Finally, the Athenaeum played an important role in civic education and prestige. The public lectures organized at the Athenaeum, to which all burgers had free access, bespoke Amsterdam’s prestige and, no doubt, invigorated its “urban civic culture.”

While no records survive of Hartsoeker’s quotidian class attendance at the Amsterdam Athenaeum (to my knowledge), several travel accounts and student diaries have yielded information about what a typical day’s activities looked like. The Athenaeum’s teaching professoriate was much less populated than a university’s, never exceeding the number of seven professors. This also translated to a less packed class roster. On the whole between 1663 and 1690, professors lectured daily on the hour, starting at 8 a.m. until 1 p.m. and again from 2 p.m. until 3 or 4 p.m., except on Sundays. As in the Dutch universities, there were no classes on Wednesdays and Saturdays. These two days were customarily reserved for holding disputations, with a morning lecture on Wednesdays on a rare occasion. For example, the student Caspar Commelin reportedly started his day with an 8

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a.m. lecture in logic by Alexander de Bie, followed by Petrus Francius’ lecture on Cicero’s *De Oratore*, a 10 a.m. theology lecture on *Galatians* by Gerbrandus van Leeuwen, a medical lecture by Johannes van den Broeck on the *Institutiones* and, at noon, a general history lecture by Louis Wolzogen. After lunch, at 2 p.m., Commelin concluded his day of classes with a lecture in physics by Johannes de Raey, on some weekdays followed by a lecture in astronomy and navigation read by De Bie.44

Johannes de Raey (1622-1702) was one of the first proponents of Descartes’ philosophy who was teaching at the Amsterdam Athenaeum Illustre when Hartsoeker began his studies. Already as Henricus Regius’ student at Utrecht University, De Raey counted among the early admirers of Descartes’ philosophy. In 1641, he defended theses under the supervision of the Cartesian Henricus Regius at Utrecht, and in July of 1647 took his doctoral degrees in philosophy and medicine at Leiden.45 Like Heereboord and others before him, De Raey believed that Aristotelian and Cartesian accounts of knowledge acquisition complemented one another.46 His teacher Regius (1598-1679), in turn, had been much influenced by Henricus Renerius, next-door neighbor and friend of René Descartes (who taught philosophy at the Utrecht Academy and the Illustre School in Deventer). Renerius’ recounting of Descartes’ ideas must have made quite an impression on Regius, for initially he became “a fiery supporter” of the French philosopher.47 With this enthusiasm he no doubt infected his student, De Raey, who pursued an academic career after his studies at the University of Utrecht. For a while, Johannes de Raey taught at Leiden without a formal faculty appointment, steadily gaining popularity among students who were intrigued by his Cartesian ideas and the way in which he used Aristotle against the Aristotelians themselves.48 In 1653 De Raey was appointed to the post of extraordinary professor in philosophy and then in 1661 he became ordinary professor at

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46 Leen Spruit, *Species Intelligibilis*, 432.
47 Ten Doesschate, *De Utrechtse Universiteit en de Geneeskunde*, 17.
the University of Leiden. After garnering fame at Leiden, the curators and burgemeesters of Amsterdam offered De Raey in 1668 a very lucrative appointment at the Amsterdam Athenaeum Illustre, where at 3000 gulden per annum he was the city’s best salaried hoogleraar (instructor). Another Utrecht Cartesian, Louis Wolzogen, joined De Raey on the faculty at the Athenaeum that same year and was appointed to teach church history. He was concurrently appointed pastor for the Walloon community in Amsterdam. De Raey’s most famous scholarly and philosophical contribution was the *Clavis Philosophiae Naturalis Aristotelico-Cartesiana*, first published in Amsterdam in 1654. In this bulky compilation of various essays and lectures, he adopted Aristotle’s explanatory framework in large measure but distanced himself from the Peripatetics on the relation between sensory perception and thought. While the latter believed mental processes depended on sensory images, De Raey supported Descartes’ position that both intellectual thought and sensory perception originated from the mind. In other words, “All knowledge is based either on perception or on intuition.” Contrary to what Hartsoeker argued, as we shall later see, De Raey did not think that the senses rendered the true nature or essence of things.

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V. Imprimis igitur omnis percepio seu simplex apprehensio, qua sine affirmatione & negatione alicuius cognoscimus, seu, quod eodem edit, qua imaginem, notionem, conceptum & ideam contemplamur tantum & praesentem nobis sitimus, cogitatio est. Sive mens se sola utatur & ad se ipsam tantum respiciat, dum hoc facit, quod est intelligere: Sive ad corpus se convertat, & alicuius in eo ideae, vel à se intellectae, vel sensu perceptae, conforme intueatur: Quod est imaginari, vel sentire.

VI. Ergo percepio intellectus solius mentis actus & mera cogitatio est, cujus in toto consciis nobis sumus: quatenus nihil ad eam contribuit corpus, cui repugnat omnis conscientia & perceptio. Ut nihil falsius sit communi illo axiomate, Intelligentem oportet phantasmata speculari, & nihil esse in intellectu, quod prius non fuerit in sensu.”

52 Leen Spruit, *Species Intelligibilis*, 432.

In the “first Cartesian war,” Leiden University’s curators sanctioned a disciplinary separation between the faculty of philosophy and theology in order to ensure order. Knegtmans argues that due to the lack of an instructor in theology at the Amsterdam Athenaeum, clashes, such as those at Leiden, did not exist. De Raey must have felt more intellectually free (and probably better remunerated) there than at Leiden, since he gave up his university chair and moved to Amsterdam in 1668. And so already in his first year at the Athenaeum, De Raey, guided by Descartes’ fundamental philosophical principle of systematic doubt, allowed students to defend “disputations in logic . . . that were cast in Cartesian terms.” However, according to Knegtmans, De Raey had no interest in experiments and thought Descartes’ method was not applicable to theology or medicine. Moreover, De Raey, following Descartes, believed matter to consist of ever-moving particles that were too small to be seen. As such, they could not be measured by any experiments. Descartes’ philosophical method remained abstract and prescriptive, and could most of the time not be applied directly to the study of nature, according to De Raey. Theo Verbeek goes even further than Knegtmans in arguing that De Raey generally believed natural philosophy to be an abstract intellectual discipline and method, which was not suited to the study of theology, physics, medicine or law:

De Raey, on the other hand, claims that philosophy is above all ‘contemplation of nature’ and that, as a result, it cannot be used for providing the conceptual framework of the higher faculties [such as law, medicine and theology]. Whereas physics relies on mathematics and systematic doubt, sciences like medicine and law require an interpretative (or, as we perhaps would say, ‘hermeneutic’) logic which starts from common language and sense experience. A reform of these disciplines, therefore, such as was undertaken by Meyer and Spinoza, is opposed to sound Cartesian method. Indeed, De Raey advances the interesting paradox that, the more true philosophy is, the less useful it is to theology, medicine, and law.

54 Knegtmans, Professoren van de stad, 59.
55 Knegtmans, Professoren van de stad, 59.
**Drawing the Lines**

Disagreements over the disciplinary boundaries between philosophy and theology stood at the heart of the Cartesian disputes at Leiden. Cartesian proponents in the faculty of theology, such as Abraham Heidanus, often faced serious repercussions for their attempts to separate philosophy from theology. Fervent Cartesians on the faculty of philosophy were sometimes demoted to the faculty of medicine, which historically held less prestige than theology and philosophy—disciplines which dealt in matters of metaphysics. This happened in the case of Theodoor Craanen\(^57\), who in 1673 replaced the recently deceased Sylvius on the faculty of medicine and from whom Hartsoeker learnt Cartesian medicine.

Shortly after Hartsoeker arrived at Leiden in the fall of 1675,\(^58\) “the last Cartesian war”\(^59\) was coming to an end. The spark that ignited the last struggle came from the faculty of medicine where Cornelis Bontekoe, Craanen’s pupil, and Johannes Swartenhengst\(^60\) had been devoted teachers of the new Cartesian philosophy. (Cornelis Bontekoe propagated Craanen’s theories in Germany and Central Europe in particular.\(^61\)) In December of 1675 the curators withdrew Swartenhengst’s permission to teach philosophy, accusing him of proselytizing Cartesianism with “‘immoderate zeal’” and publically disparaging Aristotelianism. They also found fault with Bontekoe, whom they chastised for suppressing the Peripatetic doctrine. The curators of Leiden University, who usually were three state-elected patricians\(^62\), and the city’s ruling Burgermeesters kicked off a pamphlet war with a resolution against twenty propositions, or “noxious novelties [schadelijke Nieuwigheden],” that

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\(^{58}\) *Album Studiosorum Academiae Lugduno Batavae MDLXXV-MDCCCLXXV* (The Hague: Martin Nijhoff, 1875), 600.

\(^{59}\) Otterspeer, *Groepsportet met dame*, vol. II, 58. The last Cartesian war was between 1672 and 1676.

\(^{60}\) Johannes Swartenhengst got permission to preside over disputations in the faculty of philosophy. See Molhuysen, *Bronnen*, vol. III, 259.

\(^{61}\) Schneppen, 107.

were allegedly based on the Cartesian philosophy (but were mostly Coccejan or Spinozist\(^63\)). Cartesian sympathizers on the professoriate were accused of teaching them against Scripture. To this list of unorthodox notions, Cartesians faculty members, among whom also De Volder, responded as follows: “We are free Men, who love truth and freedom, we are friends of Calvin and Cocceius, but even more so of the truth, which, wherever we find it, we gladly accept and protect . . .’” In addition, these Cartesian sympathizers attacked their accusers for not even having read Descartes’ work and, instead, approaching it with ignorant prejudice. These truth-loving scholars were protecting both Descartes and their \textit{libertas philosophandi}. Such a bold response from the professorate did not go unpunished. Immediately thereafter, Heidanus,\(^64\) professor of theology and first author of the reply to the curators’ resolution, was sacked.\(^65\) More generally, this incident also highlights the social and political stakes—and the spirit of self-assertiveness and anti-authoritarianism—at the center of Descartes’ doctrine.

The stories on the other side of the ideological divide were no less dramatic. Professors hired to replace Voetians, or Aristotelians, did not stay long in their new posts but were driven out by angry young men. Irreverent students often hurled insults and injuries at professors who taught traditional Aristotelian doctrine or were critical of Descartes.\(^66\) It is unsurprising then that many non-Cartesians were appalled more by “the rashness of the would-be Cartesians rather than the precise content of their philosophy.”\(^67\) What is important to keep in mind in this development is that the Cartesian disputes were happening across disciplinary boundaries. That is, outspoken Cartesian professors were often found in the departments of philosophy and medicine but also in theology, as

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64 Abraham Heidanus (1597-1678) was friends with Descartes and also a famous preacher in Leiden. He was appointed professor in theology in 1648. Verbeek, \textit{Descartes and the Dutch}, 34: “But in 1639 his Cartesianism must have been visible only, if at all, in his style of preaching, which, according to Baillet, was ‘Cartesian.’ ”


we saw in the example of Heidanus. In similar vein, in the department of philosophy there were professors who were traditional Aristotelians. Moreover, being a Cartesian did not mean completely rejecting the teachings of Aristotle, or espousing atheism per se. Burchard de Volder, one of the most prominent Cartesians and Hartsoeker’s teacher, included Aristotle along with Plato and other ancients in the list of authors whom he cited in his lectures. To be a Cartesian then seemed to entail being more willing to question, even if nominally, the establishment and the standard sources (like Aristotle) that stood for tradition. Not least of all, these academic disputes also highlighted the confessional struggles and the grip of the Calvinist movement that colored the Dutch Republic as a whole and the city of Leiden specifically at this time. It is within this hostile context that we can take seriously Hartsoeker’s initial allegiance to the Cartesian camp and appreciate the seriousness of a later change in his beliefs. To be a “Cartesien outré” or an “extreme/fervent Cartesian” then was not an exaggeration. As we saw in the above examples, people took sides and careers and even sometimes lives hung in the balance of these philosophical wars.

What should moreover be stressed is that many Cartesians were not and did not see themselves as radically breaking with scholastic ideas and ancient philosophies. Aristotelianism “proved a very flexible philosophy” that also suited Cartesians. As Verbeek notes, “the Cartesians’ concern to prove that their concepts and categories were already used by Aristotle testifies to their sincere need to confirm that they were not breaking with tradition.” Johannes de Raey, for instance, commended Aristotle for his investigations in natural history, even though he criticized him for insufficiently separating history and science. As shown above, De Volder, too, made sure to discuss Aristotle in his lectures.

69 Nicolas Hartsoeker, Extrait critique des lettres de feu M. Leeuwenboek in Cours de physique, accompagné de plusieurs pièces concernant la physique qui ont déjà paru et d’un extrait critique des lettres de M. Leeuwenboek (The Hague: Jean Swart, 1730), 45.
70 Verbeek, Descartes and the Dutch, 8.
Nicolas Hartsoeker at Amsterdam’s *Athenaeum Illustre* and Leiden University

In the fall of 1674, Christiaan Hartsoeker sent his son Nicolas to the Amsterdam Athenaeum Illustre. The young Nicolas reported that he studied philosophy with Johannes de Raey who had by then moved from teaching at the University of Leiden to the Amsterdam Athenaeum, literature with the Latin poet Francius\(^1\) who joined the faculty in 1674 as professor of Roman history and rhetoric\(^2\), and ancient Greek with Limbourg\(^3\). For the last, Hartsoeker most likely meant the theologian Philip van Limborch—a colleague and close friend of Hartsoeker’s father—who not only knew the young Nicolas but introduced him to John Locke\(^4\) and may very well have instructed Hartsoeker in ancient Greek at his house\(^5\) in Amsterdam at this time. Van Limborch himself was a student of the Remonstrant scholars Caspar Barlaeus and Gerardus Vossius, the founders of the Athenaeum Illustre in Amsterdam who taught him ethics and history, respectively.\(^6\) In his autobiographical account, Hartsoeker argued that he became “an outspoken Cartesian [*Cartesien outré*]” under De Raey’s tutelage.\(^7\) In the fall of the following year, at age nineteen, he arrived at the University of Leiden and enrolled in the faculty of philosophy in October 1675. Even though

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1 This was most likely Pieter de Frans or Petrus Francius (1654-1704), originally from Amsterdam, “de grote rector van de Amsterdamse illustere school,” *Groepportret met dame*, 75. Not only a Latin poet and professor of history, Francius became a regent of the theatre, brokered connections with the artists’ association *Nil volentibus arduum* and organized student poetry recitations to promote and boost the public visibility of the Amsterdam Athenaeum. See Miert, *Humanism in an Age of Science*, 101.


3 There was nobody by the name of Limbourg on the Athenaeum faculty (see Miert’s *Humanism in an Age of Science*, Appendix 1, 365). It is however possible that Hartsoeker meant to indicate Philip van Limborch—a colleague and great friend of Hartsoeker’s father—who may have very well instructed Hartsoeker in ancient Greek at or outside of his home in Amsterdam at this time. In general, the faculty in 1674 at the Amsterdam Athenaeum comprised Meiboom, Faber, Christenius/Francius, Wolzogen, De Raei and Blasius. At a later occasion, Limborch wrote a letter of introduction to John Locke on behalf of Nicolas Hartsoeker, when the latter visited England in 1689.

4 Philippus van Limborch to John Locke, 31 July 1689 [Gregorian], trans. Paul Lodge in J. Locke OUP.

5 Philip van Limborch to Christiaan Hartsoeker, Universiteitsbibliotheek Amsterdam, Special Collections, III D 17, fol. 95r (undated).


7 Hartsoeker, *Extrait critique*, 45.
Hartsoeker wrote he left Leiden University for Rotterdam at the beginning of 1677, records show he enrolled each year until (at least) 28 February 1682 and was lodged at the house of Wessel Knippingh (and, later, of his widow). Surprisingly, he continued to enroll even after he had married Elisabeth Vettekeucken on 27 October 1680 in Rotterdam, a rather unusual practice. Once married, students would not normally continue to enroll at university.

For all of his years of study, Hartsoeker lived in the house of Wessel Knippingh in Noordeinde, a street close to the central grounds of the university. He was joined by two or three housemates who all apparently studied law. The practice of students living with host families or even lodging in their professors’ homes for the academic year was not uncommon then. At the university he studied anatomy under Drélincourt, philosophy under De Volder (who also taught physics) and medicine under Craanen. Hartsoeker claimed that Craanen taught him “a completely Cartesian [kind of] Medicine . . .” Although he later often wrote and published on medical topics, I have found no evidence of Hartsoeker’s public disputations or any theses he may

78 Hartsoeker, Extrait critique, 46.
80 Leiden UB, Special Collections, Archief van Senaat en Faculteiten (ASF) and the enrollment lists are called “recensiellijsten” and go from 1582-1877. Hartsoeker is listed in ASF 45 (year 1675) through 51 (1681).
81 Rotterdam Gemeente Archief, Rotterdam Stadstheo, M, 1576-1811, Hartog – Heijligers [unpaginated].
82 I wish to thank Mr Ernst-Jan Munnik at Leiden University Library, Special Collections, who recommended I look at the original manuscript enrollment lists where I found this information. See, “Volumen inscriptionum” for 1675: ASF inv. nr. 11, p. 479, 7 Oct 1675, where Hartsoeker appears under the name of “Nicolaus Hardtsuiker, Rotterdamensis, 20 annorum, philosophiae studiosus, bij Wessel Knipping int Nordend.” From 1676 until 1681 he appears each year in the enrollment lists. See, ASF inv. nr. 45: 1675; inv. nr. 46: 14 Feb 1676; ASF inv. nr. 47: 19 Feb 1677; ASF inv. nr. 48: 17 Feb 1678; ASF inv. nr. 49: 25 Feb 1679; ASF inv. nr. 50: 1 Mar 1680; ASF inv. nr. 51: 18 Apr 1681; ASF inv. nr. 52: 28 Feb 1682.
83 Archief van Senaat en Faculteiten (ASF), inv. nr. 46 through 52. His housemates were Leonardo Potael (15 Feb 1676, 19 Feb 1677, 21 Feb 1678, 25 Feb 1679, 28 Feb 1680), Damasius van Gerwen (17 Feb 1677, 24 Feb 1678, 22 Feb 1679), Jacobus de Lange (27 Feb 1677), Theodorus Van Euijck (25 Feb 1679, 23 Feb 1680, 27 Feb 1681, 27 Feb 1682), Jacobus de Haese (26 Feb 1682), Bruno van Mol (1680 and 1681, without exact day) and Andreas de Roij (27 Feb 1682) lived in the house of the same land lord.
84 Mountague, The delights of Holland, 96-97.
85 In 1670, De Volder asked the Curators of the university for permission to lecture on physics, teaching Institutiones Logicae twice a week and the Institutiones Physicae twice a week. See Mollhuysen, Bronnen, vol. III, 245.
86 Hartsoeker, Extrait critique, 45.
87 Hartsoeker, Extrait critique, 45: “Je partis de cette ville vers le mois de Septembre de l’année 1675 pour aller demeurer à Leiden, afin d’y apprendre l’Anatomie sous M. Drelincourt ; la Philosophie sous M. de Volder, & la Medicine sous M. Craanen, qui m’apprit une Medecine tout à fait Cartesienne . . .”
have written either in philosophy or in medicine as a student at Leiden. Nor did he ever mention having written or defended any university work in his published treatises.

Charles Drélincourt (1633-1696) taught courses in general medical practice and anatomy on the faculty of medicine. Before being appointed professor of medicine at Leiden in December 1670, Drélincourt served as “inspector of the medical services of the French armies in Flanders” and later as court physician to Louis XIV. He taught anatomy and performed public as well as private dissections. Drélincourt conducted daily anatomical investigations to the point of endangering his health “by the handling of the cadavers and the frequent use of microscopes.” He used microscopes to study “‘the most subtle parts’” of anatomical structures in private lectures. Moreover, he often conducted demonstrations on live and dead specimens in the main anatomical theatre. Little is known about Drélincourt’s specific philosophical leanings, therefore, it is difficult to say whether his teaching indoctrinated Hartsoeker in any way. In his published technical treatises on anatomy, however, he would mention Descartes, as well as many ancient and modern authorities (such as Galen or Steno, respectively), in passing, but would refrain from discussing their theories at length. Concerning his anatomical practice, however, it is safe to believe that Hartsoeker learnt anatomy from his demonstrations.

Drélincourt’s teaching style differed widely from Craanen’s. While the French-born (and French-speaking) Drélincourt taught anatomy “as a kind of Baroque rhetoric,” Craanen garnered notoriety for his highly speculative manner of instruction. While both men were not averse to using microscopes in the examination of bodily structures and fluids, they used their findings differently. Drélincourt wielded a microscope to verify and examine anatomical structures, seemingly uninterested in connecting what he found to Cartesian doctrine. Craanen, on the other

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88 Otterspeer, Groepsportret met dame, vol. II, 357.
hand, used it as a tool that would corroborate his theoretical commitment to Descartes’ corpuscles in motion. Antonie Luyendijk-Elshout follows Craanen’s explanation of how variously shaped particles of chyle found their way through the designated pores of the intestinal villi, lacteal vessels and thoracic ducts, as they traveled to the appropriate organs. Craanen’s Cartesian model of variously shaped and sized invisible corpuscles (that distinguish themselves through heat, which is synonymous with motion), she argues, was driven by theory: “Experiment is cast aside, while observation is merely used in support of favoured theories. The corpuscular theory of matter is applied to the food he observes through the microscope.” The mismatching of particles to pores, then, Craanen interpreted as causing disease.91

Theodor Craanen (1620-1690) received the most frequent mention in Hartsoeker’s accounts of his time at Leiden. Hartsoeker reported that he learnt an altogether Cartesian medicine from Craanen, who was the successor to Franciscus de le Boë Sylvius—the illustrious physician, skilled anatomist and outstanding clinician who had founded the iatrochemical school at Leiden. Influenced by Paracelsus and corpuscular theories, Sylvius hoped to arrive at an explanation of the body based on its chemical and mechanical processes.92 He was a gifted teacher, conducted public postmortems in the hospital, and reintroduced the practice of interrogating students at the bedside as an effective method in teaching them how to diagnose patients.93 After Sylvius’ death in 1672, Lucas Schacht, Sylvius’ former pupil, took over clinical instruction until he died in 1689.94 Already after Sylvius’ passing, the medical interests of subsequent instructors were driven less by any particular “theoretical” program than by mere practice and knowledge of anatomical structures. The successors in anatomy, at least, were first and foremost practitioners who favored “a more limited scope of the postmortems.” In addition to a faculty less inclined to practice hands-on anatomy, the

93 Lindeboom, “Medical Education in the Netherlands,” 206.
94 Lindeboom, “Medical Education in the Netherlands,” 206.
university of Leiden was experiencing a period of financial troubles that cinched the purse of clinical teaching and further diminished the possibilities for (teaching and learning) practical medicine.95

Theodoor Craanen, a German-born physician who came to Leiden from the University of Nijmegen, was a “full-blooded Cartesian.”96 His reputation as a Cartesian preceded him and made his appointment in philosophy at Leiden controversial.97 Afraid that he would go out of the bounds of proper doctrine, the curators of Leiden University allowed him to teach logic and metaphysics, only if he followed orthodox doctrine articulated by Franco Burgersdijk (1590-1635), one of the most prominent Dutch Aristotelians.98 Three years after his appointment to teach philosophy, Craanen stirred up trouble over Cartesian doctrine with university librarian Fredericus Spanheim, and was permanently moved to the faculty of medicine.99 On the provision that he was to “‘keep out of all controversies’” in the teaching of his institutio medicinae, “the German trouble-maker” (as historian Luyendijk-Elshout calls him) thus replaced Sylvius in the medical faculty.100

According to the general historiography, neither Craanen nor Drélincourt had devoted much time to clinical work and both were unwilling to engage in bedside teaching. Despite pressure from the university’s Curators, Craanen remained unmoved and did not take on the collegium practico-medicum.101 That said, Craanen, along with others on the medical faculty like Lucas Schacht and Charles Drélincourt, often received requests to give counsel to other physicians and magistrates who were confronted with difficult medical cases. These cases routinely involved people who had met an untimely or violent death and whose bodily markings and other circumstances were used to establish the cause of death. Such postmortems involved much conjecturing and cross-consultation with other physicians.

95 Huisman, “The Finger of God,” 144.
For instance, a case on 19 October 1676 dealt with the death of a five-year-old boy who probably had swallowed poison or some kind of toxic substance. The physicians at the University of Leiden — Craanen, Drélincourt and Schacht — were called on in writing to determine whether or not the physical symptoms exhibited by the boy came from the ingestion of poison. After having deliberated “on such a grim case,” they declared that “from the alleged signs, a strong and well-founded suspicion supports some kind of ingested poison, although, importantly, this, for many and various reasons, can neither be, nor should it be, certainly or undoubtedly decided (something that was not asked of us); even less so [the matter of] whether the uncle or the father’s brother had given it [to the boy].”

Another case involved Jan Blûisée, who was found dead on 8 June 1677 with blood having come out of his mouth and the right side of his face and throat swollen. Two days later, two physicians and two surgeons in Dordrecht had conducted an autopsy on his skull and brain, since he had seemingly only suffered superficial wounds to the head. Job de la Croij, presumably one of Jan’s relatives, called on the university physicians at Leiden to judge whether or not the postmortem results drawn up by the medical group in Dordrecht indicated an inflicted wound [“voodelijcke wonde”] and whether or not the injury may have originated “by itself [per se]” or “by accident [bij toeval].” On 27 August 1677, Craanen opined that the wound itself was not lethal and thus per se could not have been the cause of death. Other circumstances, such as afflictions [“ontsteltenisse”] of the blood or humoral imbalance, must have precipitated the victim’s demise.

Perhaps because he was a philosopher by training and a Cartesian in method, “Craanen was more inclined to [theorize] about the human body than [conduct] empirical observations and

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102 ASF, 85: “De Faculteyt in de Medicynen in de Universiteyt tot Leyden, hier over rypelyck en op t’ beste, datse in soo duyster een ghevall konde, gedelibereert hebbende, heeft geoordeelt, gelykke oordeelt met deelen, dat uyt de bygebrachte teekenen, een groot en een gefoondeert vermoeden valt van eenigh genoomen venijn, doch dat suilk om veele en verscheyde reeden, belangh hier byte brenghen, niet secker noch ontuyffelbaar (t’ welck is het geen het welk gevraagt werd) kan of magh beslooten werden; vell min dat der oom of vaders broeder daar van souw de gever zijn.”

103 ASF, 86-87.

104 Theodoor Craanen, ASF, 87: “...dat de gegeven wonde van sich zelfs niet lethael is; ende dat de daer op gevolgte doot niet per se van de wonde veroorsaect; maer door andere ontsteltenisse van het bloedt, hûmeûren en des vorderen lichaems toegevallen is.”
Herman Boerhaave once said of Craanen that he was “‘someone of great intellect’” and natural eloquence, “‘but in whom the students would have desired more profound knowledge of medicine and less unbridled extravagance of thought.’” Even worse, Boerhaave believed that Craanen “‘preached’” to a reckless youth a personally convenient philosophy that was ultimately “‘unsupported by Cartesian hypotheses’.” To be sure, Craanen was believed to be “the most notorious representative of militant Cartesianism in the Dutch universities.”

Interestingly, there was a difference as to what Craanen thought about Descartes as philosopher versus Descartes as anatomist or medical practitioner. Craanen defended Descartes to his reader, reminding him that “we would have easily forgiven had Descartes . . . not been a careful Anatomist, or Physician, but not so much [if he had been a careless] Philosopher . . .” In another part of the Tractatus, Craanen sounded a different tune: “Descartes, who, to be sure, was not a great Anatomist and was merely inspecting this matter with a philosophical eye, perceived that due to the rarefied blood in the heart its sides would have to be expanded and enlarged.” And while Craanen no doubt admired Descartes’ work, he underlined that he was not an Anatomist and therefore not an irrefutable authority on the fabric of the body. In another section on the heart’s motion, Craanen gently reminded his reader, “. . . but let us say one word, Descartes has inspected this ventricle with a philosophical and not with an Anatomical eye . . .” Descartes kept himself honest when it came to claiming anatomical knowledge. In the Tractatus de Homine, he informed his reader that he would not

109 Theodoor Craanen, Tractatus Physico-Medicus de Homine, in quo status ejus tam naturalis, quam præternaturalis, quoad Theoriam rationalem mechanicè demonstratur, ed. Theodoor Schoon (Leiden: Peter van der Aa, 1689), 7-8: “Cartesio hoc facile condonaverimus, cum non fuerit exactus Anatomicus, nec Medicus, sed tantum Philosophus; Sed reliqui [p. 8] Medici quotidian praxin exercentes, non tam facile hâc in parte sunt excusandi, cum hujus rei falsitatem in praxi non tantum, sed etiam ratione possunt assequi.”
110 Craanen, Tractatus Physico-Medicus, 155: “Cartesius vero, qui non Anatomicus erat magnus, hanc rem solummodo oculo philosophico inspiciens, deprehendebat sanguine rarefacto intra cor, ejus latera debere extendi, ampliari . . .”
111 Craanen, Tractatus Physico-Medicus, 159: “. . . sed uno verbo dicimus, Cartesium hunc ventriculum inspexisse oculo philosophico & non Anatomico, & cum sanguis ebulliret in codem, non quando nullus ei ineffet motus.”
enumerate all the parts of the human body, but delegated him to “an expert Anatomist” who would be able to show him at least all the visible parts.112 For all his dissections and anatomical learning, Descartes’ primary aim was to make a mark on philosophy rather than anatomy or medicine. In following this convention, Craanen himself regularly referred his student or reader to the works of Charles Louwer, Nicolaus Steno (who, incidentally, was Sylvius’ student) and other recognized anatomists.113 And although, Craanen was very much attached to explaining disease according to the ill-fitting and mismatching of particles to pores, he nonetheless had respect for anatomical knowledge. Craanen, who had after all been trained in the Hippocratic tradition, believed along with all the old and new Hippocratics that knowledge of the structure of the body was essential to the curing of disease.114

Craanen’s medical treatises show that he taught physiology from Descartes’ Treatise on Man, or L’Homme. He followed Descartes’ famous opinion that “the body is nothing other than an earthen statue or machine, that God intentionally created to make it resemble us as much as possible.”115 More specifically, Craanen sought to apply Descartes’ method and dualism of the body and soul to systematize the human body. As the Preface to Craanen’s Oeconomia Animalis promised, his three-pronged method consisted of first discussing “the human automaton, or animal body,” then, “the nature and function of our mind” and, lastly, of uniting “the mind with the body and explain[ing] the functions that result from their conjunction . . . and what the mind and the body

112 Renatus Descartes, Tractatus de Homine et de Formatione Foetus (Amsterdam: Daniel Elzevier, 1677), 2-3: “Eas enim per omnia similes suppono partibus nostri quae haec nomina habent, & quas curare quis potest sibi demonstrari à peri- [p. 3:] to Anatomico, saltem quae adeo magnae sunt ut videri possint, si eas jam satis ex se ipso non noverit.” / René Descartes, L’Homme (1664), in Oeuvres de Descartes, ed. Charles Adam & Paul Tannery, vol. XI (Paris: J. Vrin, 1996), 120-121: “. . . car ie les suppose su tout semblables aux parties de nostre Corps qui ont les mesmes noms, & que vous pouuez vous faire monster par quelque sçavant Anatomiste, [p. 121:] au moins celles qui sont assez grosses pour estre vues, si vous ne les connoissez desia assez suffisamment de vous mesme.”
113 On the structure of the heart, see for example, Craanen, Tractatus Physico-Medicus, 150 (among many others).
115 Descartes, Tractatus de Homine et de Formatione Foetus, 2: “Suppono corpus aliud nihil esse quam terrream statuam seu machinam, quam Deus formet data opera, ut eam, quam maxime potest, nobis similem reddat.”
This tripartite division went somewhat beyond Descartes’ organization of his *Tractatus de Homine et de Formatione Foetus*. The first part considered the human machine; the second, the motion of the machine and the third, the external senses of the machine. While essentially similar in subject to Descartes’ *Tractatus*, the organization of Craanen’s *Oeconomia animalis* sought to integrate Descartes’ philosophical model of the body as machine with practical medicine. This is evident in the third section of his *Oeconomia*. Most notably, by applying Descartes’ philosophical construct of the body as a machine (or the body as a clock) he hoped to elucidate and explain the ways in which complex physiological processes happen and interact with one another. This is also evident in Craanen’s *Tractatus Physico-Medicus*. He emphasized his debt to Descartes as follows:

Let us consider the body of an adult human being, to the extent that it is healthy; it itself is called a *Machine* by Descartes, as can be seen in his treatise on man §. 2. medit. 6 and he . . . compares the same with a Clock that has its [own] self-moving motions, that consists of various wheels of different construction, and order . . . that, after having motion introduced in its engines, displays the hours, months and days accurately etc. and . . . conserves its own motion . . . This here we will therefore apply to our body, as a comparison, just as Descartes has instituted between our body & the clock . . .

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116 Theodor Craanen, preface to *Oeconomia animalis* (Gouda: Willem van der Hoeve, 1685), unpaginated: “Ut constet Methodus, quam sumus observavi in explicatione hujus *Oeconomiae animalis*, tribus verbis con indicasse sufficiat. Primo tractabimus de hominis automato, sicre corpore animali, videbimusque, quaeam functiones ex artificio sissimâ ejus structurâ dependeant, nihil ad eas conferente mente nostra. Secundo inquiremus in naturam mentis nostræ, ejusque functionum, quæ nullum plane commercium habent cum corpore. Tertio hanc mentem cum corpore uniemus, & functiones, quæ ex illâ conjunctione resultant, id est, quæ & mentem & corpus requirunt, exponemus.”


118 Craanen, *Tractatus Physico-Medicus*, 4-5: “Consideramus itaque corpus hominis adulti, quatenus sanum existit; hoc ipsum vocatur à *Cartesio*, Machina, uti videre est in suo tractatu de homine §. 2. medit. 6. nec male idem comparat cum Horologio, quod Authomaticos suos motus habet, quod constat ex variis rotulis varie constructis, & cerrâ ratione manu artificis inter se ordinatis, quod introducto motu in his organis, accurate monstrat suas horas; menes; dies; &c. quod ipsum, si pondus, quod ipsi appendum est, & motum ejus (intellige localem, aliquum [p. 5] enim nullum cum *Cartesio* admittimus) conservat, gravitate sua ad terram descendat, eique inhaeret, sua amplius perficere nequit, cui rotulae, reliquaque organa quiescant; sique horologium quasi mortuum & immotum jacet; ut autem idem horologium moveatur, & sua peragat, necessum est, ut pondus attollatur, quo rotularum motus conservetur, atque ita horologium rursus quasi vivum spectabant; quatenus scilicet rursum horas &c. monstrat. Hujus Horologii rotula quaevis, vel aliiquliquo organum, ubi male dispositum fuerit, vel confractum, statim horologium hocce, non accurate monstrabit horas ut ante, & spectavitur tanquam aegrotum; id est male dispositum; quae mala dispositio, si fuerit sublata unus rotulae, ilico totum horologium accurate rursum monstrabit horas suas, &c. Haece jam applicabimus ad corpus nostrum, ut comparisonem, quam instituit Cartesius inter corpus nostrum & horologium, redamus verosimiliorum & paulo clariorem.”
Craanen was profoundly influenced by Descartes’ metaphor of man as machine, or clock. He mapped the mechanical language of Descartes onto the human body in the hope of understanding its inner processes.

Conclusion

This last example is particularly vivid and also echoes Hartsoeker’s debt to Descartes, via Craanen, in his *Suite des Éclaircissements sur les conjectures physiques* of 1712 (discussed in more depth in Chapter Two):

But it seems to me that the person who seeks to make sense of natural phenomena is rather similar to a man who is led in front of a very complex machine, whose parts he cannot see. This man can only examine the machine from the outside and try to make sense of its various movements by imagining the different parts, wheels and springs of the Artisan who has made them. Let us suppose that this machine is a watch that shows the hours, the days of the week, the movements of the moon and the other planets and so on…

The body as a machine (or clock) for Craanen—and the world as a machine for Hartsoeker—suggest some of the reasons for the endurance of the clock/machine metaphor popularized by Descartes’ mechanical philosophy. It was rhetorically powerful, because one could easily identify and visualize the comparison; and, it was also analytically effective in deconstructing parts and processes and then assembling them together in order to make sense of the body and, by extension, the world. It also assumed an Artisan who was the author of these complex creations. The Cartesian framework was simple enough to allow for multiple and malleable interpretations of natural phenomena. Craanen infused his medical ideas with Descartes’ atoms in motion, and conceived of the body as a self-contained machine governed by different but interlocking parts and

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119 Hartsoeker, *Suite des éclaircissements sur les Conjectures Physiques* (Amsterdam: Nicolas Viollet, 1712), 55 : « Mais pour moi il me paroit que celui qui entreprend de rendre raison des phenomenes de la Nature, est assez semblable à un Homme, qui, étant conduit au-près d’une Machine extrêmement composée, qu’il ne peut voir & examiner que par dehors, entreprend de rendre raison de ses differens mouvements, par les differentes pieces, rouës & ressorts qu’il s’imagine, que l’Ouvrier qui l’a faite, peut avoir employez pour y réussir. Supposons que cette Machine est une Horloge qui montre les heures, les jours de la Semaine, le mouvement de la Lune & des autres Planettes, &c. »
processes. These translated into a corpuscular etiology of disease and a mechanical view of anatomy. As Garber notes, “For the mechanical philosopher everything, be it terrestrial or celestial, natural motion or constrained, must be explained in terms of the size, shape, and motion of the parts that make it up, just as we explain the behavior of a machine.” Hartsoeker, as we will see especially in Chapter Three and Four, was first star-struck by the Cartesian model, only to recoil from it when he realized the physical and metaphysical challenges it posed.

Finally, as we saw above, Cartesianism in the 1670s spelled out an active intellectual engagement with the problems in social, religious, and political landscape of the time. The generational struggle to establish orthodoxy was at times fervent and violent, and, at other times, reconciliatory and irenicist. It betrayed an idealist vision for what the contemporary world order should look like; what the place of medicine, theology, and philosophy and the new physics was, and what these four could share and argue about; and how religious goals could be redefined.

Chapter 2

The Natural Philosopher and the Microscope: Nicolas Hartsoeker Unravels Nature’s “Admirable Economy”

Introduction

In a 1685 letter to his younger brother Christiaan, Constantijn Huygens wrote, “How can a garçon like him who hardly knows any mathematics and hasn’t had a master-teacher (maistre) set himself up as the first master of everybody?”¹ The ‘boy’ in question was the twenty-nine-year-old Nicolas Hartsoeker² (1656-1727). Constantijn seemed indignant at the news that “the same Hartsoecker who taught us how to make the small bead lenses for microscopes” had now mastered the art of making very large telescope lenses.³ There was more to Constantijn’s sarcastic tone, however. From the letter exchange between the Huygens brothers, we learn that the young lens maker had been missing in action for a long time. Since September 1679, the brothers had not heard anything from him directly. And this after Huygens played a crucial role in taking Hartsoeker

¹ Constantyn Huygens to Christiaan Huygens, Letter 2405, 25 October 1685, Oeuvres complètes de Christiaan Huygens (The Hague, 1901, vol. IX; hereafter: OC), 36: “Comment un garçon comme luy qui ne scait gueres de mathematique et n’a point eu de maistre peut il s’eriger en premier maistre de tout le monde?”
³ Christiaan Huygens to Constantyn Huygens, Letter 2404, 23 October 1685, OC (The Hague, 1901, vol. IX), 35 : « Vous saurez donc que c’est le mesme Hartsoecker qui nous apprit a faire les petites boules, pour les microscopes, et qui fist avec moy le voyag de Paris. »
with him to Paris and introducing his younger compatriot to the French Academy of Sciences.\footnote{Leiden University Library, Special Collections, Ms. Huygens 45, Letter 2122, fol. 2v, Nicolaes Hartsoeker to Christiaan Huygens, 12 April 1678. Hartsoeker asked Huygens whether he would be able to accompany him to Paris. See, OC (The Hague, 1888, vol. VIII), 70-71; and, Alice Stroup, A company of scientists: Botany, patronage, and community at the seventeenth-century Parisian Royal Academy of Sciences (Berkeley, 1990), 203.}

Aware of his brother’s help in launching Hartsoeker’s career, Constantijn seemed indignant about Hartsoeker’s silence. “I beg you to write to Paris as soon as possible to find out all the details. You could even write to Hartsoeker himself, provided that he doesn’t disdain corresponding with poor people like us”, harrumphed Constantijn. “If his lenses are as perfect as they should be”, he continued, “you will see that this man will soon be sought after by some great patron . . .”.\footnote{See footnote 1: “Je vous prie d’escrire au plustost à Paris pour scavoir le detail du tout. Vous pourriez bien mesme escrire a Hartsoecker luy mesme pourveu qu’il ne dedaigne pas de tenir correspondence avec des miserables comme nous. Si ses verres sont de la perfection qu’il faut vous verrez que cet homme sera bientost recherché de quelque grand Mecenas . . .”} But how could a \textit{garçon} like Hartsoeker have become “such a great [lens grinding] master on the sly”\footnote{\textit{Ibid.}: “J’ay failly tomber de mon haut lisant ce que vous me mandez d’avoir appris de Joulot touchant nostre Hartsoecker devenu si grand maistre en cachette et sans que l’on en ait ouy parler.”}\footnote{Constantyn Huygens to Christiaan Huygens, Letter 2188, 26 August 1679, OC (The Hague, 1888, vol. VIII), 206: “Dites moy un peu qu’est devenu [sic] l’inventeur de nos microscope le Sr. Hartsoeker dont je n’entends plus parler.”} This is a striking remark from Constantijn, who in a letter to his brother Christiaan once called Hartsoeker “the inventor of our microscopes”.\footnote{Constantyn Huygens to Christiaan Huygens, Letter 2188, 26 August 1679, OC (The Hague, 1888, vol. VIII), 206: “Dites moy un peu qu’est devenu [sic] l’inventeur de nos microscope le Sr. Hartsoeker dont je n’entends plus parler.”} This episode reveals yet another key element here. Both Christiaan and Constantijn Huygens were avid lens grinders, who much of the time discussed techniques, instruments and new strategies in applied optics. Therefore, both were interested in lens-related novelties and gifted lens makers who were few and far between. Hartsoeker was one of these young and skilled lens makers.

In this chapter, I explore Nicolas Hartsoeker’s role as instrument maker and his use of materials and tools in launching his own natural philosophical program. His lens grinding talents got the attention of Christiaan Huygens (1629-95) and Giovanni Domenico Cassini (1625-1712) at the Académie who invited him to work there. At the Parisian Academy, Hartsoeker supervised the production of glassware for all the scientific instruments destined for the Jesuit missionaries in Siam.
and India. His skills earned him a job at the Academy’s Observatory, for which he made telescopic lenses. He ground lenses, invented new lens-making machines, conducted chymical experiments with burning mirrors, magnetized needles and metal bars, dissected animal parts, and observed the behavior of spermatozoa. Gradually, he also tried to establish himself as a natural philosopher and author of a system of physics at the Academy of Sciences in Paris. In 1699 he earned the title of foreign associate of the Academy. Hartsoeker occupied a labile position as both instrument maker and philosophe; hence the light he can shine on the role of instruments in his natural philosophical works deserves attention. How did his natural philosophy inform his artisanal practice as a lens grinder and, vice versa, how did his artisanal occupations infiltrate his philosophical investigations? Moreover, how did his thinking about the use and utility of instruments like the microscope change over the course of his life? What kind of certainty did he accord to the microscope? Ultimately, what role did instruments play in how he gained knowledge about the natural world? This examination is not meant to separate the theoretical from the empirical spheres artificially. Instead, it will reveal how closely the two spheres were intertwined and how Hartsoeker used them.

**Microscopy in the Dutch Republic and Beyond**

The Parisian and Dutch contexts color the background of Hartsoeker’s story, in which he and his contemporaries were grappling with the principles and research methods set forth in Descartes’ mechanical philosophy. Some scholars stress that developments in Dutch microscopy happened without an engagement with the Cartesian philosophy. In fact, they argue that the Dutch tradition in the natural sciences, preoccupied with empirical detail and data, ran counter to the

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10 Académie Royale des Sciences, *Procès-Verbaux*, tome 18, 12 November 1689-30 May 1699, 121.
deductive and definitional tendencies of Descartes’ epistemology.\(^{11}\) Meanwhile, other historians reveal the intellectual networks in the Dutch Republic that connected Descartes with amateur as well as expert lens makers, like Sir Constantijn Huygens and Isaac Beeckman.\(^{12}\) They argue that Descartes helped foster developments in optics and microscopy. Descartes’ *Dioptrique* in the Dutch Republic was not only an important and popular work, but also inspired some of its readers to learn the art of lens grinding.\(^{13}\) Moreover, the natural philosophy of Descartes provided the framework within which microscopy could function systematically.\(^{14}\) The Cartesian system sought to explain the sensory world within arm’s reach, as much as it continued to rely on the written heritage of ancient sources. Also embedded in the Parisian context were the experimental demonstrations in support of Descartes’ physics conducted by first-generation Cartesians like Jacques Rohault (1620-72) in the 1650s.\(^{15}\) Especially for the Dutch context, Cartesianism gave researchers and *curiosi* the impetus to look at nature from a new perspective\(^{16}\), and found a considerable following in Holland.

On the one hand, several historians of science argue that microscopy took off after 1665, the year of the publication of Robert Hooke’s *Micrographia*.\(^{17}\) The book’s lavish illustrations took Europe by storm and suggested a link with the mechanical philosophy. On the other hand, recent Dutch


\(^{13}\) For more on Descartes’ own optical pursuits and relationship with lens makers, see D. Graham Burnett’s seminal work, *Descartes and the Hyperbolic Quest: Lens Making Machines and Their Significance in the Seventeenth Century* (Philadelphia, PA: American Philosophical Society, 2005).


\(^{11}\) Jorink, “‘These wonderful glasses’”, 116. See also Marian Fournier, *The fabric of life: Microscopy in the seventeenth century* (Baltimore, 1996), 201-2, and her chapter in *From makers to users* cited below.
historiography has drawn attention to an earlier engagement with the microscope, well before Hooke’s *capolavoro*. Jorink, for example, argues that Dutch humanist scholars used the microscope in two ways: in religious contemplation of the wonders of God’s creation and in scholarly study of ancient natural historical texts, such as those of Pliny and Aristotle.  

Both learned empiricism and *liefhebberij* came into being during a time of economic and social prosperity in the Dutch Republic. On the one hand, the Dutch navy’s pursuits overseas triggered increasing need for a workforce fluent in applied mathematics, including optics, surveying and navigation techniques. On the other hand, the newly flourishing business and merchant classes partook in the latest fashions and surrounded themselves with luxury items. They knew “how best to transform worldly things into valued specimens of consumer taste and personal good”. As Anne Goldgar eloquently summarizes, this upward mobility also created space for self-fashioning that was “itself related both to knowledge and to commerce. In both worlds—the commercial and the intellectual—structures of authority [were] based in part on the display of expertise”. In other words, “To show that you were knowledgeable was to show that you were of high status, at least in a community valuing that knowledge”. Scientific objects were not outside of these realms of

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21 Cook, Matters of exchange, 81.

exchange and self-fashioning, but helped define people’s “fascination with the sublime”. To the amateurs, they were curiosities that filtered the perception of the eye through the lens of the imagination. To the initiated, they offered access to the microcosm and the macrocosm beyond the ordinary reach of the senses. Pictured in paintings and pondered in poems, the microscope and the telescope symbolized accessing the micro- and macrocosms and were part and parcel of early modern, and especially Dutch, material culture.

The practice of lens-grinding and instrument-making were artisanal trades that had been around since the Middle Ages, before they became fashionable pastimes for the ruling classes. Other crafts, such as turning, rose through the ranks of social class in similar ways. However, the profession or craft of producing scientific glass instruments, such as microscopes and telescopes, began emerging on a larger scale in the 1660s and 1670s. While guild trades like painting, glass-making, printing and embroidery flourished during the first three quarters of the seventeenth century, there were very few instrument makers. For example, Alkmaar was the only Dutch city where there was a guild for telescope makers. The 1671 guild contract listed fifteen members who were sworn to keep telescope making a trade secret. Microscopists, on the other hand, often

23 Mary Blaine Campbell, _Wonder and science: Imagining worlds in early modern Europe_ (Ithaca, 1999), 181. Alpers discusses how the microscope allowed viewers to become “unseen seers, eyes fixed to lenses or mirrors, catching sight of something otherwise unseen that is unaware of their gaze”, _The art of describing_, 201. Eileen Reeves relates how “heavenly spectacles” exposed celestial bodies and sometimes “‘manifest absurdities’”. See, _Painting the heavens_ (Princeton, 1999), 97.

24 For specific examples of microscopes in paintings, see Hartsoeker’s portrait by Caspar Netscher in the Kurpfälzisches Museum in Heidelberg or at the Louvre, Paris or the portrait painting of (presumably) microscopist Nicolas Joblot by Constantijn Netscher in the State Hermitage Museum, St Petersburg. See, Peter de Clercq, “Two seventeenth-century Dutch portraits with optical and mathematical instruments”, _Bulletin of the scientific instrument society_, lxxxvii (2005), 4-6. See also the famous portrait, “Anthonie van Leeuwenhoek” by Jan Verkolje at the Rijksmuseum in Amsterdam. On the celebration of lenses, microscopes and telescopes, see Constantijn Huygens’ poem _Dagh-werk van Constantijn Huygens_, ed. by F. L. Zwaan (Assen, 1973), commentary to II. 1140-57. Alpers offers her analysis, _The art of describing_, 15-18.

25 In my specific dealing with lens-making for instruments, not with spectacle-making, which had been practiced since the Middle Ages.

26 John Michael Montias, _Artists and artisans in Delft_ (Princeton, 1982).


resorted to making their instruments themselves.\textsuperscript{29} A notable early manufacturer of single-lens microscopes, and “a machine . . . for using small bead lenses”, was Johannes Hudde (1628-1704).\textsuperscript{30} He was not only a government administrator who served as Amsterdam’s \textit{burgemeester}, but also an expert mathematician, well versed in Cartesian geometry and optics. Hudde instructed Jan Swammerdam and Antoni van Leeuwenhoek, and advised Baruch Spinoza on various practical and mathematical questions concerning lens-grinding in the 1660s.\textsuperscript{31} Besides Spinoza and Daniel Depiere (d. 1682), the first craftsman who made and sold simple microscopes and air pumps was Samuel van Musschenbroek (1640-81) in Leiden.\textsuperscript{32} However, for some like Spinoza lens grinding was primarily a way to earn a living, even if combined with a personal interest in optics.\textsuperscript{33} Moreover, lens manufacture and microscopy continued to be done in informal circles of “scientific amateurs” (\textit{wetenschappelijke amateurs} or \textit{liefhebbers}) in the late seventeenth and early eighteenth century.\textsuperscript{34} These groups comprised like-minded individuals from the cultural elite with diverse religious and political backgrounds but with shared literary and natural philosophical interests. Such past-times happened on an individual level but often became collective enterprises as more than one family member became absorbed in them. Even Hartsoeker’s father, Christian Hartsoecker, fashioned telescopes and microscopes, which he circulated in the friend circle (\textit{vriendenkring}) of the English merchant

\textsuperscript{29} Marian Fournier, “Personal styles in microscopy: Leeuwenhoek, Swammerdam and Huygens”, in From makers to users, 212.

\textsuperscript{30} Nicolas Hartsoeker, \textit{Extrait critique des lettres de M. Leeuwenhoek} in \textit{Cours de physique} (Amsterdam, 1730); hereafter: \textit{Extrait critique}, 44-45 : « M. le Bourguemestre Hudde, ce grand & fameux mathématicien, me fit voir peu de temps avant sa mort une machine, qu’il avoit inventée depuis plus de 40 ans, pour se servir de petites boules de verre, en faisant passer assés de lumiere entre le verre & l’objet, mais comme cela étoit impossible, elle ne servoit presque de rien.


\textsuperscript{33} Rebecca Goldstein, \textit{Betraying Spinoza: The renegade Jew who gave us modernity} (Cambridge, 2001), 5, 222.

\textsuperscript{34} Vermij, “De Nederlandse vriendenkring van E.W. von Tschirnhaus” and Keil, “Microscopes made in Augsburg”. According to Keil, microscopy as an amateur or virtuoso past-time persisted well into the eighteenth century—hence, the general term of amateur as \textit{Liebhaber} in German, or \textit{liefhebber} in Dutch. Note, for example, Conrad Cuno’s 1685 pamphlet, \textit{Bericht an die Herren Liebhabe Opfacher Kunst-Wercken…} See also, Huib Zuidervaart, “‘A plague to the learned world’: Pieter Gabry, F.R.S. (1715-1770) and his use of natural philosophy to gain prestige and social status”, \textit{History of Science}, xlv (2007), 287-326. See also, Jori Zijlmans, \textit{Vriendenkringen in de zeventiende eeuw: Verenigingvormen van het informele culturele leven te Rotterdam} (The Hague, 1999). And, more recently also, Dupré, “Trading Luxury Glass.”
Benjamin Furly in Rotterdam.\textsuperscript{35} Hartsoeker himself claimed to have learnt lens grinding from his mathematics tutor. His training lasted from the fall of 1673 until he left for the Amsterdam Athenaeum Illustre in the fall of the following year.\textsuperscript{36} Later, reports from France alleged that Nicolas’ wife, Elizabeth Vettekeucken, was helping him grind telescopic lenses for Cassini.\textsuperscript{37} Generally speaking, however, the demand for instruments within the sciences was “still insufficient to support more than a very few instrument-makers, and these few would probably have been insufficient to produce the wide variety of instruments and apparatus now required”.\textsuperscript{38}

Here the obvious but tacit distinction in the practice is that between making microscopes and telescopes and using such instruments. Not all lens makers were microscopists and micrographers, but it seems that most microscopists were lens makers. The latter group developed slowly but surely over the course of the seventeenth century. They used their own instruments, perfected observation techniques, exchanged letters and lenses across vast distances with other experts, and often wrote privately about their findings or published their micrographies. As the emergent informal circles of lens makers suggest, their “search for a community” of microscopists “prefigured a profession”.\textsuperscript{39} Conversely, this seemed much less so in the case of telescope makers and astronomers. Most manufacturers of telescopic lenses were not astronomers, but some astronomers engaged in lens grinding. Astronomy, unlike microscopy, had been a well-established practice and discipline.

\textsuperscript{35} Zijlmans, Vriendenkringen in de zeventiende eeuw, 188.
\textsuperscript{36} Hartsoeker, Extrait critique, 44. Hartsoeker—born in Gouda in 1656—lived with his parents in Alkmaar from 1661 to 1669 and then in Rotterdam from 1669 to 1674. A potential candidate for his “mathematics tutor” could be the Rotterdam mathematician Nicolaus Stampioen (The Hague (?, 1640-Rotterdam, 1731), ‘schout van Kralingen’). Nicolaus was the son of the better known mathematician Johan Jansz Stampioen de Jonge whom Constantijn Huygens Sr hired to instruct his eldest sons in mathematics and Descartes’ philosophy. On this last point, see Fokko Jan Dijksterhuis, “Stampioen Jr, Jan Janszoon (1610-after 1689)?”, in The dictionary of seventeenth and eighteenth-century Dutch philosophers (Bristol, 2003, vol. II), 938-40; C. D. Andriesse, Huygens: The man behind the principle (Cambridge, 2005), 65-66; and, C. Louise Thijsen-Schoute, Nederlands Cartesianisme (Amsterdam, 1954), 62, 74-79.
Huygens and Hartsoeker at the Parisian Academy

The special role of Christiaan Huygens in the Parisian and Dutch contexts of the practice and emergent profession of lens-making in this period cannot be overlooked. He was a mathematician and natural philosopher who delighted in showing microscopical demonstrations to “the curious” and prided himself on the fact that “my microscopes have made a big splash . . .”. Huygens was a prominent individual who helped to heighten the visibility of several lens makers and, by extension, the craft of working lenses. A gifted lens grinder and instrument designer himself, Huygens also hired skilled instrument makers and kept abreast of new developments in the field. For instance, Huygens often used microscopes made by Van Musschenbroek and collaborated on instruments with him. He admired the polish and technique Spinoza applied to his microscope lenses. Huygens feverishly followed the advances in microscopy of various compatriots including the microscopist-drape maker Antoni van Leeuwenhoek, whose letters he translated for the Royal Society in London. Similarly, Hartsoeker’s own biography confirms Huygens’ personal interest in lens-making techniques and microscopical observations (which no doubt was kindled by father Huygens and spread to his brother Constantijn as well). Huygens collaborated on microscopes with Hartsoeker, Romer and De La Hire, informing himself on what Papin, Gayot, Joblot and other instrument makers were doing in the meantime. Furthermore, Huygens’ father’s suggestion that

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40 Christiaan Huygens to Constantyn Huygens, Letter 2133, 11 August 1678, OC (The Hague, 1899, vol. VIII), 91 : « Au reste mes microscopes ont fait grand bruit icy, et quoy que plusieurs d’abord se missent apres a en faire, ils n’y ont pas encore sceu reussir. J’ay fait voir le mien a bien des curieux qui se sont estonnez du grand effect qu’il fait.»
42 Christiaan Huygens to Constantyn Huygens, Letter 1606, 14 October 1667, OC (The Hague, 1895, vol. VI), 155, and also Letter 1638, 11 May 1668, 213.
43 Constantijn also ground lenses and was involved in appraising and testing new microscopical advances made by his brother, Hartsoeker, Romer and other microscopists. See, for example, Constantyn Huygens to Christiaan Huygens, Letter 2144, 27 October 1678, OC (The Hague, 1899, vol. VIII), 114-15.
excellence in lens making was somehow not merited by France, but by the Dutch Republic, is very suggestive and brings into question national styles in the craft. When Huygens broke the news of Hartsoeker’s new bead-lens microscope in the Journal des scéavans, he, too, underlined that this discovery “was made in Holland for the first time”. In Amsterdam, Hartsoeker’s new method of making bead lenses soon found its way into the Collectanea medico-physica, the first scholarly journal in the Dutch language published by the physician Steven Blankaart in 1680. National pride aside, Huygens’ connections made several Dutch lens makers known abroad. In turn, wider exposure increasingly gave these instrument makers and observers of nature an opportunity to capitalize on the interest in optics and natural minutiae within academic and courtly circles. This was particularly true for Drebbel, Van Musschenbroek, Van Leeuwenhoek and Hartsoeker, who excelled as internationally renowned lens and instrument makers. In Paris, Huygens’ and Hartsoeker’s arrival at the Academy in 1678 further inspired optical researches among other academicians, like the professor of mathematics Louis Joblot (1645-1723). Louis Joblot’s Descriptions et usages de plusieurs nouveaux microscopes (Paris, 1718) established him as “the first French microscopist” (and micrographer).

45 Christiaan Huygens to Constantyn Huygens, Letter 2142, 21 October 1678, OC (The Hague, 1899, vol. VIII), 112. The Huygens family had some reason to believe that especially the Dutch excelled at lens making, considering their early national tradition that started with lens maker Zacharias Janssen and included other internationally renowned microscopists Johannes Hudde, Cornelis Drebbel, Jan Swammerdam and Baruch Spinoza.
47 Steven Blankaart, Collectanea medico-physica oft hollands jaarregister der genees- en natuurkundige aanmerkingen van gantsch Europa 1 (1680): 200-1. The journal also had a German edition from 1680 to 1690. For more on the editor of this journal, see Han van Ruler, “Blankaart, Steven (1650-1704)”, The dictionary of seventeenth and eighteenth Dutch philosophers, ed. by Wiep Van Bunge et al. (Bristol: Thoemmes Continuum, 2003, vol. I), 106-10.
48 P. W. Van der Pas, “Joblot, Louis”, in Dictionary of scientific biography (Detroit, 1973, vol. VII), 110. See also Wlodimir Konanski, “Un savant barrisien précurseur de M. Pasteur: Louis Joblot, 1645-1723”, Mémoires de la Société des lettres, sciences et arts de Bar-le-Duc, 3e série, 4 (1895): 235. Even though Joblot was Professor of Mathematics at the Parisian Royal Academy of Painting and Sculpture, he was acquainted with both Hartsoeker and Huygens and his optical researches were also known at the Royal Academy of Sciences.
Huygens’ interactions with instrument makers did not go without controversy. The famous Dutch mathematician was more than once engaged in priority disputes and accused of intellectual property theft. Robert Hooke charged Huygens with stealing his invention of the spring-regulated clock. On the same invention, clock makers Isaac Thuret and Jean de Hautefeuille challenged Huygens’ priority. Mahoney has argued convincingly that Huygens’ knowing why an instrument worked mathematically eclipsed the two clockmakers’ knowing how it worked mechanically. Knowledge conquered know-how when Huygens won priority in the clock disputes. In the realm of microscopy, Hartsoeker accused Huygens of publishing the details of his newly minted microscope under his own name in the Journal des sçavans. In this case, however, Huygens was obliged to cite Hartsoeker’s contribution in the development of the simple microscope in a subsequent article. Nonetheless, this episode may have been the reason for Hartsoeker’s abrupt return to Holland in 1679, and subsequent alienation from Christiaan Huygens.

As we have seen earlier, the community of microscopists and lens makers was porous and heterogenous. Still, certain socio-economic boundaries prevailed. In Hartsoeker’s case, lens grinding offered a way—albeit laborious, risky and time-consuming—to advance in social and intellectual prestige. Unlike Van Leeuwenhoek or Hooke, Hartsoeker was university-educated and came from a socially respectable family. However, at the end of his studies, he had neither taken a degree in philosophy nor in medicine (even though he styled himself as a “medical doctor”). In
the case of seasoned philosophers like Descartes or Huygens, lens making was a means to test their mathematical theories and to make philosophical claims. Perhaps unlike most natural philosophers, Huygens was fascinated by the actual techniques and practice of making lenses. However, neither he nor Descartes made lenses for a living; for them, optics was not a commercial venture. The following anecdote encapsulates the socio-economic distinction between them and a lens-maker like Hartsoeker: a stranger once showed Huygens a drawing [dessein] of a large objective and inquired whether he knew anyone in Holland who could fashion such a telescopic lens. Huygens at first said no. He then continued that he knew how to make them, but only for his own purposes and not for sale. He recommended the man hire Hartsoeker and Campani.

The Proof is in the Lens

In the spring of 1678, Nicolas Hartsoeker, then twenty three, returned to his father’s home in Rotterdam, after having spent two and a half years enrolled in the faculty of philosophy at Leiden University. There he had studied philosophy and experimental physics under Burchard de Volder, medicine under Theodoor Craanen and anatomy under Charles Drelincourt. From now on, he

through 51 (1681). He enrolled as a student in the faculty of philosophy, not medicine, on 7 October 1675 (as “Nicolaus Hardtsuiker”), and was registered every year after that until 1681. However, he is absent from graduation lists, and most likely never took his degree in Philosophy. I wish to thank Mr Ernst-Jan Munnik from Leiden’s Special Collections who pointed me to the original manuscript enrollment lists. See also, Album Studiosorum Academiae Lugduno Batavae, MDLXXV-MDCCCLXXV (The Hague, 1875), 600.

54 On his marriage certificate of 1680, he styled himself as “Medicinen Doctor”. Even though Hartsoeker had studied medicine under Theodor Craanen, anatomy under Charles Drelincourt and philosophy under Burchard de Volder at Leiden University and later wrote on medical topics, he most likely never practiced medicine. Rotterdamse Gemeente Archief, Rotterdam Stadstrouw, M, 1576-1811, Hartog Heijligers, Hartsoeker, Nicolaas.

55 Maurice Daumas, Les instruments scientifiques aux XVIIe et XVIIIe siècles (Paris, 1953), 44.


57 In 1670, De Volder asked the Curators of the university for permission to lecture on physics, teaching Institutiones logicae twice a week and the Institutiones physicae twice a week. When he came back from England in 1674, he petitioned the Curators for permission to teach a course in experimental physics. In a newly furnished auditorium—the theatrum physicum—De Volder and Senguerdus alternated conducting experimental demonstrations that became part of student training in philosophy. No doubt, Hartsoeker attended De Volder’s demonstrations in experimental at Leiden University from 1675. See P.C. Mollhuyzen, Bronnen tot de geschiedenis der Leidse Universiteit (‘s-Gravenhage, 1918, vol. III), 245 and Edward G. Ruestow, Physics at seventeenth and eighteenth-century Leiden: philosophy and the new science in the university (The Hague, 1973), 96-106.

58 Nicolas Hartsoeker, Extrait critique, 45.
planned to continue his studies in France, away from the war-torn Dutch Republic. One possibility for Hartsoeker was to accompany the son of Ambassador Adriaan Paets to Paris.⁵⁹ For unknown reasons, this opportunity fell through. While home, he resumed his microscopical observations after a hiatus of more than two years.⁶⁰ In his autobiographical narrative, he chronicled how he continued to observe “an infinity of small animals of the same shape and size that resembled tadpoles” in human semen. This “discovery” puzzled him, since the phenomenon seemed indicative of an illness. Hartsoeker reported that rumors about his discoveries traveled as far as The Hague. Supposedly, Christiaan Huygens heard about a young man in Rotterdam who by the means of an “extraordinary microscope” was observing “an infinity of small animals”. Accordingly, Huygens wished to meet this entrepreneurial youth. Hartsoeker traveled with an agenda to The Hague “not only to have the opportunity to get to know this great man, but also in the hope that he could give me a few letters of recommendation to savants in Paris, where I wanted to go”.⁶¹ Whether Hartsoeker was historically accurate in his story is not important, for the moment. What is certain, however, is that he lost no time advertising his observational tools and discoveries himself. In the hopes of enticing Huygens’ interest, Hartsoeker initially sent him a letter in the spring of 1678. If Huygens was intrigued, Hartsoeker hoped that he would introduce him to savants in Paris, and

⁵⁹ Huygens, OC (The Hague, 1899, vol. VIII), 101, note 5. Adriaen Paets was not only an ambassador, he was also a “liberal Remonstrant lawyer and defender of toleration”. See Rosalie L. Colie, Light and enlightenment: A study of the Cambridge Platonists and the Dutch Arminians (Cambridge, 1957), 96.
⁶⁰ Hartsoeker, Extrait critique, 46.
⁶¹ Ibid.: « Ayant quité Leiden au commencement de l’année 1677, & étant retourné à Rotterdam dans le dessein d’aller en France à la première occasion qui se présenteroit, pour y achever mes études ; je recommencai à faire quelques observatons avec le microscope, que j’avois negligé depuis plus de deux ans.

Puisque je trouvai alors de nouveau, que la semence de l’homme étoit remplie d’une infinité de petits animaux, d’une même grandeur & figure, & ressemblants à ces grenouilles naissantes ; je communiqai ma découverte à mon maître en Mathématique & à un de mes amis ; & comme nous nous apperçumes de la même chose dans la semence d’un chien, nous conclués que ce n’étoit rien moins qu’une maladie ; mais que ces animaux y appatenoient, & qu’on les trouveroit sans doute dans la semence de tous les animaux [. . .]

Le célébre M. Huygens, étant en ce temps venu de France, pour se rétablir à la Haïe d’une indisposition qu’il avoit, & ayant appris qu’un jeune homme à Rotterdam faisoit voir, par un microscope extraordinaire, que la saliva étoit remplie d’une infinité de petits animaux, il en témoigna sa surprise à une personne de qualité qui demeuroit à Rotterdam, & souhaita de me voir.

Dès que je sçus cela, j’allai à la Haïe, non seulement pour avoir l’avantage de connoître ce grand homme, mais aussi dans l’esperance, qu’il pourroit me donner quelques Lettres de recommandation aux Sçavans de Paris, où je devois aller. »
possibly even warrant his safe passage to France. He enclosed his tiny bead lenses, an explanation of how he had made them and a description of his microscopical observations in a letter to Huygens. The objects, their origin and their maker impressed Huygens enough that he secured Hartsoeker a valid passport for his trip to Paris. Thus, Hartsoeker’s qualification as lens maker gained him preliminary entry into the Academy of Sciences in Paris.

First, what did instruments, and more specifically, lenses and microscopes mean to Hartsoeker? The tiny bead lenses for his microscopes that he perfected over a candle flame were possibly lucrative objects he could sell to make a living. More importantly still, they were also portable things: objects that could travel, change hands and be used by other people to confirm or make new microscopical observations. Not least of all, such objects were more versatile and useful than business cards. Rather, they were more like passports or selections from a portfolio — they were proof of Hartsoeker’s skill as lens maker and a sample of his expertise. These products of craftsmanship and expertise eventually gave him access to new professional circles, such as the Royal Academy of Sciences in Paris. When Hartsoeker’s career was only just beginning, his lenses—the material outcomes of his skill—were the final word on his expertise. Lens experts and amateurs alike customarily sent by mail not only drawings of lenses or descriptions of observational techniques, but the lenses themselves. The fact that Hartsoeker’s word was not enough, and he had to produce the lens in order to be believed is another factor that made lens grinding an uncertain and demanding practice.

62 Hartsoeker, *Extrait critique*, 46-47: « Comme je lui parlois du voyage que j’avois dessein de faire à Paris, il m’offrit des Lettres de recommandations aux Scavans de cette ville, [p. 47 :] & de me faire avoir un passeport vûque la Hollande étoit encore en guerre avec la France, ajoutant de plus à ces offres très-obligantes [sic], que si je voulois attendre jusqu’à l’année suivante, je pourrois y aller avec lui, ce que mon pere & moi nous acceptames avec beaucoup de plaisir. » See also Appendix to N. 2136 in *OC* (The Hague, 1899, vol. VIII), 98-99.
64 In tracing the fascination with optics between Descartes and Constantijn Huygens Sr, Eric Jorink shows that such a practice was quite common. ‘*Geef zicht aan de blinden*’, 27.
Lens making was challenging for several other reasons as well. First, it required good-quality materials, especially glass with as few blemishes as possible. Furthermore, any lens manufacturer had to master a high degree of precision and a polishing technique that would not damage, crack or scratch the lens. And finally, the manual process of polishing the lens was often long and physically demanding on the lens maker himself.\(^{65}\) To master lens making could take many years.\(^{66}\) Once Hartsoeker had perfected his polishing technique, it took him between four to six weeks to produce a large telescopic lens. Because he used basins (or hollow dishes) for the grinding of lenses, the task was physically grueling and left even Huygens exasperated. In contrast, Huygens and his brother Constantijn used a lathe—a mechanized tool—to produce their lenses.\(^{67}\) Whatever the method, Huygens always insisted on comparing his lenses with Hartsoeker’s.\(^{68}\) The Dutch mathematician pronounced the three lenses he tested along with Hartsoeker to be of variable quality, although “ Admirably well made and polished”. One lens was “ perfectly good”, the second “ very mediocre”, and the third “ entirely worthless [mauvais] even though the material appeared to be spotless”. Considering these results, Huygens told mathematician Philippe de la Hire (1640-1718) that he preferred his own lens-making technique. Hartsoeker’s method seemed to him less reliable and, he argued, not as “ geometrically demonstrable”. Only further trials of their respective lenses of the


\(^{66}\) Huygens reported to have perfected his own method over the course of three years in Paris. See Christiaan Huygens to Philippe de la Hire, Letter 2767, 9 October 1692, in OC (The Hague, 1905, vol. X), 324.


\(^{68}\) Christiaan Huygens to N. Fatio de Duillier, Letter 2748, 5 April 1692, OC (The Hague, 1905, vol. X), 278: « Un Hollandais nommé Hartsoecker venant de Paris ou il s’est retourné, m’a esté voir, et m’a dit que sa maniere de travailler aux verres des Telescopes va paroitre imprimee dans las Mémoires de Mathematiques et de Physique de l’Académie des Sciences , qu’un libraire des nostres copie a mesure qu’ils viennent de Paris, mais il n’y en a ey encore qu’un, ou il y a les Observations de Mr. Cassini des taches et nuages dans Jupiter. Il m’a mesme communiqué sa methode mais n’ayant apporté aucun objectif de sa façon, je suspens mon jugement. Il dit pourtant qu’il en a fait de 155 pieds dont on se sert à l’Observatoire, et qu’il m’en envoiera un de 40 pieds, que je luy ay demandé pour le comparer aves les miens. »
same caliber could compel Huygens to reconsider his opinion about Hartsoeker’s lens-grinding method.  

Of course, replication of the observations and public demonstrations were instrumental in gaining credibility. Although microscopist Antoni van Leeuwenhoek kept the construction of his microscopes a secret, he regularly received visitors who came to confirm his findings and marvel at his instruments.  

After Van Leeuwenhoek discovered the capillaries, he disclosed on one occasion only how his microscope was built. He was compelled to do so, because he wanted the members of the Royal Society in London to reproduce (and confirm) the observation themselves. As for the Italian context, Biagioli discusses elegantly how Galileo used distance and either the withholding or sharing of the telescope across national boundaries to build credit for his discoveries. Meanwhile, Righini Bonelli and Van Helden have revealed how the Campani brothers conducted trials to establish the superiority of their lenses in public demonstrations of telescopes. As we can see, without the microscope or telescope lenses in hand, Hartsoeker’s claims would mean little. We will soon see how important this last factor of proof and sample was in Hartsoeker’s rapport with academics for whom he manufactured them.

69 Christiaan Huygens to Philippe De la Hire, Letter 2767, 9 October 1692, in OC (The Hague, 1905, vol. X), 323-4 : «Cette mention de Lunettes me fait souvenir de Mr. Hartsoecker qui m’apporta il y a quelque temps trois de ses verres objectifs admirablement bien achevez et polis des quels pourtant a l’epreuve que nous en fismes ensemble aux flambeaux sur des characters imprimez il ne s’en trouva qu’un qui fut parfaitement bon, d’environ 40 pieds, un autre de 60 tres mediocre et un 3me d’environ 34 tout a fait mauvais, quoy que la matiere parust estre sans defaut. Cela me fait juger que sa maniere dont il m’a appris quelque chose n’est pas si sure qu’il pense ni si geometriquement demonstrable comme j’ay vu qu l’on a debite dans le Journal des scavants. De plus elle demande extremement du temps a ce qu’il m’a dit comme d’un mois ou 6 semaines pour un seul verre ce qui est une autre raison pour quoy je prefere beaucoup la miene, que j’ay estudiee pendant 3 ans depuis mon retour de France, et qui nous a produit quantite de tres bons verres de toute sorte de longueur jusqu’a 210 pieds. Nous essaierons au premier jour contre le plus long de ceux cy un objectif de Mr. Hartsoeker qu’il dit avoir a peu pres du mesme calibre. S’il peut tenir a cette epreuve, j’en auray meilleure opinion de sa methode.»  

70 Fournier, The fabric of life, 219; Mario Biagioli, Galileo’s instruments of credit: Telescopes, images, secrecy (Chicago, 2006), note on 130.  

71 Ibid.  

72 Biagioli, Galileo’s instruments of credit.  

The lenses had to be shown and preferably tested in person by the potential user to verify their quality and the promises of their maker. Well made lenses were a direct example of their maker’s craftsmanship. In 1689, Burchard de Volder (1643-1709), a mathematician and Hartsoeker’s former university professor, showed Huygens a lens with a focal length of 50 feet that Hartsoeker had made for the Observatory at Leiden University, his alma mater. Huygens deemed the material out of which the lens was made very good, but he and De Volder did not have enough time to judge its magnifying power. Later De Volder sent Huygens his report about the lens, which he trained on the moon a few days later from his attic. De Volder found it “roughly made”, but good enough to magnify things. Three years later, Hartsoeker came to see Huygens and informed him of his new method of grinding lenses for telescopes, which would soon be published in the Mémoires of the Academy of Sciences. The young Dutchman said he had made several large lenses. One lens had a focal length of 155 feet and was in use at the Observatory in Paris, while the other had a focal length of 40 feet. Huygens described the episode to fellow academician Fatio de Duillier in the following manner: Hartsoeker “even told me of his method, but having brought no objectives along with him, I suspend my judgment”. Since Huygens himself could not test the lens in a demonstration, Hartsoeker would have to send Huygens one of the lenses before the latter would take his word for it.

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74 The lens in question bears the inscription, “Nicolaas Hartsoeker fecit pro academia lugd. Batav lutet parisiorum 1688”, and is on display at the Museum Boerhaave in Leiden, object no. V09197. Another lens by Hartsoeker is preserved at the Utrecht University Museum.

75 Burchard de Volder to Christiaan Huygens, Letter 2537, 26 April 1689, OC (The Hague, 1901, vol. IX), 316: « Ick sal oock, soo UEdt. geen volkomen genoegen had in de proef op de solder, maar liever het glas aan de maan selfs probeerde, niet manqueren op het aldereerst advys, UEdt. de blickke ring met de steert toe te stueren sij is wel heel ruw gemaackt, maar sal voor een proefje meen ik, genoech verstreken. »

76 Christiaan Huygens to N. Fatio de Duillier, Letter 2748, 5 April 1692, OC (The Hague, 1905, vol. X), 278: “Un Hollandais nommé Hartsoecker venant de Paris ou il s’est retourné, m’a esté voir, et m’a dit que sa maniere de travailler aux verres des Telescopes va paroir imprimee dans les Mémoires de Mathematique et de Physique de l’Academie des Sciences, qu’un libraire des nostres copie a mesure qu’ils viennent de Paris, mais il n’y en a eu encore qu’un, ou il y a les Observations de Mr. Cassini des taches et nuages dans Jupiter. Il m’a mesme communiqué sa methode mais n’ayant apporté aucun objectif de sa façon, je suspens mon jugement. Il dit pourtant qu’il en a fait de 155 pieds don’t on se sert à l’Observatoire, et qu’il m’en envoiera un de 40 pieds, que je luy ay demandé pour le comparer avec les miens.”
Of course the judgment of people one knew also affected the way in which expertise and credibility played out. As mentioned above, both De Volder and Fatio de Duillier served as witnesses and judges of Hartsoeker’s lenses and craftsmanship. In addition, Huygens often relied on other academicians’ reports in assessing information and deciding interest. For instance, Huygens heard through Auzout that Hartsoeker and his wife were making good microscopes and also high-quality, large telescopic lenses in Passy, a village near Paris. In another epistolary exchange, Huygens gathered from Du Hamel how Hartsoeker’s lenses had performed in Paris. The Academy’s foremost astronomer Giovanni Domenico Cassini had tested a lens of focal length of 330 feet in the hallways of the Louvre. Du Hamel reported that “Cassini thought it was rather good, and better than had seemed the first time around”. A few months later, Constantijn Huygens wrote to his brother about the same lens that Hartsoeker had made for Cassini, this time citing another witness. Lens-grinder Joblot praised Hartsoeker’s lens as “extremely good, while Mr Du Hamel had informed me that Cassini had judged it quite good. He doesn’t know the diameter of this lens but he says that the same Hartsoeker has made another one with a focal length of 720 feet and an 18 inch diameter, believing it to be polished [douce] rather well and clear for a glass of this size”. Huygens wanted to see what the lens with 330 feet focal length would yield once it was put to the test in Paris. Meanwhile, he did not even “dare to hope” that the rumor of Hartsoeker’s larger lens of 720 feet was true. He found “it hard to believe that [the lens] would be the way it should”.

78 Constantyn Huygens to Christiaan Huygens, OC.
80 According to the editors of the *Oeuvres complètes de Christiaan Huygens*, this reference was most likely made to Nicolas Joblot, the brother of Louis Joblot, both of whom made lenses and were interested in optics.
81 Christiaan Huygens to Constantyn Huygens, OC, vol. IX, 34-35: “Vous scaurez donc que c’est le mesme Hartsoecker qui nous apprit a faire les petites boules, pour les microscopes, et qui fist avec moy le voyiage de Paris. [. . .] C’est donc luy ou sa femme (car elle travaille aussi) qui a fait ce verre de 330 pieds, qui au dire de Joubelot est fort bon, quoque Mr. Du Hamel m’aït mandé que Cassini l’avoit jugé assez bon. Il ne seait pas de quel diametre est ce verre mais il dit que le mesme Hartsoecker en a fait un de 720 pieds, et qui a 18 pouces de diametre, et qu’on le trouve assez bien douci et assez
The quality of the glass used for lenses was crucial. It determined the longevity of the lens during the polishing process and its final magnifying power. No doubt Hartsoeker gathered much of the know-how about the various kinds of glass during his time as technical advisor (conseiller technique) at Colbert’s royal glassworks near Cherbourg between 1684 and 1696, while in the service of the Academy.\(^{82}\) Hartsoeker explained his practice of lens making all the way from choosing the right chemical components for the best glass to the best materials for polishing the final lens. The fragile nature of glass and the ease with which it could be damaged constantly posed a threat. For instance, out of more than 200 large pieces of glass that Hartsoeker polished very carefully, only two turned out reasonably well and only five fairly well.\(^{83}\) He cautioned that especially large objectives\(^{84}\) were easily ruined during polishing. In addition to that, there were always impurities in a piece of glass. So-called points, teardrops, fibers, and tiny air canals were only a few of the usual imperfections that impeded the work on a lens and threatened its purity. Points were particles from the air that entered the glass as soon as it left the furnace. Teardrops and canals were air bubbles that formed when the outer surface of glass cooled off too quickly and trapped the air from the still liquid center.\(^{85}\) The more of them there were, the more vulnerable the piece of glass would be during the polishing process. “From experience”, Hartsoeker warned, one can say “that when one polishes them on paper soaked in tripoli\(^{86}\) [a type of limestone reduced to powder], the edges [of the lens] . . . round themselves a little bit. And since the same thing happens [to] the edges of all . . .

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clair pour un verre de cette grandeur. Il faut de grands bassins, comme vous pourrez juger et de grandes épaisseurs de verre pour un ouvrage comme cettui la ; de forte que l’ouvrier doit avoir fait quelque dépense, devant que d’en estre venu là. Joubelot dit qu’il l’a connu à Rotterdam devant son départ et qu’il ait desia commenced alors a travailler. Peut estre en aura ’t il fait plus qu’il n’appartient a un marchand prudent et prenant garde a ses affaires. Nous sçaurons a quoy aboutiront ces vastes entreprises, et si l’on se met en estat à Paris pour pouvoir employer seulement ce verre de 330 pieds ; car pour l’autre je n’ose pas l’esperer, et j’ay mesme bien de la peine a croire qu’il soit comme il faut.»


\(^{83}\) Nicolas Hartsoeker, Essay de dioptrique (Paris, 1694), 91.

\(^{84}\) Earlier examples in the chapter illustrate how the making of telescopic lenses was especially difficult. Many factors played a role: the time-consuming nature of polishing large lenses, the larger margin of error (because of a larger surface area) for finding blemishes in the glass or scratching the lens during polishing, etc.

\(^{85}\) Hartsoeker, Essay de dioptrique, 91-93.

\(^{86}\) Tripoli is a weathered and decomposed siliceous limestone; in powdered form, it is used in polishing.
lenses before one begins to polish them, this . . . disfigures the lenses enormously. So the best thing one can do is to polish the lenses just to the point where there are only very tiny holes” on the glass surface.\textsuperscript{87} Evidently, Hartsoeker’s lens making was detail-driven, time-consuming and involved a lot of trial and error.\textsuperscript{88} Expertise did not always preclude failure in the making of lenses, but it did secure Hartsoeker credibility and authority as lens maker over time.

**Managing Know-How and Know-See: The Unfortunate Case of Antoni van Leeuwenhoek**

What distinguished Hartsoeker from other opticians was how candid he was about his lens craft and other technical inventions. Unlike Van Leeuwenhoek and the Campani brothers who warily shrouded their lens making methods, Hartsoeker did not keep trade secrets. In fact, his treatise on dioptrics explained in great detail what kind of glass to use, how best to grind lenses, and how to configure them most effectively. Even before his *Essay de dioptrique* came out in 1694, he shared with Huygens his idea of the simple microscope. He then collaborated with Huygens and Rømer on the design that was eventually published in the *Journal des sçavans* in 1678.\textsuperscript{89} Only when Huygens appropriated Hartsoeker’s design of the simple microscope and passed off as his own in the *Journal des sçavans*, did Hartsoeker react with indignation.\textsuperscript{90} He wanted authorial credit for his invention. But when he began manufacturing telescopic lenses, he continued to share his techniques and lenses with Huygens and others at the Academy. As Dijkstra put it, Hartsoeker “paraded

\textsuperscript{87} Nicolas Hartsoeker, *Eclairissemens sur les conjectures physiques* (Amsterdam, 1710; hereafter: *Eclairissemens*), 162: « Pour ce qui est des grands verres objectifs, on les gâte principalement en les polissant ; car si on les poli, par exemple, sur du papier enduit de tripoli, on trouve par l’expérience que les bords, qui reçoivent toujours le premier choc, s’arrondissent un peu ; & comme la même chose arrive aux bords de tous les petits trous qui se trouvent répandus dans la surface des verres avant qu’on commence à les polir, cela doit extremément défigurer les verres. Ainsi le plus sur est de les adoucir jusqu’à les polir, cela doit extremément défigurer les verres. »

\textsuperscript{88} Christiaan Huygens on Hartsoeker’s lens making technique, OC (The Hague, 1905, vol. X), 311.

\textsuperscript{89} Nicolas Hartsoeker, “Extrait d’une lettre de M. Nicolas Hartsoeker écrite à l’auteur du journal touchant la maniere de faire les nouveaux microscopes, dont il a esté parlé dans le journal il y a quelques jours,” *Journal des Sçavans*, xxx (29 August 1678), 355-6.

\textsuperscript{90} For an account of the whole controversy, see Hartsoeker, *Extrait critique*, 47-48, and Fontenelle, “Éloge de Monsieur Hartsoeker.”
his mastery of glass-works”. To some extent, it appears he deliberately capitalized on transparency when he first asked Huygens to be his benefactor. After the debacle with Huygens in 1678, he conducted himself more prudently. He learnt to protect his ideas and inventions in print. Publishing his ideas in articles, letters and treatises allowed him to communicate them freely.

Evidently, Hartsoeker espoused a more open, public ideal of communication, more akin to that of the natural philosopher rather than that of the craftsman, afraid of being robbed of his techniques, inventions and instruments. In this way, he consciously set himself apart from the tradesmen whose expertise was contained solely in their products.

Transparency (or perceived transparency) was a rhetorical, if not often practiced, stance of the seventeenth-century natural philosopher. One of the most pronounced grievances that Hartsoeker brought against Van Leeuwenhoek was his lack of transparency and openness about microscopical techniques. In the *Extrait critique des lettres de M. Leeuwenhoek*, he unleashed his frustration on Van Leeuwenhoek’s tight-lipped *modus operandi*:

How do you dissect a louse, for example, or, even more so, a moth? Or remove the testicles from their bodies? Or open the testicle to remove the semen, to finally see that this semen is filled with little animals in the shape of small, very long, thin eels? What kind of lenses do you use to make this dissection? If the lens is small, you will not have enough light, because you yourself will cast a shadow on it. If it is large, it will not magnify enough. But what kind of knives do you use? The one that has the finest and sharpest cutting edge will crush the vessel rather than [cut it] open. Moreover, this knife would have to be between the lens and the object, and thus the object would be concealed and you could only work blindly.

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93 Hartsoeker, *Extrait critique*, 7-8: “Comment faites-vous, lui disois-je, pour disséquer, par exemple, une puce, & qui plus est une mite; pour tirer les testicules de leur corps; pour ouvrir ces testicules et en ôter la semence; enfin pour voir que cette semence est remplie de petits animaux en forme de petites anguilles fort longues & fort minces; de quels verres vous servez-vous pour faire cette anatomie? Si le verre est petit, vous n’avez pas assez de lumière, parce que vous la cachez à vous-même; s’il est grand il ne grossit pas assés. Mais de quels couteaux vous servez-vous? Celui qui aurait le tranchant le plus fin & [p. 8] le plus aigu écraseroit le vaisseau plutôt que de l’ouvrir. De plus ce couteau doit être entre le verre & l’objet, & alors l’objet est caché & vous ne pouvez travailler qu’à l’aveugle.”
Van Leeuwenhoek, unlike Hartsoeker, worked in secrecy. He jealously hid his best microscopes, working tools and observational methods.\textsuperscript{94} Van Leeuwenhoek still practiced microscopy within “the artisanal tradition of trade secrets”.\textsuperscript{95} His drawings of microscopically observed salt crystals were poor on account of his reluctance to reveal his technique. As he wrote to Henry Oldenburg at the Royal Society, “Sir, be assured that my microscope showed the same as clearly and distinctly as one can imagine to see figures with the naked eye but the fault is mine, since I cannot draw and on the other hand since I have the intention to keep the method I use secret from everybody. Therefore I draw the lines rough and simple only to assist my memory . . .”\textsuperscript{96} To make the point, Hartsoeker underscored Van Leeuwenhoek’s uneducated background and scorned his tradesman’s approach to microscopy by calling him “the biggest ignoramus and lier” who wrote “in a style worthy of an uneducated brute [crocheteur]”.\textsuperscript{97} As a counter point, a physicien was someone who, above all, searched after the truth and discovered “the secrets of nature”, according to Hartsoeker.\textsuperscript{98} He clearly put microscopy in the service of natural philosophy. In presentation and work ethic, he had a good deal more in common with Robert Hooke, whom he admired and classed with Robert Boyle as “two of the greatest men of the previous century”.\textsuperscript{99} The \textit{Essay de dioptrique} was related in

\textsuperscript{94} Marc J. Ratcliff, \textit{The quest for the invisible: Microscopy in the Enlightenment} (Surrey, 2009), 27-28.
\textsuperscript{96} Antoni van Leeuwenhoek, \textit{Alle de brieven van Antoni van Leeuwenhoek} (Amsterdam, 1939, vol. I), Van Leeuwenhoek to Oldenburg, 26 March 1675, 293-5. I cite the published English translation from this edition.
\textsuperscript{97} Gottfried Wilhelm Leibniz Bibliothek - Niedersächsische Landesbibliothek, Ms. Lbr. 371, Hartsoeker to Leibniz, Düsseldorf, 15 February 1707, 15/27, 2: “. . . un certain Leeuwenhoek, le plus grand ignorant et menteur qu’il y ait, qui a écrit avec un stile digne d’un crocheteur cinq ou six gros volumes in quarto, qu’on pourrait mettre en peu de pages si on en voulait extraire ce qui est bon, et laisser ce qui est faux ou inutile, et si ses ouvrages avoient valu la peine d’y faire des remarques, il y a long temps que je l’aurois fait, et que j’aurois disabusé le public. Hereafter: GWLB, Ms. Lbr. 371.
\textsuperscript{98} Hartsoeker to Leibniz, \textit{op. cit.}, 25 November 1706, 25/11, 2: “. . . et comme rien ne contribuë plus à decouvrir les secrets de la nature, ce qui doit être l’unique but d’un physicien, je vous prie instamment de vouloir y continuer.”
\textsuperscript{99} Hartsoeker to Leibniz, \textit{op. cit.}, 15 February 1707, 15/27, 2: “Permettez moi de vous dire Monsieur que vous faites tout à la manière de Messieurs Boyle et Hoock, deux des plus grands hommes du siècle passé, de les mettre en parallèle avec un certain Leeuwenhoek, le plus grand ignorant et menteur qu’il y ait . . .”
register to Hooke’s *Micrographia*, which championed “the open tone of a microscopy manual”.\(^{100}\)

Both informed the reader of various microscopic observations as well as probed at why things are as they are. Like Hartsoeker, Hooke “saw the construction of general theories and the role of hypotheses as central to science”.\(^{101}\) And although Hooke did not publish many treatises—provoking the epithet of “reluctant author” from some historians—he nevertheless shared his contemporaries’ enthusiasm for systemic empirical reform of knowledge.\(^{102}\) In their respective publications, both Hooke and Hartsoeker advised the reader on the instruments used and the observational techniques practiced.

Both the making and the use of lenses were demanding, discouraging and often precarious. But what utility or lucre did Hartsoeker see in the pursuit of microscopy? In his critique of Van Leeuwenhoek’s microscopic observations, we will see most clearly how he defined a suitable or “useful” practice of microscopy. By emphasizing what not to do, he prescribed what the microscopist ought to do. Overall, Van Leeuwenhoek’s work failed on three accounts: It provided protracted descriptions but no analysis, lacked an explanatory system or mechanism, and concealed instrumental procedures.

Even though Van Leeuwenhoek’s biographer Clifford Dobell believed that Hartsoeker’s criticisms of Van Leeuwenhoek’s work were “best consigned to the oblivion which they deserve”, I think it is worth considering Hartsoeker’s grievances against the microscopist from Delft.\(^{103}\) Hartsoeker’s analysis of Van Leeuwenhoek’s investigations affords an entryway to his—and by extension, his contemporaries’—ideas about the place of particulars versus universals in natural philosophy and the role of the critical observer of nature. For the most part Hartsoeker considered

\(^{100}\) Hamou, *La mutation du visible*, 159: “. . . Hooke qui donnait à la *Micrographia* le ton ouvert d’un manuel de microscopie . . .” Hamou goes on to argue that Van Leeuwenhoek’s attitude put him in, what he calls, “the first period of visual empiricism” that started with Galileo, 160-1.


\(^{103}\) Clifford Dobell, *Antony van Leeuwenhoek and his ‘little animals’* (New York, 1932), 70.
Van Leeuwenhoek’s bulky observations “useless and chimeral”. Hartsoeker believed that publishing all of one’s observations was excessive and futile in that it too quickly degenerated into quantity over quality. Too often the author would forget to discuss the actual point of the observations and would not offer any pertinent conclusions. Predictably, Van Leeuwenhoek’s verbose microscopical descriptions peeved Hartsoeker to no end. Hartsoeker wondered why Van Leeuwenhoek could not analogize the same discovery of seed, for instance, to other species of plants, but instead chose to go into detail about every single one: “I observe in five or six kinds of seeds the whole plant [in miniature], and this is sufficient for me to conclude that I will find the same in all those [other seeds] that I could examine.” After all, “Nature always follows the same blueprint in her works, though with infinite diversity.” Hartsoeker’s vision of structure and order in nature compelled him to produce a critical extract from Van Leeuwenhoek’s multi-volume collection of microscopical observations. Hartsoeker wanted to save the reader time and highlight what was important in Van Leeuwenhoek’s microscopic peregrinations. As he wrote in his *Extrait critique*, written sometime before 1725: “It is true that those who love detail in all things will be satisfied with it [Van Leeuwenhoek’s entire work]; but this [kind of] detail is too boring to those, who are only looking to know and to discover the general plan of Nature.” Evidently, he believed that not every observed fact deserved the same amount of attention and importance. The tedium of drawing up inchoate natural histories seemed to take away from the pleasure of making philosophical claims about nature or arriving at universal truths. In this respect then, Hartsoeker set

104 Hartsoeker, *Extrait critique*, 3: «...parmi quantité d’observations inutiles & chimeriques, quelques unes de très-bonnen & qui servent à l’avancement des Sciences ; j’ai eu depuis long-temps dessein de les publier en abregé ; d’y ajouter quelques unes des mes propres observations, & de faire des remarques sur quelques unes des siennes.»

105 Hartsoeker, *Extrait critique*, 17: «J’aperçois dans cinq ou six sortes de semences que la plante entiére s’y trouve, & cela me suffit pour en conclure que je la trouverois de même dans toutes celles que je pourrois examiner.»

106 Hartsoeker, *Extrait critique*, 7, 16, respectively: «Comme la Nature travaille toujours à peu près sur un même plan...» and «Ainsi la Nature suit toujours un même plan dans ses ouvrages, mais pourtant avec une diversité infinie;...»

107 Hartsoeker, *Extrait critique*, 23: «Il est vrai que ceux qui aiment le détail en toutes choses y peuvent trouver leur compte ; mais ce détail est trop ennuieux pour ceux, qui ne cherchent qu’à sçavoir & qu’à découvrir le plan général de la Nature.»
himself apart from the Dutch microscopists of the seventeenth century who, like Swammerdam or Van Leeuwenhoek, relished the endless cornucopia of minute living things and focused on “elusive events, behavior, and mechanisms rather than how to frame theoretical explanations”. To Hartsoeker, the act of describing was always in the service of analyzing, hypothesizing about and finally systematizing nature.

Besides purposeless prose about the micro-world, Hartsoeker also derided the practice of reporting observations that seemed to have no apparent utility (“utilité”). He defined useful observations as those that would teach the reader something new or advance the sciences in some way. For instance, he criticized Van Leeuwenhoek for speaking about globules of blood, beer and other liquids, wondering what could be gleaned from an enumeration of physical characteristics such as their shape or number. He wrote indignantly, “But what do we learn from all of this? Will we know by such [talk] the shape of specific bodies from which these liquids are composed and whose shape is surely not globular?” Why did Van Leeuwenhoek let his reader wallow in a mount of senseless details without giving him a clear reason to peruse it in the first place?

Moreover, the engravings which accompanied Van Leeuwenhoek’s micrography neither instructed nor indicated “his mechanism”. Van Leeuwenhoek’s reader was lost in a sea of words and images without a compass to guide him. In Hartsoeker’s opinion, Van Leeuwenhoek failed to provide the reader with two things. First, he fell short by not establishing an overarching physical

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109 The Extrait critique is peppered with observations that are or should be “utiles” and others that are “inutiles”, etc. Hartsoeker was very much underlining the importance of “utilité” in microscopy and how Van Leeuwenhoek’s work fell below this standard of usefulness in the advancement of the sciences.
110 Hartsoeker, Extrait critique, 5 : « ... parle des globules du sang, de la biére & de quelques autres liqueurs ; de globules composés de six autres globules &c. Mais que nous apprend-il par tout ceci ? Connoît-on par là la figure des corps spécifiques dont ces liqueurs sont composées, & qui sans doute ne sont pas des globules ? ».
111 Ibid.
112 Hartsoeker, Extrait critique, 4 : « Au reste les figures, qu’il a fait graver du bois qu’il a observé, ne nous apprennent rien du tout, & ne nous donnent pas la moindre connaissance de son mécanisme, puisqu’on n’y voit presque autre chose qu’une confusion de traits & rien de plus. »
system or some kind of mechanism within which one could understand his observations and, by extension, the overall microcosm. By recording his observations just as they were, it was as if Van Leeuwenhoek had deprived the art of microscopy of its theoretical backbone. To Hartsoeker, such descriptions further revealed Van Leeuwenhoek’s inability to generalize and select from particulars. Hartsoeker’s grievance against his method seems rooted in Aristotle’s *Metaphysics*. Aristotle argued that knowledge of particulars is based on experience, while knowledge of universals on art and reason: “Thus the master craftsmen [ἀρχιτέκτονες, contrasted with the artisans, or χειροτέχναι] are superior in wisdom, not because they can do things, but because they possess a theory [τὸ λόγον] and know the causes.” While Hartsoeker often directly borrowed—unwittingly and at times deliberately—from Aristotle, his brand of Aristotelianism was more akin to that of, for example, the atomist alchemists of the seventeenth century who conducted experiments and believed in knowledge obtained through the senses. To Hartsoeker, microscopy was a means to arrive at causal explanations—it was one of the tools of a natural philosopher. That is, through microscopy Hartsoeker was able to make hypotheses and eventually arrive at the principles that governed the natural world. But his own descriptions of observations were selective and argued for a particular system of the world, while Van Leeuwenhoek’s seemed boundless and purposeless.

Second, according to Hartsoeker, Van Leeuwenhoek failed to realize that the microscope could not

113 Charles Dempsey made this point in an article on Caravaggio and his critics, who believed that Caravaggio “had deprived painting of art itself”, by stripping art off theory. I believe this point can be transposed to illuminate Hartsoeker’s fundamental problems with Van Leeuwenhoek’s micrography. Hartsoeker was bothered by the lack of a system, or of a theory that would harness and give order and reason to Van Leeuwenhoek’s observations. Dempsey, “Caravaggio and the two naturalistic styles: Specular versus macular”, in *Caravaggio: Realism, rebellion, reception*, ed. Genevieve Warwick (Delaware, 2006), 95-96.


glean information about the atoms that constitute matter. In a word, Hartsoeker deemed his work not very systematic and, by extension, not natural philosophical. The microscopist from Delft was more interested in the accurate descriptions of his observations than in the formulation of natural philosophical hypotheses. In the end, Van Leeuwenhoek was “first and foremost an artisan, a kind of technical genius, and not a theoretician; he neither thought it necessary nor really possible to say what the essence of his know-how or know-see was.” Hartsoeker, on the other hand, prioritized theoretical explanations over descriptions of microscopical particulars.

According to Hartsoeker’s own report, he saw objects distinctly faraway as well as close up until the age of forty. In letters to Leibniz, Hartsoeker, then fifty four, sounded a more pessimistic tone about the physical limits to microscopical magnification. He had realized that one could not discover the insensible particles of matter through observation. In fact, he wrote, “All that can be expected of microscopes is to understand through their means the construction and admirable oeconomy of living creatures . . . .” In other words, one could to some extent examine material structures, but to discover finer parts, such as ultimate particles that make up natural bodies, would

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116 Hartsoeker, Extrait critique, 13, 65.
117 Interestingly, historian Maria Rooseboom wrote the opposite about Van Leeuwenhoek’s work: “Meanwhile our indefatigable microscopist continued his observations, carefully writing down any of his discoveries which he considered important. Only rarely did he deal with a single subject as a complete entity; again and again he [p. 33:] reverted to subjects dealt with in previous letters, until he felt that they had been fully and adequately discussed. As a result his letters often seem desultory to us, but Leeuwenhoek’s investigations were far from unsystematic. For year after year he continued unswervingly the study of certain subjects, such as reproduction, steadily reporting his new findings as they arose,” in introductory chapter to Measuring the invisible world: The life and works of Antoni van Leeuwenhoek F R S, Abraham Schierbeek (London/New York, 1959), 32-33. Lisa Jardine also presents a more favorable picture of Van Leeuwenhoek’s method and his Cartesian “mechanistic view of matter” in Ingenious pursuits: Building the Scientific Revolution (New York, 1999), 96.
118 Wiep van Bunge, From Stevin to Spinoza, 62.
119 Hamou, La mutation du visible, 16b: « Parce qu’il fut avant tout un artisan, une sorte de génie technique, et non pas un théoricien, il ne jugea pas nécessaire, ni même vraiment possible de dire ce qui faisait l’essence de son savoir-faire, ou de son savoir-voir. »
120 Nicolas Hartsoeker, Seconde partie de la suite des conjectures physiques (Amsterdam, 1712), 53-54.
122 Hartsoeker to Leibniz, GWLB, Ms. Lbr. 371, 29 March 1707, 14-15: “Tout ce qu’on peut esperer des microscopes, c’est de connoitre par leur moyen la construction et l’oeconomie admirables des creatures vivantes, et d’aller en cela au de là des conjectures, comme j’espère de le faire voir dans le second volume de mes Conjectures.”
for now be impossible. As Ruestow has argued in his landmark study of the microscope, the limits of what could be seen were reached by the beginning of the eighteenth century and discoveries made with microscopes steadily declined.123

In 1710, Hartsoeker revisited the usefulness of microscopy in an even more explicitly cautious passage in his *Eclaircissements sur les conjectures physiques*: “microscopical observations are of great utility and allow us to go beyond conjectures, but it must be said that those who apply themselves to observing must make use of more . . . than just their eyes, . . . otherwise they will imagine themselves to have seen a thousand things that [are not actually there] at all”; they will end up like “those who see in the clouds all that their imagination projects onto them.”124 For instance, he lambasted Van Leeuwenhoek for putting too much faith in microscopes and letting “his imagination play a larger part in his observations than his eyes”.125 If Van Leeuwenhoek thought he could “discover the insensible parts from which salts are composed with a microscope, he is horribly wrong, for it is impossible to know by their means the insensible parts of natural bodies. And it is because of this that one must have recourse to conjectures in order to explain their effects”. According to Hartsoeker, microscopes primarily served to expand our knowledge and understanding of “the structure of the parts that [make up] the admirable economy of living creatures”, so that through their means we could go beyond mere conjectures.126 His research had taught him that details of insect parts eluded even the best microscopes (and, by extension, the best microscopists).

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124 Hartsoeker, *Eclaircissements sur les Conjectures Physiques* (Amsterdam: Pierre Humbert, 1710), 82 : “Je conviens avec vous, que les observations microscopiques sont d’une très-grande utilité, & nous font aller souvent au de là des conjectures; mais il faut avouer aussi que ceux qui s’y appliquent [sic], doivent avoir autre chose que leurs yeux en partage; car sans cela ils s’imaginent bien souvent voir mille choses qu’ils ne voyent point, semblables à ceux qui voyent dans les nuës tout ce que leur imagination leur représente.”
125 Hartsoeker, *Extrait critique*, 57-58 : « Pour moi je crois, principalement par cette dernière circonstance, que [p. 58 :] son [Leeuwenhoek’s] imagination a eu beaucoup plus de part à ses observations que ses yeux. »
126 Hartsoeker, *Eclaircissements*, 83 : « Les Microscopes doivent être employez principalement à nous faire connoître la structure des parties qui servent à l’économie admirable des créatures vivantes, afin que nous puissions en cela aller par leur moyen au de là des Conjectures. »
Limited magnifying powers and the deceptive nature of the imagination\textsuperscript{127} played against the observer.

Moreover, he found the study of insect parts not very apposite to the study of man, a much larger and more complex creature. Instead, Hartsoeker wanted to devote his time to comparative anatomy of animals larger than the human being, whose parts would be more visible and thus more suitable for study. After all, he hinted, “Nature has a tendency to hide in man what she reveals in another animal”. He hoped comparative anatomy of larger animals and humans would serve at least two purposes. First, it would teach us about the structure and overall make-up of man and the lower animals; and second, it would further our medical knowledge.\textsuperscript{128} Hartsoeker’s Baconian vision of microscopy was very applied and driven by the goal to collect instructive rather than purely descriptive details about nature.

**Conjectures Made the Philosopher**

Hartsoeker also used the microscope to study the composition of inorganic matter. His life-long commitment to an atomist natural philosophy made him especially curious about the physical structure of natural substances, such as gold, mercury, and others. The limitations of the microscope in studying inorganic substances become evident in the following episode. Hartsoeker contested Nicolas Lémery, a famous chymist whom he knew and whose treatise he had read, on the composition of gold. The French chymist had argued that gold was “a very compact, malleable matter” and consisted of irregular parts. Apparently, Lémery’s and Hartsoeker’s claims rested on

\textsuperscript{127} Simon Schaffer relates how telescopic viewing of the sun produced the side effect of fantastical bright images and microscopical observations gave Robert Boyle hope of getting at the “asperities” that produced colors. See “Regeneration: the body of natural philosophers in Restoration England”, in *Science incarnate: Historical embodiments of natural knowledge*, eds. Christopher Lawrence and Steven Shapin (Chicago, 1998), 92-93.

\textsuperscript{128} Hartsoeker, *Eclairissemens*, 83 : « Car il arrive bien souvent que ce que la Nature a soin de cacher dans l’Homme, se manifeste dans un autre animal. Et ainsi l’on peut connoître la structure de presque tous les viscères de l’Homme par une anatomie comparée, & faire par leur moyen beaucoup de progrès dans la Medecine, qui jusqu’à présent est encore enveloppée d’épaisses ténèbres. »
what they had seen (or not seen) with a good-quality microscope. The Dutch philosophe interpreted matters differently. He explained: “. . . one sees [in the gold] pores of varying shapes, when one looks at it with a good microscope. But since those pores are just swellings, one can hardly conclude from them that gold has irregular parts, in the same way that one [cannot really] assert that water consists of irregular parts, from [just] seeing air bubbles in ice.” He continued: “The usual pores that particles of gold . . . leave between each other are invisible to the best microscope, and we are still quite far from discovering them.”

The gross parts of gold could be magnified by the aid of a microscope, while the ultimate particles or the smallest constituents could not. In other words, Hartsoeker made a clear distinction between larger parts of matter and the atoms of gold that remained outside the realm of microscopy. They were so tiny that not even the best available microscopes would be able to reveal them to the inquisitive human eye. And thus, here the boundary between the seen and the unseen was drawn, and by extension, the boundary between empirical and hypothetical (or theoretical) realms of knowledge. Drawing on his atomist view of matter, Hartsoeker hypothesized that gold, among other pure substances, was made up of immutable, indivisible and indestructible particles that were homogenous. Each material substance, such as gold, mercury, air or water, had its unique particles that varied only in shape, size and weight according to the substance. As Hartsoeker put it, “gold, for example, has to be composed of particles of an established shape and size and arranged in a certain manner [suitable] for gold and for no other thing”.

In his treatises he always reinstated his conviction that gold

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129 Hartsoeker, Eclaircissmens, 175 : « L’Or, dit M. Lemeri dans son Traité de Chymie, est une matière très-compacte, malléable, inégale en ses parties; en sorte qu’on y remarque des pores de différentes figures, lors qu’on le regarde avec un bon Microscope. Mais comme ces pores ne sont que des boursoufflures, on en peut aussi peu conclure que l’Or est inégal en ses parties, qu’on pourrait conclure que l’eau est inégale en ses parties, de ce qu’on voit des bulles d’air dans la glace. Les pores ordinaires que les parcelles de l’Or doivent laisser entre elles sont invisibles par le meilleur Microscope, & nous sommes encore bien éloigner de les découvrir. »

130 Nicolas Hartsoeker, Conjectures physiques (Amsterdam, 1706), 122 ; Eclaircissmens, 168, 173; and, Hartsoeker to Leibniz, GWLB, Ms. Lbr. 371, 15 February 1707, 15.

131 Hartsoeker, Conjectures physiques, 124 : « Car puis que l’Or, par exemple, doit être composé de parcelles d’une figure & grandeur déterminées & arrangées d’une certaine façon pour être Or & non pas quelque autre chose . . . ». 
particles were by nature uniform and homogenous. In his *Principes de physique*, he conjectured more specific dimensions for gold atoms: “since magnetic matter passes through them very freely, they would have to be polyhedrons, which leave rather large intervals between each other.” Figure 2 B is a sample of what gold particles must look like:

![Figure 2 B](image)

FIG. 2. Examples of fundamental particles of matter.

Thus, Hartsoeker’s atomist beliefs informed many of his observations, as we see in his refutation of Lémery. In this episode Hartsoeker used the microscope to its furthest observational potential and hypothesized based on how gold behaved in experiments with a magnet. But the point, at which his natural philosophical imagining took over, also comes into closer view. Hartsoeker confessed that “it is impossible to know the essence of Matter”, but nonetheless, his atomist sympathies informed his philosophical system of the world. And like Descartes, Hartsoeker supplemented his explanations of natural phenomena with visual representations of possible structures of the invisible

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132 Hartsoeker to Leibniz, GWLB, Ms. Lbr. 371.
133 Nicolas Hartsoeker, *Principes de physique* (Paris, 1696), 95 : « L’or est le plus pesant de tous les corps que nous connaissons ; d’où l’on pourrait conjecturer que ses parties sont autant de cubes : mais comme la matière magnétique le traverse fort librement, il faut qu’elles soient des polyèdres, qui laissent des intervalles assez larges entre-eux. »
135 Nicolas Hartsoeker, *Suite des éclaircissements sur les conjectures physiques* (Amsterdam, 1712), 58 : « S’il vouloit me contester la liberté de faire ces suppositions, il me mettroit dans l’impuissance de lui expliquer la nature & les proprietez de l’Eau qu’il désireroit de sçavoir ; mais s’il me demandoit après, de quelle matiere & par quel artifice ces boules ont été faites, je lui dirois que c’est aussi difficile de le sçavoir, parce qu’il est impossible de connoître l’essence de la Matiere, que de sçavoir de quelle Matiere les rouës de nôtre Machine ont été faites . . . »
This was the place where he let his philosophical conjectures supply what was invisible and beyond the realm of the microscope’s powers.

Over the course of Hartsoeker’s life’s work, conjectures came to define his natural philosophy. There seems to be something quite liberating about his “probabilistic approach to science”. Micraelius’ seventeenth-century lexicon explained conjecture as “the middle point between knowledge and ignorance”. It describes a state of imperfect—probable but uncertain—knowledge. Goclenius was even more to the point: “we make conjectures about that of which we cannot give a certain account [rationes certas].” In examining the early history of observation, Katharine Park traces conjecture to the ancient art of divination, described by Cicero and Pliny, and to divinatory sciences, as navigation, farming and medicine. Conjecture was a way to extrapolate on the basis of accumulated, ‘old’ knowledge learnt from observation. It offered the interpreter of nature “guidance as to what to expect” from a hitherto unexamined phenomenon. But what exactly did Hartsoeker mean by “conjecture”? And what place did he accord them in his natural philosophy? He offered a partial answer to these questions in a 1703 letter, published by and addressed to Jacques Bernard, the editor of the Nouvelles de la République des Lettres. He had come to the conclusion that “almost all of Physics is based only on Conjectures and all that one can teach

137 Antonio Clericuzio, Elements, principles, and corpuscles: A study of atomism and chemistry in the seventeenth century (Dordrecht, 2000), 190.
138 Johannes Micraelius, Lexicon philosophicum terminorum philosophis usitatorum ordine alphabeticum sic digestorum, ut inde facile liceat cognosse, praelertim si tam Latinus, quam Graecus index praemissus non negligatur, quid in singulis disciplinis quomodo sit distinguendum et definendum (Jena, 1653), 269.
139 Rudolph Goclenius, Lexicon Philosophicum quo tanquam clave philosophiae fores aperiuntur, informatum opera & studio Rudolphii Goclenii senioris, in academia Mauritiana, quae est Marchioburgi, Philosophiae Professoris primarij (Frankfurt, 1613 facs.), unpaginated.
As we shall see, Hartsoeker defined a new kind of conjecturing, neither entirely ancient in meaning nor completely modern in the sense of testing theories against hard data. In Hartsoeker’s opinion, physics necessarily involved making conjectures about the causes of things yet unknown. Hartsoeker used the making of conjectures in the sciences as synonymous with the making of hypotheses. Nonetheless, he was neither the first nor the last to do so. Holding the hypothetical position in knowledge-making has a long history, stretching back at least as far as Plato; it was variously revived by Thomas Aquinas, Nicholas of Cusa, Osiander, Mersenne and others. It was expressed in the language of Descartes or Cartesians, such as Jacques Rohault. Rohault’s treatise on physics shares and predates some of Hartsoeker’s hypothetical language. For instance, he inferred probable causes for the properties of the magnet from experience. In his explanation of what caused colors in the rainbow, he conjectured that light suffered some kind of refraction that resulted in the colors of the rainbow. Rohault’s language and approach allowed him to underplay the more dogmatic inclinations of Descartes’ work and “give a probabilistic interpretation of the truth value of specific explanations”.

Likewise, Robert Hooke was another philosophical microscopist who avowed speculating about “‘the Subtilty of Nature’”. In 1705, Hooke wrote the following revealing passage about the place of conjectures in natural philosophy:

Now tho’ in Physical Inquiries, by reason of the abstruseness of Causes, and the limited Power of the Senses we cannot thus reason, and without many Inductions from a multitude of Particulars come to raise exact Definitions of things and general Propositions; yet by comparing the varieties of such Inductions we may arrive to so great an assurance and

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141 Nicolas Hartsoeker, “Lettre de Mr Hartsoeker à l’Auteur de ces Nouvelles, contenant des Conjectures sur la Circulation du sang”, in Nouvelles de la République des Lettres, 2 (1703) : 153 : « Je vous envoie mes pensées sur la Circulation du Sang, que j’ai insérées, mais en trois mots seulement, dans mes Principes de Physique. Je les [mes pensées] apelle Conjectures, parce que je n’ose les débiter sous un autre titre: car, nous avons beau dire, presque toute la Physique n’est fondée que sur les Conjectures, & presque tout ce qu’on y enseigne n’est que par probabilité. »


143 Rohault, Traité de physique, 319.

144 Schuster, “Rohault, Jacques (1620-1672),” 506.

Judging by its pervasiveness in the works of various authors, hypothetical language seems to have been “accepted as a commonplace” in the early modern period.\textsuperscript{147} In good measure, Hartsoeker’s conjecturalism in his conception of physics appears a direct descendant of Descartes’ hypotheticalism that weaves through \textit{Les principes de la philosophie} (as will be shown below).

Armed with a microscope in one hand and hypotheses in the other, Hartsoeker sought to make sense of the microscopic world on a macroscopic scale. The second part of this chapter examines the role of microscopes and theoretical frameworks in the gathering of knowledge. In other words, how did these instruments influence what Hartsoeker saw or what role did they play in transforming his vision of the world? How much importance did he accord to the theoretical imagination in dealing with the limits of microscopical magnification? One of the instances where their mutual roles manifested themselves in the most memorable way was in his aforementioned work on optics. In this treatise Hartsoeker not only explained how to work lenses but also made some natural philosophical claims on generation. For instance, he argued for pre-formation based on his observations with a microscope. The theory stipulated that parts of an organism, for example the fly, were already present in miniature form in the maggot and merely grew as the organism further developed. The way in which he did this shows nicely how his philosophical hypotheses complemented his observations. For many years he had been observing the sperm of quadrupeds and human beings, which he thought resembled tadpoles. Ever since he had made these observations, he realized that birds, flies, and butterflies were born out of these “worms which

\textsuperscript{146} Hooke (1705, p. 331) cited in Hunter, “Hooke the natural philosopher,” 124.
enclose them inside and hide them from our view”. ¹⁴⁸ No doubt the idea of pre-formation influenced Hartsoeker’s observations. For instance, he believed “that each worm that one sees in the semen of birds encloses actually a male or female [organism] of the same species” as the parent. ¹⁴⁹ He presupposed “the same thing of the . . . [little animals] that there are found in the semen of men and quadrupeds”. Namely, “each animalcule contains and for the moment conceals . . . either a male or female animal from the same species”. ¹⁵⁰

In his *Essay de dioptrique*, Hartsoeker speculated that for man, the spermatic animalcule (FIG. 3)¹⁵¹ would look like a “little animal” (popularly coined as a homunculus) (FIG. 4).¹⁵² That is, he only supposed it would resemble a tiny replica of a human being, with a head that is larger than his body, crouching in a fetal position inside the delicate membrane of the spermatozoon.

![FIG. 3. Observed spermatozoon.](image)

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Yet, he never explicitly stated that he *had seen* a homunculus precisely like the one he described: it was a presumption rather than an observation (FIG. 4). He “imagine[d]” that this “little animal” would “perhaps look like this” on the inside.\(^{153}\) His pre-formationist argument joined with the

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\(^{153}\) Hartsoeker, *Essay de dioptrique*, 229: “Nous venons de dire que le petit animal se joint à l’œuf par la partie la plus tendre de son corps. Or je crois que cette partie est le bout de sa queue, que cette queue renferme les vaisseaux umbilicaux, & que si l’on pouvait voir le petit animal au travers de la peau qui le cache, nous le verrions peut-être comme cette figure le représente . . .”.

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theory of encasement (or *emboîtement*), championed by Father Malebranche in 1674. The French *philosophe* presumed that the seed of any animal and plant species contained infinitely many seeds within itself—as many as would be necessary for reproduction until the end of time. Malebranche hoped his “encasement of germs” would address the shortcomings of Cartesian theories of generation.\(^{154}\) Using Malebranche’s *emboîtement*, Hartsoeker pushed his idea of pre-formation even further: He conjectured that each male homunculus, in turn, already possessed a countless number of these little homunculi of both genders in his semen. So each homunculus contained ever more tiny homunculi, and so on until infinity. And he came full circle by concluding that “the first males [must have been] created with all those male animalcules from the same species that they [later] fathered”. The male part of the offspring then would pass on to future generations these original animalcules, and do so until the end of time.\(^{155}\) The same was true for generation in plants. When he examined some seeds under the microscope, he discovered the entire plant in miniature form in the germ. He believed that those germs contained ever smaller new germs, or seeds, wherein were enclosed ever smaller new plants.

By 1692, Huygens was curious about Hartsoeker’s philosophical ideas, all the while anticipating controversy. Huygens and Marquis de L’Hôpital (1661-1704) remained in the know about Hartsoeker’s optical and philosophical ideas throughout the 1690s. As Stroup has shown, Hartsoeker helped L’Hôpital smuggle new developments in the calculus from the Parisian Academy to Huygens, who was back home in Holland. During this time, Hartsoeker persistently tried to convince Huygens of his method for grinding telescopic lenses with long focal lengths.\(^{156}\)

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\(^{155}\) Hartsoeker, *Essay de dioptrique*, 230-1 : « L’on peut pousser bien plus loin cette nouvelle pensée de la generation, & dire que chacun de ces animaux mâles, renferme lui-même une infinité d’autres [p. 231] animaux mâles & femelles de même espèce ; mais qui sont infiniment petits, & ces animaux mâles encore d’autres animaux mâles & femelles de même espece, & ainsi de suite ; de sorte que selon cette pensée les premiers mâles auraient été créez avec tous ceux de même espèce qu’ils ont engendrez & qui s’engendreront jusqu’à la fin des siecles. »

Hartsoeker's lens making method and accompanying system of the world eventually resulted in the *Essay de dioptrique*, in which he advertised for the first time all the aforementioned observations and suppositions. Christiaan Huygens, his brother Constantijn, L'Hôpital and other savants eagerly awaited the publication of the treatise. They expected it to contain details of Hartsoeker's microscopes and, more importantly, his lens making method. L'Hôpital received the treatise with mixed feelings: on the one hand, he was thrilled about its possible novelties; but on the other hand, he reacted indignantly to the ideas it contained. Although the book dealt with optics and lens manufacture, it also offered Hartsoeker's microscopical observations and ideas on generation.

L'Hôpital and Huygens had looked forward to Hartsoeker's lens-making secrets with bated breath, but they did not expect him to publish his ideas on natural philosophy in the book as well. In a letter to Huygens in 1695, L'Hôpital wrote that he had seen Hartsoeker's new treatise. But he made sure to add his dismay about Hartsoeker's natural philosophical claims: “Mr Hartsoeker has brought me his . . . essay on dioptrics that I have not yet read, but from what he has told me about it in the past I am not at all pleased with his ideas on physics.”

A close examination of Hartsoeker's writings on microscopy reveals notable nuances. First, it clearly demonstrates what he saw in his investigations and how he interpreted them. It shows his interaction with the microscope and the realization of its powers and shortcomings. Everything aside, the microscope let him see enough to make larger philosophical claims about nature: He used the idea of animalcules and the possibility of the homunculus to support preformation and encasement theories of generation. Observing animal as well as plant seeds microscopically let him moreover suppose that these two life forms were homologous and could be easily compared. From comparing one could proceed more readily to understanding. Second, it demonstrates the visually

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157 Le Marquis de L'Hospital to Christiaan Huygens, 14 March 1695, *OC* (The Hague, 1905, vol. X), 711 : « Mr Hartsoeker m'est venu aporter son livre qui est intitulé essay de dioptrique que je n'ai point encore lu, mais sur ce qu'il m'en a dit autre fois je ne suis point content de ses idées sur la phisique. »
suggestive nature of the microscope as a research tool and the concomitant role of hypotheses in exploiting this feature. Hartsoeker conjectured that spermatozoa would have to look like homunculi enclosed in the tear-like membranes that he spied under the microscope. Third, L'Hôpital's critical reception of Hartsoeker's natural knowledge claims (in the aforementioned letter to Huygens) seems to suggest that he had overstepped a boundary. Perhaps the unfavorable response to Hartsoeker's physics bears closer scrutiny. In letters to his brother, Huygens called Hartsoeker “the young Dutch maker of large telescopes”, “the one who taught us how to make small beads [bead lenses] for microscopes”.

Obviously, there is an age and status differential at play here as well. When the treatise reached Huygens, he was 65 years old and stood at the end of a successful career as a geometer (“géomètre”), astronomer and mathematical practitioner at the Academy. L'Hôpital was younger, but a successful mathematician and, by 1693, also an academician. He, however, sought favor from Huygens for his mathematical ideas. Hartsoeker, on the other hand, was 38 and a diligent lens maker who had not yet been nominated to the post of academician. Socially Hartsoeker started as Huygens’ protégé. Professionally he was a rather successful lens maker with somewhat controversial philosophical ideas. In the eyes of Huygens and L'Hôpital, he was a skilled, educated craftsman who made a living by grinding lenses for the Academy and not yet a full-fledged philosopher who could make knowledge claims about nature. What set the two men apart from Hartsoeker and his ilk even further was the importance they granted mathematics.

Nevertheless, Hartsoeker was no lowly artisan, even though he neither shared Huygens' and L'Hôpital's passion for the calculus nor their insistence on the primacy of mathematics for

158 Christiaan Huygens to Constantyn Huygens, OC, vol. IX, 34-35: “... le jeune Hollanois faiseur des grands telescopes. Vous saurez done que c'est le meme Hartsoecker qui nous apprit a faire les petites boules, pour les microscopes, et qui fist avec moy le voyiage de Paris.”

159 Dijksterhuis, “Constructive Thinking”, 59-61. Dijksterhuis distinguishes categories within mathematical practitioners: “‘Géomètre’ would be more apt to address Christiaan Huygens, indicating his social status and denoting the more academic status of his amateur scholarship. The words ‘mathématicien’ and ‘géomètre’ connoted a clear social distinction between the thinker and the doer, between the disinterested and the professional pursuit of mathematics. Such a distinction ought not to be transgressed lightly.”

explaining natural phenomena. He believed, however, that, in order to have greater purchase, his know-how had to participate and be embedded in philosophical networks where theory defined and made intelligible nature’s endless particulars. At the Academy he had the privilege of conducting lectures and disseminating his ideas in the pages of its journals. To Hartsoeker, these were the avenues a natural philosopher took to forge and circulate a système of his own. In good Aristotelian fashion, he claimed mathematics would distract him too much from physics. Moreover, he believed natural philosophy to be a more precarious and demanding discipline, one that did not offer the same kind of certainty as mathematics. As a natural philosopher, he waded through various uncertainties by “feeling [his] way” from one idea to the next.161

By sharing his ideas on generation, Hartsoeker had gone from the realm of things and material knowledge into the realm of ideas. In the treatise, he obviously used his expertise as lens maker to make a name for himself and subsequently gain new ground for making theoretical claims about nature.162 Remarkably, for all his empirical competence, Hartsoeker still saw theory trumping practice and believed that his principal contributions were in that domain. He styled himself foremost as a natural philosopher rather than instrument maker or microscopist. The fact that Hartsoeker himself was reluctant to favor empirical knowledge over theoretical explanations of natural phenomena reflects the social organization of natural philosophy in this period. At the same time, it also shows the professional diversity and mobility within natural philosophy that was still available to someone like Hartsoeker.

161 Hartsoeker, Eclaircissements, 125: « Au reste, la Physique n’est pas comme les Mathematiques, ou comme l’Algebre des Modernes, qui est si fort en vogue à présent. Comme il faut envisager mille & mille choses à la fois dans la Physique, l’on s’y trompe très-facilement ; mais dans l’Algebre, il ne faut qu’avoir beaucoup de patience & une clef pour ouvrir la porte par où l’on veut entrer. Pourvu qu’un Algebraste ait assez d’esprit, pour ne pas laisser échapper de sa main la fisselle qui le doit conduire où il souhaite d’aller, il y arrive toujours seurement, sans qu’il ait même besoin de savoir le chemin par où il va. Mais il n’en est pas de même d’un Physicien qui est privé de ce secours, & ne marche le plus souvent qu’à taton. »
162 Dijksterhuis, “Constructive Thinking”, 77.
“A Philosophe is rather like someone who walks through a labyrinth: He goes from conclusion to conclusion up to the point when he is trapped and then has to turn back in order to look for another one that is better and can lead him to the truth”, mused Hartsoeker.\textsuperscript{163} When confronted with such labyrinthine realities, speculation was a tool that improved rather than competed with a natural philosopher’s reasoning powers. He compared the job of the natural philosopher to a man who tried to divine the parts and processes of a machine whose interior mechanism was off limits to him. Poignantly, vision plays a fundamental role here: the philosopher, like the man in the simile, cannot see the interior moving components of the machine. The original passage is worth quoting here at length:

\begin{quote}
But it seems to me that the person who seeks to make sense of natural phenomena is rather similar to a man who is led in front of a very complex machine, whose parts he cannot see. This man can only examine the machine from the outside and try to make sense of its various movements by imagining the different parts, wheels and springs of the Artisan who has made them. Let us suppose that this machine is a watch that shows the hours, the days of the week, the movements of the moon and the other planets and so on…\textsuperscript{164}
\end{quote}

Hartsoeker’s passage is no doubt indebted to Descartes’ characterization of the body as machine in \textit{L’homme} and \textit{Les principes de la philosophie}. There, Descartes argued that although our senses were not able to access the interior workings of bodily machines, their parts—perceptible and imperceptible—were nonetheless subject to and could be deduced from the same governing rules of mechanics.\textsuperscript{165} Also in the background of Hartsoeker’s vivid image looms the metaphor of the universe as a great watch, whose interior parts and mechanism the philosopher ought to divine from

\textsuperscript{163} Hartsoeker, \textit{Eclaircissements}, 110: « Un Philosophe est assez semblable à un homme qui marche dans un labyrinthe : Il va de conclusion en conclusion jusqu’à ce qu’il se trouve pris, & qu’il est obligé de rebrousser chemin, pour en chercher un autre qui soit meilleur, & qui le puisse mener à la vérité. »

\textsuperscript{164} Hartsoeker, \textit{Suite des éclaircissements}, 55: « Mais pour moi il me paroit que celui qui entreprend de rendre raison des phenomenes de la Nature, est assez semblable à un Homme, qui, étant conduit au-près d’une Machine extrêmement composée, qu’il ne peut voir & examiner que par dehors, entreprend de rendre raison de ses differens mouvements, par les differentes pieces, rouës & ressorts qu’il s’imagine, que l’Ouvrier qui l’a faite, peut avoir employez pour y réussir.

Supposons que cette Machine est une Horloge qui montre les heures, les jours de la Semaine, le mouvement de la Lune & des autres Planettes, &c. »

its effects. It can be traced back not only to the impressive clocks of Richard of Wallingford (ca. 1327-30) and Giovanni de Dondi (1348-64), but also to the tradition of astronomical clocks and geared planetaria of classical times.¹⁶⁶

A subsequent passage continues even more explicitly. It is important for two reasons. On the one hand, it shows how Hartsoeker defined what the work of a natural philosopher entailed and what kinds of absolute physical limitations he had to manage; and, on the other hand, it illuminates the role of conjecture in the work of a natural philosopher:

He who sets out to explain the phenomena of this great and admirable machine (i.e. the world) must have unlimited freedom to imagine whatever he wants of the size, the shape, the arrangement and movement of the little bodies that compose it . . . ; and he [will] not be able to succeed in his endeavor, as long as this freedom is taken away from him or as soon as someone wants to limit this freedom.¹⁶⁷

This very revealing paragraph casts an interesting light on the relation between practice and theory as well as the creative process as a whole in Hartsoeker’s work as natural philosopher. As we saw in the examples with the microscope, empirical results were limited and the philosopher inevitably had to deal with incomplete knowledge about the world. Workable instruments coupled with probable speculations had to fill in the missing puzzles. Hartsoeker often repeated that the best thing a physicist could do was to offer conjectures, suppositions, and not exact proofs (the last were the prerogative of mathematicians). Further he stated that conjectures were not only the final resort of a physicist, but that they originated from the physicist’s creative labor of examining and explaining natural phenomena. In other words, if one tried to limit a physicist’s conjectures by labeling them

¹⁶⁶ Derek De Solla Price, Gears from the Greeks: The Antikythera mechanism—A calendar computer from ca. 80 B.C. (Philadelphia, 1974), 54-55.
¹⁶⁷ Hartsoeker, Suite des éclairissements, 56: « Celui qui entreprend d’expliquer les phénomènes de cette grande & admirable Machine, doit avoir une liberté sans bornes de s’imaginer ce qu’il lui plait de la grandeur, de la figure, de l’arrangement & du mouvement des petits Corps qui la composent, selon qu’il en a besoin; & il se trouveroit dans l’impuissance de réussir dans son entreprise, dès qu’on lui ôteroit cette liberté ou qu’on voulût y mettre des bornes. »
outlandish or impossible, he would be less able to arrive at a sound explanation of the truth of the matter.

Conclusion

Broadly taken, what sets Hartsoeker apart as a microscopist is that he was not interested in the endless nitty-gritty particulars of the micro-world (in contrast to a Van Leeuwenhoek or a Swammerdam). He gained entry into a community of thinkers and practitioners like Huygens and Cassini by virtue of his lens making skills and his adeptness at selling this kind of hard-won expertise. From the beginning, however, he wanted to build a physical system of his own and participate in the intellectual community of his time. Under a Collinsian lens, the case of a Nicolas Hartsoeker would be negligible, for it would presumably fall outside of the “cascade of creative circles”, centered around the intellectual contributions and networks of Descartes, Leibniz, Berkeley, Hobbes, Spinoza, Newton and Huygens. This chapter, however, shows that the social and intellectual boundaries in a story like Hartsoeker’s were not neatly drawn. In fact, the high degree of mobility possible for philosopher-practitioners like him highlights the limits of Collins’ knowledge diffusion model.168

Hartsoeker was unusual because he was both a lens maker and a philosopher who was persuaded by certain Cartesian (and other) beliefs. He aspired to make his name foremost as a natural philosopher, using the skills of lens and instrument maker to achieve this. He did this quite adeptly, first by gaining ground in the realm of things and platonically proceeding upwards to the realm of ideas. From the days of youth, his approach to the natural world had been material and empirical. Yet he set a premium on the role of ideas rather than things. The life goal of a natural philosopher was to unravel the secrets of nature by making knowledge claims and suggesting

answers to crucial questions about nature, life and the universe. Interestingly, his expertise as instrument maker gained him access into circles where hypotheses and philosophical ideas made the philosopher (even if at times, reluctantly). Of course, ideas carried more weight if supported by empirical evidence and observations. But social and intellectual politics played a role in how ideas, evidence and practices circulated and how they were evaluated. In the end, it was challenging for Hartsoeker, originally a lens maker, to convince already established mathematicians and philosophers of his natural philosophical ideas.

Throughout his life, theoretical convictions, such as his atomism, shaped how he interpreted and used what he saw under the microscope. Lémery’s supposed irregularities in gold particles were not acceptable to Hartsoeker. He explained them as superficial bubbles of air or of another substance that had nothing to do with the fundamental particles of the gold. Matter particles of any material had to be regular, homogenous and immutable. Of course, these fundamental particles were off limits to microscopical study. Similarly, his pre-formationist ideas had a symbiotic relationship with his microscopical investigations on spermatozoa. His ideas seemed to bias and then confirm his observations, and vice versa. But he also knew that one had to be critical of one’s microscopical observations, considering the ever-present imperfections and margin of error.

Even the best microscopes, in most cases, only approximated what the smallest organic and inorganic structures looked like and how they interacted. But they were powerless to supply information about the minute operations at the particulate level. On the whole, they engendered more questions than they answered. Hartsoeker became aware of their limitations as his lens making efforts reached a threshold. The somewhat satisfactory solution he found for dealing with them was in his hypotheses. Hartsoeker ended up managing insufficient information with conjectures, upon which he constructed his theories about natural phenomena. As Daston has shown for other natural philosophers, “in practice, only by summarizing, taking means, attending
only to the most robust effect, omitting swarms of detail and otherwise smoothing out the particularities of the data did early Enlightenment natural philosophers take the first step towards a generalization”.169

But there is more. Hartsoeker’s conjectures, or causal hypotheses, were not just strategies for building his initial empirical investigations or explanatory models of natural phenomena. They were his explanatory model of the universe. The making of conjectures proved a helpful resort in the thought and interpretation processes of a natural philosopher. On the one hand, Hartsoeker cautioned against the imagination’s sway over the senses when making observations. But on the other hand, he supported the role of the conjectures in the explanatory realm of knowledge production. Curtailing a philosopher’s speculations was like clipping a bird’s wings. Freedom to hypothesize about natural phenomena meant increased possibilities to arrive at true answers.

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Chapter 3

From Principles to Conjectures: Hartsoeker’s Peregrinations in Germany and His Break with Descartes

PART I: In the Service of Elector Johann Wilhelm II

The German scholar, bibliophile and chronicler Zacharias Conrad von Uffenbach visited Nicolas Hartsoeker in Düsseldorf in the afternoon of 10 April 1711. Author of the famous travel writings, *Merkwürdige Reisen*, Uffenbach recorded his visits in great detail. His first impression of Hartsoeker was that he was “unusually polite.” But he wondered why Hartsoeker had not yet learnt to speak German since his arrival in Düsseldorf in 1704. The nature of Uffenbach’s visit—like his morning saunter that same day to the cabinet of medals and coins—was natural philosophical curiosity. The Dutchman did not disappoint. Hartsoeker showed his guest some of his magnets, while he complained about how expensive they could be: his son had once paid 2000 gulden for a magnet half the size of Hartsoeker’s fist. Hartsoeker also showed him various microscopes, among which “a small lens . . . which [Hartsoeker] praised as something exquisite and extraordinary,” for it “had a far greater effect¹ than the others. The lens was not larger than a Heller² and, remarkably, was not polished on both sides but only around the edge to ensure that it would not break. [Hartsoeker] considered this to be the greatest daring feat in glass grinding.”³ Having come all this

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¹ Uffenbach probably means that the small lens had greater magnifying powers.
² Old German coin valued at half of a Pfennig.
way to meet “the famous physicist and mathematician (den berühmten Physicum und Mathematicum)” from Holland, Uffenbach asked if his brother could be apprenticed by him in lens grinding. Hartsoeker neither said yes nor no, but laughed. Uffenbach explained that his brother had learnt little in the practice of lens grinding in England, even though he was well supplied with glass, pewter, copper and other materials. Hartsoeker eventually answered that he did not think there was much to learn, since he himself had not gotten far in lens grinding. This curious remark could suggest one of two things: either Hartsoeker was politely refusing to apprentice Uffenbach’s brother, or he was being modest about his own lens grinding talents. On the whole, there were very few “lovers (Liebhaber) of the mathematical and physical sciences,” he told Uffenbach. Nevertheless, the feeling of isolation Hartsoeker felt at Düsseldorf was not trivial. Hartsoeker was the only natural philosopher at court, in addition to several court physicians and the Jesuit mathematician Father Orban, who was the Elector’s confessor and trusted advisor and also cast his horoscopes. In the building of his massive telescope, Hartsoeker had received help from the lens-maker Schäffer, the keeper of the princely collection of optical instruments. Uffenbach also met him and considered him a “good astronomer.” And while his patron Johann Wilhelm II was a scientifically minded fellow, Hartsoeker had a rather low opinion of the other courtier. He had good reason to believe that the court entourage considered his telescopes mere toys (Lustbarkeiten). One time—Hartsoeker complained to Uffenbach—the careless, princely court had ruined his three telescopes (with focal...
length of 40 feet) that he had stored at the castle. To add insult to injury, they had also smashed the lenses, which Hartsoeker was unable to replace. Many of his instruments and expensive magnets he had bought at his own expense. This made his loss all the more bitter.

For three years, the Elector Palatine tried to lure Hartsoeker to his court, before he finally accepted his offer and moved with his family to Düsseldorf. The German Prince certainly made it worth his while: Apparently, the Dutch natural philosopher was the only salaried learned man in Johann Wilhelm’s constellation of luminaries; and he was paid handsomely. As an added perk to his new position at the court in Düsseldorf, Hartsoeker was nominated honorary professor of mathematics at the University of Heidelberg already in 1702. In November of 1704, the University was ordered (by the Elector Palatine, presumably) to disburse him a salary of 1400 florins. This was hitherto the highest amount ever paid to a professor. From December 1706, he agreed with the University to receive a considerably more modest salary of 315 fl. per year. Both Nicolas Hartsoeker and his son Christian (who actually taught at Heidelberg and lived in Mannheim) seem to have earned quite a bit of money at Heidelberg. In one case, the rector and other professors asked Johann Wilhelm to cut Christian Hartsoeker’s lavish pay and instead offer income to others who taught at Heidelberg but were not salaried. Some of the professors and physicians the older Hartsoeker met at the Palatine court were also employed at the University of Heidelberg. One such example was Swiss anatomist and professor of medicine Johann Konrad Brunner, who also served as a court physician.

10 Uffenbach cited in Mauer, Der Fürst und seine Stadt, 182.
12 Friederich Lau, “Die Regierungskollegien zu Düsseldorf und der Hofstaat zur Zeit Johann Wilhelms (1679-1716). I.” Düsseldorfer Jahrbuch, Band 39 (1937), 228. Hartsoeker must have been paid rather well, since he received 50 Reichsthaler. On the whole, this was the highest amount paid to artists and craftsmen (Künstler und Kunsthandwerker), exceeded only by the earnings of the director of buildings who made 125 Reichsthaler. For the sake of comparison, Gabriel Grupello, the celebrated Flemish court sculptor, received 40 Reichsthaler per year; the court architect, 30 Reichsthaler; and, the court jeweler, 25 Reichsthaler (the lowest amount in this category).
At the time Hartsoeker was appointed to the faculty of mathematics, the University of Heidelberg was a small place. Its professorate counted only seven ordinary professors, among whom were Hartsoeker and Johann Konrad Brunner. However, of these seven, four (including the last two) never attended or taught courses at the university. In part, the disorganized and inefficient administration of the court at Düsseldorf was to blame for this disorder.¹³

Hartsoeker and his family were well liked at court. In August 1707, the Elector wrote a recommendation letter on behalf of Theodor Hartsoeker, “‘the son of our excellent mathematician’” who had ambitions of becoming a painter.¹⁴ Theodor wanted to travel to Rome to study painting. The Elector asked his connection to offer him all the assistance he could grant this young man. Alas, this first trip did not materialize until the winter of 1711.¹⁵ In addition to the Elector, his wife Anna Maria Luise de’ Medici also personally interceded on Theodor’s behalf. She wrote a letter of recommendation to her father Cosimo III, asking him to accommodate Hartsoeker’s son who wanted to stop in Florence on his way to Rome.¹⁶ Cosimo III welcomed him in Florence, as evidenced by his letter of 22 December 1711.¹⁷

Not much remains today of the old princely castle in Düsseldorf. The bombardment of the palace by the French—and the fire that ensued—in 1794 badly damaged it. The castle was patched up and eventually restored, housing several electors and dukes until the great fire of 1872 led to its ultimate ruin. Only a castle-tower that overlooks the Rhine and a small part of Düsseldorf’s once

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¹⁷ Vollmer, ed., Düsseldorfer Jahrbuch, 129. The original letter is in the National Archives in Florence, Med. 1070, fol. 567.
famous picture gallery survive in the Altstadt.\textsuperscript{18} This gallery, commissioned by Johann Wilhelm in 1710,\textsuperscript{19} was a testament to his and his wife Anna Maria Luisa de’ Medici’s taste for collecting fine artwork. But the collection was of course also a marker of power, wealth and authority. It was particularly rich in Dutch art, abounding in the works of Pieter Paul Rubens, his pupil Anthony van Dyck, Adrian van der Werff (“this precious Magician of the eye”\textsuperscript{20}), and other painters of the Flemish school.\textsuperscript{21} The Flemish sculptor Gabriel Grupello (1644-1730) and the Dutch painter Jan Frans Douven were not only accomplished artists but also served as Johann Wilhelm’s most important art consultants.\textsuperscript{22} A major fixture of city Markt­platz is Grupello’s majestic bronze statue of Johann Wilhelm poised on a horse. During Hartsoeker’s stay, the Rhinian court teemed with life and revelry; courtiers included learned men, diplomats, architects, sculptors, painters, poets, priests, and musicians who hailed from various parts of Europe.

\textbf{Princely Culture of \textit{Wissenschaften} and \textit{Maschinen} in Düsseldorf and Kassel}

Duke Philipp Ludwig (grandfather of Johann Wilhelm II) was Protestant, but his son, Wolfgang Wilhelm von Pfalz-Neuburg converted to Catholicism to marry the daughter of a Bavarian prince. His son, Johann Wilhelm II, was educated by Jesuits and maintained the Catholic faith.\textsuperscript{23} In 1688, Johann Wilhelm’s father, moved his court from Heidelberg to Düsseldorf, after the

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\textsuperscript{18} Benedikt Mauer, \textit{Der Fürst und seine Stadt: Bauten aus der Jan-Wellem-Zeit in Düsseldorf} (Düsseldorf: Droste Verlag GmbH, 2008), 33.
\textsuperscript{19} George Henry Townsend, \textit{The Manual of Dates: A Dictionary of Reference to the Most Important Events in the History of Mankind to be Found in Authentic Records} (London: Frederick Warne & Co., 1867), 348. Uffenbach traveled to Düsseldorf in early April of 1711 and reported that the picture gallery was not yet finished then (\textit{Merkwürdige Reisen} in Mauer, \textit{Der Fürst und seine Stadt}, 179).
\textsuperscript{20} George Marie Rapparini, \textit{Le Portrait du Vrai Merite dans la personne servissime de Monseigneur L’Electeur Palatin} (Neusäß/Augsburg: Paul Kieser GmbH Druckerei und Verlag, facs. no. 0635 of 1709 ms., 1988), fol. 18: “Van der Werf de Roterdam [sic], ce mignon Magicien de l’oeil, et qui a trouvé le beau secret d’enchanter l’admiration sur le front de quiconque s’arrête devant ses tableaux, par les graces continuelles qu’il mêle à ses teinted, en a aussi laissé une Idée en peinture approche de la perfection . . .”
\textsuperscript{21} Charles Frederick Partington, \textit{The British cyclopædia of literature, history, geography, law, and politics} (London: Orr and Smith, 1836), 1: 655. See also, Mauer, \textit{Der Fürst und seine Stadt}, 36.
\textsuperscript{22} Mauer, \textit{Der Fürst und seine Stadt}, 131.
\textsuperscript{23} Mauer, \textit{Der Fürst und seine Stadt}, 15-16.
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region around the Neckar River and the Middle Rhine was turned into a central battle zone during
the Nine Years’ War, or the War of the League of Augsburg, that continued until 1697. The castle
of the Palatinate at Heidelberg was burnt to the ground, while the area around the city robbed and
destroyed by the French. The conflict involved most of Europe’s main rulers and sparked a series
of coalitions to oppose Louis XIV’s plans of extending France’s boundaries to the Rhine. In the
middle of all this warfare, Johann Wilhelm assumed power in 1690 and in 1691 he married his
second wife, Anna Maria Luise de’ Medici, daughter of Cosimo III, Grand Duke of Tuscany. The
Peace of Ryswijk in October 1697 finally ended the war, but one of its conditions required Johann
Wilhelm not to revert the Palatinate to Protestantism. Enlisting the Jesuits to the cause, the Elector
openly and forcibly began to convert his Protestant subjects. Johann Wilhelm eventually enforced
religious toleration in November 1705. Still, confessional friction between the Catholics and the
reformed Christians did not disappear with the new decree. In theory he was interested in uniting
the faiths, but in practice he did much to strengthen Catholicism in Heidelberg and in the Palatinate
by establishing saint cults and holy orders.

Like many German princes at the time, Johann Wilhelm II had a taste for the arts and
sciences, which he actively pursued through reading, experimenting, and collecting. Historians have
begun mapping princely patronage of and involvement in alchemy, medicine, the natural sciences
during the sixteenth and seventeenth centuries. This continued well into the eighteenth century and,
in particular, in the German lands, as individual courts were competing for power and prestige

27 Kleinschmidt, “Johann Wilhelm (Kurfürst von der Pfalz),” 315-316.
amongst each other. Princely patronage, in turn, created employment opportunities for talented craftsmen, mathematicians, natural philosophers, and machine builders. Often, these men came from abroad. Langrave Karl of Hesse-Kassel drew especially talented Swiss and French clockmakers to his court (well into the eighteenth century). Clocks served not only as timekeepers and “symbols of fleeting time (Symbolen der fließenden Zeit),” or as precision instruments; but also as luxury items, expensive gifts to mark an anniversary, and curiosities (Raritäten) that showcased the maker’s virtuosity and the receiver’s social cachet. Opticians, lens makers, mathematicians, clockmakers and various precision mechanics or engineers (Feinmechaniker) built instruments from night clocks and sundials to thermometers and telescopes, and contributed to the intellectual life at court. Sometimes they would bring precious objects along with them, such as embossed celestial globes made of copper or various optical lenses. For example, Karl Lothar Zumbach aus Koesfeld (who received his doctorate degree from Leiden University and was a friend of Hartsoeker’s) entered the service of the Landgrave of Hesse-Kassel with booty. He enriched the princely collection with two very costly terrestrial globes, an expensive atlas, and geographical charts. He also organized a course of lectures at court. Other times, instruments would make their way from abroad. The natural sciences cabinet of Hesse-Kassel also housed Denis Papin’s vapor machines, Johann Musschenbroek’s Leiden airpump, and (the latter’s son’s) electrostatic generator, or “friction machine (Reibungselektrisiermaschine).” Furthermore, the courts of Hesse-Kassel and Düsseldorf were both outfitted with astronomical observatories.

Hartsoeker’s contemporaries bear witness of the fact he wore many hats at court in Düsseldorf, from writing philosophical treatises and conducting alchymical trials to crafting optical and mathematical tools and experimenting with magnets. However, it seems his mechanical know-how received much more publicity than his natural philosophical ideas. This is perhaps unusual, if we remember that he developed some of his most important ideas after moving to Düsseldorf. As the above discussion suggests, however, the courtly culture Hartsoeker participated in often favored practical knowledge in the guise of vapor-and-smoke-producing machines or dazzling spyglasses. Such an attitude sometimes helped construe the image of “fashionable science.” Indeed, some nobles were more interested in display; others in natural philosophy; still others in arcane knowledge and processes.

It is of course a matter for debate to what extent these princes were involved in the philosophical and technical pursuits of their illustrious court *curiosi*. Biographer and historian Philippi notes the limits of the statesman’s abilities to follow his brightest philosophers. Landgrave Karl’s philosophical prowess was probably not always quick enough to follow a Leibniz, but he surely made up for it with his passion for practical experiment. In similar fascination with practical and applied know-how, Hartsoeker’s patron Johann Wilhelm II seemed most interested in instruments, alchemy, and experimentation broadly conceived. Nonetheless, he must have been fluent in the journals and recent literature of his time, for he informed Hartsoeker of Réaumur’s crayfish experiments at the Parisian Academy (as discussed in Chapter Four). The spread of print

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32 Philippi, *Landgraf Karl von Hessen-Kassel*, 613: “Freilich blieb es nur bei einem allgemeinen Ideenaustach, den Landgraf Karl war ein unphilosophischer Kopf, zu wenig intellektuell, um dem geistigen Höhenflug eines Leibniz folgen zu können. Sein Drang war auf das Experiment, das praktisch nützliche und anwendbare Ergebnis gerichtet, soweit er nicht durch die Entfaltung des Schönen und Erhabenen als Ausdruck fürstlichen Lebensstils ausgesprochen war. Der Trieb zur Erkenntnis allein um ihrer selbst willen war ihm kaum eigen, hierfür brach es ihm wohl an systematischer geistiger Schulung und Disziplin des Denkens.”
culture bears particular mention, and its effects should not be underestimated. When Willem Jacob ‘s Gravesande published his new *Physica elementa mathematica experimentis confirmata* in 1720 (in which he laid the foundations for teaching physics), he became quickly sought after by Landgrave Karl of Hesse-Kassel for his experimental knowledge. The Leiden physicist eventually made his way to Kassel where he, along with Baron Joseph Emmanuel Fischer von Erlach, was asked to inspect and give his opinion on a perpetuum mobile machine. (Denis Papin and Gottfried Wilhelm Leibniz had seen the same machine earlier and been highly skeptical about its promise.) This kind of prompt recruitment of able minds and hands from abroad and a deep fascination with—indeed, a need for—mechanical tools was motivated by application in warcraft as well as by simple curiosity. Building and speaking cogently about machines and instruments characterized and defined court culture of the early eighteenth-century Holy Roman Empire. 

Comparing Johann Wilhelm II to Alexander the Great, Rapparini praised his dedication to both “Philosophy” and “the secret sciences, which others have called Curious”—that is, alchemy. For these pursuits, the Prince had set up laboratories and enlisted numerous “learned spies of Nature” who, through many experiments and research, tried to unveil nature’s secrets. While it is unclear to what extent Hartsoeker partook in these investigations, he was nonetheless very interested in alchemy and conducted alchymical experiments, especially as it pertained to his atomistic natural philosophy. Building optical and surveying instruments was his predominant occupation at the Düsseldorf court. His court contemporary Rapparini described his construction of telescopes, microscopes, and an unusually large burning mirror. For his prince, Hartsoeker also built two (surveyor’s) leveling instruments designed to determine whether a surface was horizontal. One of these was constructed in such a way that its center of gravity was below, while the other’s was above,

the point of support. In 1711, Hartsoeker published a brief explanation as well as engravings of the two machines in a short essay that made it into several instrument compendia of the time. This work was later excerpted and briefly reviewed in January of 1712 in the *Acta Eruditorum* published in Leipzig. In the fall of 1709, Uffenbach must have seen one of these leveling devices on his visit to Cassel, where he inspected the instrument exhibition rooms at the court of Landgrave of Hesse-Cassel. In 1708, Hartsoeker reportedly presented the Landgrave of Hesse-Kassel with several instruments and inventions, and in 1709 was a guest at court. Uffenbach’s account not only corroborates this, but helps to demystify these “curious inventions” attributed to Hartsoeker.

### The Rapparini Manuscript (1709)

In 1709, Giorgio Maria Rapparini (1660-1726) wrote a eulogy in honor of his patron Johann Wilhelm II, *Le Portrait du Vrai Merite dans la personne serenissime de Monseigneur L’Electeur Palatin.* In it he compared the Elector to Alexander the Great. His trilingual account—written in French, Italian and Latin—offers a unique insider perspective on courtly life in Düsseldorf in the early eighteenth century.

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37. Nicolas Hartsoeker, *Description de Deux Niveaux d'une Nouvelle Construction* (Amsterdam: [unknown publisher], 1711).
38. [Author unknown], “Description de Deux Niveaux d'une Nouvelle Construction / h .e. Description Durarum Libellarum nova ratione constructarum. Autore Nicolao Hartsoeker,” *Acta Eruditorum* (January 1712): 34-35. Interestingly, historian Laeven argues that especially after 1700, the *Acta* “gave litte cause for scholarly dispute,” as editor-in-chief Otto Meneke (until 1707) enforced a more restrained approach to reviewing works in the Republic of Letters. After Otto’s death in 1707, his son Johann Burchhardt assumed stewardship of the journal, but it is unclear who among the Acta’s journalists reviewed this particular work by Hartsoeker. Excerpts and reviews of Hartsoeker’s earlier works had been written by Martin Knorre (in issues of 1695 and 1697 of the *Acta*); he was known for his careful and neutral style of reporting, in line with Otto Meneke’s dislike for controversy (but frustrating to some like Leibniz who preferred a more critical reviewer). On the journal’s tone until 1707, see Augustinus Hubertus Laeven, *The “Acta Eruditorum” under the Editorship of Otto Meneke: The History of an International Learned Journal between 1682 and 1707*, trans. Lynne Richards (Amsterdam & Maarssen: APA-Holland University Press, 1990), 96, 164-165.
41. Rapparini’s work has remained in manuscript form until Hermine Kühn-Steinhausen published it as Part IV of the publications of the Landesbibliothek und Stadtbibliothek Düsseldorf in 1958.
century. An Italian librettist and writer from a musical Bolognese family, Rapparini was 

_Hofkammerrat_ and “French Secretary” at the court of Johann Wilhelm II from 1685 to 1716.  

In his _Portrait du Vrai Merite_, Rapparini briefly discussed Hartsoeker’s contributions in Düsseldorf. “This celebrated theoretician [ _ce célèbre spéculatif_ ],” too, Rapparini compared to a classical Greek figure. The Italian librettist rhapsodized about the Dutch philosopher:  

It is this modern Archimedes, who not too long ago has constructed an extraordinarily large parabolic mirror with an unusual diameter as well as a Telescope of prodigious length, and done many other beautiful demonstrations pertaining to mathematics and Physics; in return for which I intend to strike Him a medal that will do his memory justice, and be more enduring in the spirit of the learned World and more famous in the schools, but will not by this raise his merit and credit, which is at its height.” 

Rapparini’s praise sounds, on the one hand, celebratory of Hartsoeker’s accomplishments and, on the hand, somewhat cautious. His admiration quickly morphed into veiled disapproval, especially what concerned Hartsoeker’s conjectural system of nature. This is especially evident in the passage that follows:  

But unfortunately it is only too true that our vision is too weak, our eyes [too] dull, to reach this knowledge. And the more we try to run towards these remote inquiries to feed our Souls in order to keep them away from uncertainty, [the more] we only make them sink into confusion and darkness even more by a great mass of opinions, which come to light, and thus each one forms a separate system, founded on mere conjectures; but [the latter are] so strongly regarded as indisputable facts ( _réalitez incontestables_ ), taking such strong hold on the minds of their authors, that they make reformed believers out of them ( _elles en font des religionnaires_ ). 

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43 Friederich Lau, _Düsseldorfer Jahrbuch_ 39 (1937): 240. Foreign secretaries part of the Court Chamber (or, _Hofkammer_), including Rapparini, received on average a salary of 400 Reichsthaler per year.  
44 Rapparini, _Le Portrait du Vrai Merite_, fol. 54: “À ce propos, je passe à raisonner ici de ce célèbre spéculatif Monsieur Hartsoeker, Membre de l’Academie roiale des Sciences à Paris, de celle roiale de Prusse, et Docteur en Medicine, qui a merité et trouvé auprés de mon Prince un appuy plus solide à sa vertu. C’est ce moderne Archimedes, qui a depuis peu construit un miroir parabolique d’une grandeur extraordinaire, et d’un diamètre hors du commun; comme aussi un Telescope d’une longueur prodigieuse, et fait beaucoup d’autres belles demonstrations, concernantes aux mathematiques, et à la Physique; moiennant quoi j’entens Lui frapper sa medaille, qui rendra bien la memoire de sa Personne, et plus durable dans l’esprit du Monde savant, et plus fameuse dans les écoles; mais n’augmentera pas pour cela son merite, et son credit qui est au comble.”  
45 Rapparini, _Le Portrait du Vrai Merite_, fol. 56: “Mais helas qu’il n’est que trop vrai que nôtre veue, est trop foible, nos regards émoussés pour atteindre à ces connoissances, et plus que nous tachons de courrir à ces recherches éloignées pour l’érudition de nos Ames, pour les retirer hors de l’incertitude, nous ne faisons que les plonger plus avant dans la confusion et dans l’obscurité, par la grande foule des opinions qui s’engendrent à la journée, et donc chacune forme un
In this passage, Rapparini seemed to be echoing his contemporaries’ reservations about the pitfalls of forging a system out of hypotheses and the dangers of considering them as “indisputable facts.” Worse yet, philosophers become so enchanted with their suppositions to the point of religious zeal, suggested Rapparini. He closed his discussion with a moral admonition, advising his reader that, if he could, “. . . I’d say that it would be better simply to keep our eyes closer to ourselves and to pay attention to our behavior, by studying the very important art of knowing ourselves [on the inside].” With this sentiment, Rapparini let escape what he regarded as true vision: mastering oneself and one’s reason first, before searching for the invisible and the unreachable. This moral, Rapparini hoped, should not prejudice anyone against him who “applies himself to the discovery of things that ignorance hides from our view and to the manufacture of optical Instruments.”

Two drawings, showing a medal from both sides, serve as conclusion to Rapparini’s text on Hartsoeker. On the edge of the Hartsoeker medal, he inscribed the following complimentary dictum: “If the head were surrounded with those stars that you see in a clear sky, they would be even brighter (Illa serenato quae lustras sidera coelo si capiti aptares Lucidiora forent).”

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système à part, fondé sur des simples conjectures, mais si fortement soutenues pour des réalitéz incontestables, qui tiennent dans la tête de leurs auteurs si fermes, qu’elles en font des religionnaires.”

46 Rapparini, Le Portrait du Vrai Merite, fols. 56-57: “. . . je dirais qu’il en vaudroit bien mieu se contenter de tenir l’oeil plus prés de nous mêmes, et de veiller à nôtre conduite, en étudiant l’art tres-important de nous bien connoître en dedans.

Que ce trait de morale soit laissé en passant sur mon Tableau, et qu’il ne face le moindre préjudice au merite de qui s’applique à la [fol. 57:] découverte des choses qui nous sont voilées par l’ignorance, et a la fabrique des Instrumentes qui servent à l’optique.”

47 Rapparini, Le Portrait du Vrai Merite, fol. 57.
FIG. 5. Hartsoeker Medal no. 11 and 12 from Rapparini’s *Portait du Vrai Merite* (Düsseldorf 1709, facs.), fol. 57.

One side of the medal shows Hartsoeker’s head in profile. The other side depicts him kneeling on one knee in front of a standing telescope that he is training on the stars in the sky. Next to Hartsoeker, a large burning mirror is picking up sunrays. It is both night and day on this face of the medal. This image in particular commemorates and celebrates his natural philosophical contributions and technical expertise in crafting optical instruments at Düsseldorf. It is unclear whether Rapparini ever minted the medal he had dedicated to the Dutch natural philosopher. Perhaps that intrepid traveler Uffenbach had caught a glimpse of it on the morning of 10 April 1711,
when he came to admire the medals cabinet at Johann Wilhelm’s castle merely hours before paying Hartsoeker a home visit.48

PART II: Leibniz and Hartsoeker Debate What Animated Matter in Motion

The most frequently mentioned letter from Leibniz to Hartsoeker is dated 7 December 1711. In it Leibniz explained his principle of sufficient reason and hinted at how monads worked in his system. Perhaps less well known, but no less intriguing, was Hartsoeker’s entire correspondence with Leibniz. It spanned more than six years and ended a year before Leibniz’s death (1706-1715). Their letters reveal not only the mutual admiration of each other’s work and person, but also the varied nature of the two savants’ inquiries into natural phenomena. Their epistolary exchange covered many topics, from debates on the fundamental composition of matter to chymical experimentation. In this chapter, I will look at how Leibniz and Hartsoeker’s ideas took shape during their most mature years. More specifically, I will examine Leibniz’s and Hartsoeker’s disagreements on the nature of matter in motion and what role each of them accorded to the vital forces that animate matter. The Leibniz-Hartsoeker correspondence shows that both men used empirical examples from chymistry and magnetism to bolster their case for their idea of matter and motion. At the same time, it reveals their mutual disagreements on framing the two issues at hand. The analysis will moreover shed light on what was still unresolved in debates about matter in motion at the beginning of the eighteenth century in Europe.

At the time the correspondence began, Hartsoeker was living in Düsseldorf and had become member of Leibniz’s Berlin Academy. A letter from Leibniz to Johann Bernoulli indicates that Leibniz had met Hartsoeker at least once before 1715. According to the letter, Hartsoeker had

48 Uffenbach, Merkwürdige Reisen (1711) in Mauer, Der Fürst und seine Stadt, 180.
shown Leibniz his magnetic experiments, a topic of much interest to Leibniz. Leibniz also mentioned that Leibniz introduced Hartsoeker to the Elector of Hanover and his wife. Leibniz’s first letter of December 1706 reveals that Hartsoeker had asked Baron de Croseck to present Leibniz with his newly published *Conjectures physiques*. Hartsoeker had requested that the Baron deliver the work to Leibniz and, in return, get Leibniz’s opinion on it. As this episode suggests, each of the two men hoped to learn quite specific things from the other through this correspondence. One of the reasons why Hartsoeker began writing to Leibniz was to improve his own work. In the very first letter, Hartsoeker asked Leibniz to refute his ideas, so that he could send Leibniz his reflections and counterarguments. In inviting and responding to objections, Hartsoeker—a former Cartesian—modeled himself on Descartes’ example. The Dutch philosopher found Leibniz a formidable and honorable “ennemi,” who could help him improve and sharpen his arguments in the *Conjectures physiques*. Remarkably, Hartsoeker seems to have meant what he said. In a later letter, Hartsoeker thanked Leibniz for sending his objections, “of which I always make the best possible use, by always building on them and rectifying my thoughts . . . as best as I can.”

By contrast, Leibniz’s letters to Hartsoeker show a more general curiosity. He was usually genuinely and sometimes politely interested in all of Hartsoeker’s work, and encouraged him to

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50 Fontenelle, “Éloge de M. Hartsoeker,” 244.
51 Leibniz to Hartsoeker, Beilage, 4 Oct 1706, in Gerhardt, C. I. (ed.), *Die Philosophischen Schriften von Gottfried Wilhelm Leibniz*, vol. III, 497: “Je suis obligé à M. Hartsoeker du present exquis de la partie déjà achevée de son ouvrage nouveau de physique, que Monsieur le Baron de Croseck a eu la bonté de me donner de sa part, en me marquant que l’auteur en desireit mon sentiment, et demandoit même qu’on lui fit part de quelques reflexions venues dans la lecture.”
52 Hartsoeker to Leibniz, Dusseldorp, 25 Nov 1706, LBr. 371 fol. 2r-v: “Je vous prie Monsieur d’examiner principalement les discours de l’aiman, des principes du corps naturel, du mouvement, du feu, et de l’arc en Ciel, et de me faire sçavoir quel est votre sentiment là dessus, apres quoi il me donnerai l’honneur de vous envoyer mes réponses et reflexions sur vos objections. Je ne doute pas que vous ne trouviez de tres grandes difficultes à me faire sur ces matières qui sont d’une difficulté infinie, sur tout à cause que je me suis le plus souvent écarté du grand chemin pour en frayer un autre tout nouveau, et aller par des routes inconnues.” My transcription.
53 Ibid. LBr. 371 fol. 2v: “Votre profond sçavoir est si connu de tous les sçavans de l’Europe que je dois toujours tenir à grand honneur d’être attaqué par un ennemi tel que vous ; et j’aurai moins de honte d’en être terrassé que par un ennemi moins redoutable que vous.” My transcription.
54 Hartsoeker to Leibniz, Dusseldorp, 29 Mar 1707, LBr. 371 fol. 21r: “Vous ne sçauriez jamais m’obliger plus sensiblement, qu’en me faisant avoir de vos sçavantes objections, dont je fais toujours le meilleur usage du monde, en les mettant toujours à profit, et rectifiant là dessus mes pensées tant que je puis.” My transcription.
develop further his research in medicine, optics and magnetism. He also solicited Hartsoeker’s submission of his researches on any topic of his choice for the Berlin Society’s *Miscellanea berolinensia*. Writing to other correspondents like Burchard de Volder or Bartholomew Des Bosses, Leibniz always inquired about news concerning Hartsoeker’s work on the magnet or improvements in lens-making techniques. Leibniz spoke of him as “the celebrated Dutchman,” while Des Bosses called him “the excellent Hartsoeker,” and Leibniz’s “esteemed adversary.” Leibniz’s respect for Hartsoeker the man and his craft skills, however, did not always carry over to Hartsoeker’s written work. To Des Bosses, Leibniz confessed that he had read Hartsoeker’s work, and while he thought his natural philosophy “contain[ed] many clever things,” in the end he thought it “childish.” Their philosophical and personal differences aside, for the scope of this essay the importance lies in how they both played off the experimental evidence against their arguments in setting up matter in motion.

The two men disagreed radically about the basic principles of natural philosophy. Both were trying to deal with the challenges that Cartesianism posed in reconciling a particulate, mechanical system with vitalist explanations of matter. And both thinkers had been working on their respective systems of natural philosophy for many years. According to Hartsoeker, all natural bodies were composed of two first principles, namely, liquidity and hardness. These two main principles corresponded to his first two elements, one being liquid extension and the other being

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55 Leibniz to Hartsoeker, Berlin, 12 Dec 1706 in Gerhardt, 490: « La Société des Sciences qui est établie ici pense à publier quelques Miscellanea de temps en temps. Comme vous en estes, Monsieur, et que vous avés bien des belles choses, on se flate que vous voudrés bien envoyer quelque chose pour ce dessein, et si on le pouvoit avoir avant la fin de l’année, ce seroit tant mieux. Mais enfin vous estes le maistre et de la chose et du temps. »
56 For Leibniz’s letters with de Volder in which they mention Hartsoeker, see Gerhardt, C. I. (ed.), *Die Philosophischen Schriften von Gottfried Wilhelm Leibniz*, vol. II, letters 39-41. For Des Bosses, see Brandon C. Look and Donald Rutherford, eds. and trans., *The Leibniz-Des Bosses Correspondence* (New Haven, CT, 2007).
57 Leibniz to Des Bosses, Berlin, 5 Feb 1707, in *The Leibniz-Des Bosses Correspondence*, 85.
58 Des Bosses to Leibniz, Cologne, 20 July 1715, Ibid., 341.
59 Des Bosses to Leibniz, Cologne, 18 Aug 1711, Ibid., 209.
60 Leibniz to Des Bosses, Berlin, 5 Feb 1707, Ibid., 85.
matter in the form of hard atoms. According to Hartsoeker, these two principles made sense on the basis of common experience, since without them one could never compose physical bodies. Only “geometrical” bodies would exist. But that was evidently not the case, because metals, stones, trees, and animals, which were all “physical” in nature, existed.  

He compared the liquid first substance, or his first element, to an infinite sea, upon which an infinity of bodies move without colliding with each other. By contrast, he likened his first element to pure fire. No one knew its nature, he penned, and yet, its being was “real” and could “push the atoms or little bodies floating in it, and keep them from colliding with one another.” What was more, the first principle was endowed with intelligence, which gave it the power to organize matter without end. The first element was the “soul of the Universe,” where the “universe is like a great animal full of life and intelligence.” Aided by subordinate Intelligences, this first element acted as an intermediary force between God and matter. Hartsoeker’s scheme was a modified version of Ralph Cudworth’s naturae plasticae, since his “plastic forms” were also endowed with intelligence. Meanwhile, the second principle was matter, which was made up of atoms. Hartsoeker defined atoms as small solid masses that were simple, homogenous, perfectly hard, and indivisible, but incapable of any movement or any thing by themselves. According to him, “each atom is a continuous body that is a whole without parts.”

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63 Hartsoeker, Suite des Éclaircissements sur les Conjectures Physiques (Amsterdam : Nicolas Viollet, 1712), 2.
64 Hartsoeker to Leibniz, Dusseldorp, 22 Aug 1710, in Gerhardt, 502.
65 Hartsoeker to Leibniz, Dusseldorp, 30 Dec 1710, in Gerhardt, 514: “Mon premier element est une substance infinie où les atomes se meuent de lieu en lieu, et dont ils recoivent tout leur mouvement et toute leur direction; enfin c’est l’ame de l’Univers, de sorte que l’on peut dire que l’Univers est comme un grand animal plein de vie et d’intelligence. ”
66 Nicolas Hartsoeker, Seconde Partie de la Suite des Conjectures Physiques (Amsterdam: Nicolas Viollet, 1712), 20. C. Louise Thijsen-Schoute, Nederlands Cartesianisme (Utrecht, 1989), 207. See also Fontenelle, “Éloge de M. Hartsoeker,” 242. See also Chapter Four of this dissertation.
67 Hartsoeker to Leibniz, Dusseldorp, 30 Dec 1710, in Gerhardt, 514: « Les atomes, Monsieur, sont comme j’ai deja dit, de petites masses solides, simples, homogenes, d’une dureté invincible, et incapables par eux memes d’aucun mouvement et d’aucune chose. Mon premier element est une substance infinie où les atomes se meuent de lieu en lieu, et dont ils recoivent tout leur mouvement et toute leur direction; enfin c’est l’ame de l’Univers, de sorte que l’on peut dire que l’Univers est comme un grand animal plein de vie et d’intelligence. »
68 Ibid., 512: « … chaque atome est un corps continu et un tout sans parties. »
Since the atoms were passive, the first substance or infinite extension was the active element that imparted motion to the atoms, and organized them with insight and knowledge.\textsuperscript{69}

Leibniz rejected atomism. In fact, he called atoms products of “the weakness of the imagination.”\textsuperscript{70} He refused to accept either the idea that atoms were indivisible or the lack of continuity in nature that their existence implied.\textsuperscript{71} But he said his idea of matter was of “the same nature” as Hartsoeker’s first fluid element. According to Leibniz, matter was perfectly fluid, and the connection of its parts was controlled by the conspiring motions of the vortex. Only the motions and their shapes could vary matter itself.\textsuperscript{72} Matter could never be absolutely hard and was always, to a degree, elastic. Leibniz wrote to Hartsoeker that everything in matter acted mechanically, that is, by the communication of movements. The world was a divine, preformed machine, which developed and transformed itself according to the possibilities that “the course of nature” has provided in advance.\textsuperscript{73} In a second letter, he made clear the relation between this vision of the universe and the larger harmony which, he held, characterized it. Thanks to pre-established harmony, the soul of a body had in itself the perception or the representation of organs. By the

\textsuperscript{69} Hartsoeker to Leibniz, Dusseldorp, 22 Aug 1710, in Gerhardt, 502-3.
\textsuperscript{70} Leibniz to Hartsoeker, 30 Oct 1710 in Gerhardt, 507: « Les Atomes sont l’effet de la foiblesse de nostre imagination... »
\textsuperscript{71} Leibniz had an earlier exchange on atoms and their indivisibility with Christiaan Huygens in 1692-1694, where Huygens also defended the argument for indivisible and absolutely hard particles of matter. See Huygens, \textit{Oeuvres Complètes de Christiaan Huygens}, tome X (The Hague, 1905), for instance, 296-304 (Huygens to Leibniz), 316-321 (Leibniz to Huygens).
\textsuperscript{72} Leibniz to Hartsoeker (Answer to Hartsoeker’s letter from 10 Jun 1710), without date, in Gerhardt, 497: « Selon moy toute la matiere en elle même est de la nature de cet Element [referring to Hartsoeker’s fluid first element], c’est à dire parfaitement fluide par elle même, la connexion des parties ou la resistance à la separation ne venant que des mouvemens conspirans, puisqu’il n’y a que les mouvemens et leur figures qui puissent varier la matiere. »
\textsuperscript{73} Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 508: « Tout se peut faire et se fait mecaniquement dans la matiere et par la seule communication des mouvemens; mais c’est a cause d’une preformation divine d’une machine deja faite depuis long temps, qui ne fait que se developper ou envelopper et se transformer selon les occasions qui luy sont fournies par le cours de la nature reglé par avance. »
same token, organs carried in them the shapes and movements that acted on the appetites of the soul. The movements of the body thus corresponded to the appetites of the soul.

In their correspondence, both men cited experimental evidence to support their larger theories. One of the experiments that highlights how Leibniz and Hartsoeker’s hypotheses and previous experimentation affected their reasoning about matter in motion involved steel filings whose behavior changed based on experiments with the magnet. Without the magnet, which possesses a sort of magnetic matter, the steel filings did nothing. When a magnet was present, they began arranging themselves. With this empirical case, Leibniz wanted to illustrate the unity of his own anti-atomist account of matter in motion. He wrote that the “great constancy of Nature, far from making one believe in Atoms, overthrows them.” He explained further, “If we had eyes that could penetrate this far enough, we would even see that the little parts damage and break each other, and that there isn’t anything there that would be the cause of infinite resistance.” In other words, because atoms could not be absolutely hard, an atomist explanation of matter like Hartsoeker’s eventually would not hold on a micro scale. Leibniz suggested the conspiring motion of the vortex of bodies as a more robust explanation of the experimental evidence. This would account for the fluidity of matter as well as explain its behavior. To enforce the truth of this “principle of connection,” he reverted to experiments done with a magnet, where the movement of magnetic matter laced steel filings together. Leibniz explained his idea of “conspiring motion (mouvements conspirans)” one more time to Hartsoeker in a letter dated 30 October 1710:

By mouvements conspirans I mean motions that agree with each other . . . There is always some conspiring or some degree of harmony between the movements of neighboring bodies, and it is also because of this that I believe that matter has firmness and fluidity, namely, a certain

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74 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 509: “L’ame a en elle la perception ou la representation des organes, et les organes ont en eux les figures et les mouvements qui executent les appetits de l’ame en vertu de l’harmonie préetablie.”
75 Leibniz to Hartsoeker, without a date according to Gerhardt, but most likely written on 9 Aug 1710, 500.
76 Ibid.
77 Ibid.
degree of cohesion in the most liquid . . . and in the hardest [bodies]. Thus I hold that bodies are cohesive, while the movements that are in them are disturbed by separation and resist it.  

Leibniz argued that once established in a body, the principle of motion that resisted separation would continue to last and conserve itself, like all motion. He claimed that he was not trying to prove or disprove the existence of atoms with his magnet example. Instead, he wrote that motion of the magnetic substance glued bodies together and thus makes atoms superfluous, “since the motion makes the connection” happen. And although the steel filings had some hardness to them, nothing stopped “fluid vortices” from being joined in a similar way. An even more subtle and free-flowing fluid connected these vortices and made them converge at the most suitable points.

Of course, just as Leibniz preferred vortices to atoms, so Hartsoeker chose atoms above vortices. Hartsoeker went so far as to deride Leibnizian vortices as “incomprehensible and imaginary.” And he construed the same magnetic example to mean something entirely different.

He adduced the action of the magnetic matter as evidence for the absolute hardness of atoms, not as

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78 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 504: « Par mouvements conspirans j’entends des mouvements qui s’accordent: or il est manifeste, qu’il faut bien qu’il y en ait, et qu’il y en ait d’autres qui ne s’accordent point, ou qui s’accordent moins. Il y a toujours quelque conspiration ou accord entre des mouvements des corps voisins, plus ou moins grande, et c’est aussi pour cela que je crois que la matiere a par tout de la fermeté et de la fluidité, c’est à dire un certain degré de cohesion dans les plus liquides, qui ne laisse pas d’etre surmontable dans les plus durs. Ainsi je tiens que les corps ont de la cohesion à mesure que les mouvements qui s’y trouvent sont troublés par la separation et s’y opposent » [Leibniz’s emphasis].

79 Ibid.: « Et l’on conçoit qu’un mouvement conspirant quand il est une fois établi, est un etat qui tend à se conserver et à durer, comme fait tout mouvement. »

80 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 509: « Quand j’ay parlé de la limaille d’acier liée en filets ou poils par le mouvement de la matiere magnetique, je n’ay point pretendu prouver par là, qu’il n’y a point d’atomes, si non en faisant mieux voir qu’ils sont inutiles, puisque le mouvement peut faire de la liaison. »

81 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 505: « Quand j’ay parlé de la liaison de la limaille d’acier par la matiere magnetique, je n’ay point pretenu prouver par là qu’il n’a point d’atomes, mais j’ay voulu montrer par un exemple familier que le mouvement fait quelques fois la liaison des corps. Et quoique les grains de la limaille ayent quelque solidité, rien n’empeche que des tourbillons fluides ne puissent etre liés d’une maniere semblable. »

82 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 509: « Et quoique les grains de la limaille ayent de la solidité, rien n’empeche que des tourbillons d’une matiere fluide ne puissent estre liés par un moyen semblable, c’est à dire par un mouvement d’une materie encor plus subtile qui coule plus facilement, quand ces tourbillons se touchent par des endroits les plus convenables. »

83 Hartsoeker to Leibniz, 30 Dec 1710, in Gerhardt, 511-512: « Mais les mouvements conspirans, Monsieur, ne sont ce pas pour le moins des fictions aussi grandes, puisqu’il semble qu’il n’y en a point d’autres que ceux par lesquels les corps vont actuellement de lieu en lieu avec des vitesses differentes, et ne feroit on par consequent pas mieux de prendre pour une seule bonne fois un fondement solide et inebanlable, et de soutenir qu’il y a des atomes, c’est à dire de petites masses solides, simples, homogenes, parfaitement dures et sans parties, et que ces masses sont ainsi de tout temps par la volonté éternelle de Dieu, que d’avoir recours à des mouvements incomprehensibles et imaginaires. »
an explanation of, or evidence for, conspiring motion like Leibniz. That is, if the atoms of the steel filings were not absolutely hard, the magnetic substance would just pass through them, without being able to push or affect the filings in any way. The fact that the magnetic matter threaded each grain of the steel filings together was a confirmation of the absolute hardness of atoms. Hartsoeker extended the example to include the reduction of the magnet to powder. One saw this when one crushed a first class magnet and watches its fine grains come back together (when they have been moistened with water). This demonstrates once again Hartsoeker’s hardness principle at work with the magnetic substance that strung atoms together. It also showed how his empirical methodology informed his thinking, and how, in turn, his thinking influenced what he observed.

The second example revolves around the chymical process of transmutation of metals— which neither man actually believed in. Hartsoeker rejected the transmutation of metals, especially gold, based on the immutable and indestructible nature of atoms. Leibniz never fully admitted the possibility of transmutation, and claimed that there was no proof that it took place. He believed his conspiring motions of the vortex to be a more potent force than any chymical operation or other type of man-made or natural manipulation of matter. In an early letter to Hartsoeker, Leibniz wrote that no chymical operation was capable of producing or destroying substances like common salt, acids or alkali. In fact, he thought that such chymical operations only ammassed or dissipated a chymical substance, but never destroyed it. That did not mean that these substances were

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84 Hartsoeker to Leibniz, Dusseldorp, 22 Aug 1710, in Gerhardt, 503: “L'exemple de la limaille d'acier que vous apportez, Monsieur, ne prouve rien, ce me semble, et si les petits corps ou atomes qui composent chaque grain de cette limaille n'avoient pas deja une dureté absolue, la matiere magnetique n'en feroit aucune connexion, et ne lieroit pas les grains de cette limaille ensemble. On voit cet effet tres sensiblement et avec beaucoup de contentement, quand on écrase un tres excellent aimant, et qu'on le reduit en petits grains gros comme des grains de sable ordinaire, car tous ces grains se tiennent et se lient ensemble, s'ils étoient mouilliez.”

85 While M.R. Wielema’s article is very valuable, I don’t agree with his final conclusion that Hartsoeker’s “theory is very abstract and metaphysical and can hardly be evaluated with empirical criteria.” See, “Nicolaas Hartsoeker (1656-1725): Van mechanisme naar vitalisme” in Gewina 15 (1992): 260. The correspondence with Leibniz reveals the nuances and tensions at play between empirical criteria and philosophical underpinnings in Hartsoeker’s work.

86 Leibniz to Hartsoeker, Beilage, 4 Oct 1706, in Gerhardt, 491: “...Aussi ay je du penchant à croire que ny l'un ny l'autre n'est point produit ou détruit par nos operations, mais seulement amassé ou dissipé.” Hartsoeker’s reply to this letter is dated 25 Nov 1706.
invincible and eternal, however. Unlike Hartsoeker who believed atoms to be indestructible and everlasting, Leibniz claimed that any material body, whether gold or salt or mercury, has a beginning and an end. We could say that on the transmutation of gold, for instance, both Leibniz and Hartsoeker saw eye to eye: they both rejected it as a viable, fundamental transformation of matter. Leibniz was skeptical of the success of transmutation, but he reserved judgment until the operation could be proven or disproved. Hartsoeker, on the other hand, was more critical of the process and categorically objected to its being possible. Later he qualified his categorical statement to apply only within his own system, as we will see in the following example.

Another chymical experiment, done by Guillaume Homberg and recounted by Hartsoeker to Leibniz, gives us a fuller sense of how Hartsoeker’s empiricism interacted with his hypotheses—and shows that these too played a major role in his work. Homberg, a Dutch physician and chymist, claimed he had vitrified gold by using a burning mirror. Vitrification involved heating a usually solid material at a very high temperature in order to produce a glass-like solid. According to Hartsoeker, Homberg asserted that gold could vitrify because it was composed of two principles, namely, a mercury principle and a sulfur principle. Hartsoeker rejected Homberg’s claim, based on his own experiments, which he also reported to Leibniz. The results of Hartsoeker’s vitrification experiments led him to believe that gold did not vitrify, as Homberg asserted. In fact, the experimenter himself reported finding little droplets of real gold all around the locus of the experiment. Evidently, some parts of the gold had become volatile and had left the original piece of gold.

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87 Leibniz to Hartsoeker, 30 Oct 1710, in Gerhardt, 505-506: « Quoyque je croye fort facile que les mouvemens conspirans qui maintiennent l’or dans sa consistance soyent au dessus de l’operation du feu ou d’autres operations (assés grossiéres par rapport à la subtilité de la nature) que nous sommes capables d’employer; je n’ay garde pourtant de m’imaginer que cette force des mouvemens conspirans aille à l’infini, et soit capable de maintenir l’or contre tous les efforts de la nature. Aussi suis je persuadé, qu’or, sel, et tout autre corps qui nous paroit similaire et insurmontable, ne l’est point dans la verité et qu’il a commencement et fin. »

88 Hartsoeker to Leibniz, Dusseldorp, 15 Feb 1707, LBr. 371 fol. 12v-15v.
Hartsoeker saw this fact as reinforcing his hypothesis that gold, among other metals, was made up of immutable, indivisible and indestructible particles that could not be much greater in size than those of mercury. Hence, he saw no reason why gold particles, like mercury particles, could not become volatile. In Homberg’s experiment, Hartsoeker saw evidence that gold particles did not change their nature; they gained movement from the violent fire of the chymical process that allowed them to separate and fly off in a smoke cloud from the original mass of gold.\textsuperscript{89} What is more, he noted that the piece of gold conserved the same weight before and after the operation. This was another empirical fact that supported Hartsoeker’s argument against any change in its substance.\textsuperscript{90} Yet he also sounded a note of caution. His own experiments on the same metals, and others, like lead, made him careful about the experimental equipment he used. For instance, he cautioned that coals or the crucible involved in smelting the metals could vitrify too and release secondary substances that could skew the experiment.\textsuperscript{91} Perhaps because he was speaking from experience, his position appeared more authoritative than that of Leibniz. However, what strikes the modern reader of his experiment report is his final addition to the debate on the transmutation of metals. In Hartsoeker’s words, “I’m not saying that the transmutation of metals is absolutely impossible, but I’m saying that it is impossible in my system.”\textsuperscript{92} Hartsoeker took the framework of his physical system to explain his experience of the natural world.

In evaluating Homberg’s vitrification experiment, Leibniz, as usual, was cautious. He wrote that he was unsure whether Homberg’s mercury principle actually existed and whether it was

\textsuperscript{89} Hartsoeker to Leibniz, Dusseldorp, 15 Feb 1707, LBr. 371 fol. 13r.
\textsuperscript{90} Hartsoeker, Eclaircissemens sur les Conjectures Physiques (Amsterdam : Pierre Humbert, 1710), 167.
\textsuperscript{91} Hartsoeker to Leibniz, Dusseldorp, 26 Jun 1709, LBr. 371 fol. 33v : « Je fis ensuite les mêmes experiences sur les autres metaux et pour ne parler que du plomb je trouvi qu’il ne se vitriïa non plus que l’or. C’est le creuset ou le charbon où l’on tient les metaux, qui se vitrifient si l’on n’y prend pas toutes les precautions necessaires, et point du tout les metaux eux mêmes, qui ne se vitrifient jamais, et demeurent eternellement metaux » My transcription.
\textsuperscript{92} Hartsoeker to Leibniz, Dusseldorp, 22 Aug 1710, in Gerhardt, 503: « Je ne dis pas que la transmutation des metaux est absolument impossible, mais je dis qu’elle est impossible dans mon systeme. »
possible to draw it out of metals as Homberg would have it.\textsuperscript{93} After hearing of another such experiment attempted by Tschirnhaus, Leibniz suggested enlarging the scope of the experiment by examining also the metal composition of colored glass and enamels.\textsuperscript{94} It is noteworthy that in his correspondence with Hartsoeker, Leibniz did not mention conducting any experiments of his own, but always referred to those of his associates, who included the chymists Tschirnhaus, Kraft, Cassius, and Kunkel.\textsuperscript{95}

**Conclusion to PART II**

At the end of their correspondence, Leibniz and Hartsoeker had barely managed to make each other see their points of view on physics: they rejected one another’s physical systems and often disagreed about empirical results, be it those of metal vitrifications or magnetism. Neither ever conceded to the other on the central issue of atomism.\textsuperscript{96} Leibniz wholly rejected Hartsoeker’s atoms, but seemed interested in making Hartsoeker see how his theory of perception showed the shortcomings of Hartsoeker’s elements. The fluid first element endowed with intelligence would have to be organic, according to Leibniz. In Leibniz’s words, Hartsoeker’s depiction of the first element as active and intelligent would mean that it had perception.

\textsuperscript{93} Leibniz to Hartsoeker, Berlin, 10 Mar 1707, in Gerhardt, 492: « Mais je ne suis pas bien assuré s’il y a un tel principe, et si nous le pouvons tirer des metaux comme M. Homberg nous le fait esperer. »

\textsuperscript{94} Leibniz to Hartsoeker, without date but in reply to Hartsoeker’s letter from 26 June 1709, in Gerhardt, 496.

\textsuperscript{95} Ibid. Fontenelle mentions in his « Eloge de Monsieur Leibnitz » that Leibniz had been interested and involved in chymistry already in his early twenties. Leibniz supposedly became the secretary of a secret society of chymistry in Nuremberg, shortly after receiving his law degree. However, there is little evidence of his conducting experiments at any time. See Fontenelle, Oeuvres Complètes, Tome VI (Paris: Fayard, 1994), 389.

\textsuperscript{96} Hartsoeker to Leibniz, 6 Jan 1712, in Gerhardt, 530-31: « Mais il suffit, me direz vous, que Dieu ait cree une fois la matiere, et qu’il l’ait une fois mise en mouvement, pour qu’elle continue d’exister et de se mouvoir pendant toute l’éternité, sans qu’il ait besoin d’en faire une nouvelle creation à chaque instant, et par consequent de faire sans cesse de nouveaux miracles. Mais je dirai la même chose de mes atomes, et je soutiendrai avec tout autant de raison, ce me semble, qu’ils sont parfaitement durs de toute éternité par la volonté éternelle de Dieu, sans qu’on ait besoin pour cela de recourir à des miracles continuels. Voulez vous que je vous dise franchement, Monsieur, ce que je m’aperçois de notre dispute sur les atomes, c’est qu’elle pourrait durer une éternité et que nous redirions toujours la même chose. Ainsi je crois que nous pouvons la finir. »
We also arrive at the always tense relationship between empirical evidence and natural philosophical explanation. What the letters between Hartsoeker and Leibniz teach, is the dubious position of experiments and empirical evidence in the sometimes less quantifiable branches of knowledge production, like magnetic and chymical researches, in the beginning of the eighteenth century. Establishing trust in the experimenter and the evidence seemed much more difficult here than in the mathematical sciences, as Dear has shown for the latter.97

Both men used experiments to bolster their arguments in favor of their natural philosophical commitments. To Hartsoeker, experiments that demonstrated the transmutation of metals necessarily proved impossible, because matter consisted of atoms that were immutable. He interpreted all empirical results in light of his atomist theory of matter. Remarkably, for all his empirical competence, Hartsoeker still saw theory as higher than practice and believed that his principal contributions were in that domain. To Leibniz, empirical evidence seemed to carry more authority than hypotheses, at least at first glance. Physical principles aside, there is also a difference in scholarly status between our two correspondents. Hartsoeker turned to Leibniz for criticism on his natural philosophical work, and saw him as an honorable epistolary rival. Leibniz took Hartsoeker seriously on empirical evidence, because Hartsoeker was, among other things, an empiric. But when we look closer at what he actually wrote, we discover that Leibniz, too, was very committed to his own explanation of the nature of matter.

What makes this correspondence remarkable is that it began primarily for intellectual rather than social reasons, unlike others that Anne Goldgar summons in her Impolite Learning.98 As Grafton has argued, Cartesian philosophy as well as “a new religion of intellectual progress” markedly

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informed and shaped the “status anxieties” of savants.99 Nevertheless, civility and politeness did not exclude criticism and dissent. As other scholars have shown, the Republic of Letters was a “place of inevitable tensions between ideas and facts.”100 Civil criticism allowed Leibniz and Hartsoeker to put competing explanations and systems forward, because they were joined in a common sense of purpose. Leibniz and Hartsoeker were idealists whose letters and work demonstrate not only a commitment to the advancement of their own ideas, but to the general advancement of knowledge.101 Both men were plugging away at a comprehensive explanation for matter in motion. Des Bosses reminded Leibniz that he and Hartsoeker were in a similar, though often conflicting, quest for a system. He remarked to Leibniz: “Clearly, his beloved atoms stand in the way of his comprehending your principle [of sufficient reason], which is undoubtedly productive of great truths. But what parent of a new system can reject his own offspring and relinquish it as a prize in the face of your withering criticisms?”102

Part III: Heart Attack—Where Descartes’ Mechanism Failed

Continuing from Chapter One, this section of Chapter Three examines Nicolas Hartsoeker’s grounds for rejecting, in part, the explanatory power of Descartes’ mechanical model. To anchor the more general Cartesian debates, I will specifically address the problematic Cartesian explanation of the continuous motion of the heart. The example reveals a host of permanent issues with a mechanical analysis of a physiological phenomenon crucial to life. Hartsoeker first accepted Theodoor Craanen’s Cartesian-based explanation, which he later revised in his treatises, as we will see in Chapter Three. I hope this investigation will illuminate whether or not Hartsoeker’s decision

100 Hans Bots and Françoise Waquet, La République des Lettres (Paris: Belin-De Boeck, 1997), 27.
102 Des Bosses to Leibniz, Paderborn, 28 January 1712, The Leibniz-Dess Bosses Correspondence, 213.
to publicly renounce his early Cartesianism speaks to the larger Zeitgeist of the period. While many people change their minds over the course of their lifetime, the vehemence with which Hartsoeker claimed to have cast off his Cartesian beliefs ought to be explored and explained. As has been signaled elsewhere, the tide against Cartesian thought began to turn after Theodoor Craanen’s death in 1690.103 The critical onslaught, spearheaded by Herman Boerhaave, came primarily from anatomists and microscopists, such as Marcello Malpighi, Frederik Ruysch, Giovanni Alfonso Borelli104 and Antonius Nuck. They proffered structural arguments based on their anatomical findings against Cartesian tenets which, they claimed, were largely grounded in theory only. For example, Descartes believed that the pineal gland was the seat of the soul and that the heart and the blood in the heart naturally contained more heat than other parts or organs of the body. This new generation of natural investigators pitted observational evidence against these Cartesian tenets. For example, they measured the temperature of the blood to show quantitatively that, in fact, the blood was not hotter inside the heart than elsewhere in the body.105

From the college bench at Leiden, Hartsoeker admired the work “with Cartesian zeal, which Mr. de Volder reinforced all the more so,” since he “was not less of a Cartesian than Mr. Craanen.”106 But after leaving “the Colleges of the most fervent Cartesians”—that is, of De Raey, Craanen and De Volder—Descartes’ Treatise on Man began “to frustrate” him.107 He deemed

106 Nicolas Hartsoeker, Extrait critique des lettres de feu M. Leeuwenboeck in Cours de physique, accompagné de plusieurs pièces concernant la physique qui ont déjà paru et d’un extrait critique des lettres de M. Leeuwenboeck (The Hague: Jean Swart, 1730), 45: “j’avois appris de M. Cranen que l’ame avoit son siege dans la glande pineale, d’où elle donnoit ses ordres comme un Roi de son throne ; que tous les nerfs y aboutissoient ; que l’ame faisoit par le moyen de ces nerfs remuer toute la machine [ . . .] enfin mille autres belles choses de cette nature, tirées de l’homme que le celebre Descartes avoit fabriqué lui-même, & toutes également fausses & ridicules ; mais que j’admirai alors en zéle Cartesien ; d’autant plus que j’y fus confirmé par M. de Vorder, qui n’étoit pas moins Cartesien que M. Cranen.”
107 Hartsoeker, Eclaircissements, 113.
Descartes’ ideas “as false as they were ridiculous.” 108 “From all of Descartes’ sentiments, none appears to me more extravagant or furthest from good sense than the one which he has imparted to us on the mechanical soul of animals [l’ame machinale des bêtes],” Hartsoeker wrote indignantly in his Éclaircissements sur les conjectures physiques of 1710. 109 Although Descartes discussed the reasonable soul in human beings in his Tractatus de homine, 110 he only attributed sensitive souls to animals. This proved troublesome to Hartsoeker who believed animals were capable of reason, pitting empirical evidence against the Cartesian model of animal automata. He contrasted Descartes’ abstract presentation of animals as “mere machines” with “the cleverness of animals” [l’industrie des bêtes] he observed in everyday life. Experience “ought to be the only foundation for all our thoughts,” Hartsoeker underlined. And it was experience that, in Hartsoeker’s mind, manifestly contradicted Descartes’ notion of animals and humans as simple machines. The danger lurked in extending the notion of animals as machines to men, and in becoming “convinced that all men, except for [Descartes] alone, are just mere machines.” 111 As one contemporary reviewer of Hartsoeker’s Éclaircissements put it succinctly, “Whoever believes that Beasts are mere Machines, cannot be sure

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108 Hartsoeker, Extrait critique, 45: “J’avois appris de M. Cranen que l’ame avoit son siege dans la glande pineale, d’ou elle donnait ses ordres comme un Roi de son throne ; que tous les nerfs y aboutissoient ; que l’ame faisoit par le moyen de ces nerfs remuer toute la machine, à peu prés de même qu’on voit arriver à ces petites poupées qu’on appelle marionettes ; que nôttre machine pouvoit faire toutes les fonctions sans ame, & seulement par les loix méchaniques comme un automate ; que le coeur ayant été fait le prémier, par je ne sçai quelles loix méchaniques, faisoit du sang, poussoit ce sang vers le haut & vers le bas au travers d’une matière fluide, & faisoit ainsi les artères ; que le sang le plus subtil allant tousjours vers le haut de la machine formoit le cerveau ; enfin mille autres belles choses de cette nature, tirées de l’homme que le célébre Descartes avoit fabriqué lui-même, & toutes également fausses & ridicules ; mais que j’admirai alors en zelé Cartesien ; d’autant plus que j’y fus confirmé par M. de Volder, qui n’étoit pas moins Cartesien que M. Cranen.”

109 Hartsoeker, Eclaircissements, 111: “De tous les sentimens de Descartes, aucun ne me paroit plus extravagant ni plus éloigné du bon sens, que celui qu’il nous a laissé sur l’ame machinale des bêtes.”


111 Hartsoeker, Eclaircissements, 111: “Et certes il a beau dire & vouloir prouver par mille subtilitez, qu’elles ne sont que de pures machines; toutes ces subtilitez ne concluent rien, parce que l’expérience, qui seule doit être le fondement de tous nos raisonnemens, nous dit manifestement le contraire; ou bien elles concluent trop, parce qu’après cela il ne peut être convaincu, que tous les hommes, excepté lui seul, ne soient de pures machines.”
that all Men, besides himself, are not so too.” The kind of medical Cartesianism that Hartsoeker learned at Leiden shows the problems Hartsoeker encountered later in revising his explanations of natural phenomena. The central Cartesian idea that “our machine could do all its functions without the soul, and only by mechanical laws like an automaton” continued to recur in Hartsoeker’s writings and became impossible for him to accept. Specifically, he refused the idea that the heart had been created and functioned according to some mechanical laws. He understood how blood flow could produce motion and, in a spring-like fashion, make blood vessels contract and expand. However, what he could not understand was how vital spirits flowing through the nerves could animate and maintain a beating heart. What force propelled those vital spirits [esprits vitaux] that originated in the cerebellum to the nerves? And whence came the force that enabled the nerves to wind up the heart and all other vessels and to produce a continuous motion in them? Aware of the slippery slope in the search for a cause, Hartsoeker aired his growing apprehensions: “One cannot say that they [esprits vitaux] get their force from the motion of the Blood, & that this Blood takes its [motion] from the compression of the Heart & all the other vessels in our body; because one circles back to the first problematic . . .” Hartsoeker’s objections, uttered in 1710, were not unlike the objections raised by the curators and other critics of Cartesian teachings in 1676. For Hartsoeker, these were new arguments in the evolution of his natural philosophy.

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113 Hartsoeker, Extrait critique, 45 (see quote above). Hartsoeker’s doubts about mechanical explanations for living things surfaced in his Eclaircissements of 1710, but he continued to address them in his later writings.
114 Hartsoeker, Eclaircissements, 113-114.
115 Hartsoeker, Eclaircissements, 114: “On ne dira pas qu’ils le tirent du mouvement du Sang, & que ce Sang tire le sien de la compression du Coeur & de tous les vaisseaux de notre corps; car c’est revenir à la premiere difficulté . . .”
116 Hartsoeker, Eclaircissements, 116: “Tout cela se fait à l’inscû de cette Ame, & bien souvent contre sa volonté, & cela m’est un nouvel argument . . .”
Matters of the Heart and the Soul: Harvey, Descartes, Craanen and Hartsoeker

This organ deserves to be styled the starting point of life and the sun of our microcosm just as much as the sun deserves to be styled the heart of the world. For it is because of the heart’s vigorous beat that the blood is moved, perfected, activated, and protected from injury and coagulation. The heart is the tutelary deity of the body, the basis of life, the source of all things, carrying out its function of nourishing, warming, and activating the body as a whole.

Thus wrote William Harvey in his *Circulation of the Blood and Other Writings*, popularly known as *De Motu Cordis*. In many respects, Descartes was impressed with Harvey’s discovery of the circulation of the blood. He even believed Harvey’s theory could support his new philosophy, as articulated in the *Discours de la Méthode* (1637). Descartes had conducted anatomical dissections which reinforced Harvey’s systemic circulation. However, he disagreed with Harvey on the action of the heart. Harvey ascribed the pulsative faculty of the heart to vitalistic forces that ultimately originated from the soul. In Descartes’ philosophy, the soul had no extension and therefore no bodily, or material, existence. He, nevertheless, framed bodily actions as matter in motion and endeavored to explain them mechanically. Descartes rejected Harvey’s explanation of the cause of the heart’s motion for its speculative and mysterious character and gave an alternative interpretation of it. As he wrote in *La Description du Corps Humain*, “And if we suppose that the heart moves in the way that Harvey describes, we must . . . imagine some faculty that causes the movement; the nature [of this faculty] is much more difficult to conceive of than all that he purports to explain by it . . .” For Descartes, the diastole (rather than the systole) was when the heart was active. Descartes explained that, during the diastole, the drops of blood that entered the heart were “immediately rarefied and dilated by [its

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119 Descartes, *L’Homme*, AT XI, 243: “Or en supposant que le coeur se meut en la façon qu’Hervœus le décrit, non seulement il faut imaginer quelque faculté qui cause ce mouvement, la nature de laquelle est beaucoup plus difficile à concevoir, que tout ce qu’il pretend expliquer par elle; mais il faudroit sup- [p. 244] poser, outre cela, d’autres facultez qui changeassent les qualitez du sang, pendant qu’il est dans le coeur.”
This internal heat then made the chambers of the heart expand and propelled particles of blood into the arteries. Of these blood particles, the smallest and fastest ones “went on to become the animal spirits that flowed through the brain, nerves, and muscles conveying sensation and motion.” Descartes held that his explanation of the heart and its motions did not rely on occult or unknown faculties, but were grounded in empirical observation. Regardless of his partial approbation of Harvey’s theory, Descartes had to reject it in part “because it could be used as a weapon in his fight to become the new Philosopher.”

In a similar way to Harvey, perhaps, Hartsoeker’s enthusiasm about the extent to which Cartesian mechanism functioned productively in his own system of nature waned. He realized that Descartes never successfully accounted for the soul or any kind of vital spirit. This led him to reexamine Descartes’ system and formulate his opposition to the French philosopher’s doctrine in a deliberate way. Not mincing any words, he proclaimed in his treatise that he held neither Descartes’ metaphysics nor his physics in high esteem. His physics, based on extension and motion, sprung from “simple, intelligible, probable” mathematical principles, which did not originate “from the biases of the senses, but from the light of reason,” so much so that nothing could seemingly undermine them. Hartsoeker reckoned Descartes’ two principles “too fertile” for their own good, in that they could very easily give birth to any kind of chimera, or monstrous explanation.

Flummoxed by this realization, Hartsoeker retracted his earlier explanation of the motion of the heart that he had originally published in his Suite des Conjectures Physiques in 1708. In the Éclaircissemens of 1710, Hartsoeker cast his ideas in the form of a formal debate. He excerpted

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121 Wear, “Medicine in Early Modern Europe,” 339.
123 Hartsoeker, Éclaircissemens, 108.
124 Hartsoeker, Éclaircissemens, 109: “Ils sont si feconds . . . Mais ils sont si feconds qu’ils le sont trop, puis qu’ils servent à expliquer sans peine toutes les chimeres que jamais homme pourroit se mettre dans l’esprit.”
125 Hartsoeker, Éclaircissemens, 113.
“objections” from either an anonymous source or a known discussant, who customarily bristled at his ideas. Then, for each objection, Hartsoeker would offer a rebuttal. In this particular query, the unnamed correspondent wanted to know why Hartsoeker had criticized Descartes and his followers so mercilessly:

If Descartes was sometimes wrong in his Conjectures, for want of necessary experiments, he has at least paved the way for us to think properly in the matter of Physics. It is he who has banned from Philosophy the obscure and barbarian terms of the Ancients. It is he who has taught us to explain all effects of Nature by the one and only laws of Mechanics. After all, it is he who has taught us to make sense of the entire animal œconomy without recourse to the vegetative soul of the Ancients and a thousand other chimeras that they have imparted to us in their Works. He conceived of the human body just as an automaton replete with levers, pulleys, ropes, pipes, reservoirs, filters and other mechanical instruments, by means of which he has been able to explain all that takes place inside.  

In response to this criticism, Hartsoeker built his case against a mechanical – here, synonymous with a Cartesian – interpretation of animal œconomy in 1710. Without a doubt, Descartes was “one of the first Geometers of his time.” However, being an excellent geometer did not necessarily render Descartes an excellent philosopher. As Hartsoeker said elsewhere, Descartes “has not availed himself much of his Geometry in his [work on] Physics.” More crucially, he frogmarched Descartes for proposing a doctrine ridden with “vicious circles” [cercle vicienx] in logic. One such circle in Descartes’ philosophy stood at the heart of his method of doubt – “I think, therefore, I am.” Here Descartes’ logic presupposed his own existence in the act of thinking, for thinking is...
acting and no one can act without existing. Hartsoeker pointed out that the action of thinking was awkwardly and inappropriately synonymous with the substance itself in the dictum’s formulation. As Hartsoeker explained a bit further, “Descartes says that the human Soul needs innate ideas in order to think; but he muddles the ideas [themselves] with the ability to think, which itself is innate to the soul & is a gift from God: And that manifests itself in the perception of sensible qualities of which we have no innate ideas.” To illustrate the falseness of the belief in inborn ideas, Hartsoeker avowed that neither the deaf nor the blind have any preconceived, innate idea of sound or color, respectively.129

Hartsoeker was also deeply troubled by the arbitrariness and vagueness with which Descartes qualified the relation between thought, motion, and extension. First of all, Descartes “should have demonstrated that the Being that thinks is not corporeal, if he had demonstrated that there is nothing in Nature that is corporeal . . .”130 As Hartsoeker put it, the French philosopher had mixed up “the being that thinks with the thought that is the action of this being, in the same way that he confuses the being that is extended, and which could be the same as the one that thinks, with the extension that is the quality [attribut] of this being. That is to say that he muddles the substances with their actions and their qualities [attributs], by which we know the substances: & it is there that the source of his errors resides.”131 Moreover, the senses did not lie and Descartes was wrong to think so, Hartsoeker believed:

. . . for the senses are never wrong, since they always report to the soul things simply as they are without truth or falsity: And from the moment we dissociate ourselves a little from the

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129 Hartsoeker, Eclaircissements, 107: “L’Ame humaine, dit Descartes, a besoin d’idées innées pour penser; mais il confond les idées avec la faculté de penser, qui est innée à l’ame & un présent de Dieu: Et cela est manifeste dans la perception des qualitez sensibles dont nous n’avons aucune idée innée.”
130 Hartsoeker, Eclaircissements, 104: “Je conviens qu’il auroit démontré que l’Etre qui pense n’est pas corporel, s’il avoit démontré qu’il n’y a rien de corporel dans la Nature . . .”
131 Hartsoeker, Eclaircissements, 105: “Mais il confond ici l’être qui pense avec la pensée qui est l’action de cet être; comme il confond l’être qui est étendu, & qui pourroit être le même que celui qui pense, avec l’étendue qui est l’attribut de cet être, c’est-à-dire, qu’il confond les substances avec leurs actions & leurs attributs, par lesquels nous connaissons les substances: & c’est là la source de ses erreurs . . .”
senses, we fall into the land of conjectures. Even the axioms of Geometers are verified only through the senses; & it is also for this reason that there are never any disputes about this, or about anything that is built on such a solid foundation. The senses were given to us by God to serve as guides over the course of our lives, & to teach us that we either have to flee or pursue [fuir ou poursuivre]: They are like messengers who give to the soul an account of everything that is happening outside of her, because they receive impressions of objects that are outside of us and they transport them to the soul, which forms ideas about them & keeps them, as if in a reservoir from which to draw from when in need.  

Of course, Hartsoeker did not believe the soul was error-free. After all, “we are subject to be mistaken by the false judgment of the soul” when she ponders and weighs various ideas against each other. But Hartsoeker was not so kind when judging Descartes. Rather than pave the way for philosophy, Descartes the Iconoclast smashed everything in his way to advance his ideas. In Hartsoeker’s words, Descartes destroyed everything that deterred him and continued along “a thousand unknown paths, where he had to make a mess at every step, rather than turn around and go back to the place” from where he had started. Hartsoeker’s unforgiving rhetoric culminated in calling Cartesian ethereal substance and “fluted” particles “a pompous load of rubbish to cover up ignorance of magnificent proportions.”

The interpretation of the motion of the heart stood at the center of a deeper philosophical problem: plotting a complex living thing onto a mechanical model. The explanatory paradigm Hartsoeker was using in his 1708 treatise changed under pressure of his changing Cartesianism,

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132 Hartsoeker, *Eclaircissemens*, 106: “... car les sense ne nous trompent jamais, puis qu’ils raportent toujous à l’ame les choses simplement sans verité ou sans fausseté: Et dès que nous nous éloignons un peu des sens, nous tombons dans le pais des conjectures. Les axiomes mêmes des Geometres ne se verifient que par les sens; & c’est aussi par cette raison qu’il n’y a jamais de disputes là-dessus, ni sur tout ce qui est bâti sur un fondement si solide. Les sense nous ont été donné de Dieu pour nous servir de guides pendant notre vie, & pour nous apprendre ce que nous devons ou fuir ou poursuivre: Ils sont comme des messagers pour rendre compte à l’ame de tout ce qui se passe hors d’elle, car ils reçoivent les impressions des objets qui sont hors de nous & les transportent à l’ame, qui s’en forme des idées & les garde comme dans un reservoir pour s’en servir dans le besoin.”

133 Hartsoeker, *Eclaircissemens*, 106: “... nous sommes sujets à nous tromper par le faux jugement que l’ame s’en peut faire.”

134 Hartsoeker, *Eclaircissemens*, 110: “Mais Descartes a mieux aimé rompre tout ce qui l’arrêtoit, & se detourner du veritable chemin, pour aller par mille toutes inconnus, où il devoit broncher à chaque pas, que de retourner d’où il étoit parti.”

135 Hartsoeker, *Eclaircissemens*, 111: “... sa matiere étherée, ses parties canelées, ... ne sont qu’un pompous galimatias pour couvrir une glorieuse ignorance.”
which he had begun to reexamine and qualify in more nuanced ways. Only two years before, Hartsoeker claimed in his *Suite des conjectures physiques* that “Ultimately, it is God himself who runs the Universe, where we are but little marionettes that move in a thousand different ways by means of an infinity of hidden springs, for the sake of the rightful enjoyment *[le bon plaisir]* of the one who makes them act.” He even went as far as to conclude that “these little machines” were “the cause and the principle of all [their] movements.” Hartsoeker’s ideas sound like a problematic marriage between dogmatic mechanism and divine providence that was bound to run aground. Essentially, he posited animal and human organisms that, like puppets or automata, were manipulated by God and had no will of their own. In two years’ time, he reframed his thesis, and he did so by rejecting Descartes’ soulless animal automata and, among other things, a mechanized interpretation of the workings of the heart. From Craanen Hartsoeker had learnt that the heart and the vessels that surrounded it moved as part of an intricate mechanism of pipes and springs that pushed and pulled on each other, moved the heart, and thus made blood flow. The German Cartesian from Cologne “compared the human body to a clock, whose wheels [were] analogous to the organs of the human body and weights to its blood and animal spirits.” However, a mechanical answer only delegated the causal question further down to what fundamentally and actually was responsible for these continuous motions. “One must therefore look for a cause of this continuous motion, which may come from outside and could be foreign,” Hartsoeker reasoned. The origin of the tension and the force that kept a system of springs in motion sat at the center of the problem with a mechanical interpretation of the heart and other organs. Here is how Hartsoeker explained this conundrum:

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136 Hartsoeker, *Suite des Conjectures Physiques* (Amsterdam: Henri Desbordes, 1708), 95: “Enfin c’est Dieu lui-même qui conduit l’Univers, où nous sommes comme ces petites marionnettes qui se remuent en mille manières différentes par une infinité de ressorts cachez, selon le bon plaisir de celui qui les fait agir.”

137 Hartsoeker, *Suite des Conjectures Physiques*, 95-96: “Accordez pour un moment la raison à ces petites machines, elles ne seront point de difficulté d’assurer, [p. 96:] qu’elles sont elles-mêmes la cause & le principe de tous ces mouvemens.”


139 Hartsoeker, *Eclairissements*, 113.
But to stretch a body [made] of springs one would need a certain force, & I do not see from where the fluid parts could have acquired it in order to thus stretch the Heart & all the other vessels of our machine. They could not have acquired it from these vessels, because one would suppose that they themselves had given it to the solid parts in stretching them; & consequently these two forces, which cancel each other out, have to be counted for nothing.

Therefore, one has to look for a cause of this continuous motion, which seems to originate from outside & appears to be foreign [comme étranger].

And since the laws of mechanics ruled out a perpetuum mobile system of pipes and pulleys in reality, the answer had to lie elsewhere. Here Hartsoeker ventured a conjecture that the cause of continuous mechanical motion had to come from outside or, rather, from an alien source. In his case, the source of continuous motion in the body was “a Soul, whatever she may be, maybe a portion of my first Element,” which resided in the cerebellum, and from there pushed “the vital spirits to all parts of our body, so that they may perform all the functions for which they are intended.” As soon as blood entered the heart, the soul would send the necessary vital spirits to compress the heart and keep it beating. That same soul was responsible for all kinds of mechanical movements that kept bodily organs functioning “without our participation, that is, without the participation of the Soul.”

Hartsoeker posited two types of souls: the vegetative and the reasonable soul. Of course, the vegetative soul, which occupied itself with vital spirits and involuntary motions, was yoked to the reasonable soul, which, in turn, had its seat in the large brain and “perceive[d], judge[d] & reason[ed] with innate faculty.” At the same time, these souls were not omniscient or perfect; over time, they

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140 Hartsoeker, Eclaircissemens, 113: “Mais pour un corps à ressort il faut une certaine force, & je ne vois pas d’où les parties fluides pourroient l’avoir aquise, pour bander ainsi le Coeur & tous les autres vaisseaux de notre machine. Elles ne l’ont pas aquise de ces vaisseaux, parce qu’on supose qu’elles l’ont donnée elles-mêmes à ces parties solides en les bandant; & ainsi ces deux forces s’effaçant l’une l’autre, doivent être comptées pour rien.

Il faut donc chercher une cause de ce mouvement continu, qui vienne de dehors & qui soit comme étrangère.”

141 Hartsoeker, Eclaircissemens, 114: “Il faut donc avoir recours à quelque cause étrangère, c’est-à-dire à une Ame quelle qu’elle soit, peut-être une portion de mon premier Element, qui, résidant dans le cervelet jusqu’à ce qu’elle s’en retire pour être absorbée de la grande ame du Monde, pousse de là les esprits vitaux vers toutes les parties de notre corps, afin qu’elles puissent faire les fonctions à quoi elles sont destinées. [. . .] Cette Ame fait toutes les fonctions, qu’on apelle vitales, sans notre participation, c’est-à-dire sans la participation de l’Ame . . .”
became more proficient at executing various bodily functions that are necessary for existence. In this respect, Hartsoeker adhered to Locke’s (and Heereboord’s\textsuperscript{142}) notion that human beings were born with a \textit{tabula rasa}, that is, devoid of innate ideas. He, nonetheless, admitted an innate ability for learning and cognition.\textsuperscript{143} The connection between the two kinds of soul was compromised only when the vegetative soul sent too few or too many vital spirits to the organs to complete their necessary functions. This happened when the reasonable soul was agitated by the passions, Hartsoeker explained.\textsuperscript{144} For example, sadness or fear negatively impacted on the physical processes of bodily organs. Proper digestion or the peristaltic movements of the intestines instantaneously grew weaker as a result of anxiety or stress. Yet these critical effects were out of our hands: “And as this [vegetative] Soul does all these things without our participation, we are not masters of remedying such disorders, at least not in the beginning, when she only receives the message from the reasonable Soul who then proceeds to reassure her through her reasoning, &c.”\textsuperscript{145} Even though Hartsoeker specified this link between the two souls, he seemed vague on the extent to which the two interacted and the extent to which a human being had control over his or her body. In this passage, the reasonable soul also indicated the conscious soul (or conscious nature) through which we could assert our will and reason. The reasonable soul made sense of basic instincts, controlled the passions, and ultimately asserted her will “like a king from his throne.”\textsuperscript{146} In his analysis, he extended the vegetative soul to all living creatures, plants as well as animals, believing it “equally

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\textsuperscript{143} Hartsoeker, \textit{Seconde Partie de la Suite des Conjectures Physiques}, 132-133 : « Quand nous venons de naître, l'Ame quelle qu'elle soit, n'est que comme ce qu'on appelle tabula rasa, vide de tous caractères, sans idées & sans connaissances, de sorte qu'en cet état nous ne différerons pas beaucoup [p. 133 ] des vegetaux, si ce n'est que nous avons en nous-mêmes certaines capacitez, facultez, ou puissances qui sont nées avec nous, & dont nous avons besoin pour la conduite de nôtre vie. »

\textsuperscript{144} Hartsoeker, \textit{Eclairissemens}, 114: “. . . l'Ame, qui, ayant son siege dans le grand cerveau, y aperçoit, juge & raisonne par une faculté qui lui est innée . . .”

\textsuperscript{145} Hartsoeker, \textit{Eclairissemens}, 115: “Et comme cette Ame fait toutes ces choses sans nôtre participation, nous ne sommes pas les maîtres de remedier à ces désordres, du moins dans le commencement, & lors qu'elle ne fait que recevoir l'avertissement de l'Ame raisonnable, qui dans la suite la peut rassurer par son raisonnement, &c.”

\textsuperscript{146} Hartsoeker, \textit{Extrait critique}, 45: “J’avois appris de M. Cranen que l’ame avoit son siege dans la glande pineale, d’où elle donnoit ses ordres comme un Roi de son throne . . .”
absurd to want to explain the vegetation of plants only through mechanical laws as to explain the animal economy by these laws.” 147 In anticipation of criticism, Hartsoeker explained why he accounted for two souls, instead of just one. One soul—the reasonable soul—would simply have too much work juggling the exercise of reason and judgment as well as the physiological needs of internal organs. Instead, he proposed, the reasonable soul whose tasks were “more noble and refined” delegated other, lesser duties to the vegetative soul in the same way that “a master makes use of a servant.” 148

To be fair, Craanen did not eschew the matter of the soul. However, he saw the matter in a straightforward light, as the following casual statement on the soul from his Tractatus suggests: “The soul is one and only and simple, and it consists of mere thought, which Descartes has proven throughout his philosophy.” 149 Craanen, like other Cartesians, believed the seat of the soul to be in the pineal gland. 150 However, Hartsoeker’s indignant response to Craanen’s ‘pure mechanism’ can be understood as not necessarily overstated but rather justified, if we consider the statement that directly followed Craanen’s terse remark on the soul. In a passage even more surprising for its forceful mechanical argument in the chapter on the heart, Craanen boldly set out the following:

And therefore we conclude with Descartes that our body is a machine . . . where all functions . . . are executed only mechanically, and not by means of a combination of a thinking soul, which altogether has not granted anything to our life; our body, clearly [in] the likeness of clocks and Automatons, produces actions which are not animal-like. 151

147 Hartsoeker, Eclaircissements, 115: “Cette Ame agit dans toutes les créatures vivantes, c’est-à-dire dans les plantes aussi bien que dans les animaux; car il me paraît aussi absurde de vouloir expliquer la vegetation des plantes par les seules loix mechaniques, que d’expliquer par ces loix l’oeconomie animale.”
148 Hartsoeker, Eclaircissements, 115: “Son emploi est bien plus noble & plus relevé, & elle se sert peut-être de l’autre comme un maître se sert d’un domestique.”
149 Theodoor Craanen, Tractatus Physico-Medicus de Homine, in quo status ejus tam naturalis, quam præternaturalis, quoad Theoriam rationalem mechanice demonstratur, ed. Theodoor Schoon (Leiden: Peter van der Aa, 1689), 141: “Anima unica & simplex est, & consistit in merâ cogitatione, quod passim Cartesius probavit in sua philosophiâ.”
150 Theodoor Craanen, Oeconomia animalis ad Circulationem Sanguinis Breviter Delineata (Gouda: Willem van der Hoeve, 1685), 156, for example: “Concludimus igitur solam Glandulam Pinealem esse immediatam sedem animae . . .”
151 Craanen, Tractatus, 141: “Et concludimus igitur cum Cartesio, corpus nostrum esse machinam quandam, ubi omnes functiones (corpori intellige & proprie ad vitam spectantes) mechanice tantum peraguntur, & non concursu animae cogitatis, quae ad vitam nostram nihil omnino tribuit; & plane horologii & Automatorum instar, edit corpus nostrum suas actiones, quae animales non sunt.”
Now, it seems that the two aforementioned lines of thought by Craanen contradict each other. While with the former he argued that each body had a soul that was thought, he opined with the latter that a thinking soul had nothing to do with bodily actions. Those two preceeding quotations make sense, however, if we remember Craanen’s staunch adherence to the Cartesian body-soul dichotomy and his consequent rejection of a physical link between the body and the soul.

To Hartsoeker, the connection between the body and the soul grew in importance, as he digested critical literature that grappled with the legacy of Descartes’ mechanism and as he observed mounting number of phenomena whose complexity outgrew their mechanistic interpretations.

Although Hartsoeker kept questions of anatomy, physiology and the mental faculties at bay in his earlier treatises, he addressed them in subsequent works on physics. In his Éclaircissements, he clarified and revisited his earlier ideas. He “condemn[ed]” as well as corrected his earlier mechanical interpretations, in particular those of the workings of the heart. If this treatise were considered against his whole bibliography, it would be safe to say that the work contains some of Hartsoeker’s most forceful and extensive criticisms of Descartes’ philosophy: a public, intellectual awakening at age 54. He confessed his fury against Cartesian philosophy (and Cartesian followers, specifically, Craanen, De Raey and De Volder, whom he singled out): “... as much as I liked [Cartesian philosophy] before—primarily when I had just left the Colleges of the most extreme Cartesians who had ever lived—it now displeases me just as greatly.”

How then could one account for free will and the soul’s independence? Even more basically, how did one begin to explain the basic intelligent behavior of animals? As Hartsoeker asked his reader, “Could one explain these facts without ascribing to these animals a soul that

152 Hartsoeker, Éclaircissements, 113: “Je condamne même l’explication que j’ai donnée sur ce fondement, dans la Suite des mes Conjectures, du mouvement du Coeur; car si ce mouvement se fairoit ainsi que je l’ai expliqué à la pag. 29. de ce Traité, comment pourroit-on expliquer après cela le mouvement peristaltique de tous les autres vaisseaux de nôtre Corps, qui semble partir d’un même principe?”
153 Hartsoeker, Éclaircissements, 113: “... & autant que cela me plût autrefois, principalement quand je ne venois que de quitter les Colleges des plus outrez Cartesiens qui furent jamais, autant cela me déplait-il à présent.”
reflects on its own actions, remembers the past, foresees the future, draws analogies between ideas & draws inferences from them?”154 To Hartsoeker, the soul was as much tied to a body’s mental faculties ensuring its survival as to the internal organization, or ‘animal œconomy,’ of its physical structures. In Hartsoeker’s eyes, Descartes had tried and ultimately failed to describe “the entire animal œconomy” with mechanical laws in his Tractatus de homine.155 In explaining physiological processes, Hartsoeker distinguished between a vegetative and a reasonable soul. Each living creature had one of each. The vegetative soul controlled the involuntary motions and vital operations, such as the beating of the heart, circulation of the blood, or peristaltic movements of the intestines. Meanwhile, the reasonable soul gave orders to the vegetative soul and controlled voluntary movement. The functions of the reasonable soul could greatly influence the vegetative soul, especially if the passions had been agitated or, conversely, mollified. If the reasonable soul experienced fear, the heart would palpitate and so influence the state of the body. Through the exercise of reason and will, however, the reasonable soul could reign in the actions of the vegetative soul in the body.156 Hartsoeker elevated the reasonable above the vegetative soul and, in this way, addressed the problem of free will and the role of reason in a mechanical view of the body.

A final vocal—but later also critical—proponent of the Cartesian doctrine and Hartsoeker’s teacher was Burchard de Volder (1643-1709). Also a product of the Amsterdam Athenaeum Illustre, De Volder studied philosophy and mathematical sciences with Arnold Senguerdius and Alexander de Bie in 1657. In 1659, he enrolled at the University of Utrecht, where he received degrees of Master of Arts and Doctor of Philosophy in one year. But he did not stop there. De

154 Hartsoeker, Eclaircissemens, 112: “Peut-on expliquer ces faits sans accorder à ces animaux une ame qui reflechit sur ses actions, qui se souvient du passé, qui prévoit l’avenir, qui compare ses idées & en tire des conclusions? In this case, “ces animaux” whom Hartsoeker is referring to are dogs, but earlier in the passages he had also mentioned beavers, roosters, bees, ants, spiders and flies.

155 Hartsoeker, Eclaircissemens, 112-113: “Pour ce qui est de son Traité de l’homme, où il a tâché d’expliquer toute l’oeconomie animale par les seules loix Méchaniques, [p. 113:] tout le monde convient à présent qu’il la fait de la manière du monde la plus pitoiable . . .”

156 Hartsoeker, Eclaircissemens, 114-116.
Volder then studied medicine with Sylvius at Leiden University and in 1664 defended a doctoral thesis in medicine. After his studies, he worked as a physician in Amsterdam for a stint of six years, only to return to Leiden to teach philosophy in 1670.\textsuperscript{157} Almost as soon as he arrived in the city of Rembrandt’s youth, De Volder asked the Curators of the university for permission to lecture on physics (teaching \textit{Institutiones logicæ} twice a week and the \textit{Institutiones physicae} twice a week). Inspired by a visit to the Royal Society of London, De Volder hoped to transpose its model of experimental demonstrations.\textsuperscript{158} When he came back from England in 1674, he petitioned the Curators for permission to teach a course in experimental physics. In a newly furnished auditorium—the \textit{Theatrum Physicum}—De Volder and Senguerdius alternated conducting experimental demonstrations that became part of student training in philosophy. No doubt, Hartsoeker attended De Volder’s demonstrations in experimental at Leiden University from 1675.\textsuperscript{159} During these experimental lectures, De Volder frequently criticized Descartes and referred to Boyle’s natural philosophy as well as reproduced his canonical experiments with the air pump.

The trajectory of De Volder’s natural philosophical thought is hard to pin down. While some scholars, such as Jonathan Israel, argue enthusiastically that De Volder put much emphasis on experiment and was famed for his “attachment to experiment and scientific empiricism,”\textsuperscript{160} others are a bit more cautious. Ruestow, for example, reminds that while De Volder was “a pioneer in introducing experimental physics at Leiden,” he “still emphasized the ideal of a rationalist basis for

\textsuperscript{158} Wiesenfeldt, “VOLDER, Burchard de,” 1042.
What he most admired and adhered to in Descartes’ philosophy was the strength of its metaphysical arguments. In his manuscript lecture notes on natural philosophy, entitled the *Dictata*, De Volder defined physics as opening the door for medicine: “It is generally held that Medicine is a certain part Physics*, and for that reason a certain part Philosophy . . ., so we can deduce certain and evident consequences from the first principles themselves (in other words, *where the Physicist ends, there the Physician begins)*.” From the start, De Volder deliberately anchored the fundaments of the study of medicine in the domain of natural philosophy. Surely his sentiment was not novel and was even mirrored in the (aforementioned) institutional subordination of medicine to philosophy and its frequently challenged disciplinary status within the university, whenever it encroached on metaphysical matters. Significantly, De Volder identified himself first and foremost as a natural philosopher, even though he was a university-trained physician with considerable years of medical practice under his belt.

Like Craanen and the other Cartesians, De Volder believed in the primacy of the intellect in attaining clear and distinct ideas about the world. On the one hand, Descartes’ rational philosophy proved the idea of God with mathematical certainty, which could be used to combat atheism. On the other hand, he maintained—in the beginning, at least—that any real physical phenomena could be deduced from or boiled down to the two fundamental principles of Cartesian physics, which were extension and motion. “Because the ideas of extension and motion were perceived by the mind” clearly and distinctly, De Volder and other Cartesians believed that these principles ostensibly corresponded “to the true essentials of physical existence.” They “were the initial ‘clear and distinct

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163 Wiesenfeldt, “VOLDER, Burchard de,” 1042.
ideas’ from which a true, certain, and completely comprehensible science of nature could alone be built. Consequently, the demonstration of the validity of these principles was of paramount concern to the proponents of Cartesian physics at Leiden.”

As Ruestow argued elsewhere, “Descartes and his followers . . . had developed their imagery of invisible mechanisms in a quest for [clarity and understanding] that could rest only on foundations laid in the mind, isolated from the uncertainty and deceptiveness of the senses.” In a published collection of lectures, De Volder praised philosophy that was “founded on reason and carefully obtained experiments.”

Over the course of the 1680s, De Volder’s natural philosophical interests veered more and more into experimental and mathematical territory. He (in similar ways to Galileo) believed mathematics was the best tool for organizing, articulating and explaining physics in accordance with strict laws of mechanics. In some respects, De Volder equated Cartesian metaphysics with mathematics in that both started from the principle of clear and distinct ideas. In natural philosophy, however, reason was not enough and had to work in tandem with sensory perception in gaining knowledge about nature. There was no guarantee that even good reasoning would coincide with the perceived objects themselves and would be able to explain them completely.

Conclusion to PART III

Looking at instructors like Craanen, Cartesianism did not per se inspire a rigorous experimental approach to nature, as defined (and hoped for) by scholars like Ruestow or Luyendijck-Elshout. However, in this particular context Cartesian philosophy produced nonetheless a different approach to examining nature and introduced a different kind of empiricism. Craanen

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164 Ruestow, Physics in seventeenth and eighteenth-century Leiden, 94.
165 Ruestow, Microscope, 67-68.
168 Burchard de Volder, Oratio de rationibus viribus et usu in scientiis (Leiden, 1698).
and his Cartesian ilk were neither anomalies in Leiden’s history of scientific instruction nor, worse yet, “waiting room” denizens who stumbled and staggered between two historical greats, Sylvius and Boerhaave. In fact, it seems to me that these Cartesian medical philosophers prepared the scene for viewing the body not only as a laboratory (as in the case of Sylvius and his Iatrochemical school) nor simply as a machine (Descartes), but as a little bit of both – a hydraulic machine (Boerhaave) – or as a machine that was ensouled (Hartsoeker).

Over time, Hartsoeker came to embrace certain arguments made by the critics of Cartesianism at Leiden. This seems to highlight the inevitable explanatory pitfalls of Cartesianism in a world that was still preoccupied with explaining the causes and not merely the effects of natural phenomena. What ultimately troubled Hartsoeker was the subtle slippery slope of a system that could be explained by Descartes’ matter in motion, but, crucially, sidestepped the matter of free will and the soul. To our modern eyes, Hartsoeker’s and his contemporaries’ conundrum is, of course, one with an ancient history and one that remains fundamental. Its development continues into our present day, as we reevaluate our ideas of where the boundaries of a living being’s neural machinery stops and free-willed decision-making begins.169 How, indeed, do we explain the complex interactions between the hardware of the body and the less localizable and less material processes of the mind?

When we consider Hartsoeker’s arguments as a whole, we see him recoiling to a more traditionalist, perhaps a neo-scholastic, philosophical stance. He especially shared Craanen’s tendency to make philosophical pronouncements, many of which he could never conclusively prove, as in the case of the souls. He grew disillusioned with a Cartesian explanans that, when pushed to its logical conclusion, collapsed on itself, and, in some cases, ended up dwarfed by its explananda. At the same time, the instruction sympathetic to the Cartesian philosophy that he received instilled in

him a certain methodology for thinking about nature. He, like Craanen, De Raey and De Volder, placed high importance on the power of reason to reveal natural truths. And he, as they, ultimately grew disillusioned with the extent to which human reason and the senses could glean answers to natural causes.

Significantly, Hartsoeker was seen by his contemporaries as trying to solve the limitations of Cartesian mechanism. Citing Hartsoeker’s *Principes de Physique*, Pierre Bayle opined in his *Dictionaire historique et critique* that Hartsoeker was “a good Physicist and good Mathematician,” who positioned himself “mid-way between Descartes and the new Proponents [Sectateurs] of the void.”

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Chapter 4

Réaumur’s Crayfish Experiments in Hartsoeker’s *Système*: Regeneration and the Limits of Mechanism

“Il paroît en général que les plus admirables de tous les animaux, quant au mécanisme, ce sont ceux qui nous ressemblent le moins.”

– Fontenelle, *HARS* 1712, p. 37

Introduction

Early modern naturalists believed they could capture and master the world’s universal truths by collecting and describing its particulars in works of encyclopedic breadth.1 Every animate and inanimate specimen reflected nature’s bounty, endless variety and occasional blunders; and also served as a building block in an increasingly systemic enterprise to understand nature as a whole. From lavishing attention on the most minute and mundane particulars, one would arrive at higher universal truths about nature and man’s place in it. The scope of doing natural history was all-encompassing and the meticulousness with which naturalists pursued it was all-consuming. The following passage from Olaus Magnus’ *Historia de gentibus septentrionalibus* (*Description of the Northern Peoples*), first published in 1555, illustrates this point: “. . . nothing has driven me to this immensely tangled work, or more correctly, this dizzying labyrinth, apart from my love and sympathy for those who since the beginning of the world have anxiously yearned for knowledge and strive each day to learn what more might be expected . . .”2

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Archbishop of Uppsala Olaus Magnus (1490-1558) steered his reader through the “dizzying labyrinth” of knowledge and images he had cobbled together about northern European people and places. In his *magnum opus* that counts more than 800 pages, Olaus not only wrote about the peoples who inhabited and navigated such cold, unchartered territories, but he also documented fantastical creatures and wonders of nature. In a book section on sea monsters, he depicted a giant crayfish attacking a mariner and yanking him off his ship with one of its pincers (FIG. 6).

![Image of a giant crayfish attacking a mariner](image)

**FIG. 6.** Olaus Magnus, *Historia de gentibus septentrionalibus* (Antwerp, 1562), Book XXI, chapter 21, p. 185. The first edition was printed in Rome in 1555.

The image, however, belies easy and direct correspondence to the text it accompanies. For one, Olaus identified this ship-destroying leviathan as *polypus* (a many-footed creature) rather than *astacus*.

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footnotes for direct quotations from Olaus Magnus’ *Historia*, I first cite the accepted translation by Peter Fisher and Humphrey Higgens, followed by the 1555 original Latin version.

3 Indeed, the editors and translators of Olaus Magnus’ *Historia de Gentibus Septentrionalibus* argue that, while Magnus described human and animal activity of northern Europe in great detail, “[h]is enthusiastic curiosity sometimes leads him to include creatures which do not exist in the North, and some indeed which have never existed anywhere.” See Olaus Magnus, introduction, xli.

4 The translators of Olaus Magnus’ *Historia de Gentibus Septentrionalibus* interpreted *polypus* as octopus. See, Olaus Magnus, *Historia de Gentibus Septentrionalibus, Rome 1555; Description of the Northern Peoples, Rome 1555*, vol. III, 1118. Polypus is one of the possible terms used to describe certain subspecies or kinds of octopus. See OECD, *Multilingual Dictionary of Fish*.
or *cambarus* (lobster or crayfish), as Aristotle, Gesner, and others had done. Some animals were thought to be only native to northern Europe and therefore to lack any equivalent Greek or Latin names. Olaus Magnus waived off the problem of pinning the correct classification and nomenclature on the more elusive animals he discussed: “The northern lakes and streams contain so many species of fish, distinct from others in appearance, kind, and number, that it would be pleasanter to enjoy their taste than argue about their exact names.” Despite his own vague notions of taxonomic difference among species, Olaus provided his reader with vivid descriptions and references to supposedly similar creatures discussed in ancient texts. On the one hand, Olaus’ *Historia* was situated within the broader context of ancient and humanist traditions of describing people and places. On the other hand, it also grew out of the tradition of *mirabilia* or wonders; and its vivid portrayal of animals, monsters and marvels spoke directly to the work of later naturalists. Additionally, Olaus hoped the variety—and at times exotic nature—of his subject matter and the diversity of illustrations would mitigate the readers’ boredom. Swiss naturalist Conrad Gesner remained skeptical about some of Olaus’ pictures. Still, Gesner and Ulisse Aldrovandi reproduced, in somewhat less elaborate fashion than Olaus, a superhuman-sized crayfish attacking a swimmer in their respective, massive *Historiae animalium* (FIG. 7 & 8).


5 In the fourth book of *History of Animals*, Aristotle subsumed the crayfish under the generic name of *Astacus* (Gr. ἄσταχος or ὄσταχος), a term he also used for lobsters. Sixteenth-century naturalist Conrad Gesner followed Aristotle’s terminology in describing the crayfish. See moreover, Francois Hobart Herrick, *The American Lobster: A Study of Its Habits and Developments* (Washington, 1895), 6-7.


7 Introduction to *Olaus Magnus, Historia de Gentibus Septentrionalibus, Rome 1555; Description of the Northern Peoples, Rome 1555*, vol. I, xxxvii.


9 Olaus Magnus, Book XX, chapter 22, *Historia de Gentibus Septentrionalibus, Rome 1555; Description of the Northern Peoples, Rome 1555*, vol. III, 1184. Latin original from 1555, 802: “. . . quod etiam in hoc volumine, qualunque sit, si nihil aliud efficiet, saltem varietate sua, atque picturam diversitate fastidium legentium reprehendiur moderare.”


FIG. 8. Aldrovandi, *Historia animalium...De crustacis, lib. II* (Bologna, 1606), pp. 124-125. At least the image on the left seems imported into Aldrovandi’s *Historia animalium* from Gesner’s and/or Olaus Magnus’ work.
All of these naturalists were engaged in two overlapping projects: the recovery of ancient Greek and Latin works on the history and medicinal uses of plants and animals, and the identification of modern species. In the late fifteenth and early sixteenth century, natural history occupied an uncircumscribed place among practices and even methods of learning. As Ogilvie has shown, natural history “entailed neither a clearly demarcated realm of phenomena nor a set of precepts and methods for study.” This, however, gradually changed over the course of the seventeenth century. By 1600, naturalists positioned themselves within a clearly defined community of like-minded practitioners who had mastered its techniques. More specifically still, efforts to represent what was seen as accurately and adequately as possible began taking precedence, as the discipline took shape over the course of the seventeenth century. Crucial to this was the development of a technical descriptive language that, to its champions, became paramount to pictorial representation. With this, naturalists aimed less at regaling the reader with delightful, fictitious and whimsical details and more at conveying a sober, matter-of-fact narrative.

With the publication of Francis Bacon’s *Novum Organum* in 1620, natural historical description assumed new valences in both its purpose and exposition. In the *Parasceve ad historiam naturalem et experimentalem* published as an appendix to the first two books of the *Novum Organum*, Bacon sharply contrasted his own forray into natural history with those of Gesner, Aldrovandi, Dodoens and other naturalists. His project was different from those extant natural histories that “serve the pleasure of the reader [or] the immediate advantage which can be got from reports.” Rather, Bacon argued, natural histories “must find and build a store of things sufficiently large and

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11 Ibid., 1.
12 Ibid., 4.
13 Ibid., 5.
14 Ibid., 6.
varied to formulate true axioms.” Nonetheless, Bacon seemed wary of the genre of natural history. He warned his reader on more than one occasion to stray from natural histories that indulged “in numerous descriptions and pictures of species and in minute varieties of the same things. Such petty variations are nothing more than nature’s fun and game [. . .] They offer a kind of ramble through the things themselves which is attractive and delightful, but give little information for the sciences, and what they do give is more or less superfluous.” In Bacon’s opinion, natural history was not about collecting indigested particulars and producing endless speculations. His brand of natural history was put in the service of natural philosophy. A fruitful natural historical program would yield practical results, based on “a proper combination of physics and mathematics.” Lord Verulam, of course, died before completing his philosophical program which aimed to collect facts and draw philosophical axioms from them. Perhaps not entirely as Bacon imagined, one of nature’s small and seemingly insignificant particulars, the crayfish, took center stage and indeed helped a new philosophy emerge.

Following a trajectory of surprising twists and turns, the crayfish was taken up by yet another group of natural philosophers: René-Antoine Ferchault de Réaumur (1683-1757) and Nicolas Hartsoeker (1656-1727). This curious creature—at once, an imagined monstrous leviathan that sank ships and swallowed sailors; at other times, a harmless, quaint river rat that figured in the kitchen

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and the medicine cabinet—and its extraordinary regenerative abilities helped natural philosophers challenge ideas about animal soul.

**Growing Doubt: 1712 Crayfish Regeneration**

It was in 1712 that René-Antoine Ferchault de Réaumur\(^{18}\) shocked the scientific community with the findings of his crayfish experiments. Réaumur’s extensive observations confirmed spontaneous regeneration of amputated crayfish claws. According to the report, when Réaumur severed the leg of a crayfish at the joint, the leg grew back (FIG. 9).\(^{19}\)

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While Réaumur was not the first to report about regenerative capacities of crayfish, his lengthy observations built on those of Jean-Baptiste Du Tertre (1610-1687) and circulated more widely.20 Du Tertre had written about regeneration in crabs in his travelogue on the Antilles, which was published first in 1654, but did not receive much attention until Réaumur revived the topic. This experimental news from Paris transformed Nicolaas Hartsoeker’s system-building. He professed to have converted his philosophical beliefs after his patron, Johann Wilhelm II of the Palatinate in Düsseldorf, told him of Réaumur’s experiments in 1712. Hartsoeker did not take Réaumur’s experiments at face value; he repeated the experiment on more than two hundred crayfish, always harvesting the same results as Réaumur. Time after time the crayfish would regrow their missing legs. In a 1722 article in the Bibliothèque ancienne et moderne, Hartsoeker corroborated Réaumur’s findings: “I deemed this experiment conclusive against those who claim that in the beginning God has created all plants, trees and animals that have already been and that will be in the centuries to come, as if he had encased them one in the other.”21 On the basis of this experiment, our Dutchman rejected the theory of encasement/preformation (emboîtement) and thus made room for his own formative principle. Before he laid out his new explanatory scheme, he considered two alternative scenarios to account for the crayfish trials that he quickly rejected: 1) that we live in a

20 Jean Baptiste Du Tertre, Histoire générale des isles des Christophe, de le Guelonpe, de la Martinique et autres dans l’Amerique, ou l’on verra l’establissement des Colonies Françoises, dans ces Isles; leurs guerres Civiles & Estrangeres, & tout ce qui se passe dans les voyages & retours des Indes (Paris: Jacques et Emmanvel Langlois, 1654), 377-378: “Ces animaux ont vne faculté qui ne doit estre ennuiée que des coupeurs de bourse, où de ceux que le Preuost tient desia au collet: C’est que si vous les prenez par vn mordan ou par vne parte, elles s’en deffont comme bon leur semble, les detachent de la joitunte, aussi proprement que si on les auoit coupez auec vn rasoir, vous les laissent dans la [p. 378:] main & se sauuent, & s’il en est besoin, elles les quittent toutes les vnes apres les autres. Iugez si semblables gens ne doiuent pas souhaiter vne chose qui leur seroit si necessaire. Si elles sont blessées à vn mordan ou à vne patte, elles extirpent promptement le membre & le mal tout ensemble, sans avoir besoin de l’assistance de quelqu’expert Chirurgien. Tous ces membres coupuez leur reuiennent au bout de l’an, ou au moins d’autres en leur place.”

21 Nicolas Hartsoeker, « Lettre de Mr. Hartsoeker à l’auteur de la Bibliothèque A. & M. sur les Serres, qui recroissent aux Ecrevisses, quand on les a rompues, sur la petitesse des Animaux qui quelques-uns supposent avoir été tous créez au commencement du Monde & sur les Natures, qui forment présentement les Corps Organizes, & qui y résident, » Bibliothèque ancienne et moderne 18 (1722): 195: « . . . je croyois cette experience décisive, contre ceux qui souiennent, que dans le commencement Dieu a créz toutes les plantes, tous les arbres, & tous les animaux, qui ont déjà été, & qui seront dans tous les siecles à venir, & qu’il les a comme emboitez les uns dans les autres. Mais comme j’apprens qu’il y en a, qui ont revoqué en doute cette experience, quoi qu’il n’y ait rien de plus vrai, & que je l’aye faite sur plus de deux cens Ecrevisses, avec toutes les précautions nécessaires ; . . . »
universe where God makes everything continually, “as if by his own hands,” and 2) that a universe is a great machine where everything moves according to a prime mover that God triggered in the very beginning, depending on “a mere mechanism.” In both alternatives mankind would be deprived of freedom and free will. Hartsoeker opted for a third explanation: an intelligent force or soul was responsible for the repair of the leg. He explained intelligences as “subordinate to God” but constantly at work in the production and conservation of living things.22

In what follows, I explore the role of the 1712 crayfish experiments in Hartsoeker’s construction of a workable system of natural philosophy. Significantly, Hartsoeker had begun his philosophical turn already 16 years before hearing of Réaumur’s crayfish findings. That is, since 1696, he had gradually begun reforming his Cartesian-inspired cosmology to include Neoplatonist ideas on the soul. I argue that the crayfish trials allowed Hartsoeker to further develop and assert his proposition that Intelligences mediated between inert matter and God. In so doing, I discuss the relationship between Hartsoeker’s Remonstrant milieu and several English philosophers, and suggest the ways in which his immediate family and intellectual circles influenced his ideas about free will and the soul. Crucial to this development were Hartsoeker’s intellectual debts to the Cambridge Neoplatonists Henry More and Ralph Cudworth. Their arguments for a metaphysics of physics persuaded Hartsoeker to begin modifying parts of his system. In a published article, Hartsoeker claimed that More’s arguments in his letters to Descartes convinced him to begin looking outside the Cartesian framework for answers. Meanwhile, Cudworth’s idea of plastic natures, at least in part,

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22 Hartsoeker, « Lettre de Mr. Hartsoeker à l'Auteur de la Bibliothèque A. & M. sur les Serres, » 200-201: “Mais si ce système étoit faux, dira-t-on, ne seroit-on pas obligé de soutenir, que Dieu fait continuellement, & sans cesse, tout lui-même, comme par ses propres mains, ou que le Monde n’est qu’une grande machine, qui ne va que par un premier [p. 201:] mouvement, que Dieu lui a imprimé, au commencement, & qu’ainsi rien ne s’y fait que par un pur mechanisme? Mais dans l’un, & dans l’autre cas, je serois privé de cette grande liberté, que j’appereçois avec toute l’evidence possible, en moi-même, & rien ne se feroit que par necessité, ce qui paroit être de la derniere absurdité.

Il ne reste donc qu’a dire, qu’il y a des Intelligences, qui sont subalternes à Dieu, qui est infini, éternel, tout-puissant & Pere de tout; ou qui sont subalternes à d’autres Intelligences, qui sont elles-mêmes subalternes à Dieu; & que ces Intelligences inferieures & du plus bas ordres travaillent, continuellement & sans cesse, à la production & à la conservations des plantes, des arbres & des animaux, selon le pouvoir, qu’elles ont reçu pour cela.”
inspired Hartsoeker’s “organizational” first element that imbued matter particles with motion in his revised system of physics. This chapter aims to elucidate the philosophical traditions, within which Hartsoeker was developing his cosmology. It is also an example of the reception of Cambridge Platonism in continental Europe and the challenges to free will that cosmologies, like Descartes’, continued to pose.

Hartsoeker applied his interpretation of the crayfish trials to general natural phenomena, such as regenerative faculties and survival instincts in humans and animals. These hitherto remained without a causal explanation. For instance, it was the Intelligence residing in Hartsoeker’s body that was responsible for healing him when he had cut himself: “It is only the Intelligence that lives in my body that cures me by repairing the cut veins . . .” What, if not an Intelligence at work, gives an infant the instinct to suckle at its mother’s breast? What, if not an Intelligence, induces a baby spider to spin a web to catch flies? He not only explained the basic instincts of preservation in this manner, but motion, too. The intelligent force that resided in a body governed it and “impart[ed] it with or deprive[d] it of movement.”

Before the crayfish experiment, Hartsoeker had believed that preexistent germs, absorbed into the body with air or food, nourished, replenished and developed the body from within. Réaumur’s crayfish experiment saw him rejecting “so absurd and bizarre a thought.” Hartsoeker

23 Hartsoeker, « Lettre de Mr. Hartsoeker à l’Auteur de la Bibliothèque A. & M. sur les Serres, » 202: “Mais c’est l’Intelligence, qui habite mon corps, qui seule me guérit, en rejoignant les vaisseaux coupez, à quoi l’air & l’acreté des humeurs extravasées l’auroient empêché de réussir.”
24 Hartsoeker, « Lettre de Mr. Hartsoeker à l’Auteur de la Bibliothèque A. & M. sur les Serres, » 203: “Et en vérité, qui a appris à un enfant qui ne vient que de naître, de têter & de faire tout ce qui lui est nécessaire, pour conserver sa vie, si ce n’est une Intelligence qui habite son corps? Qui est-ce qui a appris à une Araignée, qui ne vient que de sortir de son œuf, à faire une toile pour prendre des mouches, si ce n’est une Intelligence, qui se trouve dans le corps de cet animal?”
25 Hartsoeker, « Lettre de Mr. Hartsoeker à l’Auteur de la Bibliothèque A. & M. sur les Serres, » 204-205: “Mais quoi qu’il en soit, je suis du moins très-assuré qu’il y en a une qui habite mon corps, qui le gouverne, & qui peut, selon son bon plaisir, non seulement donner du mouvement à ce corps ou l’en priver, mais aussi aux corps qui l’environnent, & par conséquent augmenter, ou diminuer à chaque instant, le [p. 205:] quantité de mouvement, qui se trouve dans l’Univers.”
26 Nicolas Hartsoeker, “Remarques sur une These de Physique que Mr. Muller, Professeur en Philosophie &c. à Léipsic, a fait soutenir par Mr. Platner sur la Generation des Animaux, à l’occasion du septième Discours de la Suite de mes Conjectures Physiques, où je parle de cette generation,” Recueil de plusieurs pièces de physique (Utrecht: la Vueve de G. Broedelet & Fils Libraires, 1722), 193: “J’ai été d’opinion que ces animaux pouvaient venir de l’air que nous respirons,
discarded both Cartesian mechanism and the preexistence of germs as viable explanatory theories. Instead, he considered the possibility that “the mechanical formation of a single claw, or leg, is not less inconceivable, not less impossible,” than that of a complete animal. Hence, “it is no less absurd to think that God would make a new creation out of it. Thus we must by absolute necessity have recourse . . . to an intelligence . . . that dwells in this animal and repairs the loss, as soon as it happens.”

What corroborated Hartsoeker’s invention of an Intelligence was the crayfish’s own seemingly conscious role in the amputation. Réaumur explained that the fullest regeneration happened when the pincer was severed right above the fourth articulation, where the forelimb is slenderest. Another source adduces that crayfish bleed very freely; thus, casting off the limb or amputating it voluntarily at the narrowest point or upper joint would be the safest way to stave off a fatal hemorrhage. At times crayfish would lose one of their limbs during the seasonal moult, or shedding, of their carapace. The moult is a physically exhausting phenomenon: It requires violent efforts on the part of the crayfish to extricate itself from its old shell, all the while exposing a vulnerable, soft body that does not yet have a hardened exoskeleton to protect itself. The shedding process stretches over (usually three) days and can be fatal to the crayfish. Not infrequently, the

ou qu’ils se cachoient dans les alimens que nous prenons, & Mr. Muller a eu bien raison de condamner p. 12. art. 5. une pensée si absurde & si bizarre, que je condamnai moi-même, dès que je connus par l’experience, que S. A. S. Monseigneur l’Eleuteur Palatin me fit faire sur les écrevisses, que lors qu’on leur coupe une patte ou une serre, il leur en revient une autre au bout de quelque temps; car j’en conclus alors qu’il falloit de nécessité, qu’il y eût une Intelligence dans ces animaux qui reparât cette perte.”

Nicolas Hartsoeker, “Lettre sur quelques endroits des ouvrages des Mrs Cheyne et Derham, à l’auteur de la Bibliothèque ancienne et moderne,” Bibliothèque ancienne et moderne 8 (1717): 336. In a letter to Jean Le Clerc that was published in the Recueil de plusieurs pieces de physique (Utrecht, 1722), Hartsoeker once again revisited the topic of regeneration in crayfish. In one breath, he rejected the theory that held that animals were encased within animals from the beginning of time and that they were mechanically formed on 7-8: “Comme, selon M. Cheyne lui-même, la formation mécanique de l’animal est inconcevable & impossible, & qu’il est absurde de penser que Dieu fait une nouvelle création dans la production de chaque animal ; la formation mécanique d’une seule serre ou patte n’est ni moins inconcevable ni moins impossible ; [p. 8 ] & il n’est pas moins absurde de penser que Dieu en fait une nouvelle création.” My translation: “Since, according to M. Cheyne himself, the mechanical formation of the animal is inconceivable & impossible, & since it is absurd to think that God makes a new creation in the production of each animal, the mechanical formation of one single leg or limb is not any less inconceivable or impossible; [p. 8] & it is not less absurd to think that God has made a new creation out of it.”
moult results in a limb being torn off along with the carapace.\textsuperscript{28} Geoffroy the Younger, for instance, believed the crayfish were weak and sickly during this time, and posited that a “disease . . . causes the moult” in crayfish.\textsuperscript{29} If injured at any lower joint, the crayfish allegedly maimed itself above the fourth articulation on purpose to escape its captor alive and have its limb regrow in full.\textsuperscript{30} Such a response in the crayfish was exemplary of natural—if not, divine—providence. It was as if the crayfish instinctively knew how nature could help it to remedy a potentially horrible injury, especially since such accidental amputations were common among these crustaceans (according to tales from Breton fishermen).

A few years before Réaumur’s trials, Jean-Baptiste Van Helmont (1579-1644) and Geoffroy the Younger\textsuperscript{31} had recorded various observations and written natural histories of crayfish, in which they discussed the shedding of its shell, mating and feeding seasons.\textsuperscript{32} Perhaps the renewed interest in crayfish and other animals was concomitant with a broader, more general revived interest in natural history and the practical use of crayfish parts in the medical pharmacopeia. Curiously, Geoffroy’s reason for writing about crayfish was that “[i]t is nevertheless not enough to make new discoveries to advance Physics; one must ensure not to lose ancient ones.”\textsuperscript{33} In his early account about crayfish in the \textit{Histoire de l’Académie Royale des Sciences}, Geoffroy confirmed many observations made by Van Helmont. The Flemish physician had discussed how river (or freshwater) crayfish slough their shell in mid-June and, most interestingly to Geoffroy, how they come to have tiny rocks

\textsuperscript{28}Thomas Henry Huxley, \textit{An introduction to the study of zoology, illustrated by the crayfish} (New York, 1901), 37-39.
\textsuperscript{30}Réaumur, “Sur les diverses Reproductions qui se font dans les Écrevisses,” 228. Nineteenth-century naturalists believed decapods, such as the crab and lobster, to « practice defensive mutilation or autonomy. » See Herrick, \textit{The American Lobster}, 100.
\textsuperscript{31}This is most likely Claude Joseph Geoffroy (1685–1752), known as Geoffroy le jeune, apothecary and botanist in service of the Parisian Academy of Sciences.
\textsuperscript{33}Geoffroy le jeune, “Observations sur les ecrevisses de riviere,” 309: “Cependant pour rendre la Physique florissante, ce n’est pas assez de faire de nouvelles découvertes, il est encore important d’empêcher que les anciennes ne se perdent.”
inside their brain or stomach, commonly called “crayfish eyes.” These crab or “crayfish eyes” were used for medicinal purposes and believed to remedy the stone and other ailments. They were essentially small calcareous formations (or gastroliths), consisting mostly of carbonate of lime with a bit of phosphate of lime and animal matter. Geoffroy concluded that the rocks could be found only during the period of the crayfish’s moult. Afterwards, they were swiftly dissolved in the juices of the new stomach. Six years after his initial crayfish observations (and nine years after Geoffroy’s report on the crayfish moult), Réaumur conjectured the raison d’être of the “crayfish eyes.” These mini pebbles dissolved inside the crayfish’s stomach so that they could be used to harden the membrane that enveloped the soft body of the crayfish into its new exoskeleton. Dissections on crayfish soon after they had gone through the moult revealed no “crayfish eyes” in their stomachs. Fontenelle found Réaumur’s hypothesis so “convincing [juste]” that it was “hard to believe that it would be only a play of the imagination.”

Fontenelle chose to cite Geoffroy’s crayfish observations rather than Van Helmont’s most likely due to Van Helmont’s inclination to report curious myths about crayfish. Geoffroy had written that Van Helmont had “compromised himself on many occasions.” As another author explained:

35 Huxley, An introduction to the study of zoology, 44-45.
36 Geoffroy le jeune, “Observations sur les ecrevisses de riviere,” 312: “Il est encore à remarquer, que les pierres ne se trouvent dans les Ecrevisses qu’au tems de leur mûë; qu’elles se trouvent ensuite envelopées dans le nouvel estomach, où elles diminuent insensiblement jusqu’à leur entière destruction.”
39 Geoffroy le jeune, “Observations sur les ecrevisses de riviere,” 309-310: “Vanhelmont paroit être le premier qui s’en soit apper- [p. 310:] çû; mais comme il s’est rendu suspect en bien des rencontres, son sentiment n’a pu prévaloir sur celui qui étoit déjà reçu.”
It was, formerly, a current belief that crayfishes grow poor [thin?] at the time of new moon, and fat at that of full moon; and, perhaps, there may be some foundation for the notion, considering the nocturnal habits of the animals. Van Helmont, a great dealer in wonders, is responsible for the story that, in Brandenburg, where there is a great abundance of crayfishes, the dealers were obliged to transport them to market by night, lest a pig should run under the cart. For if such a misfortune should happen, every crayfish would be found dead in the morning: “Tam exitialis est porcus cancro.”

Of course, crayfish had long occupied a place in the human imagination and been described in ancient as well as early modern natural histories. Regeneration of limbs in crayfish, however, had not been discussed since Du Tertre’s 1654 brief account of crustaceans in Guadeloupe. The fact that Fontenelle praised Réaumur as a naturalist who had “curiosity, skill and patience” to investigate seriously and “verify” the regeneration of limbs among crayfish was a newer development.

But why then didn’t humans regrow their limbs after an amputation? Hartsoeker categorized human amputations as relatively rare chance occurrences. Therefore, like Réaumur, he reasoned by invoking the principle of necessity: “. . . and perhaps if some of our limbs were also as easily torn off as those of crayfish, we would have received from Nature the same advantage as these animals.” Crucially, although Hartsoeker fell back on the theory of informed matter to explain regeneration, Réaumur offered the theory of preexistence of germs as a possible account. The Frenchman speculated that the new limb regrew from little eggs in the crayfish that contained the

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40 Huxley, *An introduction to the study of zoology*, 45. Geoffroy le jeune also recounts the same story as reported by Van Helmont at the end of his article, “Observations sur les ecrevisses de rivière,” 314.
43 Hartsoeker, « Lettre de Mr. Hartsoeker à l‘Auteur de la Bibliothèque A. & M. sur les Serres, qui recroissent aux Ecrevisses… », 202 : « . . . & peut-être que si quelques-uns de nos membres étoient aussi faciles à se rompre que ceux des Ecrevisses, nous n’aurions pas reçu de la Nature moins d’avantages, que ces animaux. » For Réaumur’s statement, see « Sur les Diverses Reproductions qui se font dans les Écrevisses… », 226.
limb in miniature. The nourishing juices that flowed through a living crayfish then would have triggered that germ to grow and become the new leg (as if from an activated stem cell). In short, Réaumur continued to explain the crayfish experiment with the theory of preexistent germs.

Regeneration in crayfish stupefied another contemporary, Fontenelle, the Parisian Academy’s Secretary who recorded and commented on Réaumur’s findings. He remained more skeptical than Réaumur and did not volunteer a separate theory to explain the regrowth of crayfish limbs. Fontenelle admitted that Réaumur’s crayfish experiments undermined the theory of preformation. He carefully reckoned that “[a]lthough the theory that maintains that the animal is already fully formed in the egg explains generation rather well, the phenomenon of generation is still rather marvelous. But that another organic part of an animal similar to the one which has been cut off is reborn, that is a second marvel of a different nature from the first one and cannot be explained by the theory of ovism [système des Oeufs]” (preformation). In other words, the theory of preformation explained generation successfully, but seemed to fizzle out when applied to regeneration. Interestingly, Hartsoeker ventured beyond Réaumur and Fontenelle in proffering an explanation for the crayfish experiment. Fontenelle believed the crayfish to exemplify “rare phenomena.” Hartsoeker, meanwhile, took the extraordinary phenomenon of regeneration in crayfish as illustrative of and proof for intelligent matter. In fact, the crayfish experiments had a profound impact on Hartsoeker’s notions of matter and soul, and served to support one of the main principles of his system.

Fontenelle, “Sur la reproduction de quelques parties des ecrevisses,” 35: “Quoique le système de l’animal déjà tout formé dans l’Oeuf en rende la génération concevable, il ne l’empêche pas d’être encore bien merveilleuse. Mais qu’à la place d’une partie organique d’un animal retranchée il en renaîsse une autre toute semblable, c’est une seconde merveille d’un ordre différent de la première, & où le système des Oeufs ne peut atteindre.”
Generation Debates and Regeneration

Generation stood at the heart of questions about life. Thus ideas about the reasons for and ways in which living things were formed and grew were hotly contested issues in the middle of the seventeenth century. The debate centered on the question of the ensoulment of the seed and thus the ultimate origin of a living being. In the early seventeenth century, physicians and thinkers offered an explanation for this conundrum in the theory of preformation of the germ or seed⁴⁷. According to this doctrine, the organism already existed entirely formed in miniature in the semen of the animal and developed into a full-fledged living being thanks to the soul it received in the seed of the male parent. This belief supported Aristotle’s dualist claim that the male parent conferred a form or soul, while the female contributed matter or her body in producing offspring. Partially overlapping with preformation of the germ, the theory of the preexistence of germs began to circulate around 1670. It also presupposed the enlargement of a preformed organism, but it rejected the male parent as the author of the seed. Instead, the doctrine held that God had created the germ in the beginning of time and the male parent served merely as its host. The paganism inherent in Aristotle’s scheme found refuge in Platonic thought, which offered a complex, more nuanced and perhaps mystical exposition of forms. In addition, the threat of materialism inherent in the mechanical philosophy made way for Neoplatonic, chymical and spiritualist philosophies to explore how matter organized itself. For instance, Jean-Baptiste Morin believed in a divine immaterial spirit, while Jean-Baptiste van Helmont postulated a seminal principle responsible for the generation of beings.⁴⁸

At the time, spontaneous generation from dead and living matter was corroborated by daily experience and by eminent natural philosophers, such as Mersenne, Harvey and Descartes.

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⁴⁷ The ancient Greek notion of σπέρμα (sperm) carried the larger connotation of seed or germ, applicable to the animal as well as plant kingdoms.

Spontaneous generation, especially of insects, worms and slugs, was accepted almost unanimously until the last third of the seventeenth century.\(^{49}\) It was believed to occur through the providence of God or by chance. Nicolas Hartsoeker, for one, explained monstrous births as nature erring at random and healthy births, conversely, as ordained by God. According to Hartsoeker, two animalcules of semen produced a monster “by chance,” if they both entered a single egg.\(^{50}\)

Spontaneous generation—or generation by chance—challenged the notion that beings, such as worms that were born out of putrid matter, were also the work of God. Augustine’s “semenal principle” suggested that in order to produce living things matter must have seed.\(^{51}\) Despite the possible theological and theoretical arguments, the exact process of spontaneous generation remained unclear. One thing seemed obvious: not just any matter could generate any kind of being. As in explanations of generation, those of spontaneous generation necessarily invoked some kind of nutritive spirit or soul acting on matter that was necessary for life.\(^{52}\)

Spontaneous generation was a widely held theory in the first half of the seventeenth century. One of the reasons for its popularity was its compatibility with Descartes’ mechanism, which relied on a set of natural laws that could produce life at any time. Spontaneous generation ran out of steam, though, by the end of the century with the minute observations of Hooke, Leeuwenhoek, Malpighi and Swammerdam. These microscopists brought to light the highly ordered, complex structures of organic life. The newly unveiled microcosms were more neatly explained with theories such as preformation and the pre-existence of germs.\(^{53}\) Regeneration in animal species, on the other

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\(^{50}\) Nicolas Hartsoeker, *Suite des Conjectures Physiques* (Amsterdam: Henri Desbordes, 1708), 130: “Mais s'il arrive par hazard que deux petits animaux de la semence s'introduisent dans un seul œuf, il en doit naître un Monstre; c'est-à-dire, deux enfants attachez l'un à l'autre par quelque endroit de leur corps . . .”


hand, was largely ignored by natural philosophers of the day.\(^54\) In antiquity, Aristotle had indeed described how the eyes of very young swallows would regrow and “sprout afresh” after having been “put out”\(^55\). And Pliny the Elder had told of how lizards and serpents would regrow their lost tails.\(^56\) Their observations were revived and corroborated by humanist natural historians. Overall, however, regeneration was thought to occur almost exclusively in the plant kingdom.\(^57\)

Regeneration of organic parts was well established in trees, whose cut-off branches would grow back and whose ability to adopt and nourish a foreign tree shoot was exploited in the practice of grafting already known in ancient times.\(^58\) “But the parts lost by Animals are lost forever, & they would definitely not get a new [body] part that would be grafted [grefferoit] onto them,” wrote Fontenelle. “Only the legs of Crayfish are reborn, but this privilege is peculiar to them; and should it extend to other Animals, it will always be rather unusual.”\(^59\) (Punishment for criminal behavior often involved mutilating or cutting off the nose, lips or ears of the perpetrator. The surgical repair of these body parts, however, was discussed more than practiced in the early modern period. It had a low success rate and involved painful, complex and dangerous procedures and long recovery.\(^60\))

When Réaumur first sought to explain regeneration of crayfish limbs in 1712, he and his contemporaries like Fontenelle understood the phenomenon in the context of early eighteenth-century debates on reproduction and rebirth. Furthermore, the crayfish’s shedding of its carapace on a nearly yearly basis was yet another, though far less atypical, example of its unique regenerative

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\(^{54}\) Corcos, “Fontenelle and the Problem of Generation,” 370.

\(^{55}\) Aristotle, *De Generatione animalium* in *The Works of Aristotle*, vol. V, trans. Arthur Platt (Oxford: Clarendon Press, 1912), Book IV.6, 774b31-34: “Hence if the eyes of swallows while still young be put out they recover their sight again, for the birds are still developing, not yet developed, when the injury is inflicted, so that the eyes grow and sprout afresh.”


\(^{59}\) Fontenelle, “Sur la Reparation de quelques parties du Corps humain mutilées,” 29: “Mais les parties que les Animaux perdent, ils les perdent pour jamais, & ils n’en reçoivent point une nouvelle qu’on leur grefferoit. Seulement les jambes des Écrevisses renaissent; mais ce privilege leur est particulier, & dût-il s’étendre encore à d’autres Animaux, il sera toujours bien rare.”

capabilities. Rather than couch the phenomenon of limb regrowth within regeneration, Réaumur spoke of “the reproduction of legs and shells” of crayfish.61 Interestingly, Hartsoeker took Réaumur’s, and his own repeated, experiments to make a case for regeneration. He saw that the leading theory of reproduction—germ theory—envoked by both Réaumur and Fontenelle proved useless in explaining limb regrowth in crayfish. Why did Hartsoeker venture to do this and seek a new explanatory framework as a result? I argue that his exposure to Cambridge Platonism in tandem with his growing awareness of the shortcomings of Cartesian system of nature made him sympathetic to non-mechanistic explanations, which he came to adopt over the years.

To identify how Hartsoeker’s experimental investigations applied to his theorizing, it is crucial to understand why and how his thoughts had to travel across the English Channel to adopt ideas of a World Soul and a Plastic Nature. Evidently, Cartesian mechanism could not provide a satisfactory explanation of living things. Matter particles in motion could not suggest causes for phenomena like regeneration or animal souls. Overall consensus in Christian Europe believed that the role of free will had been compromised by the mechanistic, materialist, and seemingly deterministic implications of Descartes’, Hobbes’ and Spinoza’s natural philosophies. Still, this factor alone did not warrant Hartsoeker’s choice of an active intelligence governing matter in his system. As we have seen with Réaumur himself, a plastic nature theory was not the only possible interpretation of regeneration.

Early in his student days in Amsterdam and at the University of Leiden Hartsoeker was exposed to Cartesian thought. From 1678, Hartsoeker spent time at the Royal Academy of Sciences in Paris and, from 1704, at the court in Düsseldorf. However, he began to rethink some of its

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principles and assumptions in the 1690s along the lines of the Cambridge Platonists. The most principal and prolific authors of this group were Henry More (1614-1687) and Ralph Cudworth (1617-1688). The English Platonists were receptive to the new Cartesian philosophy because of the primacy it placed on reason. At the same time, they were hostile to the determinism it implied. They believed that there were two sources of arriving at truth: scriptural revelation and human reason. Not surprisingly, the Cambridge Platonists distrusted a physics without metaphysics.

The Cambridge Platonists and other theologian-philosophers appeared in various registers over the course of Hartsoeker’s life, but most significantly in his reading and research and in the immediate intellectual circle of his father Christiaan Hartsoeker (1626-1683), a well known Remonstrant preacher and close friend of the famous theologian Philip van Limborch.

The Dutch-English Connection and Reformed Religion

The unique ties between Dutch Remonstrant and English theologians and political thinkers figured prominently in the background to these religious, philosophical and political debates. Dutch Remonstrants, also named Arminians after the Remonstrant theologian Jacobus Arminius, faced religious persecution at home. They comprised a small elite of theologians and intellectuals who

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65 A crucial part of Hartsoeker’s intellectual life was spent at the Academy of Sciences in Paris. Numerous academy members held heterodox views. There were many Jansenists, Cartesian and Spinozists, but few Neoplatonists. See Alice Stroup, “Censure ou querelles scientifiques: l’affaire Duclos (1675-1685),” *Règlement, usages et science dans la France de l’absolutisme* (Paris, 2002), 451.

In the words of Sarah Hutton, Cambridge Platonists advocated theological optimism and clashed with “the harsh predestinarian theology of Calvinism.” They emphasized freedom of the will and insisted on the “importance of reason in religion.” Furthermore, “by widening the traditional Platonic defense of the immortality of the soul to a defense of spirit in general, they sought to combat what they saw as atheistic tendencies in contemporary thought.” They saw determinism and atheistic materialism in the works of Hobbes and Spinoza – and even to some extent in that of Descartes. The Platonists’ opposition to materialist philosophies equaled their rejection of Calvinist predestination. See, Sarah Hutton, “Introduction to the Renaissance and the seventeenth century,” in *Platonism and the English Imagination*, 73.
were politically influential. Sir William Temple, an ambassador in The Hague, described what distinguished the Remonstrants from their reformed brethren in an account of his travels to the United Provinces in the late 1660s and early 1670s: “The Arminians, though they make a great Name among them, by being rather the distinction of a Party in the State, than a Sect in the Church; yet are, in comparison of others, but few in number, though considerable by the persons, who are of the better quality, the more learned and intelligent men, and many of them in the Government.”

They wrote letters to English theologians and representatives of the Church of England, including to Henry More; and they lobbied for support from a much larger (although not less religiously volatile) country on their behalf. And so it was vice versa. On the whole, the works of Colie, Simonutti, Zijlmans, Jardine and others demonstrate the ways in which the Dutch and the English shared strong intellectual ties, religious convictions and information networks that exceeded their countries’ interwoven royal genealogies.

To the English, the Dutch Republic was a safe haven away from political persecution and religious troubles at home. When John Locke, for example, was accused of plotting against the English Crown, he fled to Rotterdam in 1683 and later moved to Amsterdam. His political exile lasted until February 1689 and had a profound impact on his life and creativity. Among the Dutch, Philip van Limborch, for one, actively positioned himself as an ambassador or spokesperson for the Remonstrant cause abroad. He not only emerged as the leading representative of the Remonstrant Brotherhood of his time. But he also sought “to convey the truth” to English

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theologians and clergy about the Remonstrant beliefs and ideological standpoint. He and his Remonstrant circle were invested in advancing “a rational, anti-fanatical, anti-tyrannical view of Christianity such as that of the English latitudinarians and neo-Platonists, the Socinians, and the French Protestants.” The Revocation of the Edict of Nantes officially closed France to the reformed religion in 1685. As a result, the United Provinces were inundated by French Protestant preachers. Faced with unemployment at the pulpit, religious refugees and exiles, such as Pierre Bayle, Jean Le Clerc, Pierre Coste and Pierre Desmaizeaux, channeled their preaching into journalism and correspondence.

Van Limborch’s circle of correspondents comprised his compatriots and fellow theologians—Christiaan Hartsoeker, Jacob Johannes Batelier, Nicolaas Borremans—as well as the physician Lambert van Velthuysen, the lawyer Gerard Noodt, the English Earl of Shaftesbury and philosopher John Locke, who authored the Essay on Toleration (1667). His vast network stretched east and west across fluid national boundaries. It included the German theologians Daniel Wülfer and Philippus Hieronimus Andreae and the French theologians, Louis le Blanc and Pierre Allix. These men exchanged their thoughts and ideas about theological and philosophical matters, and frequently sent each other their newly printed publications. However, they also informed each other about their personal lives. Both Locke and Limborch actively debated the relationship between political and ecclesiastical power, and argued passionately and insistently for religious toleration.

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68 Pieter Jacobus Barnouw, Philippus van Limborch (The Hague: Mouton & co., 1963), 24: “Van Limborch zond ook vele brieven naar andere theologen, maar de vertegenwoordigers van de kerk van Engeland hadden ongetwijfeld zijn voorkeur. In een brief aan Timan Gessel te Utrecht, van 15 mei 1669, gaf hij een gedeeltelijke verklaring voor deze voorliefde: het doel van zijn correspondentie met de theologen uit Engeland was gezag aan de waarheid te verschaffen! Dit was noodzakelijk, omdat er maar al te veel mensen waren die met ieder meepraten, en de Remonstranten als minderheid konden de steun van het grotere land goed gebruiken.”


71 Barnouw, Philippus van Limborch, 24-26.

One of the reasons that led Limborch to establish connections with his English colleagues was to inform them specifically of the Synod of Dordrecht and its very real consequences. Some religious groups had accused Remonstrants of slandering the evangelical and reformed religions. The Calvinists’ attack on the Remonstrant faith in 1618-1619 culminated in their expulsion from the Dutch Republic. This relatively small religious minority was not allowed to repatriate until the 1680s. With the goal of setting the record straight, then, Philip van Limborch sent Henry More four copies of a published compilation of letters (from both Dutch and English theologians and thinkers). Van Limborch had originally co-edited them with Hartsoeker’s father, Christiaan, in a volume, entitled Praestantium ac Eruditorum Virorum Epistolae Ecclesiasticae et Theologicae varii argumenti: Inter quas eminent eae, quae à Iac. Arminio, Conr. Vorstio, Sim. Episcopio, Hug. Grotoio, Caspar Barlaeo conscriptae sunt. While one copy was destined for More, the other three were meant to reach the hands of Ralph Cudworth, Oliver Doiley and Henry Jenkes.

Van Limborch’s (and, by extension, Hartsoeker’s) intellectual circle discussed, wrote and lectured on a wide variety of subjects, ranging from theology to natural philosophy. While Van Limborch was not an outspoken Cartesian, he was well versed in the natural philosophy of his day. In a letter to Hartsoeker’s father, Van Limborch disclosed how he let his students read at home the then unorthodox works by Gassendi and Descartes: “Every day I myself will examine them, explain ambiguities, and expand on their doubts,” so that his students “will all perceive the thoughts of the ancients in philosophy and will be able to read all Philosophers’ books, even Descartes’, without an

73 Nederlandse Hervormde Kerk. Synoden, A proclamation given by the discreet lords and states, against the slanders laid upon the evangelical and reformed religion, by the Arminians and separatists containing all the points, accusations, declarations and confessions, taken out of the last provincial synode holden at Arnhem, the 15. day of September last past. 1618. Together with the several examinations and confessions (at Vtrecht and the Hage) of one Leydenbergh, petitioner of Leyden, and Taurinus; with their sudden and fearfull ends. [London] : Printed according to the Dutch originals, at London, by G[eorge] E[lde] for Th[omas]: Th[orpe]: and Richard Chambers, and are to be solde at the signe of the blacke Beare in Paules Church-yard [at the shop of Edward Blount], 1618.

74 Barnouw, Philippus van Limborch, 15-16.
The young Hartsoeker himself reported to have been a student of Van Limborch for a brief period of time in Amsterdam. It seems highly plausible that he was instructed in, or at least aware of, the writings of various orthodox and less orthodox contemporary thinkers. Consequently, it would not be a far stretch to suggest that Hartsoeker’s Arminian upbringing had “made him sympathetic to Platonism,” since “his father Christiaan had belonged to a circle of Arminian theologians [who] corresponded with Henry More, Ralph Cudworth, and other Cambridge Platonists during the 1660s and 1670s.” In her seminal work, Rosalie Colie traces the informal networks between Neo-Platonists in Cambridge and Remonstrants in Amsterdam. What seemed to trouble these circles was “the apparent determinism of Cartesian physics, which seemed to disallow both human free will and divine intervention in the world.”

In what follows, I explore Nicolas Hartsoeker’s intellectual relationship with the Cambridge Neoplatonists Ralph Cudworth and Henry More. The latter’s arguments in his letters to Descartes convinced Hartsoeker to begin looking outside the Cartesian framework for answers. Meanwhile, Ralph Cudworth’s idea of plastic natures inspired the “organizational” first element that imbued matter particles with motion, and eventually also with intelligence, in Hartsoeker’s system of physics. In particular, this chapter aims to elucidate the philosophical and religious traditions, within which

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75 Philip van Limborch to Christiaan Hartsoeker, Universiteitsbibliotheek Amsterdam, Special Collections, III D 17, fol. 95r (undated): “Video, nihil ferme promotum explicationibus meis apud eos, qui unica mea explicatione contenti, domi libros e manibus depositos negligunt, neque lectioni neque meditationi incumbunt. Ut itaque sed aliquatenus ad lectionem compellentur votis: ipsis Gassendum domi ab ipsis legi: ego autem quotidiem ipsos examinabo, obscura explicabo, dubia evolvam: ita, nisi aliquorum s [...] ac [...] velint exponere, cogentur omnes esse diligentes; omnes, etiam antiquorum sententias, in philosophia habeunt perspectas, poteruntque omnium Philosophorum, etiam Cartesii, libros, sine praeceptore legere: si qui tamen et praeterea a D. Professore de Raeij sibi explicari velint Principia Cartesii, me non repugnantem habeunt: sed si [et?] quo apud me [...] Cartesium legant, nihil proficiunt. Spero autem intra anni, aut ad summum sesqui anni spatiu integrum Gassendi physicam (quam solam legemus) ad finem perducere. Velim coram Amplissimo P[...] rationes instituti mei aperire; non dubito quin eas approbaturus sit. Insoles videtur, tanti distu [...] tradi juventibus Scriptorem. Sed Res dura, ignoti juvenes, me talia cogunt Moliri.” See also Barnouw, Philippus van Limborch, 26.


Hartsoeker was developing his conception of the world. More broadly, it also gives an example of the natural philosophical reception of Cambridge Platonism in continental Europe.

**Henry More’s Extension**

Henry More was one of the key Platonists whose published letters to Descartes helped Hartsoeker manage his dissatisfaction with the Cartesian system. More was a moderate Anglican divine and theologian known for his revival of a Platonist interpretation of Cartesian physics and his opposition to dogmatic Calvinism. More kept abreast of developments in the new science: He was an early member of the Royal Society (elected on 25 May 166478) and even constructed experiments himself. However, “More viewed reason or intellect as the first mover in philosophical inquiry, with experiments playing a useful supporting role to rational arguments.”79 Based on More’s early interest in Descartes’ work, some of his fellow Cambridge Platonists—most notably Samuel Hartlib and Ralph Cudworth—encouraged him to write to Descartes.80 Henry More’s reactions to Descartes’ ideas were by no means uniform. Over time, his earlier ardent admiration for the French philosopher gave way to a more nuanced critical reassessment of Cartesian philosophy, and how it functioned with (and within) his own philosophical and religious concerns. But, Alan Gabbey argues, More’s basic philosophical stance on Cartesian ideas did not change significantly after 1650.81 By this time, “More had acquired a comprehensive and detailed knowledge of most of Descartes’s contributions to philosophy, and had developed an all-embracing and lasting interest in their implications for what More considered were the important theological and philosophical issues of


the time.”\textsuperscript{82} The correspondence between the two men laid bare some of the central criticisms of Descartes’ philosophy.\textsuperscript{83} The physical universe expressed a rational and moral order which More saw confirmed in Descartes’ rational and systematic explanation of the universe.\textsuperscript{84} To More, the world’s “inherent order, providential design and rationality referred not simply to the goodness of God, but to a Neoplatonic spiritual hierarchy of active and intelligent spirits informing and upholding the ‘exterior’ experienced world of the senses.”\textsuperscript{85} He argued that there must be a divine presence or spirit that infuses all matter. Unfortunately, “Descartes’ matter in motion seemed unable to suggest anything else than the active informing presence of some poorly articulated spiritual substance.”\textsuperscript{86}

Nonetheless, there were some crucial differences between More’s and Descartes’ conceptions of creation. The English thinker addressed them in his 1648-1649 correspondence with Descartes. At this time, he was primarily concerned with understanding the Frenchman’s ideas more fully.\textsuperscript{87} Unlike Descartes, Henry More counted God among extended things.\textsuperscript{88} Using this idea as foundational, More explained that “human souls, all good and bad spirits are corporeal, and consequently have a real sensation, that is, a sensation that comes from the body which they

\begin{itemize}
\item \textsuperscript{82} Gabbey, “Philosophia Cartesiana Triumphata,” 191.
\item \textsuperscript{83} Gabbey, “Philosophia Cartesiana Triumphata,” 192-193. For the interested reader, Gabbey summarizes eleven points of disagreement between More and Descartes in concise—but not exhaustive (as he himself admits)—fashion.
\item \textsuperscript{85} Crocker, introduction, xviii.
\item \textsuperscript{86} Crocker, introduction, xviii.
\item \textsuperscript{87} Henry More to Samuel Hartlib, 27 August 1649: “I am glad I shall hear from him before he takes this long journey [to Sweden]. For this letter answering is more considerable to me then the answering of any I wrote yett to him. And the two next I intend to write will be muchwhat of the same importance for my designe, viz. the thorough understanding his philosophy, that I may be self a safe and able judge of it.” And see also, More to Hartlib, 24 September 1649: “And now I begin somewhat eagerly to expect an answer from Des Cartes of my last letter [July 23, 1649] to him. For I can settle my self to nothing to any purpose till I have thoroughly perused his Philosophy, nor can I go on in the perusal thereof till such time as I hear from him . . . ” Both letters cited in Gabbey, “Philosophia Cartesiana Triumphata,” 196.
\end{itemize}
Descartes disagreed. In a letter to More, he supposed that a human soul separated from the body felt nothing whatsoever. More asked Descartes if a philosopher could not accept an incorporeal substance in nature that endowed matter with properties such as motion, figure and general structure. Couldn’t there be an incorporeal substance that resided in the body and governed how that body moved, divided, united, dissipated, and organized its parts? Descartes responded that all a philosopher could grasp about the nature of immaterial substances and the soul were conjectures, and could not be accounted for by mechanistic explanations. Regarding material substances, however, Descartes wrote that he had “found nothing on the[n] nature... for which [he] couldn’t very easily give a mechanical reason.” Essentially, motion was the only glue that bound matter particles together. Descartes’ God had infused matter with motion in the moment of the world’s creation, but did not actively manage matter at every instance. God merely conserved what motion he had granted in the beginning. Descartes avoided discussing this question for fear of “seeming to favor those who liken God to the soul of the world that imbues matter.” Thus ended the direct correspondence between More and Descartes. More’s *Collection of Several Philosophical Writings*, published in 1662, contained the correspondence. So by 1678, the year when Hartsoeker was a fourth-year student at Leiden University and about to travel to Paris for the first time, all of

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89 More to Descartes, Cambridge, 23 Jul 1649, *A Collection of Several Philosophical Writings*, 86: “Me verò lubentem cum Platonice, antiquis Patribus, Magisque ferme omnibus, & animas & genios omnes, tam bonos quam malos, planè corporeos agnoscere, ac proinde sensum habere propriè dictum (i.e.) mediante corpore, quo induuntur, exortum.”

90 More to Descartes, Cambridge, 5 Mar 1649, *A Collection of Several Philosophical Writings*, 80: “Imò verò, cóm ferme constet de motu; sine mora superaddere etiam quæ motús consequentia sunt, ut dividere, conjungere, dissipare, vincire, figurare particulás, figuratas disponere, dispositas rotare, vel quovis modo movere, rotatas continere, & id genus alía; unde lumen, colores, & reliquà sensùs objecta prodire necesse est, juxta eximiam tuam Philosophiam.”

91 Descartes to More, Egmond, 17 May 1649, *A Collection of Several Philosophical Writings*, 103-104. This letter manuscript was found among Descartes’ papers in which he had begun crafting a reponse to More’s two preceding letter to him. Descartes’ response was never sent to More, but appeared in More’s published writings in 1662 and concludes their correspondence.


94 Descartes to More, Egmond, 17 May 1649, *A Collection of Several Philosophical Writings*, 104: “Et quidem illa vis in substantia creatæ est ejus modus, non autem in Deo; quod quia non ità facile ab omnibus potest intelligi, nolui de istà re in scriptis meis agere, nè viderer favere eorum sententia qui Deum tanquam animam mundi materiam unitam considerant.”
Henry More's works were freely available. Although it is impossible to pinpoint the precise moment of Hartsooker's break with the Cartesian system of nature, it is safe to say he began taking seriously More's Platonist ideas around 1696.

That was the year when Hartsooker's growing unease with Cartesian physics became evident and when he cited Henry More's correspondence with Descartes in an article in *Le Journal des Scavans*. Here, Hartsooker responded to a Cartesian professor of mathematics and philosophy La Montre who attacked Hartsooker's newly published *Principes de Physique*. Building off Henry More's objections to Descartes, Hartsooker defended his own cosmological views. For one, he, like More, argued that Descartes had not fully explained the first principles that underpinned matter in motion. They both sensed that Descartes only gave half of the story: for example, the French philosopher gave a rather sound account of matter particles but not of the subtle matter in which they moved. According to Hartsooker, Descartes supposed that this subtle matter was neither fluid nor hard, yet had infinite extension. Both Hartsooker and More conceived of extension as something that communicated essence and movement. Both believed it to be corporeal and real, though, in More's words, "more general than the body."

The Dutchman believed that he could solve the objection that More raised against Descartes' system by reducing everything to liquidity and hardness. In Hartsooker's system of the world, these two qualities underpinned his fundamental principles. Matter particles were absolutely hard and infinite in number, while the liquid first element was perfectly fluid and imparted motion to the atoms. Hartsooker trumpeted his invention of the fluid first substance with the following words:

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“it has all the advantages of Gassendi’s void and Descartes’ subtle matter, and none of their inconveniences.” Hartsoeker did not elaborate further. At this point, he did not ascribe any kind of intelligence or consciousness to the first substance of his physical system. Ironically and perhaps prematurely, Hartsoeker added that he did not want to entangle himself in “further metaphysical subtleties which have nothing to do with the work of a Physicist . . . ” That is, Hartsoeker did not argue for a spirit of nature or any additional metaphysical forces in his system. Instead, he presented a reasoned account of where Descartes’ system withstood and where it faltered under the pressure of outside arguments. Nonetheless a philosophical change had begun to take shape. For one, Hartsoeker then went on to save the phenomena with his own system of nature, which contained adaptations in the language of Henry More’s letters to Descartes.

Ralph Cudworth’s “Plastick Nature”

The arguments Hartsoeker adopted from Cudworth had their origins in an active philosophical school whose ideas he clearly found useful to think with. Ralph Cudworth’s revival of “Plastick Nature” began influencing Hartsoeker’s philosophy probably after 1703. Cudworth rejected two versions of materialism that he considered atheistic: atomism and hylozoism. The former presupposed that only matter existed, while the latter accepted self-organizing life in matter. Cudworth wrote especially against the atomists, whom he saw as atheists (namely, Hobbes, Spinoza and their ilk). In 1678, his major work, The True Intellectual System of the Universe, lumbered off the

99 Hartsoeker, “Des Elemens du Corps Naturel, et des qualitez qu’ils doivent avoir,” 329: « Le premier élément sert à expliquer le mouvement, la rarefaction, la lumière, la flexibilité des corps pliants, le ressort des corps durs & cassans ; enfin il a tous les avantages du vuide de Gassendi & de la matière subtile de Descartes, & il n’a les inconveniens ni de l’un ni de l’autre. »

100 Hartsoeker, “Des Elemens du Corps Naturel, et des qualitez qu’ils doivent avoir,” 329: “C’est pour cela que sans m’embarasser de ces differens estats de la matiere ni de toutes les autres subtilitez metaphysiques dont un Phisicien n’a que faire, j’ai d’abord supposé dans mes principes de Phisique qu’il y a deux elemens,…”

101 While Hartsoeker did not explicitly mention Cudworth by name as the originator of his ideas for intelligent forces of nature, he was seen by Fontenelle, at least, to be borrowing from Cudworth’s idea of “Plastick Nature.” See, Bernard le Bovier de Fontenelle, “Eloge de Monsieur Hartsoeker,” Éloges des Académiciens de l’Académie Royale des Sciences, morts depuis l’an 1699, Tome II (Paris: Libraires Associés, 1766), 242.
presses. But the work was not widely read, for it was not translated until 1733. In 1703, it resurfaced: Jean Le Clerc, encouraged by his friend John Locke, published a series of extracts from Cudworth’s book in French in his Bibliothèque Choisie.102 Cudworth’s excerpts on plastic nature “pleased all but the most stubborn Cartesians and Spinozists.” However, the vitriol between Le Clerc and Pierre Bayle that exploded upon their publication famously rocked the lettered republic.103 In his capolavoro, Cudworth developed his famous doctrine of plastic nature, which he derived from Plotinus’ idea of a vegetative soul. (Incidentally, Hartsoeker, too, kept Plotinus’ Opera Philosophica Omnia from 1580 and Plato’s complete works in his library.104)

Essentially, “Plastick Nature” was “the explanation for the laws of nature” without invoking God’s direct operation in the world. It was God’s instrument, unaware and unconscious of its own nature but expressing God’s order in material things.105 To Cudworth, it was not an occult cause; rather, it was “a manifestation of ‘mental causality’ in the world.”106 Cudworth believed that God, or rather the divine principle of love and goodness, expressed itself in all living things as “the Plastick Nature.”107 Being alive entailed having a kind of organic unity. Leslie Amour used the phrasing “organic unity” to describe how Cudworth’s conception of free will played out in tandem with Plastick Nature and the metaphor of an organic body. In other words, the human body, like that of other living things, had “a coordinating power” that could direct action so as to express “the character of its natural order.”108 At its basis, “freedom requires a kind of organic unity. It is not just accident that we are put together in such a way that our nature requires a unifying—and free—

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102 Colie, Light and Enlightenment, 117.
105 Colie, Light and Enlightenment, 128.
107 Amour, “Trinity, Community and Love,” 120.
However, Cudworth, rather than speak of “organic unity,” discussed the necessity for an internal ruler in a body: “[S]ome one hegemonical” in us “which comprehending all the other powers, energies, and capacities of our soul . . . determineth, not only actions, but also the whole passive capability of our nature one way or another, either for the better or the worse.” In order to illustrate this point even more clearly, he applied the overarching principle of unity to the ubiquitous metaphor of the machine. Such a hegemonic principle would have to act like glue and govern a structure as complex as a living human or animal machine:

I say there being so many wheels in this machine of our souls, unless they be all aptly knit and put together, so as to conspire into one, and unless there be some one thing presiding over them, intending itself more or less, directing, and ordering, and giving the fiat for action, it could not go forwards in motion, but there must be a confusion and distraction in it, and we must needs be perpetually in puzzle. We should be like to a disjointed machine or automaton all whose wheels are not well set together; which therefore will be either at a stand continually, or else go on very slowly heavily and cumbersomely. It could never carry on evenly any steady designs, nor manage itself orderly and agreeably in undertaking, but would be altogether a thing inapt for action.\(^\text{108}\)

As Cudworth wrote, “God Almighty could not make such a rational creature as this is, all [sic] whose joints, springs, and wheels of motion were necessarily tied together, which had no self-power, no hegemonic or ruling principle, nothing to knit and [unite] the multifarious parts of the machine into one.”\(^\text{111}\) In these last two quotations from Cudworth, the metaphor of the machine figures as both an invaluable and yet troubling mental aid: invaluable, because it so aptly and elegantly explains most living beings; and troubling, because it nonetheless fails to explain the problem of the prime mover by virtue of being exactly that, a machine. Crucially, it highlights the evolving problems thinkers were left with when confronted with the Cartesian machine and the question of whether or not animals had souls.

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\(^\text{109}\) Amour, “Trinity, Community and Love,” 115.
\(^\text{110}\) Ralph Cudworth, \textit{A Treatise of Freewill}, first ed. & publ. from Cudworth’s Ms. ca. 1654 by John Allen (London, 1838), 58-60.
Hartsoeker, however, amended Cudworth’s Plastick Nature by attributing conscience or knowledge ("connoissance") to it. The fact that Cudworth’s formative principle acted unconsciously abetted atheism in the eyes of his contemporary critics. Meanwhile, Hartsoeker’s tweaking of the formative principle involved endowing it with Intelligence, as we saw with the crayfish experiments.

Intelligent Forces and the World Soul

In 1706, Hartsoeker wrote that nature worked in ways that puzzled the human mind. In physics, “one is often obliged to admit probabilities in lieu of demonstrations.” Because atoms could not be perceived through the senses, they had to be inferred through their effects. Hartsoeker seemed hopeful that “a small number of simple and uniform laws” governed the infinite effects of nature. “[I]n my system,” he wrote, “everything was the eternal and direct ['immediate'] work of God” and “was composed of immutable and indivisible particles.” He likened his first element to pure fire, whose nature we could not know, yet whose being was “real” and could “push the atoms or little bodies floating in it, and keep them from colliding with one another.”

114 Nicolas Hartsoeker, *Conjectures Physiques* (Amsterdam: Henri Desbordes, 1706), 1-2: “…mais j’ai toujours tâché de ne rien avancer qu’après un examen rigoureux & Geometrique, autant qu’on le peut faire en matière de Physique, où l’on est souvent oblige d’admettre des Probabilitez pour des Démonstrations. Car puis que les parcelles du corps Physique sont insensibles; c’est-à-dire, qu’on n’en peut apercevoir par les sens, ni la grandeur, ni la figure, ni l’arrangement; on ne saurait faire autre chose que de e deviner par les effets.”
115 Hartsoeker, « Avertissement » to *Conjectures Physiques*, unpaginated: “Car la Nature ne produit cette varieté infinite d’effets qui font nôtre admiration, que par un petit nombre de loix simples & uniformes…”
116 Hartsoeker, « Avertissement » to *Conjectures Physiques*, unpaginated: “Car au commencement il [Descartes] ne demande presque rien, en ne demandant que de la matiere & du movement; & puis dans la suite il prend hardiment une infinité de choses sans les demander. Mais dans mon Systeme, où tout est, pour ainsi dire, l’ouvrage eternal & immediate de Dieu, & compose de parcelles immuables & indivisibles; il ne doit point paroître plus merveilleux qu’il ait, par exemple, des Cerceaux formez comme je me les suis imaginez pour expliquer les effets de l’Air, & qu’il y ait d’autres corps, comme je les ai suposez, pour render raison des Phenomenes de la Nature…”
117 Hartsoeker, *Suite des Éclaircissemens sur les Conjectures Physiques* (Amsterdam, 1712), 2 : « … mon premier Element est du Feu tout pur … un Etre étendu qui n’est point Corps, mais qui pourtant est un Etre réel, qui peut agir, pousser les atomes ou petits Corps qui y flottent, & empêcher que ces atomes ne s’entre-touchent … »
second element, or collectively matter particles, he described as small solid masses that are simple, homogenous, and perfectly hard, but incapable of any movement by themselves.\textsuperscript{118}

Over the following years, further traces of Neo-Platonist ideas came to the fore in Hartsoeker’s ever more nuanced system. Now intelligence and consciousness began to play a role in his proposed first element. In a 1710 letter to Leibniz, Hartsoeker described his first element as “pure fire and the soul of the universe.”\textsuperscript{119} This first substance was endowed with intelligence, by which it was able to arrange matter without end. This Intelligence, then, was the source of atomic motion and of many other subsidiary Intelligences or souls.\textsuperscript{120} Some of these subordinate souls had the power to maintain, for example, an entire planetary system, while others worked “continuously on the creation of animals and plants.”\textsuperscript{121} Hartsoeker’s first element seemed a bottomless pit of Intelligences, each of which had its own special function in the guidance and conservation of matter. Consequently, Hartsoeker claimed that the life of the world’s soul was fueled by these thoughts or intelligent forces. So, conversely, “. . . the total extinction of thought would be the soul’s [and thus, the universe’s] actual death . . . ”\textsuperscript{122} To Fontenelle, Hartsoeker’s “prodigious number of Intelligences spread throughout” seemed a revival of the notion of Intelligences from ancient philosophy.

Fontenelle decried these intelligent forces, which he had “believed [to be] abolished forever.”

\textsuperscript{118} Nicolas Hartsoeker to Gottfried Wilhelm Leibniz, Düsseldorf, 30 Dec 1710, in C. I. Gerhardt, \textit{Briefwechsel zwischen Leibniz und Hartsoeker}, III, 514: « Les atomes, Monsieur, sont comme j’ai deja dit, de petites masses solides, simples, homogenes, d’une dureté invincible, et incapables par eux mêmes d’aucun mouvement et d’aucune chose. Mon premier element est une substance infinie où les atomes se meuvent de lieu en lieu, et dont ils recoivent tout leur mouvement et toute leur direction; enfin c’est l’ame de l’Univers, de sorte que l’on peut dire que l’Univers est comme un grand animal plein de vie et d’intelligence. »

\textsuperscript{119} Hartsoeker to Leibniz, Düsseldorf, 22 Aug 1710, Gottfried Wilhelm Leibniz Bibliothek, Hannover, LBr. 317. Also see, Gerhardt, III, 502: « . . . j’ai appelée premier élément, le feu tout pur, et l’ame de l’Univers . . . »

\textsuperscript{120} Hartsoeker used these two terms interchangeably.

\textsuperscript{121} Hartsoeker to Leibniz, Düsseldorf, 22 Aug 1710, Gottfried Wilhelm Leibniz Bibliothek, LBr. 317. Also see, Gerhardt, III, 502-503: « La premiere [substance] est douée d’intelligence, par laquelle elle a le pouvoir d’arranger sans cesse la matière comme nous le voyons, et toutes les intelligences ou ames particulières dont les unes travaillent continuellement au bien et à la conservation d’un systeme planetaire tout entier, comme sont le Soleil et les Etoiles fixes, et dont les autres travaillent sans cesse à la production des animaux et des plantes et à leur conservation etc. sont prises de cette substance et y retournent comme à leur source sans jamais s’aneantir, de sorte que cet axiome que rien ne se fait de rien, et que rien ne retourne à rien, est vrai à l’egard de l’une et de l’autre substance. »

\textsuperscript{122} Hartsoeker to Leibniz, Düsseldorf, 30 Dec 1710, LBr. 317. Also see, Gerhardt, III, 516: « . . . mais comme la vie de l’ame consiste dans la pensé, et que l’extinction totale de la pensé seroit sa veritable mort . . . »
Evidently, they had not been “banned enough” since they managed to resurge in “modern” philosophy, as Hartsoeker’s invocation of Intelligences illustrated.  

Hartsoeker did not see it Fontenelle’s way. Descartes’ and Malebranche’s paradigms were two probable but rather contradictory explanatory frameworks. While Hartsoeker considered both, he was concerned with how each adjudicated God’s role, causality (broadly defined), free will, and animal soul. The passage where he articulated his dissatisfaction with the problems inherent in these two metaphysical propositions is worth quoting at length:

To explain all those things, some Ancients have had recourse to some sort of Instinct, or to some Substantial Form, without explaining to us what this Instinct or Substantial Form was. The celebrated author of The Search after Truth [Malebranche] has had recourse to something he called ‘occasional causes’ in order to explain voluntary movement in animals, claiming that God himself does all of man’s actions at the instance when man wants them, and thus consequently it is God who does nothing but continually obey man’s will. Thus he made God intervene to explain the union of the soul with the body . . . But it seems to me that this great man [Malebranche] wanted to avoid a small evil and, instead, has fallen into a greater one. Lastly, some authors have had recourse to a plastic Nature, which, according to them, works continuously with art and method towards a certain goal intended by God, but without choice, intelligence [discernement] and knowledge of the technique [artifice] of its own Works. But in this case, this plastic Nature would only be a simple instrument in the hands of God, and consequently, one would have to agree with the author of The Search after Truth that God does everything himself, as if with his own hands.

In response to the constraints of Cartesian, Malebranchian and even some Platonist theories,

Hartsoeker launched the spiritual aspects of his system in the Seconde Partie de la Suite des Conjectures

123 Fontenelle, “Éloge de Monsieur Hartsoeker,” unpaginated: « A ce nombre prodigieux d’Intelligences répandus par-tout il (Mr. Hartsoeker) en ajoute qui président aux mouvemens celestes & qu’on croyoit abolies pour jamais. Ce n’est pas là le seul exemple qui fasse voir qu’aucune idée de la Philosophie ancienne n’a été assez proscrite pour devoir desesperer de revenir dans la moderne. »

124 Hartsoeker, Seconde Partie de la Suite des Conjectures Physiques, 19-20 : « Quelques Anciens ont eu recours pour expliquer toutes ces choses-là à je ne saï quel Instinct, ou à je ne saï quelle Forme Substantielle, sans nous dire ce que c’était que cet Instinct ou cette Forme Substantielle. Le célèbre Auteur de la Recherche de la Verité a eu recours à ce qu’il appelle causes occasionnelles, pour expliquer les mouvemens volontaires des animaux, prétendant que c’est Dieu lui-même qui fait dans un homme toutes les actions, à l’occasion que cet homme les veut, & que c’est par consequent Dieu qui ne fait qu’obéir continuellement à sa volonté. Ainsi il fait intervenir Dieu pour [p. 20 :] expliquer l’union de l’Ame & du Corps, & le mer comme un lien entre ces deux substances. Mais il me paroit que ce grand homme, pour avoir voulu éviter un petit mal, est tombé dans un plus grand. Enfin quelques Auteurs ont eu recours à une Nature plastique, qui selon eux travaille continuellement avec art & méthode, & pour une certaine fin que Dieu s’est proposée ; mais sans choix, sans discernement & sans qu’elle sache l’artifice de ses propres Ouvrages ; mais en ce cas cette Nature plastique ne seroit que comme un simple instrument entre les mains de Dieu, & par consequent il faudroit soutenir avec l’Auteur de la Recherche de la Verité, que Dieu fait tout lui-même comme par ses propres mains. »
Physiques, published in 1712, the year of Réaumur’s crayfish experiments. His conception of active souls boiled down to the following: Each living creature – animal or human – had two souls, a vegetative soul that was subordinate to the rational soul inhabiting the same body. While the vegetative soul was in charge of involuntary bodily functions, the rational soul controlled voluntary functions. The vegetative soul or “animal spirits” had the task to “strictly obey” the “orders” of the Rational Soul, which ultimately governed all operations between it and the body and between it and God. Hartsoeker explained his thinking with a metaphor: To make a machine work, one would need

either a weight or some spring mechanism that controls the entire machine, or some artisan, and most often the same Artisan who put the machine together. And seeing that there is neither a weight nor a spring in our Machine to make it run, one must have recourse to a Being or some Artisan who knows the entire construction of this Machine perfectly . . . And so, why shouldn’t I have recourse to an intelligence which resides in me and who knows all the organs inside and out and acts upon the orders she receives from my Soul to the best of her abilities? 

Hartsoeker speculated that each of these souls could very well be “a part of my first Element, which I have regarded as the Soul of the Universe, and which . . . have received the faculty of feeling, consciousness and thought” from God.

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125 Hartsoeker, Seconde Partie de la Suite des Conjectures Physiques, 15-16: “Quand il y a une machine, il faut pour la faire aller, ou un poids, ou quelque maître ressort qui domine sur toute la machine, ou bien quelque ouvrier, & bien souvent même l'Ouvrier qui l'a faite. Et comme il n'y a ni poids ni maître ressort dans notre Machine pour la faire aller, il faut qu'il y ait un Etre ou quelque Ouvrier qui sçait parfaitement toute la construction de cette Machine, qui l'a peut-être formée elle-même, & en a tracé les premiers [p. 16 :] crayons, & qui la peut faire aller d'une manière si reglée & si constante, pendant plus d'un siecle entier.

Lorsque j'étens, par exemple, mon bras, est-ce moi, ou pour mieux dire mon Ame, qui fait cette action par le moyen des organes de mon corps, elle qui n'a bien souvent aucune connoissance de ceux qu'il faut employer pour cet effet ? & ne dois-je pas avoir recours pour cela à une intelligence qui reside en moi, qui sçait parfaitement la disposition de tous les organes, & qui execute ponctuellement, autant qu'elle peut, les ordres qu'elle reçoit de mon Ame ?”

126 Hartsoeker, Seconde Partie de la Suite des Conjectures Physiques, 147-148 : « On ne peut donc tout au plus que deviner, dans une matiere aussi obscure & aussi éloignée de nos connoissances, & conjecturer que l'Ame ne soit peut-être autre chose, qu'une substance étendue & immatérielle ; c'est- [p. 148 :] à-dire, une portion de mon premier Element, que j'ai regardé comme l'Ame de l'Univers ; & que cette portion ait reçu de Dieu la faculté de sentir, de s'appercevoir & de penser, d'autant plus qu'il nous est presque aussi difficile, de concevoir quelque Etre réel, entièrement privé de toute sorte d'étendue, que d'en concevoir un qui n'ait absolument aucune especé de durée.”
Our Dutchman believed his ideas were a more satisfactory solution than Father Malebranche’s occasionalism and Ralph Cudworth’s Plastick Nature. Crucially, Malebranche’s and Cudworth’s proposed systems seemed to leave out altogether free will. This is something Hartsoeker repeatedly pointed out in his treatises from 1712 and ca. 1730. He believed his intermediary system of hierarchical intelligent and conscious spirits successfully addressed the problems created by the Malebranchian and Cudworthian systems. If, on the one hand, occasionalism was true, then God did “nothing but continually obey man’s will.” Occasionalism essentially meant that God alone brought about all phenomena of the body and the mind in accordance with a few simple laws of nature. If, on the other, a plastic Nature existed, then it worked “continuously with art and method towards a certain goal intended by God, but without choice, discernment [discernement] and knowledge of the technique [artifice] of its own Works.” Here, once again, “God [did] everything himself.” Clearly, Hartsoeker was frustrated with a metaphysics that posited God as an active force present in and responsible for every action of every living being. Every phenomenon would then become a miracle. The theory of Plastic Nature seemed too close in spirit to Malebranche’s occasionalism, and also suggested a passive world in which God ultimately did everything himself. At the same time, Hartsoeker had clearly rejected a system in which God watched the world unfold according to His set of preordained mechanical laws. To some extent, Hartsoeker’s invention of Intelligences solved this philosophical impasse. After all, they were the intermediary forces between God and matter and preserved freedom of will. They were semi-autonomous in that they learnt gradually how to adapt the body to the external environment.

Where did God reside then? In Hartsoeker’s universal scheme, God was everywhere and yet was not directly present. That is, God acted through the first element that arranged the atoms to form sensible bodies. In sum, “the Universe is like an animal, full of life and intelligence, because I

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conceive the first element to be endowed with life and intelligence under the direction of God, and
to move the bodies incapable of moving themselves."\textsuperscript{128} In his scheme, every living thing had an
intelligent soul. To be alive was to think. As a result of this doctrine, the Jesuits of Trévoux accused
him of ascribing divinity to the universe itself. Leibniz was also shocked at his ideas. He reproved
Hartsoeker: If the universe is like an animal, then one may take it to mean that God is the soul of
this animal, instead of being the \textit{Intelligentia supramundana}.\textsuperscript{129} In this respect, Hartsoeker’s formulation
seems a fusion of cosmic vitalism and immanent vitalism (neither of which were mutually exclusive),
as defined by Kevin Chang. The former “presumed a principle of life that originated in the heavens,
pervaded the cosmos and gave both life and form to corporeal beings. This principle of life was
often identified as astral bodies, the universal spirit or \textit{anima mundi}.” The latter, in contrast,
“postulated a vital principle that was embodied in, and immanent to, the most fundamental unit of
matter, the monad or \textit{semina}, for example. This vital principle was the form of an organism, thus its
formal cause. It was also its efficient cause, as it directed the developmental course of the organism.
It was even the final cause of the organism, considering that it incorporated in itself the end of the
living organism.”\textsuperscript{130}

This schema becomes more evident in Hartsoeker’s letter to Jean Le Clerc that was
published posthumously in 1730 in a compilation of writings entitled \textit{Cours de Physique}. There,
Hartsoeker gave more concrete form to the Intelligence he had introduced after the crayfish
experiment. This very “same Intelligence” had “invisibly built & constructed this animal in the body

\textsuperscript{128} Nicolas Hartsoeker, \textit{Suite des Eclaircissens sur les Conjectures Physiques} (Amsterdam : Nicolas Viollet, 1712), 67: « J’ai dit que l’Univers est comme un Animal plein de vie & d’intelligence, parce que je conçois que le premier Element peut être doué de vie & d’intelligence sous la direction de Dieu, dont il est un Etre subalterne, & mouvoir les Corps qui sont incapables de se mouvoir eux-mêmes. »

\textsuperscript{129} Leibniz to Hartsoeker, Hannover, 6 Feb 1711, LBr. 317 (or Gerhardt, III, 520): « Il n’est pas permis de dire que l’Univers est comme un Animal plein de vie et d’intelligence: car on seroit porté à croire après cela que Dieu est l’ame de cet animal, au lieu que Dieu est Intelligentia supramundana, qui est la cause du monde... »

\textsuperscript{130} Ku-Ming (Kevin) Chang, “From Vitalistic Cosmos to Materialistic World: The Lineage of Johann Joachim Becher and Georg Ernst Stahl and the Shift of Early Modern Chymical Cosmology,” in \textit{Chymists and Chymistry: Studies in the History of Alchemy and Early Modern Chemistry} (Sagamore Beach, MA, 2007), 221.
or, better said, in one of the testicles of the male, which had fathered it, . . . with art and science, in accordance with the power she received to do this from a superior Intelligence.” Like an internal engine, the Intelligence took care of this animal as much as she could over the course of her life. “It seems without question to me that there are subaltem Intelligences to God that have a portion of matter, which they may arrange freely, under their own direction,” Hartsoeker hypothesized. After all, these Intelligences made mistakes and “fail[ed] in their creations.” “We have ourselves as examples,” he wrote, “for who would like to maintain that God Himself moves our limbs, & that the Intelligence, which lives in us indisputably, has no other role but to will this; and that God Himself makes the blood & the humors in our body circulate continuously by means of the systole & the diastole of the heart, & by the peristaltic movement of veins, through which the blood & the humors flow; or that all this is done by the laws of motion?”

This late text raises a spate of questions. Did Hartsoeker not think it problematic that animals had thinking souls or Intelligences that guided them from existence onwards and left them at death? And why should there be two separate souls, a vegetative and a rational soul, in an animal rather than one? And what about the problematic fact that his Intelligences had finite “lives,” as he seemed to imply here? In his contrivance of Intelligences, was he himself not resorting to occult causes, for which he frog-marched Newton and others with vainglorious passion?

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131 Nicolas Hartsoeker, « Lettre a Monsieur Le Clerc sur quelques endroits de la Philosophie Newtonienne, » Cours de Physique, 1730, 8: “Mais si cela est, dont il n’y a presque pas lieu de douter, on peut croire avec assés de fondement, que la même Intelligence a fait & fabriqué cet animal dans le corps, ou pour mieux dire, dans un des testicules du mâle qui l’a engendré; qu’elle l’a fabriqué invisiblement avec art & science, selon le pouvoir qu’elle a reçu pour cela d’une Intelligence supérieure, & qu’elle en a soin autant qu’elle peut, pendant tout le cours de sa vie. Qu’il y ait des Intelligences subalternes à Dieu, qui ont sous leur direction une portion de la matière, don’t elles disposent avec liberté, puisqu’elles manquent assés souvent dans leurs ouvrages, cela me paroit hord de doute, & nous en avons une preuve assés convaincante en nous mêmes; car qui voudroit soutenir que Dieu lui-même remuë nos membres, & que l’Intelligence, qui réside sans contredit en nous, n’y a d’autre part que de le vouloir; que Dieu lui-même fait circuler continuellement le sang & les humeurs de notre corps, par la systole & la diastole du coeur, & par le mouvement peristaltique des vaisseaux par où le sang & les humeurs coulent; ou que tout cela se fait par les loix du mouvement?”

More confusing still was Hartsoeker’s ambiguous use of Intelligence and soul as synonymous. Evidently, this question of souls or Intelligences occupied him at least throughout the last fifteen years of his life, if not before. Towards the end of his life, Hartsoeker still puzzled over the origin and nature of this Intelligence, with which everything in the universe was imbued:

. . . I resolved finally to conjecture that there is only one soul in us that does everything. Moreover, I conjectured that this soul might well be nothing other than a portion of the soul of the universe, which I called in my works on physics the first element or perfectly fluid substance, and which, having extension like matter—although otherwise essentially different from it—can impel bodies and be impelled by them, give them movement and receive movement from them; and I resolved all the more readily to make this conjecture in that I freed myself thereby from the great difficulty that men have always had in conceiving how communication can occur between soul and body. In this way, I conjectured that the soul is spread out through the whole body . . .

In characteristic fashion, Hartsoeker let his conjectures explain how the soul works or thinks. He believed his thinking free from the artificial, and unproductive, construct of the dichotomy between body and soul. While the soul was “a wish and gift of [the infinite and all-powerful] God,” whose nature was out of his reach, conjectures could approximate the communication between mind and body.

Conclusion

Hartsoeker’s notion of Intelligences in explaining regenerative phenomena, as those of crayfish, had an afterlife. In fact, it found resonance in later experiments conducted by Charles

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133 Hartsoeker, “Remarques sur une Thèse de Physique . . .,” Recueil de plusieurs pièces de physique, 195-196: “. . . je me déterminai à la fin à conjecturer, qu’il n’y a en nous qu’une seule âme qui y fait tout. De plus je conjecturai que cette âme pourrait bien n’être autre chose qu’une portion de l’âme de l’Univers que j’ai appelée dans mes Ouvrages de Physique, premier Élément ou Substance parfaitement fluide, & qui, étant étendue comme la matière, quoique pour le reste elle en diffère essentiellement, peut pousser les corps & en être poussée, leur donner du mouvement & en recevoir; & je me déterminai d’autant plus à faire cette conjecture, que je me livrerais par là de la grande difficulté qu’on a toujours eue de concevoir, comment se peut fai- [p. 196] re la communication entre l’âme & le corps. Ainsi je conjecturai que l’âme est repandue par tout le corps . . .” Here I follow Robert Ellrich’s translation in Roger, The Life Sciences in Eighteenth-century French Thought, 349.

134 Hartsoeker, “Remarques sur une Thèse de Physique,” Recueil de plusieurs pièces de physique, 197-198: “Si l’on me demande encore com-[p. 198] ment une portion de la substance parfaitement fluide, dont je viens de parler, peut penser par le moyen des esprits animaux, je n’ai autre chose à répondre, sinon, que c’est la volonté & un don de Dieu qui est infini & tout-puissant . . .”
Bonnet, Abraham Trembley and Réaumur on regenerative faculties of worms and polyps in the early 1740s. The question of animal soul continued to animate the investigations of these naturalists and animal experimenters. During the sectioning of worms and polyps, Bonnet witnessed that they not only remained alive, but also reproduced their amputated parts. Like Hartsoeker, Bonnet remained skeptical of interpretative frameworks such as Descartes’ soulless animal automata and Malebranche’s passive *enboîtement* theory (where germs were encased one within the other from the beginning of life and time). However, he was definitely intrigued by Jean-Louis Calandrini’s system of germs. Calandrini’s theory of germs posited that germs with soul-like properties caused the reproductions in polyps.\(^{135}\) In some respects, his hypothesis was similar to that proposed sketchily by Réaumur to explain regrowth of limbs in crayfish (seen above). The reason why Calandrini’s germ theory proved so enticing to Bonnet was that it could possibly offer a metaphysical basis for the polyp’s organizational complexity and functional unity. Trembley’s experiment of cutting the polyp in sections lengthwise should have destroyed the polyp’s “‘Animal Oeconomy’.” Instead, Bonnet, like Hartsoeker on the crayfish, believed the polyp’s regenerative behavior suggested the possibility of a soul, similar to that in man.\(^{136}\) In a 1742 letter to Professor Gabriel Cramer, Charles Bonnet asked if “‘The partisans of the system of Mr Hartsoeker’s *Intelligences rectrices* would not think themselves well supported by a similar experiment [on the polyp]?’”\(^{137}\) Bonnet would only read Leibniz’s *Theodicy* in 1747, after reflecting on Trembley’s, Réaumur’s and his own experiments on


\(^{137}\) Bonnet cited in Dawson, *Nature’s Enigma*, 163 and n163: “Je souhaiterois bien de savoir, mais je crains, Monsieur, d’abuser de votre complaisance, si l’expérience que je fais de couper à un même par la tête et la queue à mesure qu’elles lui reviennent vous paroit aussi curieuse qu’elle me le semble. Elle peut fournir au moins des éclaircissements à plusieurs questions intéressantes dont j’aicott quelques unes dans ma Lettre à M. de R. de 23 Juin dernier. Je fais aujourd’hui la 7e coup. Les partisans du systeme de *Intelligences rectrices*, du M. Hartsoeker, ne seraient-ils pas cru[s] bien appuyés par une semblable experience?” Bonnet to Cramer, 17 August 1742, Ms Suppl. 384, Bibliothèque Publique et Universitaire de Genève. Based on Dawson’s citation of the original letter (see above), I have somewhat changed her English translation of the last sentence.
aphids. While Hartsoeker did not appear troubled by the consequent metaphysical impasse of animal soul that his Intelligences inevitably gave rise to, later experimenters like Bonnet definitely were.

Hartsoeker’s gradual modifications to his Cartesian-inspired atomist system of nature show that he, like others before and after him, was struggling with the problems posed by Descartes’ philosophy. After all, the battle for a coherent explanatory model of nature in a post-Cartesian world was at hand before Réaumur’s crayfish experiments in 1712. The example of the regenerative crustacean challenged Descartes’ stark division between body and mind, material and mental processes. While physical matter could be divided, cut and quantified, the mind was indivisible, immaterial and invisible. In addition, a rather arbitrary phenomenon like regeneration in crayfish called into question Descartes’ denial of intelligent minds in animals. More specifically still, in the old Cartesian model of the animal machine life depended on the organization of its parts. Such a system inevitably broke down when marshaled to explain the rebirth of such complex, living organs like crayfish limbs in ever more, in the words of Hartsoeker, “organized bodies.” The regeneration witnessed in crayfish centered on this fundamental difference in matter and mind, body and soul. Because the crayfish regrew their limbs, Hartsoeker attributed the phenomenon to a conscious, intelligent mind rather than to a mute, inanimate bodily machine. Though not demonstrable, Hartsoeker’s intelligent spirits that grew and learnt various tasks over time in the bodies that they inhabited accommodated free will. At the same time, these Intelligences worked on God’s behalf. Hartsoeker hoped he could thus resolve God’s constant action in creation and propose a less deterministic and a more all-encompassing cosmology. What mattered to him was

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139 Hartsoeker, “Remarques sur une These de Physique…,” *Recueil de plusieurs pieces de physique*, 196-197: “… cette ame a soin, autant qu’elle peut, de son domicile, le guérissant quand il y manque quelque chose ou qu’il est blessé; que cette ame fait & fabrique, pour ainsi dire, dans les testicules des mâles, d’autres corps organisez [my emphasis] qu’elle anime, en leur donnant une portion [p. 197:] de sa propre substance…” See the expression also in the title of his article in the *Bibliothèque ancienne et moderne* 18 (1722) cited above.
that leg regeneration in crayfish was a physical fact that offered support for a newer version of his physical system, that of an intelligent soul which organized matter in the body.

On another level, Hartsoeker’s treatment of the crayfish could illuminate another domain in seventeenth century natural philosophy: natural history. Much recent historiography has demonstrated the relevance and importance of the descriptive sciences, such as botany and anatomy, in the development of natural philosophy. In addition, this story informs the historiography of collecting curiosities and wonders of nature. It is noteworthy how representations of crayfish changed throughout the seventeenth century. Naturalists such as Conrad Gessner (in 1551-1558), Pierre Belon (in 1553), François Bousseut (in 1558) and Ulisse Aldrovandi (in 1606) described the crayfish in great detail and presented images of crayfish lying dorsally or in action, wrecking ships, swallowing men and combatting other marine creatures (FIG. 7, 8 & 10-14). Such elaborate illustrations accompanied the extensive essay entries that detailed the crayfish’s physical characteristics, habitat, medicinal and culinary uses and allegorical references. In the middle of the seventeenth century, naturalists like Joannes Jonston (in 1657) depicted crayfish more soberly and refrained from luxuriating in the mythical and cultural particulars of the crayfish as Aldrovandi and Gessner had done before him (FIG. 15 & 16). A progressive stripping down of the animal’s “emblematic” importance seems to have taken place over the course of the seventeenth century in

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141 Ogilvie, The Science of Describing. Anthony Grafton and Nancy Siraisi, eds., Natural Particulars: Nature and the Disciplines in Renaissance Europe (Cambridge, MA, 1999). Sachiko Kusukawa, “Leonhart Fuchs on the Importance of Pictures,” Journal of the History of Ideas 58 (1997): 403-427. Ogilvie draws attention to the dubious status of natural history as a discipline that is neither entirely comfortable as botany nor as medical pharmacology or encyclopedism. To Vives, natural history is a literary genre; to Bacon, it is a history of creatures, marvels, and arts. Thinkers were also divided on whether it was a method of learning or a source of knowledge itself.

Kusukawa paints the complex interaction of pictures and textual description in her article on Leonhart Fuchs who argued that pictures are more powerful than words. It is interesting that botanists like Montuus could argue that words are less treacherous than images when it comes to differentiating between essential and accidental characteristics of specimens.

works of natural history: The crayfish gradually ceased to be an object on which a plethora of classical references, naturalistic descriptions, and symbolic associations were hung.\textsuperscript{143}

In addition, the crayfish experiments show us what happens when natural history is taken up by a natural philosophical program. By 1712, Hartsoeker’s and Réaumur’s examination of the crayfish entailed observing, cutting and taking it apart, as if it were a living machine.\textsuperscript{144} The viewer of the focused, schematic engraving of Réaumur’s crayfish was invited to follow visually the sectioning of its leg and its subsequent regrowth (FIG. 9). The live act of regeneration of the limb at the severed joint was captured in magnified fragments which tracked its progression over time. To the academicians, the crayfish was no longer an animal to be described, equipped with a myriad symbolic meanings and cultural uses, as it was the case in naturalists’ work a century ago. Its limb regeneration was a natural phenomenon that required systematic analysis. Nowhere was this irritation with the emblematic approach more evident and striking than in Fontenelle’s passing, derisive remark on Van Helmont’s fantastical—and thus “compromising” and untrustworthy—crayfish lore. Fantastical illustrations of crayfish now lived in books and paraphernalia that were meant to entertain and amuse, as the final hand-painted leaf from an eighteenth-century German album amicorum shows (FIG. 17). In the illustration, the traditional belief that crayfish underwent moulting during a full moon is linked to the iconography of the moon goddess Luna. Here the crayfish figure not as specimens to be studied or experimented upon by academicians or eager

\textsuperscript{143} William B. Ashworth, “Natural history and the emblematic world view,” in Reappraisals of the Scientific Revolution, eds. David C. Lindberg, Robert S. Westman (Stanford, CA, 1990), 303-333.

\textsuperscript{144} Bredekamp, The Lure of Antiquity and the Cult of the Machine, 26: “In earlier times, physics represented the knowledge of heavenly and terrestrial movements deriving purely from contemplation, and mechanics was a branch of the craftsman’s trade. Now the two had merged as theoretical speculation began to avail itself of mechanical aids to foray into nature. Surrounded by technical instruments and appearing to be a kind of living counterpart to the Cardinal, the globe seems to be a monument-like personification of this new conception of mechanics.”
princes; they, instead, embody local lore mixed with mythology in a playful way, and are not meant to be “‘true portrait’ of nature.”

The last hour for the emblematic world view had rung.

To my knowledge, Hartsoeker never reproduced Réaumur’s or any other image of the crayfish in his treatises. For all his formidable skill with microscopes, he merely reported his experiments and those of Réaumur in words, without any visual accompaniment of the celebrated crustacean. To him the crayfish was not a wonder of nature in the sense of a curiosity to be kept in a shiny glass cabinet. Rather it became a crucial block, upon which Hartsoeker’s mechanical system first stumbled and which he subsequently employed to amend his system of nature. Hartsoeker went beyond the Baconian program of “twisting the lion’s tail” to see how nature would react. He was not quite satisfied with a natural historical approach that confined itself to observation, description and occasional speculation. What mattered to him was that leg regeneration in crayfish was a physical fact that offered support for a newer version of his physical system, that of an intelligent soul which organized matter. While the crayfish’s ability to regrow full limbs was exceptional and extraordinary in kind and extent, it instantiated and became emblematic of Hartsoeker’s Intelligences.

Finally, and most importantly, Hartsoeker’s understanding of regeneration in crayfish tells us not only something about the omnivorous character of system building, but also something about the difficult practice of observing partially visible natural phenomena. Above all, Hartsoeker prized theoretical unity as well as inclusiveness of all phenomena above complete, fool-proof, demonstrable certainty in his system of nature. This choice carried with it both costs and gains. As the number of phenomena he sought to explain increased, his hopes for a general theory that would account for everything dwindled. To manage the situation, he arrogated to himself the right to speculate given the limited evidence but infinite possibilities. Conjectures in the practice of natural history,

astronomy, medicine and other domains happened during observation of unknown or poorly understood phenomena. In the case of the crayfish, their regenerative abilities and seasonal shedding of their shell left many questions unanswered. Much of the style in which Réaumur wrote down his observations was conjectural and eluded facile interpretations. It was not always evident which observed facts should be lumped together or nipped off in order to forge a sound explanation. But conjectures, by definition, did not have to turn out to be true. This open-endedness was conducive to creative thinking and problem solving. It also fostered a multitude of possible answers for a puzzling phenomenon and opened subsequent avenues for future experimentation. For example, when Réaumur wanted to explain why crayfish lost their shell, he posited his conjecture on the basis of a few observations that seemed to provide a plausible explanation for the frequent (almost annual) moult among these atypical aquatic anthropods. These observations included comparing the size of the shell-less (or moulting) crayfish to its original, cast-off exoskeleton, and measuring of the animal’s antennas and limbs. As Réaumur explained in detail:

Their shell becomes too short and too tight; it becomes uncomfortable for them and thus necessary that they cast it off. This conjecture seems reinforced by an observation that I have made. I have observed that each body part of a Crayfish that has recently undergone mouling is considerably larger in every respect than the shell that it has [just] shed. I have measured the horns or antennas & the Legs, & the respective shell encasements where they all have resided [before the moult], & I have found a big difference, even though the forms [moultes] of the Legs should have lengthened themselves due to the rupture of the membranes during the process of the moult that we have discussed before. As for the horns or antennas, which are easier to measure precisely, I have found that they exceed by at least one-fifth the length of the shell cover they have abandoned.146

Quantification, measurement and careful comparison shored up a powerful conjectural interpretation of an observed phenomenon. Réaumur’s careful observations yielded some potential new ground in the form of hypotheses, which could in turn be tried and put to the test at a later date. In a similar vein, Réaumur conjectured as to the origins and reason why crayfish had small rocks in their stomachs, which promptly disappeared after these shellfish finished their moult:

I interpret the two stones, known as “the Eyes of Crayfish,” as a substance made and reserved for the purpose of hardening the Shell. It is known that one not always finds these kinds of rocks in Crayfish; one can follow their [the rocks’] varying levels of enlargement, when one opens Crayfish at different stages . . . and ultimately, when one opens the Crayfish when its Shell has completely hardened according to its natural state, [one will find that] the two rocks have disappeared. Does it not seem from this that one increases at the other’s expense, since as the Carapace hardens, the rocks diminish in volume; and then one can no longer find them, when the Shell has hardened? Is it not natural to think that these stones have dissolved, and that their lapidose juice is thus taken to and deposited in the chinks between the fibres of the soft skin? When the Carapace has hardened to a certain point, it not longer admits the rocky particles; [and thus] its hardness stops there.

The language Réaumur employed in this paragraph is striking for the ways in which it marries observations of an elusive phenomenon with possible explanations for its occurrence. As if thinking aloud, Réaumur appealed to the common sense of the reader when he posed the following questions, “Does it not seem from this that one increases at the other’s expense . . . ?” and “Is it not natural to think that these stones have dissolved . . . ?” Without introducing or justifying his conjecture upfront, Réaumur relied on persuasive, deliberate rhetoric and the explanatory force of his repeated and extensive observations to convince his reader.

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147 The potential role of gastroliths in the formation of new shells after moult in crayfish, lobsters and other crustaceans continued to fascinate scientists well into the nineteenth century. See, Herrick, The American Lobster, 94.

148 Réaumur, “Additions Aux Observations sur la Muë des Ecrevisses, données dans les Memoires de 1712,” 271: “Je regarde les deux pierres connues sous le nom d’Yeux d’Ecrevisses, comme la matière preparée & mise en reserve pour servir dans le besoin à endurcir l’Ecaille. On sçait qu’on ne trouve pas en tout temps de ces sortes de pierres aux Ecrevisses, on peut suivre leurs differentes degrés d’accroissements, si on ouvre des Ecrevisses en differents états . . . & enfin si on ouvre l’Ecrevisse quand son Ecaille a pris toute la dureté qui lui est naturelle, les deux pierres sont disparues. Ne semble-t-il pas de là que l’une augmente aux dépens des autres, puisqu’à mesure que l’Ecaille se dureit, les pierres diminuent de volume; & qu’on ne les trouve plus, quand l’Ecaille est devenuë dure? N’est-il pas naturel de croire que ces pierres sont dissoutes, & que leur suc pierreux est ensuite porté & déposé dans les interstices que laissent entr’elles les fibres don’t la peau molle est composée. L’Ecaille étant devenuë dure jusqu’à un certain point, elle ne permet plus l’entrée à ces parties pierreuses; sa dureté en reste là.”
In one of her most recent contributions, Lorraine Daston traces the changing relationship between observation and conjecture over the course of the seventeenth and eighteenth centuries. She shows how a late-seventeenth-century propensity to strictly divorce observation from conjecture flipped to a point where “observation became a tool of conjecture.” In the older approach, observation antagonized conjecture; it was perceived as an antidote to feeble hypotheses and attempts at system-building. This changed in the eighteenth century, Daston argues. To eighteenth-century naturalists and others whose work centered on repeatedly making observations, “observation was a way of reasoning about, not just collecting experience: while it was deplorable to observe with prejudice for or against a system, it was utter folly to observe without ideas.”\(^{149}\) In those terms then, Réaumur emerges before us as an early example of this emergent eighteenth-century trend. As in the quoted passages above, Réaumur did not try to strictly abandon conjectures in his observations out of fear of sounding like a foolhardy hypothesist. In fact, his observation became the locus where he could air his conjectures and later refine, disprove or confirm them.

Réaumur, however, remained agnostic about enlisting his conjectures in any particular theoretical program. Hartsoeker, meanwhile, went a step further and made them the principal feature of his system building. The making of conjectures constituted his chosen method of inquiry. In original ways, Hartsoeker actively cultivated his conjectures in tandem with empirical observations in updating his explanatory system of physics. Hartsoeker stood at the junction between the emergent trend where “observation became a tool of conjecture” and the older notion that deemed a union of the two as unsavory and dangerous. Such a volatile marriage had to be dissolved, for it smacked of system spinning. But Hartsoeker skillfully combined observations and conjectures in less obvious fashion: He employed them to support his theoretical system in ways that borrowed from natural history; he anticipated their future potential as a tool for reasoning.

about, building upon, and understanding observations; and he helped to redefine their status as positive, creative, fertile methods in mitigating the ubiquitous problem of incomplete, opaque and often perplexing natural phenomena. “We are indebted to the speculations of Physicists” for “the discovery of a new World, and the enormous treasures that come from it,” Hartsoeker wrote in the preface to his *Conjectures physiques*. “A cornucopia of very useful things follows from the source of a purely speculative truth, for the essence of truth is fecund & a discovery never goes alone but usually brings an infinity of others with it.”

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150 Nicolas Hartsoeker, “Avertissement” to *Conjectures Physiques*: “Mais à qui est-on redevable qu’aux Physiciens & aux Mathematiciens des Arts Mechaniques qui servent à la commodité de l’homme? C’est à eux qu’on doit la découverte d’un nouveau Monde, & les trésors immenses qui en viennent, par l’invention de l’aiguille Aimantée; & ainsi l’on voit arriver très-souvent, qu’une infinité de choses très-utiles découlent de la source d’une vérité purement speculative: car il est de l’essence de la vérité d’être feconde, & une découverte ne va jamais seule, main en amene d’ordinaire une infinité d’autres avec elle.”
FIG. 13. François Boussuet, *De natura aquatilium carmen, in universam Gulielmi Rondeletii . . . quam de Piscibus marinis scriptit historiam: cum vivis eorum imaginibus [sic], opusculum nunc primum in luce emissum* (Leiden, 1558), pp. 196-197.
FIG. 15. Joannes Jonston’s crayfish, *Historia naturalis de exanguibus aquaticis libri IV cum figuris æneis* (Amsterdam, 1657), Table III, opposite p. 16. Courtesy of Princeton University Library, Department of Rare Books and Special Collections.
FIG. 16. Joannes Jonston’s lobster and crayfish, *Historia naturalis de exanguibus aquaticis libri IV cum figuris Æneis* (Amsterdam, 1657), Table II, opposite p. 12. Courtesy of Princeton University Library, Department of Rare Books and Special Collections.
FIG. 17. Crayfish powering the chariot of Luna, the ancient Roman goddess of the moon and the hunt. C. H. Leopold, Album Amicorum of Johann Conrad Ihring, 24 April 1719, KB 74 H 47, fol. 71r. Special Collections, Royal Library, The Hague, The Netherlands.
Chapter 5: Epilogue

Reception of Nicolas Hartsoeker’s Ideas: A Seeker of the Truth Mistaken for a Polemic?

When Nicolas Hartsoeker was criticized for attacking Descartes and other Cartesians, he replied with the following: “I do not attack his person but his ideas—which should be allowed to anyone who seeks the truth. And if, from this perspective, someone would attack mine, rather than being upset, I would be very much obliged to the person who would do me the honor; all the more so since this would give me the opportunity to further clarify and correct my own ideas.”¹ Yet such a proclamation fell on deaf ears with Bernard le Bovier de Fontenelle, the Perpetual Secretary of the Royal Academy of Sciences from 1699. He himself prosecuted Hartsoeker quite harshly for abusing the Academy’s rules for civil philosophical debate. “He often protests in apparent great sincerity that he is only offering simples conjectures; he would be advised to be reasonable and leave those of others in peace. All conjectures have an equal right to see the time of day, and often have nothing at all to do with battling each other,” wrote Fontenelle about Hartsoeker.² Fontenelle’s caustic remark in the *Éloge* of this foreign academician (*associé étranger*) seems especially polemical, since a eulogy was traditionally meant to celebrate an individual’s life and achievements. Conversely, Fontenelle’s *Éloges* were critiques of the lives of natural philosophers, not mere portraits. With an eye to the moral,

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¹ Nicolas Hartsoeker, *Éclaircissements sur les Conjectures Physiques* (Amsterdam, 1710), 103 : « Je n’attaque pas sa personne mais ses sentimens, ce qui devroit être toujours libre à quiconque cherche la vérité ; & si l’on attaque les miens dans cette vue, bien loin d’en être fâché, je serai très-obligé à celui qui me fera cet honneur, d’autant plus que cela me donnera occasion d’éclaircir de plus en plus mes sentimens, & de les rectifier. »
² Bernard le Bovier de Fontenelle, « Éloge de M. Hartsoeker, » in *Éloges des Académiciens de l’Académie Royale des Sciences, morts depuis l’an 1699*, Tome II (Paris : Libraires Associés, 1766), 250-251 : “Il proteste souvent, & avec un grand air de sincérité, qu’il ne prétend donner que de simples conjectures : il seroit donc assez raisonnable de laisser celles des autres en paix ; elles ont toutes un droit égal de se produire au jour, & souvent n’en ont guères de se combattre.”
mental and aesthetic values Fontenelle ascribed to the sciences, it becomes apparent he not only popularized figures in the sciences, but also helped define their language, goals, and moral code.³

Behind the preceding remark, however, hide Fontenelle’s expectations and rules for communicating natural philosophical thought in the Parisian Academy of Sciences and the Republic of Letters at large. Fontenelle hoped the new institution of the scientific academy would dissolve the differences that public debates had sparked. In fact, he believed that “‘physics holds the secret of shortening countless arguments that rhetoric makes infinite.’” Consequently, the creation of the academy was to improve collaboration, minimize prejudice, and eliminate the dominance of one doctrine or philosophy over another.⁴ Of course, some kind of official modus operandi had to be established in combination with behavioral norms that would define its community. As the academy’s secretary and author of the Histoire de l’Académie Royale des Sciences (1666-1699), Fontenelle emphasized not jumping to conclusions prematurely and not choosing one philosophical system over another. In the same spirit of Bacon’s program, which was taken up and cultivated by the Royal Society, Fontenelle believed that the sciences advanced over time. Moreover, he was convinced that the sciences would develop most successfully from the meticulous accumulation of numerous experiments and theories rather than from favoring one specific explanatory system or worldview.⁵

At the same time, Fontenelle was promoting a particular kind of academician, philosopher and savant—one whose selfless pursuit of truth Fontenelle saw as man’s highest aspiration and moral virtue, in contrast to the self-interested, less enlightened individual.⁶ Hartsoeker’s perceived violation of the rules of valid discourse in the Republic not only garnered criticism from Fontenelle,

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⁵ Hahn, 31-33.
but also received commentary from a few journal editors, book reviewers, and Hartsoeker’s contemporaries. Nonetheless, not everyone agreed completely with Fontenelle’s point of view on Hartsoeker’s lack of decorum. As we will see in the following discussion, views about Hartsoeker’s work among various participants and reviewers in the Republic of Letters were quite divergent.

It is unclear whether Nicolas Hartsoeker was still alive when Fontenelle circulated his Éloge de M. Hartsoeker. The Éloges were typically read at the Royal Academy a few weeks or months after the academian’s death. It appears, however, that Hartsoeker was aware of Fontenelle’s Éloge, or at least of the accusations contained within. It prompted him to publish a letter to Fontenelle in which he addressed his grievances. Hartsoeker inserted the letter right before Fontenelle’s Éloge, both of which were published posthumously in 1730 in a final compilation of some of Hartsoeker’s new treatises. Even after Hartsoeker’s death, his sons interceded on behalf of their father and sent a letter to the Journal Littéraire. Upset that Fontenelle had “criticized his [Hartsoeker’s] Philosophical Freedom,” they requested that he redact some of the things he wrote about their father in the Éloge. Hartsoeker’s sons argued that Fontenelle had wrongly and rudely characterized “some specific thoughts of Mr. Leibniz” in the latter’s letter exchange with Hartsoeker. They continued, “... if such 4Expressions, for which Monsieur Hartsoeker is so blamed, . . . were not allowed in the Republic of Letters, do you believe that an infinity of illustrious savants, & even the most grave & the most moderate ones, would use them so familiarly and with such impunity?”

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7 Fontenelle began writing the Éloges des Académiciens in 1697 and began publishing them in 1708. Many subsequent editions followed. Often, individual Éloges were available to the general public after a member died. See Betty Trebelle Morgan, Histoire du Journal des Scavans depuis 1665 jusqu’en 1701 (Paris: Les Presses Universitaires de France, 1929), p. 220. However, according to Charles Paul’s Science and Immortality, Hartsoeker’s Éloge was published in 1725 and read publicly on May 4, 1726, as seen in the Procès-Verbaux of the Paris Academy of Sciences and printed in the Index Biographique des Membres et Correspondants de l’Académie des Sciences (Paris, 1968), 113. Another source reports that someone informed Hartsoeker that he had been “too harshly treated” by the Parisian Academy of Sciences, which prompted him to write an “Apology, which he was not able to finish” before his death. See [Author unknown], Levensbeschryving van eenige voornaeme meest Nederlandsche Mannen en Vrouwen, part 2 (Amsterdam: Petrus Conradi, 1775), 193.

8 Journal littéraire VI, part 2 (1730), Art. I, 275.

Fontenelle’s attacks had gone too far and eclipsed their father’s person and intellectual contributions.

To other contemporaries, Hartsoeker’s work in optics and the life sciences was most important. In particular, they were most concerned with his contributions to optics, microscopical observation of microorganisms and his vitalist emendations to mechanist explanations of nature. Leibniz, for instance, cited Hartsoeker alongside Malebranche, Bayle and Swammerdam in support of the theory of the preexistence of germs. In his 1710 *Essais de théodicée*, Leibniz used these authors’ support for the preexistence of germs to argue that the doctrine of preexistence applied not only to the material structure of living bodies, but also to the ensoulment of matter. That is, just as bodies were thought to have been created at the beginning of time and lay dormant in seed and semen until they developed, so too animal and human souls were encased in those seeds from the start. Leibniz added that microscopic observations, including those of Hartsoeker, seemed to corroborate this theory.¹⁰ *Le Journal des Savants* remembered both Hartsoeker and Leibniz as proponents of the preexistence of germs in generation debates well into the nineteenth century.¹¹

This chapter looks at several journals that published Hartsoeker’s works and at the reviewers who were in conversation with him. In particular, I examine reviews from *Le Journal des Scavans, Journal Littéraire, Bibliothèque Choisie, Nouvelles de la République des Lettres, Mémoires de Trévoux, Boekzaal van Europe*, as well as mentions in books, essays and personal correspondence written by his publishers, colleagues, critics, and intellectual heirs. Several themes concerning Hartsoeker’s reputation in the Republic of Letters from Chapters Three and Four are further explored here. I investigate Hartsoeker’s supporters as well as detractors and the impact they had on the future reception of his works. Overall, Hartsoeker’s natural philosophical work—no matter how he sought

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to distance himself from the French philosopher—demonstrates his continued indebtedness to
Descartes, as many of his contemporaries observed. At the same time, his works’ reception, both
positive and negative, highlights the larger, vigorous debates of the period in which Hartsoeker as
well as his reviewers were active participants. In this chapter, I argue that their response sheds light
not only on what contemporaries made of Hartsoeker’s ideas and how they esteemed his
contribution, but also on how natural philosophical debates unfolded and what kind of rules
governed the different discussion fora that made up the Republic of Letters. More specifically still,
Hartsoeker’s case demonstrates how varied ideas of proper intellectual exchange actually were within
the Republic of Letters. In other ways, Hartsoeker was an advocate of adversarial knowledge
production, one whose vociferous public persona anticipated some of the combative polemics of
post-1720s French scientific discourse described by J. B. Shank.12 To this end, a closer look at
literary periodicals, explanatory or “clarifying” publications,13 and personal correspondence can
illustrate what research in natural philosophy or “la physique” meant and how it was being defined in
the late seventeenth and early eighteenth centuries.

Under the Lens of Literary Journals

Le Journal des Scavans

Most journals that reviewed newly published works or featured extracts from them offered
the reader a medley of articles, ranging from theological and medical to philological and antiquarian
topics. Most importantly, “Journals often functioned as a central node in the network of savants;
their necessarily far-flung correspondence and wide span of readers made them in many ways an

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13 By “clarifying” publications I mean works entitled, Éclairissements or Suite des éclairissements (such as Hartsoeker’s
Éclairissements sur les Conjectures Physiques), which served as follow-ups in intellectual debates, and offered extended
commentary on unresolved questions.
institutional equivalent of the scholarly intermediary.” Among the journals that commented on Hartsoeker’s publications, the *Journal Littéraire* and *Le Journal de Sçavans* were the most natural philosophical in character; they frequently discussed astronomical phenomena, anatomical discoveries and experimental devices, such as pneumatic pumps or surveying equipment.

At the time Hartsoeker’s first publication left the presses in 1694, he had been employed at the Academy for more than a decade in the capacity of telescopic lens maker at the Observatory. But he had not yet been nominated for membership in the Academy. This eventually took place in 1699, when he already had the *Essay de dioptrique* (1694) and *Principes de Physique* (1696) to his name. In 1695, *Le Journal des Sçavans* reviewed Hartsoeker’s first published work, *Essay de dioptrique*, about four months after the work first appeared in print. *Le Journal des Sçavans* was a publication of the Academy of Sciences that then was managed and edited by academician Jean Gallois. Apart from the *Nouvelles de la République des Lettres* and the *Bibliothèque Ancienne et Moderne*, *Le Journal des Sçavans* was the only other journal in which Hartsoeker figured both as a published and a reviewed author. That is, these three periodicals published both his articles on various findings and reviews of his printed texts.

Besides giving a summary of the content, the author provided a detailed account of the novelty of the work and its scientific contributions. One of the novelties he praised was Hartsoeker’s color theory, which, he argued, “is completely new and follows quite naturally from his new hypothesis on refraction.” The author of the review deemed the chapter on lens-making techniques to be the most interesting and useful to a great number of people, “especially since we

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15 Goldgar, 69.
16 Hahn, 64. In 1702, editorship was handed over to a group of paid editors, each overseeing a specific scholarly field. This information is at odds with Morgan’s book on the history of the *Journal des Sçavans*, which places editorial control in the hands of Louis Cousin from November 1687 to December 1701. See Betty Trebelle Morgan, *Histoire du Journal des Sçavans depuis 1665 jusqu’en 1701* (Paris: Les Presses Universitaires de France, 1929), chapter IV.
17 *Le Journal des Sçavans*, « Essai de dioptrique, » issue 30, 7 Feb 1695, 65: « Ce qu’il dit des couleurs est tout à fait nouveau, & suit assez naturelement de sa nouvelle hipotese de la refraction. »
have not yet seen anything about this subject that was accurate.” “Having joined practice to theory,” the reviewer wrote, Hartsoeker “teaches us an easy and convenient method of making telescopic lenses . . . provided that the material [for the lenses] is how it should be . . .”18

Now, Hartsoeker’s first treatise not only included lens making techniques, but also offered his thoughts on astronomical and microscopical observations. The “curious” part of the treatise was contained in the last few chapters. The reviewer found Hartsoeker’s conjectural explanations, of what one can observe on the moon and the planets and of where comets come from, “completely peculiar.” On the other hand, Hartsoeker’s method for finding the distances among the earth, the planets, and the sun he praised as innovative and new. Likewise, the reviewer was fascinated by Hartsoeker’s ideas on animal generation as well as the titillating and visually suggestive image of “the little animal”19 (now popularly known as the homunculus), which was also printed along with the review.20 On the whole, Hartsoeker’s “useful” contributions that could be directly applied to studying nature, such as new measuring or lens-grinding techniques, were applauded. Meanwhile, his speculations about inhabitants on the moon or the origin of comets – pronouncements that were not demonstrable – received a lukewarm welcome as “curious” thinking. The attitude of Le Journal des Sçavans was in line with Fontenelle’s and the Academy’s reluctance to publicly encourage hypotheses supported by little or no clear evidence.

18 Le Journal des Sçavans, « Essai de dioptrique, » issue 30, 7 Feb 1695, 67-68 : “Le huitième chapitre où il parle de la maniere de travailler les verres des lunetes, ne peut pas manquer de plaire à une infinité de gens, d’autant plus qu’on n’a encore rien vu sur cette matiere qui soit exact. . . notre Auteur ayant joint la pratique à la theorie, nous enseigne une maniere facile & aisée de travailler les verres de lunetes sans y [p. 68 :] pouvoir manquer, pourvu que la matiere soit comme il faut, depuis une dixiéme partie de ligne jusqu’à trois ou quatre cent pieds de foyer, & sans qu’on soit obligé de faire, pour ainsi dire, aucuns frais. »

19 Nicolas Hartsoeker, Essay de dioptrique (Paris: Jean Anisson, 1694), 228-229: “. . . le petit animal . . .”


La matiere qu’il donne pour connoitre le raport des distances de la terre aux planetes & au soleil, est tout à fait [p. 69 :] nouvelle, et merite bien que les sçavans y fassent reflexion, aussi-bien que sur ce qu’il dit de la generation des animaux, & comment ils viennent au monde. . . [about image of the homunculus] nous le verrions peut-être comme l’autre figure le represente, sinon que la teste seroit peut-être encore plus grande à proportion du reste du corps, qu’on ne l’a dessinée ici. »
In the Dutch context, Hartsoeker's first two works were reviewed in 1696 by Pieter Rabus, a notary from Rotterdam. Out of Hartsoeker's ten scientific treatises published in French, the first two were translated into Dutch by Ameldonk Block. Block was a merchant and member of a liefhebber group that occupied itself with mathematical and natural philosophical investigations in Amsterdam under the intellectual leadership of Tschirnhaus. 21 *De Boekzaal van Europe (The Book Room of Europe)*, a Dutch-language journal under the stewardship of Rabus, reviewed new publications in many disciplines and on a variety of topics. It reached a wide professional readership that counted jurists, doctors, clergymen, magistrates and professors. 22 The journal was launched by Rabus and then taken over in the course of 1702 by Willem Sewel and around 1706 by Jan van Graveren. Under Sewel, its title became *De boekzaal der geleerde werreld (The Book Room of the Learned World)*. Unlike Rabus, the subsequent editors Sewel and Van Graveren were not much inclined to review and publish excerpts from scientific works. Especially under van Graveren, reviews of literary, historical, theological and sometimes medical works predominated, while those with a natural philosophical focus became far less frequent. 23 Perhaps the change in management explains why Hartsoeker's early, but not his later, natural philosophical treatises were reviewed by this Dutch-language journal.

What Rabus emphasized in his review of the *Essay de dioptrique* was Hartsoeker's erudite arguments and his clean and readable writing style, which resembled “an exquisite web woven from

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23 Under van Graveren, the journal slightly changed its name to *De Boekzaal der Geleerde Wereld* (or, *The Book Room of the Learned World*).
the finest in Mathematics and Science.”

Perhaps to prove this point, Rabus reiterated Hartsoeker’s fundamental system in great detail, elaborating upon the indivisible and perfectly hard atoms and the vehicular fluid, or first element, which moved them. Another facet of Hartsoeker’s work, which Rabus took to be central, was his rejection of a random, mechanical explanation of matter in motion. This reveals not only a public appreciation for Hartsoeker’s natural philosophical ideas, but also shows where these ideas overlapped with those of his readership. Rabus himself belonged to an intellectual circle of poets and artists in Rotterdam who called themselves the “pious Libertines” and admired an Erasmian approach characterized by tolerance and anti-dogmatic Christian reform.

Rabus’ writings on Erasmus, Roman history, philology and poetry had been appearing in print since the 1670s. Moreover, he was interested in natural philosophy and counted microscopist Antoni van Leeuwenhoek among his friends. In 1692, he became the editor of *De Boekzaal*. No doubt Rabus’ godly pursuit of knowledge was shaped as much by the circle of friends he kept as by the general philosophical debates that were spawned by Cartesian and Spinozan followers and that roused much of Europe.

In a review of Hartsoeker’s second work, the *Principes de Physique*, Rabus praised him for being a faithful, god-fearing savant who believed that there was an “Almighty Being and Maker of all things, whom we call GOD.” Hartsoeker stood in contrast to the atheist mechanical philosopher,

“who, in all seriousness, could imagine that the visible world is formed by an accidental union of

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24 Pieter Rabus, *De Boekzaal van Europe*, January en February issue (Rotterdam: Pieter vander Slaart, 1696), 70.
26 Peter Rietbergen, *Pieter Rabus en de Boekzaal van Europe* (Amsterdam: Holland Universiteits Pers, 1974), 3: “‘vrome Libertijnen.’” This circle of intellectuals among whom Rabus grew up included physician and poet David van Hoogstraten (1658-1724) who was a son of the poet and bookseller François van Hoogstraten (1632-1696); Joachim Oudaen (1628-1692), a poet and tile-maker; Heiman Dullaert, the religious poet and famous student of Rembrandt (1636-1684); and Johannes Antonides van der Goes (1647-1684), a friend of Vondel and Buysero.
27 Peter Rietbergen, *Pieter Rabus*, 3, 11. Besides working as a notary and editor of the *Boekzaal*, Rabus apparently also taught six hours a day at the Erasmian Gymnasium in Rotterdam (see p. 57).
infinite particles without the Providence of some almighty Being having arranged them . . .” Such an unfortunate philosopher “must be out of his mind,” Rabus reasoned, for did not “the smallest creature, the smallest plant convince us of this truth of all truths”?29 Fortunately, Hartsoeker was neither short-sighted nor an atheist. Rabus reiterated his point that

Mr. Hartsoeker (to say it once again) believes then similarly that a craftsman [konstenaar] builds, arranges and gathers all the pieces and cogwheels; in the same way, God has also arranged and gathered all the pieces and cogwheels of the Universe in the beginning and, having imparted motion to these cogwheels according to His established Laws, keeps the large World-edifice [Wereldgebouw] nowadays in place as an everlasting theatre of changes, generations and corruptions.30

Thereafter, Rabus showed the reader how Hartsoeker’s physical system of the two elements explained how an “Omnipotent Being” gathered and put into motion this complex structure of interlocking cogwheels and springs that make up the earth, the planets and all matter.31

Another part of the review centered on the question of generation, which turned out to be a point of personal interest for Rabus as well. Interestingly, the author did not comment on the image of the “little animal” (or animalcule) nor did he, like the French reviewer of Le Journal des Scavans, reproduce the image in the book review. He simply recapitulated Hartsoeker’s findings about animalcules, or “worms,” contained in animal and plant reproductive seed. On the point of priority over the discovery of spermatozoa by the means of a microscope, Rabus was diplomatic. Rather than settling the matter of priority, Rabus wrote, “I would rather discuss . . . with my astute friend,

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29 Rabus, Boekzaal, May & June, 406: “Zulk een, die zig met ernst zoude inbeelden, dat de zienelijke wereld door een gevallige t’ zamenloop van oneindige deeltjes gevormd is, zonder dat de Voorzienigheid van een opperheerschend Wezen dezelve zoo geschikt hebbe, als wy die thans beschouwen, moet niet wel by zijn hersenen zijn.”

30 Rabus, Boekzaal, May & June, 406: “Daar is dan een Alleropperste Wezen, en Maker van alle dingen; want, zonder dat we opwaarts na de Hemelen zien, alwaar de inbeelding flux ten einde raakt, het minste beesje, het minste plantje kan ons van die waarheid aller waarden overtuigen.

De Heer Hartzoeker dan (om het nog eens te zeggen) geloof, dat, gelijkerwijs een konstenaar alle stukken en beweegraden van zijn konstwerk, dat hy bouwt, schikt en vergadert; alzoo ook God in den beginne alle stukken en alle beweegraden van’t Heelal geschikt en verzamelt heeft, en, hebbende aan die beweegcraden volgens Zijne gestelde Wetten de beweging mede gedeelt, dat groote Wereldgebouw jegenwoordig houd tot een geduerig toonneel van wisselingen, voorttelingen, en verdervingen.”

31 Rabus, Boekzaal, May & June 1696, 406-408.
Mr. Antoni van Leeuwenhoek, to what extent Mr. Hartsoeker’s ideas differ from his own in this section [of the treatise].”32 He concluded his commentary by highlighting the correspondence Hartsoeker saw between the animal and plant worlds.33 And yet again, Rabus praised Hartsoeker’s “excellent telescopic science (voortreffelijke Verrekijk-kunde)” that was a mark of Hartsoeker’s “unique experience in mathematics and philosophy.”34 Just as Pieter Rabus, Christiaan Huygens, his brother Constantijn, and others seemed most interested in Hartsoeker’s mechanical invention of how to make perfect, little glass beads for microscopes (see Chapter Two). John Locke, too, greatly anticipated hearing about Hartsoeker’s “art of forming” such minute, globular glass lenses.35 In the 1690s, Hartsoeker’s natural philosophical weight resided in his ability to marry theory and practice in explaining how optical principles could be applied to construct better lenses. His service in the capacity of technical advisor (conseiller technique) at the royal glassworks in Cherbourg between 1684 and 1696 furnished him with well worn know-how and experience.36 The geometrical accounts and images in the Essay served as intellectual instruments that showcased his mathematical expertise crucial to understanding and advancing in optics.37 Meanwhile, Hartsoeker’s detailed description of the manual dexterity involved in lens grinding exhibited his experience with materials, tools, and techniques.

32 Rabus, Boekzaal, Jan & Feb 1696, 80-81: « Maar zal ’t niet liefst geraden zijn, dit werk der dierelijke voorttellinge dus verre maar met mijn penne aangeroerd te hebben, zonder ’t zelve, in haren t’zamenhang, omstandiglijker uit te trekken? Ik wil liever over deze verhandeling met mijnen vriend den schranderen Heer Antoni van Leeuwenhoek by tijds gelegenheit een uertje slijten; om teffens na te [p. 81:] sporen, hoe verre de Heer Hartzoeker in dit stuk van hem verschilt. Beide zijn zy ’t hier in eens, dat de mensch uit een dierrijtje voortkomt. »
33 Rabus, 81.
On the whole, Hartsoeker and Rabus ascribed the apparent order in nature to providence and to a creator God who stood at the center of the universe. These ideas sprung more generally from a deeply imbedded tradition of physico-theology in the seventeenth-century Low Countries. It found expression among humanists, philosophers and liefhebbers in the study and description of minute nature. Recent historiography on the microscopical pursuits of Jan Swammerdam, Sir Constantijn Huygens, and other Dutchmen has brought this to light.38 In the words of Rabus, any “lover” of philosophy and natural science – “those sanctuaries” – would find the subjects discussed in the *Principes de Physique* of “the Nature-wise Hartzoeker” worth knowing.39 These words and other passages seem to suggest that Rabus thought Hartsoeker’s treatise to be accessible to a generalist readership interested in all matters of natural philosophy. Rabus himself was a general reader and dabbler in many subjects, as his biography shows. Perhaps unsurprisingly, he often highlighted the clarity with which the treatise was written and the entertainment value that it provided “true nature experts (regtschapene Natuerkenners)” the possibility for deepening their thoughts about natural phenomena.40

On a related note, Descartes’ mechanical philosophy had created not only growing fears of a secular approach to nature, but also left unsolved natural philosophical problems. This is evident in

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40 Rabus, *Boekzaal*, May & June 1696, 414: “Dit alles word door den Heere Hartzoeker in haren aart zeer verstandelijk beschreven. Het werk loopt ten einde met een korte dorg klare aanwijzing van den oorsprong der fonteinen, putten, en rivieren; stoffe, welker grondige nzoeking een der vermakelijkheden van regtschapene Natuerkenners is.”
the kind of questions reviewers asked of Hartsoeker’s intellectual work. Both Rabus as well as the
Journal des Sçavans reviewer noticed that Hartsoeker was influenced by Descartes. The French review
pointed out that Hartsoeker explained various questions in astronomical observation like Descartes.
For instance, why the moon appears closer to the earth than it actually is and how we gauge the size
of an object by automatically comparing its position to other objects nearby. More significantly,
Rabus from De Boekzaal van Europe pointed out in his review of the Essay de dioptrique that
Hartsoeker’s explanation of where comets come from both rejected Aristotle’s hypothesis and
differed markedly from Descartes’. One of the possible reasons why Hartsoeker’s theorizing on
the nature of comets got so much attention from Rabus is that comets were an important topic of
discussion then, and several had appeared and became public spectacles in recent years. More
broadly speaking, one of the crucial astronomical phenomena in the seventeenth century that
Descartes’ mechanical philosophy struggled to explain successfully was the origin and behavior of
comets. Another reason could simply be Rabus’ personal liefhebberij for observing astronomical
phenomena and celestial bodies with a telescope. Rabus’ concern with the mechanical philosophy
and his preoccupation with optics and scientific instruments relates no doubt to the more general
trends in Dutch material culture, optics, scientific instruments and their relation to religious ideas
also discussed in Chapter Two.

42 Rabus, Boekzaal, Jan & Feb 1696, 79.
43 For Dutch astronomy and public observations in the 18th century, see Huib J. Zuidervaart, Van ‘Konstgenoten’ en Hemelse
   Fenomenen (Rotterdam: Erasmus Publishing, 1999). The most recent comets had appeared a few months before, in the
   fall of 1695. Other comet sightings happened in 1677, 1678, 1680, 1682, 1683, 1684, 1686 and 1689. For a brief
discussion of comet of 1680, see Albert Van Helden, Measuring the Universe: Cosmic Dimensions from Aristarchus to Halley
   (Chicago: University of Chicago Press, 1985), 149.
   151-160 (see esp. 155-156).
45 Rabus, Boekzaal, Jan & Feb, 78: “Wel aan, ik hebbe my in die groote Maan zoo stikziende gekeken, dat ik, uit vreeze
   van blind te werden, mine oogen aan de dwaalstarren Venus, Merkuer, Mars, Jupiter, en zijne lijftrawanten, met alle
   hunne zwagtiels, en vlakken, niet langer wil wagen.”
Journal Littéraire

Founded and edited by Willem ‘s Gravesande, Juste Van Effen, Prosper Marchand, Albert Henri de Sallengre and Thémisule de Saint-Hyacinthe, the Journal Littéraire was a French-language journal published in The Hague.\(^{46}\) Its reviewers provided a more forceful critical commentary of Hartsoeker’s ideas than Rabus ever did. This is especially apparent in a review article of 1713, which summarized and examined both the second part to the Conjectures Physiques from 1706 and the Suite des Éclaircissements sur les Conjectures Physiques from 1710. The former dealt with the anatomy and physiology of the human body, while the latter addressed the objections to Hartsoeker’s ideas published previously in the Conjectures Physiques.

In his Suite des Conjectures Physiques, which originally lumbered off the press in 1708, Hartsoeker sought to prove that the brain controlled animal functions, while the cerebellum managed vital functions of the body. He explained that the body had three kinds of nerves: 1) those originating in the brain and responsible for sensation, 2) those originating in the brain but extending to the muscles and responsible for voluntary actions, and 3) those originating in the cerebellum and extending in a similar way into different body parts but responsible for involuntary actions.\(^{47}\) To begin with, the journalists judged unsatisfactory Hartsoeker’s division of the different types of nerves into these three distinct categories. Although his ideas about the different functions of nerves rested on common opinion, “at the very least [we] could offer strong objections against this system.”\(^{48}\) One example, which brought to the fore the shortcomings of his scheme, was the fact that it did not account for the involuntary contraction of the iris. The reviewers argued that since the optic nerve originated in the brain, then, according to Hartsoeker’s “system,” the dilation or


\(^{48}\) Journal Littéraire, Nov & Dec 1713, 290 : « Les differentes fonctions que M. Hartsoeker attribué au cerveau & au cervelet, & la differente origine qu’il assigne aux nerfs, quoique fondées sur l’opinion commune, n’en sont peut-être pas plus certaines : Du moins on pourroit faire de très fortes objections contre ce systeme. »
contraction of the iris could only be either voluntary or sensory. Hartsoeker seemed to have anticipated this particular example in the criticism of his work. He suggested that “one could think that there is a fourth kind of nerve that alerts the vegetative Soul of what is happening, and of whatever is necessary for the conservation of the machine.” But the reviewers took it as back-tracking: “Our objection will remain in its full force, until [Hartsoeker] gives an exact description of this fourth kind of nerve, which he invented to get himself off the hook.”

Another part of Hartsoeker’s system that the Journalistes objected to was his contrivance of vegetative and rational souls combined with Intelligences in the body. The rational Soul “perceives, judges and reasons by means of animal spirits” and causes the vegetative Soul to carry out all voluntary movement. Meanwhile, the vegetative Soul “faithfully obeys the orders of the rational Soul” when it comes to voluntary action and performs all other “vital or natural” functions. Supposedly, an Intelligence resided in each living body and governed, as best as she could, the knowledge flow between the rational Soul and the vegetative Soul. The Journalistes cited two main reasons for rejecting Hartsoeker’s system predicated on a hierarchy of subaltern Intelligences that governed a body. First, the critics did not believe Hartsoeker had demonstrated or proven that a vegetative Soul was necessary: “nothing compels [me] to believe that there are subaltern

49 Ibid. : « A la verité M. Hartsoeker a voulu en quelque maniere prévenir cette objection, lorsqu’il dit à la fin de ce Discours que « comme la prunelle se ferme ou s’ouvre, à mesure que la lumiere est plus ou moins forte, & qu’il n’est pas en notre pouvit d’empécher cette action, ou de faire ensorte que le contraire arrive ; que comme la membrane du tambour se bande de même à notre insçu, à mesure que le bruit s’affoiblit, on pourroit croire qu’il y a une quatriéme espece de nerfs pour avertir l’Ame vegetative de ce qui se passe, & de ce qui est necessaire pour la conservation de la machine. »

50 Ibid., 290 : « Mais puisque, suivant M. Hartsoeker, les nerfs qui tendent aux yeux, tirent leur origine du cerveau, notre objection subsistera dans toute sa force, jusqu’à ce qu’il ait donné une description exacte de cette quatrième espece de nerfs, qu’il imagine pour se tirer d’affaire. »

51 Nicolas Hartsoeker, Seconde Partie de la Suite des Conjectures Physiques (Amsterdam : Nicolas Viollet, 1712), 15 : « . . . j’appelle Ame vegetative cet etre, cette Intelligence, ce Genie (ou tel autre nom qu’on lui voudra donner) qui reside pareillement en nous, & qui obéit ponctuellement aux ordres, que l’ame raisonnable lui donne pour executor tous les mouvemens voluntaires, & qui outre cela pourvoit continuellement au besoin de corps, par l‘entremise des nerfs qui tire leur origine du cervelet ; car elle fait le plus souvent à nôtre insçu, & quelquesfois même contre nôtre volonté, toutes les fonctions qu’on appelle vitales ou naturelles. »
Intelligences of the kind Hartsoeker postulates.”

Nor did the authors of the review accept the possibility of a “general Intelligence” that could keep a planetary system in motion. They argued, “Would it not be just as easy to understand all these movements as a consequence of certain Laws that God has established since the beginning, as M. Newton has demonstrated?”

A mechanical explanation of nature seemed quite sufficient to them, since Hartsoeker’s alternatives did not convince them. To make their point rhetorically even stronger, the reviewers inserted direct quotations from Hartsoeker’s work, in which he was not entirely convinced by his own arguments. For instance, they inserted in the review his admission that many more modern philosophers explained phenomena with mechanical laws of nature instead of having recourse to Intelligences, Instincts or Plastick Natures or other substantial forms.

Both the content of and the format in which Hartsoeker presented his natural philosophy were at odds with what the journal reviewers deemed reasonable.

What follows in that same review article is also a short commentary on Hartsoeker’s later work, *Suite des Eclaircissements sur les Conjectures Physiques* published the year before, in 1712. This explanatory genre of works entitled *Eclaircissements* usually contained brief objections and questions from known or anonymous correspondents followed by Hartsoeker’s own responses to their critical remarks. The reviewers mentioned Hartsoeker’s interlocutors and challengers (to whom he responded in this printed work), but did not elaborate on the specific debates covered in the text. Interestingly, they praised the style of Hartsoeker’s responses: “whether he is defending himself or attacking [someone else], he always stays within the path of moderation, and has all possible respect for the person of his enemy.” Even when Hartsoeker’s system was condemned as atheistic by the

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52 *Journal Littéraire*, Nov & Dec 1713, 295: « Mais ne raisonneroit-on pas plus conséquemment en disant, puis que Dieu peut produire des Animaux & des Plantes, & que rien n’oblige à croire qu’il y ait des Intelligences subalternes, telles que M. Hartsoeker suppose, je n’en admette point. »

53 Ibid., 296: « N’est-il pas aussi aisé de comprendre, que tous ces mouvements se font en conséquence de certaines Loix que Dieu a établies depuis le commencement, comme M. Newton l’a démontré ? ».

54 Ibid., 294-295.
Jesuits of Trévoux, his “sharp” reply (“la vivacité de sa réponse”) was rather restrained, considering that the Jesuit journalists were accusing him of impiety. The reviewers of the Journal Littéraire suggested that his response justifiably could and should have been more outraged than it was. However, the reviewers ended with a sting: “We don’t doubt that the Public watches with delight at the way in which our Author justifies himself, and at the judicious statements he makes based on false principles, which usually serve as reason to condemn someone of Atheism.” “We rest very assured that M. Hartsoeker will not be shocked by our remarks,” since he often invited others to evaluate his knowledge claims any way.55 Such conclusions from the journal world highlight once more the contentious style in which many journals presented divergent views and visibly took sides in philosophical debates. These last remarks also highlight the inescapable human and psychological side of vigorous debate in the Republic of Letters—the author or philosophe who, like a gladiator braved being torn apart by caustic critical beasts, squirmed in the limelight, as the public watched on in suspense, thirsty for blood.

Hartsoeker’s response to the review was published in the same journal one year later, in 1714. Despite what one might consider a rather biting review, the Dutch philosopher was in fact grateful to his critic: “Far from being shocked, I am very much obliged to you [for your comments on my work] . . . which you could have extended to [my entire treatise].”56 In his reply, Hartsoeker came back to the issue of the three types of nerves in the body. He continued to hold that the iris dilated or contracted voluntarily, since we could, by our will alone, alter our view from looking at

55 Ibid., 300: “Nous ne doutons pas que le Public ne voye avec plaisir la manière dont notre Auteur se justifie, & les judicieuses remarques qu’il fait sur les faux principes, qui d’ordinaire servent de fondement pour taxer quelqu’un d’Athéisme. Nous sommes très convaincus que M. Hartsoeker ne sera pas choqué de nos remarques. C’est inviter en quelque manière tous les Journalistes à le critiquer, que de s’expliquer comme il fait en commençant la Suite de ses Eclaircissements : M. Bernard en faisant l’Extrait de mes Ouvrages, dit-il, a pris en même tems la peine d’en faire la critique, & c’est en cela qu’il m’a très sensiblement obligé.”

objects far away to those nearby. According to him, humans willfully forced the iris to adjust its aperture by turning their gaze elsewhere.\(^{57}\) He postulated that all movement residing in the eye, as that of the fingers, acted according to his will and thus stemmed from voluntary motion and, more generally, from motion that had been learnt over time. At the root of his response lies his belief in hierarchical Intelligences or souls that inhabit and govern the processes of a living body, explored in preceding chapters. He also postulated that voluntary motion had to be learnt by the body over time. Therefore, he believed that the origin for such movement could not come from a perfect sovereign being like God (where Father Malebranche’s *occasionalism* would have it originate), but rather from an imperfect being that was subaltern to God. That is, the relation between such an imperfect being and the rational Soul needed to be perfected through trial and error over time, so that this subaltern being, or Intelligence inhabiting a body, could “habituate itself to performing movements in accordance with the wish of the rational soul.”\(^{58}\) The rational soul, or “this substance that one calls \(I\),” could not, in Hartsoeker’s eyes, itself be the efficient cause of voluntary movement, “since she hardly ever knows any of the instruments she would have to use to succeed in it.”\(^{59}\) The

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\(^{57}\) Ibid., 432: “Mais, ce mouvement, Messieurs, n’est pas involontaire. Au contraire, il dépend de notre volonté, puis qu’on dilate ou qu’on retrecit l’ouverture de la prunelle quand on veut. Je la dilate pur voir un objet éloigné, & je la retrecis pour voir un objet plus proche ; & il est en mon pouvoir de dresser ma vuë vers l’un ou vers l’autre.

Il est vrai qu’on ne peut dilater cette ouverture lors qu’on regarde un objet prochain, ou quand la lumiere est forte, ni faire le contraire lors que l’objet est éloigné, ou que la lumiere est foible ; mais, cela n’empêche pas que le mouvement de l’Iris ne soit volontaire : car, tout le monde m’accordera sans doute, que mes paupieres, mes yeux, que je tourne & que je dirige comme je veux, & mes doigts se meuvent d’un mouvement volontaire. Cependant, quand quelqu’un fait semblant de me donner un coup dans les yeux, je ne saurois m’empêcher de les fermer.”

Hartsoeker actually used the word “*prunelle*” (pupil) rather than “iris” in his response to the review.

\(^{58}\) Ibid., 432-433: “Je ne puis sans beaucoup d’habitude fermer un oeil sans fermer en même tems l’autre ; remuer un doigt sans remuer en même tems son voisin ; regarder un objet éloigné sans dilater en même tems l’ouverture de l’Iris, &c. parce que j’ai pris dès l’enfance l’habitude de fermer toujours les deux yeux à la fois, de remuer toujours les deux doigts à la fois, &c. Et cela m’est une preuve invinici- [p. 433:] ble que l’Etre qui fait ces opérations n’est pas un Etre Souverain & Parfait ; c’est-à-dire Dieu lui-même, selon le sentiment du Pere Malebranche, qu’il semble que vous approuvez ; mais, au contraire, un Etre imparfait & subalterne à Dieu, parce qu’il a besoin de s’habituer à exécuter les mouvements selon le desir de l’ame raisonnable.”

\(^{59}\) Ibid., 435-436: « Pour moi, je me tiens à celle que j’ai déjà donnée, parce que je trouve des difficultez insurmontables dans les sentimens que je viens de rapporter, & qu’il est très certain que l’amé raisonnable, cette substance qu’on appelle moi, [p. 436:] ne peut-être elle-même, & immédiatement la cause efficiente des mouvements volontaires, & bien moins encore de ceux qui ne dépendent en aucune façon de sa volonté ; par exemple du mouvement du coeur, des artéres, de l’estomac, des intestins, &c. Et certes, comment pourrait-elle en être la cause immédiate, elle qui ne connoit presque jamais aucun des instrumens qu’il faut employer pour y réussir ? »
Intelligence would have to train the rational and vegetative souls in proper movement and behavior. In response to the criticism that he had not demonstrated the need for a vegetative soul, Hartsoeker wrote that he never sought to prove it in the first place. He merely conjectured the existence of a vegetative soul in the body. After all, much of what is taken as truth was arrived at by making conjectures on the basis of probabilities in the first place.60

What Hartsoeker had to say about conjectures struck a cord with the journalists of the *Journal Littéraire*. To them, however, conjectures about things to which one had no access were “mere mind games (simples Jeux d’Esprit), like Philosophical Novels of sorts.” At the same time, the reviewers maintained that many of the matters raised in Hartsoeker’s response could be strengthened by more solid arguments: “While we recognize the limits of the human Mind as much as we can, we, however, do not believe that all the questions that you point out in your letter at this time are out of Reason’s reach.”61 One example of such a cogent constellation of arguments, in the journalists’ eyes, was Newton’s *Principia*, it contained “not a single hypothesis” but instead a logical concatenation of observations and demonstrations.62 The *Journal Littéraire* published a subsequent retort to Hartsoeker’s rebuttal to the original review. The *Journalistes* praised Hartsoeker’s open-mindedness for accepting their comments without getting upset and thus for cultivating an

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60 Ibid., 434-435: « Mais, je n’ai jamais prétendu, que je sache, avoir démontré l’existence d’une âme végétative, étant très persuadé qu’on ne peut donner tout au plus que des conjectures dans une matière aussi difficile que celle-là. Ainsi je n’ai fait que conjecturer qu’il y en ait une. Et certes, qui ne sait qu’il y a mille choses dont on ne peut donner que des Conjectures, qui par malheur encore peuvent être toutes fausses, & le sont le plus souvent. Ce qui pis est, lors qu’en conjecturant sur des probabilités, on a rencontré la vérité ; comment & par quelle marque infaillible pourra-t-on la reconnaître, [p. 435 :] puisque l’erreur se représente très souvent sous le masque de la vérité. »

61 « Réponse des Journalistes à la Lettre précédente [de Nicolas Hartsoeker], » *Journal Littéraire*, tome III, Mar & Apr 1714 (The Hague: P. Gosse & J. Neaulme, 1731), 440-441: « Ce que vous dites sur les Conjectures, nous paroit très sensé, nous sommes entièrement de votre sentiment ; & c’est pour cette raison, que nous croyons que le plus sûr est de ne se point déterminer sur les matières que Dieu a voulu mettre hors de notre portée. Nous regardons tout ce qu’on peut écrire la dessus, comme de simples Jeux d’Esprit, & [p. 441 :] comme des espèces de Romans Philosophiques. Mais, quoi que nous reconnaissons, autant qu’il se peut, les bornes de l’Esprit humain, nous ne croyons pourtant pas que toutes les questions que vous indiquez à cette occasion dans votre Lettre, soient hors de la portée de la Raison. »

62 Ibid., 441 : « Sur ce que nous avons dit, que M. Newton avoit démontré que les mouvemens des Planetes, tels qu’on les observe, se font en conséquence de certaines Loiz que Dieu a établies depuis le commencement, nous croyons que les Principes de Philosophie de M. Newton nous justifient pleinement à cet égard. On n’y trouve aucune Hipothese ; son Système, qu’il explique dans son III. Livre, est fondé sur des Démonstrations qu’il a faites dans les Livres précédens, & sur des observations, auxquelles il applique ces démonstrations. »
environment where it was “permitted to differ in opinion without becoming sworn enemies.”

They admitted being wrong to have claimed that Hartsoeker failed to demonstrate the existence of a vegetative soul. They conceded that his was not a claim, but a conjecture. However, they urged him to consider that his conjecture was not very likely. In fact, it was as probable as suggesting that “God [is] the immediate author of our movements.” On the issue of how to categorize the movement of the iris, however, they pushed further. They suggested it would be better if Hartsoeker qualified the movement of the iris as involuntary but coming from a preceding voluntary action.

On the whole, it seems the Journal Littéraire reviewers misunderstood as well as were obstinate to Hartsoeker’s speculative method and the implications it had for doing natural philosophy. At various points in his treatises (and in the preceding chapters of this dissertation), Hartsoeker has explicitly articulated the place of conjectures in his thinking and in his work. Conjectures were stepping stones in “perfecting Physics.” By testing one conjecture against another, he could proceed to one that appeared more truthful than another, and thus cast off the previous one that had failed him. He warned against . . . those—who claim infalliblity and believe their conjectures to be as many mathematical demonstrations—are not at all in the right, because they neglect to make others [other conjectures] on the same topic and usually hide their experiments with care . . ., if they find that they contradict the conjectures they have already published, so as not to have to acknowledge that they had reasoned incorrectly and produced false conjectures.

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63 Ibid., 438: « Ne diroit-on pas à les entendre, qu'il n'est pas permis d'être de sentiment différent sans être ennemis déclarez ; & que nous voulons faire passer nos Remarques pour des Décisions ? Vous avez répondu, Monsieur, avec tant d'honnêteté [sic] aux Remarques que nous avons pris la liberté de faire sur vos Conjectures Physiques, que nous nous trouvons encourager à vous adresser à vous même les Difficultez qui nous restent sur vos Réponses ; persuadez que vous ne trouverez pas mauvais que nous fassions imprimer cette Lettre avec la vôtre, dans notre Journal de Mars & d'Avril, qui est sous la Presse. »

64 Ibid., 440.

65 Ibid., 440.

66 Ibid., 439.

67 Nicolas Hartsoeker, “Reflexions sur les remarques precedentes,” Recueil de plusieurs pièces de physique (Utrecht: la Vueve de G. Broedelet & Fils Libraires, 1722), 90-91: “Je conviens volontiers que cette conjecture peut être fausse, mais [p. 91:] que faire à cela sinon de m'y tenir jusques à ce que j'en trouve une qui ait encore une plus grande apparence de vérité, & de la rejeter comme la première, si je trouve encore quelque chose de meilleur, & ainsi de suite. C'est de cette manière
His matter-of-fact approach to hypothetical thinking went hand in hand with his ideas on the role of a physicist (“physicien”) or natural philosopher. In one memorable instance, he admitted the rather limited powers of the natural philosopher. “A Physicist can only but conjecture,” he thought, “. . . but in doing so he should not exceed certain limits and make conjectures at random. For conjectures to be useful (bonnes), they have to be at least based on some experience, & support each other; that way they can serve to advance the Sciences . . .”

To mitigate the uncertainty of the senses, of instruments, of nature, in general, Hartsoeker enlisted conjectures. While to the Journalistes it seemed he was exchanging one question mark with another, to Hartsoeker, conjectures—uncertain hypotheses, the questions and puzzles themselves—were the key to understanding nature and mastering physics.

**Bibliothèque Choisie**

Another Dutch-based journal was Jean Le Clerc’s *Bibliothèque Choisie*. Le Clerc (1657-1736), a refugee Calvinist theologian from Geneva, founded and edited a series of encyclopedic journals in Amsterdam. This city became his permanent residence in 1684 and eventually developed into the center of French-language printing in the eighteenth century. Le Clerc’s first enterprise was the *Bibliothèque universelle et historique*, which ran between 1686 and 1693. It began in collaboration with Jean Cornand de la Crose and was published by the brothers Wetstein. In 1703, Le Clerc published

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Ibid., 105-106: “Un Physicien ne peut, comme j’ai déjà dit, que conjecturer, mais aussi il ne doit pas en cela passer au delà de certaines bornes, & faire des conjectures au hazard. Les conjectures, pour être bonnes, doivent du moins être fondées sur quelque expérience, & se soutenir les unes les autres, & alors elles sont très-utilement employées à l’avancement des [p. 106:] Sciences, comme je viens de le faire voir.”

his independent journal, the *Bibliothèque choisie, pour servir de suite à la Bibliothèque universelle*, also in Amsterdam. The first run of the journal continued until 1713 and comprised 28 volumes, meaning that on average between 2 to 3 journals were published each year. In 1714, the journal’s name changed to the *Bibliothèque ancienne et moderne* and continued to circulate internationally until 1726. Many of the books Le Clerc reviewed in the journal were on sale at the publishing house of Henri Schelte, the libraire and publisher of the *Bibliothèque Choisie*. (Henri Schelte asked Pierre Coste to produce a French translation of Locke’s *Some Thoughts concerning Education*, which was eventually published in 1695.  

70) As shown in the preceding Chapter Four, Jean Le Clerc was not only valuable to his friends, colleagues, and contemporaries for including their works in his encyclopedic periodicals. He also played an important role in the network of Protestant thinkers, and especially Remonstrants, in the Dutch Republic and in the Republic of Letters at large. Le Clerc became professor of philosophy, humanity-learning, and Hebrew, and, until 1733, taught at the same Seminary as Philip van Limborch, who befriended and helped him get settled in Amsterdam. Inspired by Robert Chouet’s exposition of Descartes’ philosophy back in Geneva, Le Clerc pursued his interests in natural science in his new home in Holland. The periodicals he founded there were a great platform for exploring topics and developments that ran the gammut from the spiritual to the natural philosophical.  

71) Indeed, “Le Clerc’s Amsterdam office served as a clearinghouse for the Commonwealth of Learning,” which published the collected works of Erasmus and promoted the works of Locke and Newton. Thus Le Clerc connected the world of humanist learning with French enlightened thought.  

72)

Exercising his crucial role as communications operator and critic at large, the journalist was not only a powerful spokesperson in the Republic of Letters, but also a judge who could determine

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70 Goldgar, 117-118.
72 Eisenstein, 16.
the reputation of the savants under his review. Le Clerc counted among his friends the English philosopher John Locke and the Remonstrant preacher and professor Philip van Limborch. Moreover, his deep involvement in publishing made him an important player in the circulation of books, articles, and reviews in the Republic of Letters. For instance, he corresponded with Peter Needham, the editor of *Memoirs of Literature*, a journal which informed the English public about Continental matters. He was thus current on what was happening across the Channel. For example, he published extracts of Ralph Cudworth’s writings, including the *True Intellectual System of the Universe*, and Newton’s *Opticks*. Jean Le Clerc became famous for his intellectual rivalry with Pierre Bayle, who, like him, was a Calvinist refugee, a prolific writer, and the editor of the *Nouvelles de la république des lettres*—a forerunner to Le Clerc’s *Bibliothèque universelle et historique*. One of their main disagreements centered on the question of whether explanations like Cudworth’s “Plastick Nature” in the end supported arguments of atheism. Bayle held that such and similar theories abetted atheism and the doctrine of the world soul, while Le Clerc disagreed. Le Clerc, therefore, was no stranger to polemics. In fact, he excerpted writings of authors with whom he disagreed or who took part in philosophical disagreements. In the “Avertissement” to the *Bibliothèque Choisie*, Le Clerc reminded his readers that one always had the right to defend oneself in disputes within the bounds of moderation. He bore his detractors no ill will, but only sought to address both sides of a debate. And when his personal reputation suffered at the hands of wrongful accusers, he had the “liberty” to repair it in print accordingly.

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73 Goldgar, 111.
74 Colie, 138-139.
75 Jean Le Clerc, « Avertissement » in the *Bibliothèque Choisie*, tome 4, 1715 (unpaginated). In the Avertissement, Le Clerc spoke of having been wronged by two English authors, D. Whitby and R. Kidder [Evêque de Bath & Wels], – the latter now dead – whose letters he published in this volume. Le Clerc wanted to set his reputation right: « Je ne porte aucune envie à leurs dignitez, ni à leurs ren- 90 tes; mais il est juste que de leur côté ils me laissent en repos, & qu’ils ne disent pas de moi ce qui est entierement faux. Il est encore juste que j’aie la liberté de me défendre, avec toute la moderation que l’on peut demander d’un honête homme. Il y a des gens, qui par mauvaise humeur, ou autrement, disent & écrivent fort facilement du mal des autres, quoi qu’ils ne les connoissent pas. Quand on vient en suite à leur faire comprendre qu’ils se trompent, & qu’ils ont
Reviews of Hartsoeker’s later work appeared in both the *Bibliothèque Choisie* and its heir, the *Bibliothèque ancienne et moderne*. The first review dealt with parts I and II of the *Conjectures Physiques*, Hartsoeker’s third major treatise published in 1706. Meanwhile the second review surveyed the work’s remaining parts. Le Clerc (who was presumably its author) gave a detailed account of Hartsoeker’s system of nature and an extensive summary of the various discourses that structured and informed the whole work. He praised Hartsoeker’s “experiments and his conjectures,” and the whole text for its readability and accessibility. Like Rabus before him, Le Clerc recommended the *Conjectures Physiques* to anyone interested in physics.76

One of Hartsoeker’s controversial claims in the *Conjectures Physiques* was that the sun was the prime mover of the planets. Hartsoeker hypothesized that the sun’s rays were so physically powerful and far-reaching as to maintain the distances between the planets as they orbit one another and the sun. Le Clerc not only mentioned this idea but also provided his readers with the experiment on which Hartsoeker based this notion. In the *Conjectures Physiques*, Hartsoeker explained that whenever he placed a handful of sand at the focal point of a burning mirror, the concentrated rays of light drove the sand quickly and forcefully forward, “as if by a gust of wind.” He also experimented with other materials in a similar fashion. If he instead placed a spring at the focal point of a burning mirror, the converging rays of light seemed to cause sensible vibrations in the spring.77 Le Clerc wrote:

[Hartsoeker] believes that the planets use the sun’s rays to revolve around the sun, since they can neither come close to the sun because of the resistance caused by the [solar] rays,
nor move far away from it because of their own gravity (*pesanteur*). At the same time, the sun’s rays turn the planets on their axes, and also aid in the motion of their satellites . . .\textsuperscript{78}

Interestingly, Le Clerc did not outright dismiss Hartsoeker’s claim, as some earlier critics had done. On the whole, he provided his journal readership with a weighted summary of Hartsoeker’s treatise, without immediately rejecting the idea as unsound or pointless. Unlike the journalists from the *Journal Littéraire*, Le Clerc understood that Hartsoeker’s philosophical claims, especially about cosmological realities, were largely conjectural and were thus not meant to be interpreted as absolute or demonstrable truths. Le Clerc’s review of Hartsoeker’s later work, the *Eclaircissements sur les Conjectures Physiques* (1710), illustrates this very well. Here the Dutch *physicien* publicly revoked his hypothesis that the sun is the principle force behind planetary motion on the basis of an outsider’s objection. Hartsoeker qualified his position to one that drew in part on Cartesian vortex theory of planetary motion: It was not the sun that generated rays of light that imparted motion to the planets but the atmosphere around the sun which sent them out by means of its gravity.\textsuperscript{79}

Le Clerc explained why Hartsoeker so often resorted to conjectures. In a passage on the liaisons between the soul and the body, Le Clerc conceded along with Hartsoeker that “it is somewhat difficult” to accept the idea of a rational and vegetative soul that governs the body. However, an explanation of animal and plant life in terms of mechanical laws would also be difficult and unsatisfying. What distinguished Hartsoeker’s philosophizing from that of Descartes and others

\textsuperscript{78} Bibliothèque Choisie, tome 11, 1707, 367: « Il [Hartsoeker] croit que ne pouvant ni s’approcher du Soleil, à cause de la résistance de ses rayons, ni s’en reculer beaucoup, à cause de leur pesanteur, elles employent des rayons du Soleil à tourner autour de lui. En même tems ces rayons font tourner les Planetes autour de leur ace, & aident aussi aux mouvemens de leurs Satellites ; de la maniere, dont on le verra dans l’Auteur, où l’on trouvera le tems des révolutions de chaque Planete & diverses autres particularitez, auxquelles nous ne pouvons pas nous arrêter. »

\textsuperscript{79} Nicolas Hartsoeker, *Eclaircissements sur les Conjectures Physiques* (Amsterdam, 1710), 85-86: « Je ne veux pas que ce soit le Soleil qui pousse sans cesse de tous [p. 86:] côtés des rayons ou des ruisseaux de Feu [*fire*] avec une grande rapidité, mais l’atmosphère qui environne le Soleil, & qui les en exprime par sa pesanteur, comme je l’ai expliqué dans mes Conjectures Physiques . . . Je dis que ces rayons ont mis en mouvement les Planetes, & ces Planettes la matière de nôtre tourbillon à l’endroit où elles sont en équilibre avec cette matière, mais je ne dis pas qu’ils ont mis en mouvement tout ce tourbillon. »
was that the Dutchman did not take his “conjectures” to be “demonstrations.” Hartsoeker’s conjectures were often supported by common experience and contrived experiments. They enabled him to proffer possible explanations about nature in order to stimulate a discussion and, in this way, hopefully arrive at the truth. What made Le Clerc perhaps more receptive than others to Hartsoeker’s ideas was his own quibbles with mechanical explanations of natural phenomena.

Nicolas Hartsoeker structured a number of his treatises in the format of a dialogue, consisting of an objection from one of his interlocutors followed by Hartsoeker’s response to it. This desire for dialogue and constructive rebuttal was central to Hartsoeker’s functioning as a physicien. As he wrote to Leibniz in 1706, the latter’s “objections” and thoughts would, first of all, improve Hartsoeker’s thinking. Secondly, they would facilitate the discovery of “the secrets of nature, which should be the sole goal of a physicien.” In the same review article of the abovementioned Éclairissemens, Jean Le Clerc pointed out that Bernard and Leibniz could continue to disagree with Hartsoeker’s “preceding Conjectures,” if they chose. However, since their discussion dealt with “problematic issues where there are just as many reasons for as against [a

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Notre Auteur convient qu’il y a de la difficulté, dans son senti- [p. 220 :] ment, mais il remarque qu’on en trouve dans tous les Systèmes, & qu’il y en a encore plus dans les sentimens de ceux d’entre les Philosophes modernes, qui prétendent expliquer, par les Lois de la Méchanique, la formation des Animaux & des Plantes, & toute l’économie de leur nutrition, de leur végétation & de tous leurs mouvemens ; jusqu’à ôter le sentiment aux Bêtes, & à en faire de pures machines. Lors qu’en prend cette route, l’on se trouve bien souvent dans l’impuissance de rendre aucune bonne raison de tout cela. Mr. Hartsoeker, qui est fort éloigné de s’imaginer que ses Conjectures, sont des démonstrations, avoué ingenuement que cela lui est arrivé, dans la raison qu’il a donnée, dans un autre volume de ses Conjectures du mouvement du Coeur & de quelques autres Phénomènes de cette nature. C’est ce qui est arrivé aussi à plusieurs autres & sur tout à Descartes, dans ses traites de l’Homme, de la formation de Foetus, & des Passions de l’Ame, où l’on peut voir, comme parle notre Auteur, un galimatias complet & poussé au plus haut degré. »

81 Hartsoeker to Leibniz, Dusseldorp, 25 Novembre 1706, Lbr. 371, 25/11, 2-3 : « Je vous remercie tres humblement de l’a bonté que vous avez euë de me faire tenir par Monsieur le Baron de Krosik quelques reflexions sur mes conjectures physiques ; et comme rien ne contribuë plus à decouvrir les secrets de la nature, ce qui doit être l’unique but d’un physicien, je vous prie instamment de vouloir y continuer. »

82 Most likely this refers to Jacques Bernard, the editor of the Nouvelles de la République des Lettres from 1699 to 1718, who published a few letters and articles written by Hartsoeker. The journal was initially founded and run by Pierre Bayle between 1684 and 1687.
proposition], it is always permitted to propose and to defend” one’s conjecture. Le Clerc, in contrast to the others, was reading the meaning behind Hartsoeker’s conjecture and brand of physics more closely than the Journalistes, for instance. He observed that the Dutch philosopher’s use of conjectures and the act of conjecturing in natural philosophy had two distinct functions. On the one hand, Hartsoeker emulated the conjectural vocabulary of Descartes and his followers. On the other hand, he rebelled against the (perceived) misuse of the meaning of conjecture while making knowledge claims. Le Clerc was explicit to his readers: “In truth, [Hartsoeker] is attacking the Cartesians a bit. But in a way, they deserve it, when they apply the name of discoveries to conjectures that are not at all certain, let alone false: One discovers something when it is a guaranteed Truth, and not when one puts forward a mere suspicion or possibility.”

Hartsoeker seemed to be engaged in a classic objection-response method of scholastic debate—modeled in no small part on Descartes.

In some ways, Hartsoeker’s language may seem as one of tradition and scholasticism. In other ways, it shows a philosopher who was living in a less optimistic, post-Cartesian world, one in which any general unified system was bound to be fraught with difficulties. For almost every “principle” there was an opposing rule possible. Hartsoeker’s and Homberg’s experiments with vitrification of gold did not all yield the same results, as we saw in Part II of Chapter Three. Principles crumbled under the lack of a sufficient pool of conclusive trials and thus bred ever deepening scepticism and doubt. Historians generally place the culmination of scepticism in the late

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83 Jean Le Clerc, « Description de deux niveaux d’une nouvelle construction, dont l’un a le centre de pesanteur au dessous, & l’autre au dessus du point d’appui, Amsterdam, 1711 et Suite des Conjectures Physiques, Amsterdam, 1712 » in Bibliothèque Choisie, Tome 27, 1713, 233 : « Les Eclairissemens font des réponses à Mrs. Bernard, Leibnitz, et autres, qui avoient fait quelques objections sur ses Conjectures précédentes; où bien des gens jugeront qu’il ne se tire pas mal d’affaire. En effet, il s’agit de choses problematiques, où il y a bien des raisons pour & contre, qu’il est toujours permis de proposer, & de défendre; quand on le fait avec la moderation, que notre Auteur observe par tout. Il fronde à la vérité un peu les Cartesiens, mais ils le méritent, en quelque manière; lors qu’ils donnent le nom de découvertes à des conjectures tout à fait incertaines, pour ne pas dire fausses: On découvre quelque chose, lors que c’est une Verité assurée, & non lors qu’on ne fait qu’avancer ce qui n’est qu’un soupçon, ou qu’une possibilité. Je ne puis entrer dans aucun détail des objections & des réponses, qui sont en grand nombre; & qu’il faudroit rapporter toutes entières, pour les faire entendre. On ne perdra pas son temps, si on les lit avec soin, dans l’Original. »

84 Ibid.
seventeenth century and early eighteenth century. For one, measurement instruments eventually reached their maximum capacity then.\textsuperscript{85} In Chapter Two, I have also shown how Hartsoeker and his contemporaries had grown more and more disillusioned with what could be gleaned of the internal mechanics as well as macro-scale goings with and without the use of instruments. As our natural philosopher confessed, “I know from experience that air is heavy, has spring, transmits sound, is fluid . . . ; and all of this I conjecture in the capacity of Physicist, because I lack the means to know by my senses which size and shape the small particles that compose air ought to have in order to produce these effects.”\textsuperscript{86}

In another way, this disillusionment centered around the use and misuse of words. Locke cautioned against the ideological pitfalls of language in misrepresenting reality. “Principles” deceived people by having them take certain rules for absolute truths. Locke wrote that hypotheses in natural philosophy were at best “very doubtful conjectures.”\textsuperscript{87} Regardless of Hartsoeker’s doctrinal affinities with atomism and vitalist strains, his \textit{Principes de physique} gave way to \textit{Conjectures physiques} over the course of his intellectual life. He came to see the impossibility of arriving at a “perfect science of material substances,” as Hamou termed it. By this time, natural philosophy had come to a point of no return, since neither a return to Descartes’ suppositions nor to a world before the Fall was possible.\textsuperscript{88} Since causes were invisible to humans, nature had to be explained from her

\begin{footnotesize}
\begin{enumerate}
\item Nicolas Hartsoeker, “Reflexions sur les remarques precedentes,” \textit{Recueil de plusieurs pieces de physique} (Utrecht: la Vueve de G. Broedelet & Fils Libraires, 1722), 87: “Je sai par l'expérience, que l'air est pesant, qu'il fait ressort, qu'il sert à transmettre le son, qu'il est fluide, qu'il est huit cens ou mille fois plus léger que l'eau &c : & de tout cela je conjecture en qualité de Physicien, parce que les moyens me manquent pour le connoître par les sens, quelle figure & grandeur doivent avoir les petits corps qui composent l'air, pour produire ces effets.”
\item John Locke, \textit{An Essay Concerning Human Understanding} (Boston: Cummings & Hilliard and J.T. Buckingham, 1813), IV, 12, § 13, 203: “And at least that we take care, that the name of principles deceive us not, not impose on us, by making us receive that for an unquestionable truth, which is really, at best, but a very doubtful conjecture, such as are most (I had almost said all) of the hypotheses in natural philosophy.”
\end{enumerate}
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effects. Therefore, “one must almost always content oneself with simple probability” in nature.\textsuperscript{89}

Then what function and use did his “physical conjectures” serve? Hartsoeker offered the answer to this in a letter to Jacques Bernard, the editor of Pierre Bayle’s \textit{Nouvelles de la République des Lettres} between 1699 and 1718 (and a good friend of Jean Le Clerc, who appointed him the editor of his \textit{Bibliothèque universelle et historique} in 1691\textsuperscript{90}):

I am sending you my thoughts on the circulation of the blood, which I have included in a few words in my \textit{Principes de Physique}. I call them Conjectures, because I do not dare to pass them off under another title: for we can safely say that almost all of Physics is based only on Conjectures and all that one can teach from it is by probability. If you think that [my conjectures] could serve to clarify such a difficult subject in some way, I let you include them in your \textit{Nouvelles de la République des Lettres}.\textsuperscript{91}

In this passage, Hartsoeker seemed to be echoing Locke. In the eyes of the Dutch philosopher, conjectures were a reasonable, and perhaps an intellectually honest, way of dealing with a complex world of probabilities.

Moreover, the hypothetical nature of making conjectures also provided Hartsoeker with a more cautious avenue of testing his ideas in front of his audience and opposition. A review published in 1710 in the \textit{Nouvelles de la République des Lettres} began as follows: “Mr. Hartsoeker is not one of these Philosophers, who are so full of their hypotheses and discoveries that they declare that they have never been wrong, and who, protective of their work, cannot stand to be contradicted.”\textsuperscript{92}

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\textsuperscript{89} Nicolas Hartsoeker, \textit{Conjectures Physiques}, 1-2.
\textsuperscript{91} Hartsoeker, “Lettre de Mr. Hartsoeker à l’Auteur de ces Nouvelles, contenant des Conjectures sur la Circulation du sang” in \textit{Nouvelles de la République des Lettres}, Feb 1703, 153 : « Je vous envoie mes pensées sur la Circulation du Sang, que j’ai insérées, mais en trois mots seulement, dans mes Principes de Physique. Je les [mes pensées] appelle Conjectures, parce que je n’ose les débiter sous un autre titre: car, nous avons beau dire, presque toute la Physique n’est fondée que sur les Conjectures, & presque tout ce qu’on y enseigne n’est que par probabilité, si vous croyez qu’elles puissent servir à éclaircir en quelque sorte une matière si difficile, je consens, & plusieurs autres personnes en peuvent faire de même, qu’il a cherché de toutes parts des objections, soit pour se confirmer dans ses opinions, ou pour les éclaircir, si ces objections ne les détruisoient pas, soit
\end{flushright}
Like the *Journalistes*, Jacques Bernard painted the image of Hartsoeker as someone who sought out debate and was not afraid to be contradicted. In his eyes, Hartsoeker was not threatened by objections but instead wanted to address them, clarify his thoughts, and either change his mind or maintain his original ideas.

There was another side to the coin. Jacques Bernard did not forget to mention that Hartsoeker attacked other contemporary philosophers on matters with which he disagreed, so that “few academicians found themselves uncontested” by him. “Our Philosopher,” observed Bernard, “permits others to attack him . . . but he also wants to reserve the permission to attack in return, and he is right.”

Bernard underlined that Hartsoeker was not the first to proffer conjectures about natural phenomena; many came before him, including Descartes. Unfortunately, among Hartsoeker’s conjectures, by definition, there were some that were probable, while others, uncertain or false.

One enduring element of Descartes’ philosophy was its strong conviction and emphasis on reaching clear and distinct ideas through reason. However, even Descartes himself, as Daniel Garber has convincingly argued, changed his position on the kind of certainty reason was able to attain. From claiming genuine certain knowledge of corpuscular substructure (in the *Discours de la Méthode*, for instance), Descartes moved to a more modest, hypothetical position in the early 1640s when composing the *Principia*. In the later years his beliefs about corpuscular substructure were “only morally certain, or even false,” because they were based on hypothetical argument (thus

93 *Nouvelles*, 609: « En même tems, que Mr. Hartsoeker répond aux Objections qui lui ont été faites ; il attaque les sentimens de plusieurs Philosophes Modernes ; & il y a peu de Membres de l’Académie Royale de Paris, qui ayent écrit sur la Physique, l’Astronomie, & la Chymie &c. qui ne se trouvent refutez en quelques endroits de ces Eclaircissemens. Notre Philosophe permet qu’on l’attaque, il y invite même les Savans ; mais il veut aussi avoir la permission d’attaquer à son tour ; & il a raison. »
94 *Nouvelles*, 622: « Il y en a de ces Conjectures de probables, d’incertaines, de fausses. Notre Auteur voudroit-il nier qu’il n’y en ait de ces trois espéces parmi les siennes ? »
sacrificing a bid for certainty).  Hartsoeker’s thinking forged a similar path. Although skeptical of arriving at all the answers, Hartsoeker’s hypothetical approach to the study of nature exhibits his faith in the mind’s capacity for seemingly endless creative thought. In the end, he believed each newly minted conjecture held the promise of accessing nature’s secrets. For Hartsoeker as for Descartes, “It simply [did] not matter if the conjectures [were] false, as long as they agree[d] with the phenomena of experiment and observation.”

In the Eyes of Posterity: Animalcules, Controversy, and Lessons from Hindsight

As soon as Hartsoeker published the image of “the little animal” or spermatic animalcule in his first printed work, the Essay de Dioptrique of 1694, he had sealed his fate as father of the homunculus. The image—along with the wrongly interpreted claim that he had “seen” the imagined creature in a spermatozoon—became a commonplace. The homunculus was reproduced in reviews of his work, general commentaries on theories of generation and histories of microscopy. It henceforth became the curious anecdote illuminating the otherwise elusive Dutch microscopist. Countless contemporaries and later authors, from Christiaan Huygens and Julien Offrey de La Méttrie to modern historians, referenced Hartsoeker as one of the first men to have seen an animalcule or homunculus in male sperm. For example, an eighteenth-century Dutch biographer repeated that Hartsoeker was the first to observe the up-to-then invisible “seed/sperm animals” (Zaaddiertje). When Hartsoeker had first spied them, he had interpreted them as symptoms of an illness. Successive observations of the sperm of dogs and roosters, which he shared with his

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96 Garber, 127.
97 Julien Offrey de La Méttrie, L’homme plus que machine (London, 1748), 67-68.
mathematics tutor and his friend, confirmed the spermaticules as a “secret of Nature.” Another, such as Denis Diderot and Charles Bonnet, cited Hartsoeker as the promoter of spermatic “animals” or “animalcules.” Among the different theories of generation that Diderot listed, he ascribed the “absurd” system of spermatic animals to Hartsoeker. According to Diderot, two reasons for the theory’s absurdity were that only one in a million of “worms” fertilized the egg and that each sperm worm encased spermatozoa ad infinitum. This seemed very inefficient and farfetched to him.

Perhaps it does not surprise that Voltaire, who had made a name for himself as a polemicist, remembered Hartsoeker as a contentious figure. All mentions of Hartsoeker in his controversial Lettres philosophiques from 1734 alluded to the intellectual and personal disputes that marred much of Hartsoeker’s career. Voltaire especially revelled in the fight for priority between Hartsoeker and Leeuwenhoek regarding the discovery of “the little worms of which we are made.” He also mentioned Hartsoeker’s dispute with Huygens about a new method to calculate the distance of a fixed star. In the same passage, Voltaire enumerated other famous disputes in the recent history of natural philosophy: the fight for priority for the invention of the calculus between Newton and Leibniz and the opposition to Harvey’s theory of the circulation of the blood or to Perrault’s circulation of sap in plants.

Hartsoeker also crossed over into Voltaire’s world of fiction. In Micromégas of 1752, Voltaire told the story of the eponymous native of a planet that orbits the star Sirius who visited earth and

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100 Charles Bonnet, La paléogénesie philosophique, ou Idoes sur l’état passé et sur l’état futur des êtres vivans : ouvrage distiné a servir de supplément aux derniers écrits de l’auteur, et qui contient principalement le précis de ses recherches sur le christianisme (Geneva: C. Philibert et B. Chirol, 1769).
101 Diderot, 186.
was accompanied by a dwarf from Saturn. The dwarf was a caricature of Fontenelle, whom Voltaire represented as the leader of the Saturnian academy—a hint at the Parisian Academy of Sciences. In chapter five of *Micromégas*, Voltaire’s imaginary protagonists, the Sirian traveler and his Saturnian dwarf, learnt how to use a microscope for the first time. Both Hartsoeker and Leeuwenhoek made a cameo appearance, as the pioneering microscopists who first believed to have observed “the seed from which we are made.” Voltaire’s Micromégas, however, seemed an even more skilled microscopist-observer than either Hartsoeker or Leeuwenhoek, for he was able to penetrate the seed and see the atoms—“these little machines” that spun, moved around and interacted with each other. With trembling hands, the Sirian passed on the magnifying instrument to his Lilliputian companion. However, Voltaire, as usual, did not proceed without critical caution (or without underlining the naïvete of the early microscopists). He emphasized how quickly the two travelers’ incredulity melted in front of the new objects observed, and how easily they thought to have “caught nature in the act.” Voltaire concluded that appearances deceive, whether one is looking at things with a microscope or not. (“Micromégas” could itself be a deliberate pun on the act of deploying something as microscopical as atoms to argue for mega laws of nature.) To Voltaire, the episodes between Leeuwenhoek and Hartsoeker showed at the very least two things: first, the interplay between philosophical ideas and the treacherous and illusory practice of observation, and second, the inevitable friction that arises among competing observers of nature.

Voltaire understood quite well that there was more to the mechanism of a well-run Republic of Letters than receiving credit for discoveries. Personal merit and national glory were some of its most enduring foundations. In a letter to Jean Jacques Dortous de Mairan, Voltaire revealed that such competitive and irascible behavior was not motivated by naïve notions of getting at the truth

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104 Ibid.
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but by the desire for personal success. “It seems to me that there is no glory [to be found], unless
one disagrees,” he penned in 1733; “as for me, I argue with all those who are fortunate to know
you.”¹⁰⁶ A careful observer of human nature and believer in the maxim, “no such thing as bad
publicity except your own obituary,”¹⁰⁷ Voltaire, of course, was building on his own agenda. As J. B.
Shank has claimed, Voltaire was inspired by the English and Dutch contestatory intellectual cultures
that characterized the debates about Newtonianism. Consequently, he tried to pursue “bonnête
intellectual liberty” in his own writings.¹⁰⁸ Still further, Voltaire was consciously adopting “the
critical style of the coffeehouse and the periodical press” to craft “a new kind of intellectual identity
in France, that of the critical, independent philosophe.”¹⁰⁹

In practice, criticism bred controversy.¹¹⁰ Bitter polemics about priority and authorship of
discovery helped to raise one’s visibility in the Republic of Letters, even if that meant that one’s
personal reputation was at stake.¹¹¹ Criticism and judgment were the currency which the members
of the Republic used to operate within it and by which they were compensated in turn. The learned
reviewer and reader, rather than the author, had the possibility and, often, the responsibility to pass
judgment and be the critic.¹¹² Novel ways of knowledge dissemination, such as periodicals, and new
social venues, such as coffeehouses and salons, helped to create an ever more vibrant public sphere
where public opinion began to take shape.¹¹³ Along with this development, the eighteenth century

Theodore Besterman (Paris: Gallimard, 1977), 408: « Il me semble qu’il n’y a guère de gloire qu’on ne dispute, et moi je
dispute à tous ceux qui ont le bonheur de vous connaitre, le plaisir et la justice de vous aimer et vous estimer davantage. »
¹⁰⁷ Brendan Behan, Irish author & dramatist (1923 - 1964): “There is no such thing as bad publicity except your own
obituary.”
¹⁰⁸ Shank, 342.
¹⁰⁹ Shank, 304-305.
123-149, 133.
¹¹¹ Daston, 379.
¹¹² Martin Mulsow, « The Libertine’s Two Bodies: Moral Persona and Free Thought in Early Modern Europe, » Intellectual
¹¹³ Broman, 127.
saw the emergence of another public figure in the Republic of Letters: the literary critic.\textsuperscript{114} Hartsoeker can be construed as an advocate of adversarial knowledge production, one whose vociferous public persona anticipated and eventually fell in line with the combative polemics of post-1720s French scientific discourse.\textsuperscript{115} This Chapter shows, however, that philosophers who believed and participated in adversarial knowledge making—as Shank would have it—were not particularly a creation of the eighteenth century. Neither did these controversial philosophes have to wait for the coming of a Voltaire to formulate and promote their behavior, objectives, and language with which to operate. The Republic of Letters, as Hartsoeker’s example teaches, was a space for amis as well as ennemis. Their amicable as well as adversarial ways of producing knowledge were already alive and kicking in the seventeenth as well as the eighteenth centuries (as Goldgar’s and Daston’s work convincingly demonstrates).

**Conclusion: Conjectures, Civilized Debate, and the Duty of a Bon Physicien**

On the one hand, Hartsoeker gained notoriety during his lifetime for his unorthodox ideas. On the other hand, he acquired it also for the polemical way in which he expressed them. One biographer found Hartsoeker’s readiness “to attack especially great Men” to be a thorny, personal shortcoming.\textsuperscript{116} Fontenelle called Hartsoeker a very harsh critic (“un Censeur très severe”).\textsuperscript{117} He went so far as to charge Hartsoeker with violating Article XXVI of the rules of the Academy for using “terms of contempt and bitterness”\textsuperscript{118} in his exchanges with Leibniz and other academicians, and in

\textsuperscript{114} Broman, 130.
\textsuperscript{116} [Author unknown], “Het Leven van Nikolaas Hartsoeker,” in *Levensbeschryving van enige voornaeme meest Nederlandische Mannen en Vrouwen*, 190-191: “Men mag het zekerlyk als een gebrek in onzen Hartsoeker aanmerken, day hy zo gereed was om anderen, en byzonderlyk om groote Mannen, aan te vallen . . .”
\textsuperscript{117} Fontenelle, « Éloge de Monsieur Hartsoeker », 245.
\textsuperscript{118} Hartsoeker to Fontenelle, « Lettre de M. Hartsoeker à M. de Fontenelle » in *Cours de Physique accompagné de plusieurs pieces concernant la Physique qui ont déjà para... (The Hague, 1730) [without pagination]: “Vous me raprochez dans vôtre Lettre de n’avoir pas toujours observe une loi portée dans l’art. 26 du Règlement de 1699, où il est dit, que l’Academie veillera exactement à ce
his *Eclaircissements sur les Conjectures Physiques*. (The last contained most of the epistolary exchange with Leibniz.) In his letter to Fontenelle, Hartsoeker defended himself against any allegations of contemptuous and bitter remarks in his debates with Leibniz. When it came to other savants, Hartsoeker confessed that his criticisms tended a bit towards playful mockery (“*une petite raillerie*”), but he argued that they were in no way stinging or sharp (“*piquant*”).

Naturally, Leibniz was critical of Hartsoeker’s ideas where those deviated from his own. As shown in Part II of Chapter Three of this dissertation, the German polymath vehemently disagreed with the atoms and Intelligences that were part and parcel of Hartsoeker’s system of nature. Moreover, Leibniz confided his annoyance at Hartsoeker’s continued rejection of his arguments against, for instance, the existence of indivisible atoms. The exchange between Leibniz and Hartsoeker exemplifies the philosophical stakes in promoting one’s own physical system. However, it also illustrates Leibniz’s frustration with the unabashedly conjectural aspect of Hartsoeker’s philosophy. It is also possible that Leibniz still believed in creating a general system that would successfully wed physics to metaphysics. On some level then, Hartsoeker’s surrender to conjectures would seem to admit defeat in the face of such a quest.

For Hartsoeker, constructive criticism and debate were necessary for advancing the sciences in two ways. First, criticism and dissent had a material and operational side that pushed one to repeat an experiment and to produce counter-evidence. In the letter to Fontenelle, Hartsoeker showed how his dispute with Guillaume Homberg inspired him to construct a very large burning mirror that he used to verify Homberg’s vitrification experiments. It led him to fashion a burning mirror of an unusually large size, repeat Homberg’s experiments, and ultimately challenge

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119 Ibid.
120 See Part II of Chapter Three of this dissertation. See also Leibniz’s correspondence with Des Bosses: Brandon C. Look and Donald Rutherford, eds. and trans., *The Leibniz-Des Bosses Correspondence* (New Haven, CT, 2007), for instance, 213; and the correspondence between Leibniz and Hartsoeker, especially the letter from Leibniz to Hartsoeker, 30 Oct 1710: « Les Atomes sont l’effet de la foiblesse de nostre imagination... » in Gerhardt, 507.
Homberg’s conclusions. It also augmented his material expertise with tools: until his dispute with Homberg, Hartsoeker reported that he had never made such a large burning mirror before.

Second, criticism had a distinctly creative and intellectually stimulating dimensions. As shown above in the exchange with Leibniz or in Hartsoeker’s reply to the *Journal Littéraire*, feedback from an outside party would hopefully improve the quality and coherence of Hartsoeker’s (and the other party’s) natural philosophical tinkering. In the Foreword to the *Receuil de plusieurs pièces de physique*, Hartsoeker’s view on criticism of printed publications did not differ much from criticism in correspondence. Namely, he argued that “whoever buys a work that has been made public through print buys with it the right to say what he thinks about it.” That is, one may criticize it as long as one stays within the bounds of “moderation and propriety.” Still, for someone like Fontenelle, Hartsoeker seemed to have overstepped these boundaries.

Finally, to Hartsoeker, criticism was a barometer of an author’s reputation. For instance, the *Eclaircissements sur les Conjectures Physiques* was one of Hartsoeker’s most openly critical work. One Dutch biographer believed it to be written with “some harshness” and contain rather severe judgments of various academicians. Aware of the opposition to the damning tone and critical content in his *Eclaircissements*, Hartsoeker argued that he only engaged with and criticized authors whose work was worthy of criticism. It was only because he esteemed these authors’ intellectual work so much. His criticisms were, in fact, a positive evaluation of an author’s ideas: Only good books were worth the trouble of criticizing and engaging with them. According to many of his critics and interlocutors, Hartsoeker did not exaggerate or condemn spitefully. He criticized what

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121 Hartsoeker, « Avertissement au Lecteur, » *Receuil de plusieurs pièces de physique*, published in *Cours de Physique* (The Hague, 1730): « Mais quoiqu’il en soit, quiconque achète un ouvrage qui a été rendu public par l’impression, achète en même temps le droit de dire ce qu’il en pense, pourvu qu’il demeure dans les termes de la modération & de la bienséance, dont je ne suis pas sorti, que je sçache, & il est bien juste que je jouïsse du même droit... »

122 [Author unknown], “Het Leven van Nikolaas Hartsoeker,” in *Levensbeschrijving van enige voornaame meest Nederlandsche mannen en vrouwen*, part 2 (Amsterdam: Petrus Conradi, 1775), 188.

123 Ibid.
deserved criticism, but he did so in moderation and with the goal of arriving at the truth. In addition, Hartsoeker’s case shows that not only published works were up for grabs in the realm of critical review. Namely, letters to other savants were “a peculiar hybrid of the personal and the public, composed with both a particular reader and a general readership in mind.”

“One would think that Philosophers would be more moderate in their quarrels than Poets, Theologians still more so than Philosophers,” sighed the author of the Éloges des Academiciens and taskmaster of the Academy’s civility code. Fontenelle’s ideal of harmonious public debates where philosophers rose above intellectual stakes to attain some higher truth and civility had to remain exactly that, an ideal. As a Dutch writer observed rightly, poets, theologians and philosophers are, after all, human. The response of other journalists and editors, such as Le Clerc or Bernard, to Hartsoeker’s style of communication was less antagonistic. They admitted more leeway not only in presenting one’s ideas about the natural world, but also in disputing one’s interlocutors, as aforementioned examples have demonstrated. Hartsoeker’s example speaks loudly to the many different positions that journals took on normative aspects of how natural philosophical communication should be conducted in the Republic of Letters. However, what some journal reviewers and Fontenelle would have agreed upon was the job description of a physicien. Eventually, “a bon physicien” had the duty “to report the Phenomena exactly” and not merely supply conjectures. Truth be told, Fontenelle would neither have condoned Hartsoeker’s definition of a physicien nor his enthusiastic use of conjectures and the associated belief that a speculative method would advance the sciences. The Academy’s amanuensis believed “[t]hat metaphysical speculation

124 Preface, Cours de Physique, accompagné de plusieurs pièces concernant la physique qui ont déjà paru et d’un extrait critique des lettres de M. Leeuwenhoek (The Hague, 1730), without pagination. The work also contains the second edition of Hartsoeker’s Recueil de plusieurs pièces de physique (orig. published in 1722). Also, see previous mentions of Le Clerc and Jacques Bernard who argued that Hartsoeker’s tone in disputes was moderate.


126 [Author unknown], “Het Leven van Nikolaas Hartsoeker,” in Levensbeschrijving van enige voornaeme meest Nederlandische mannen en vrouwen, part 2 (Amsterdam: Petrus Conradi, 1775), 192.

127 Le Clerc, Bibliothèque Choisie, Tome 11, 1707, p. 389: « Aussi ne faut-il pas toujours conjecturer, & c’est encore plus le devoir d’un bon Physicien de rapporter exactement les Phénomènes. »
and theological argument were fruitless” and “unbefitting the creative intelligence.” He saw disciplined reason, rather than unbridled hypotheticalism, as the hallmark and foundation of the sciences.

One enduring element of Descartes’ philosophy was its strong conviction and emphasis on reaching clear and distinct ideas through reason. However, even Descartes himself, as Daniel Garber has convincingly argued, changed his position on the kind of certainty reason was able to attain. From claiming genuine certain knowledge of corpuscular substructure (in the *Discours de la Méthode*, for instance), Descartes moved to a more modest, hypothetical position in the early 1640s when composing the *Principia*. In the later years his beliefs about corpuscular substructure were “only morally certain, or even false,” because they were based on hypothetical argument (thus sacrificing a bid for certainty). Hartsoeker’s thinking forged a similar path. Although skeptical of arriving at all the answers, Hartsoeker’s hypothetical approach to the study of nature exhibits his faith in the mind’s capacity for seemingly endless creative thought. In the end, he believed each newly minted conjecture held the promise of accessing nature’s secrets. For Hartsoeker as for Descartes, “It simply [did] not matter if the conjectures [were] false, as long as they agree[d] with the phenomena of experiment and observation.”

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130 Garber, “Descartes on Knowledge and Certainty,” 127.
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