Herman Boerhaave

History of Science and Scholarship in the Netherlands, volume 3

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Herman Boerhaave (1668-1738)
Calvinist chemist and physician

Rina Knoeff

Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam 2002

Edita KNAW, P.O. Box 19121, 1000 GC Amsterdam, the Netherlands
edita@bureau.knaw.nl, www.knaw.nl/edita

ISBN 90-6984-342-0

The paper in this publication meets the requirements of ♾ ISO-norm 9706 (1994) for permanence

For my parents

Every man's work, whether it be literature or music or pictures or architecture or anything else, is always a portrait of himself, and the more he tries to conceal himself the more clearly will his character appear in spite of him.

SAMUEL BUTLER, *The Way of all Flesh*

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Abbreviations used

For references to the Bible I have used the Dutch *Statenvertaling*, the translation that came out shortly after the Synod of Dordt (1618-1619), and the English authorised version of the King James Bible (1611). All dates are according to the modern calendar. Unless otherwise stated translations are mine. I have used the following abbreviations:

Manuscript Collections

Leningrad MS	Boerhaave papers in the Kirov Manuscript Collection in the Military Medicine Library in St. Petersburg.
Leiden MF	Boerhaave papers in the Kirov Manuscript Collection on microfilm in the University Library in Leiden.

Works

Orations	Luyendijk-Elshout, A.M., & Kegel-Brinkgreve E. (1983) *Boerhaave's Orations*. Leiden, 1983.
Epicurus	Boerhaave, H., (1689). 'Oratio de bene intellecta Ciceroni sententia Epicuri de summo hominis bono' in *Orations* (pp. 31-53).
CSH	Boerhaave, H., (1701). 'Oratio de commendando studio Hippocratico' in *Orations* (pp. 65-84).
URM	Boerhaave, H., (1703). 'Oratio de usu ratiocinii mechanici in medicina' in *Orations* (pp. 94-120).
RMS	Boerhaave, H., (1709). 'Oratio in qua repurgatae medicinae facilis asseritur simplicitas' in *Orations*, (pp. 127-144).
CCP	Boerhaave, H., (1715). 'Sermo academicus de comparando certo in physicis' in *Orations* (pp. 155-179).
CSEE	Boerhaave, H., (1718). 'Dissertatio de chemia suos errores expurgante' in *Orations* (pp. 193-213).
SAC	Boerhaave, H., (1729). 'Sermo academicus quem habuit quum honesta missione impetrata botanicam et chemicam professio-

	nem publice poneret XXVIII Aprilis 1729' in *Orations* (pp. 222-236).
HMS	Boerhaave, H., (1731). 'Oratio de honore medici, servitude' in *Orations* (pp. 246-263).
Commentariolus	Boerhaave, H. 'Commentariolus de familia, studiis, vitae cursu, &c. propria Boerhaavii.' Trans. Lindeboom, G.A. *Herman Boerhaave. The Man and his Work*. Ed. G. A. Lindeboom. London, 1968 (1743). 377-386.
Correspondence 1	Lindeboom, G.A., ed. *Boerhaave's Correspondence*. Vol. 1. Leiden, 1962.
Correspondence 2	Lindeboom, G.A., ed. *Boerhaave's Correspondence*. Vol. 2. Leiden, 1964.
Correspondence 3	Lindeboom, G.A., ed. *Boerhaave's Correspondence*. Vol. 3. Leiden, 1979.

Chemical Symbols

☉	Gold
☾	Silver
☿	Mercury
♁	Antimony
♀	Copper
♂	Iron
♃	Tin
♄	Lead
♳	Sulphur

Acknowledgements

It is a great pleasure to acknowledge the support of the following people and institutions.

First of all I would like to thank my supervisor Andrew Cunningham. I feel privileged to have had his guidance during the Ph.D. research and writing of the book. No-one was more interested in the project and more encouraging. His comments and questions always made me think and his enthusiasm made me believe in the project in times when it was difficult to see any progress. Most importantly he showed me how to be a critical historian, for which I am much indebted.

I also want to thank Harold Cook, Patricia Fara, Ole P. Grell, Eddy Houwaart, Jonathan Israel, Harmke Kamminga, Sachiko Kusukawa, Alfons Labisch, Bruce Moran, Tabitta van Nouhuys, John Powers, Lawrence Principe and Richard Smith for their encouragement, helpful comments and advice during the various stages of my research and writing. I am also grateful for the help of Christoph Jedan and Elisabeth Leedham Green with particularly difficult Latin passages in Boerhaave's work.

My stay in St. Petersburg in order to visit the Library of the Military Medicine Academy, would have been entirely impossible without the valuable help of Daniel Alexandrov, his wife Lera and son Daniel jr. and Alexandra Bekasova of the St. Petersburg Department of the Russian Academy of Sciences.

I am indebted to A.M. Luyendijk-Elshout, E. Kegel-Brinkgreve and G.A. Lindeboom. Their work on Boerhaave, and especially their translations of Boerhaave's orations and correspondence paved the way for my research. If the saying is true that a dwarf standing on the shoulders of giants can see further afield, I must be the dwarf standing on their shoulders.

The help of librarians is indispensable in doing historical research. I am grateful to the staff of the Rare Books Room of the Cambridge University Library; the Whipple History of Science Library in Cambridge; the Wellcome Institute Library in London; the Rare Books Department of the British Li-

brary in London; the Douza Department of the Leiden University Library; the library of the Boerhaave History of Science Museum in Leiden, the Municipal Archive in Leiden and the University Library of the University of Amsterdam. Although my visit of the library of the Military Medicine Academy in St. Petersburg was largely unsuccessful, I am thankful for the help I received for the few hours I was allowed to work with the Boerhaave manuscripts.

I am grateful for the financial support through scholarships and grants without which the research would have been impossible. My thanks go to the Wellcome Trust, VSB-bank, Raymond and Edith Williamson Fund, Cambridge European Trust, Stichting Fonds Doctor Catharine van Tussenbroek and the British Federation of Women Graduates Charitable Foundation. I am also thankful to Darwin College and the Society for the Social History of Medicine for awarding travelgrants in order to present my work at overseas conferences.

The completion of the dissertation would not have been possible without the support of family and friends. Special thanks go to my father, who helped me understand Calvinist doctrine in numerous discussions late at night and on the phone. My brother Fredrik also must be mentioned for the many times he offered me a bed when visiting the University Library of Leiden. Barbara Allart, Palmira Fontes da Costa, Natasha Glaisyer, the late Pieter Manneke, Klaus Staubermann and Kim Taylor always offered a listening ear. Many thanks go to Jon Doye for proofreading the thesis and to Christoph Jedan for his dedicated support during the last stages of writing. Most importantly, the many good times with friends in England and in the Netherlands put the writing of a dissertation into perspective.

Introduction

Just after Boerhaave's death in 1738 the following obituary, written by Samuel Johnson, appeared in the English *Gentleman's Magazine*:

> Dr. *Boerhaave* was a religious and modest Man, and so far from giving into the silly Affections of *Freethinking*, which *Pitca[i]rne* and some *English* Physicians valued themselves on, that he never made mention of the SUPREME BEING but to admire and exalt Him in His Works, and his written Advices were always accompanied with a short Prayer for the divine Blessing on his Endeavours. [1]

Nothing in Boerhaave's life was more important than his religion. His Calvinist beliefs not only dictated his way of life, but also guided his natural philosophical investigations. This book is about Boerhaave's Calvinism and about the way his Calvinism determined his chemistry and chemistry for medicine.

So far Boerhaave scholars have mainly discussed the question *how* Boerhaave constructed his natural philosophy and they have traced Boerhaave's ideas to their various original sources. Most notably, Lindeboom, in his extensive work on Boerhaave has described Boerhaave's ideas in much detail. [2] However, Lindeboom has presented a whiggish history in which he did not pay much attention to Boerhaave's viewpoints alien to modern science. For example Lindeboom never thought much of Boerhaave's alchemy and although he admitted that Boerhaave was a very religious man, Lindeboom did not ascribe any influence to Boerhaave's Calvinism upon his natural philosophy. Similarly Luyendijk-Elshout has not paid any attention to Boerhaave's Calvinism and she has argued that Boerhaave presented a thoroughly

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[1] *Gentleman's Magazine*, (1738): viii, 491, quoted in Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and his Work*. Leiden: 261.

[2] Lindeboom published his work on Boerhaave in the series *Analecta Boerhaaviana*. Most important is his biography of Boerhaave: Lindeboom (1968). *Herman Boerhaave*.

mechanistic medicine.[3] Moreover, Harold Cook has recently argued that 'Boerhaave's medical teachings explicitly avoided any reference to immaterial powers' and that Boerhaave's faith had no major importance for his medicine.[4]

The central question of this book is not *how* but *why*? Why did Boerhaave develop his system the way he did? Why was he so keen on chemistry and why did he choose the discipline as one of the most important disciplines in medicine? Why did he attach so much value to experiment and observation? These questions are closely related to the questions Boerhaave himself asked while studying nature. What did he look for when doing chemical experiments? What was the purpose of his natural philosophical investigations?

Rather than viewing Boerhaave's pursuits from a modern scientific viewpoint, we have to go back to the early eighteenth century and contextualise Boerhaave's work.[5] Ever since the early nineteenth century, science and religion have become two separate realms with their very own questions and solutions. However this was not so in the early eighteenth century. When looking at Boerhaave's queries, we shall see that Boerhaave was not a founding father of modern science as such, but he answered questions and issues of his own time. He was not driven by the motive of developing an objective science independent from religion. On the contrary, we shall see that Boerhaave's natural philosophy was firmly rooted in his Calvinism.

The idea of breaking down the image of a former scientific hero and reconstructing his ideas is not new. As a result of the increasingly more important historical question as to what motivated intellectual pursuits many biographies have been or are in the process of being rewritten.[6] Moreover, it is

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[3] Luyendijk-Elshout, A.M. (1982). 'Mechanicisme contra Vitalisme. De School van Herman Boerhaave en de Beginselen van het Leven.' *Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek, 5* (1), 16-26; See also the commentaries upon the orations: Luyendijk-Elshout, A.M., & Kegel-Brinkgreve, E. (1983). *Boerhaave's Orations*. Leiden.

[4] Cook, H. (2000). 'Boerhaave and the Flight from Reason in Medicine.' *Bulletin for the History of Medicine, 74*, 221-240: 221, 240.

[5] Fairly recently historians have advocated this historiographic approach. See: Wilson, A., & Ashplant, T.G. (1988). 'Whig History and Present-centred History.' *Historical Journal, 31*, 1-16; Ashplant, T.G., & Wilson, A. (1988). 'Present-centred History and the Problem of Historical Knowledge.' *Historical Journal, 31*, 253-274; Cunningham, A. (1988). 'Getting the Game Right: Some Plain Words on the Identity and Invention of Science.' *Studies in the History and Philosophy of Science, 19* (3), 365-389; Cunningham, A., & Williams, P. (1993). 'De-centring the Big Picture. The Origins of Modern Science and the Modern Origins of Science.' *British Journal for the History of Science, 26*, 407-432; Jardine, N. (1991). *On the Scenes of Inquiry: On the Reality of Questions in the Sciences*. Oxford.

[6] The re-evaluation of the works of scientific heros is the topic of a recent book by Theunissen and Hakfoort: Theunissen, B., & Hakfoort, C. (1997). *Newton's God en Mendels Bastaarden: Nieuwe Visies op de 'Helden van de Wetenschap.'* Amsterdam.

often the chemistry and alchemy, hitherto neglected and considered unimportant, which shows the 'other side' of many contemporary scientific heroes. A major example is the re-evaluation of the works of Isaac Newton. The discovery and study of his alchemical manuscripts has thrown a new light upon his physics, and historians have started to see that 'all issues of passivity and activity, or mechanical and non-mechanical forces, were enmeshed for Newton in a philosophical / religious complex.' [7] Recently historians have also reconsidered the projects of Robert Boyle. They have started looking at his chemistry and alchemy and as a result they have argued that Boyle was not as 'scientific' as historians have argued before. [8] In Boerhaave's case historians have similarly neglected the importance of theories and ideas which modern science has conveniently forgotten. However, I shall argue that in the forgotten ideas, such as for example the divine nature of fire, the chemical theory of menstrua and the idea of seminal principles, we find the motives for Boerhaave's pursuits.

Before looking at Boerhaave's ideas in more detail I shall use the introduction in order to present a picture of the world of which Boerhaave was a part. I shall also address the question why Calvinism was an important factor in the rise of natural philosophy in the Low Countries and what made Boerhaave's point of view specifically Calvinist as opposed to for example Lutheran or Arian. In order to understand the development of Boerhaave's chemistry for

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[7] Dobbs, B.J.T. (1991). *The Janus Faces of Genius. The Role of Alchemy in Newton's Thought.* Cambridge. 5. For a discussion of Newton's alchemy see also: Dobbs, B.J.T. (1975). *The Foundations of Newton's Alchemy. Or 'the Hunting of the Greene Lyon.'* Cambridge. See also the work of McGuire: McGuire, J.E., & Rattansi, P.M. (1961). 'Newton and the Pipes of Pan.' *NRRS, 21*, 108-143; McGuire, J.E. (1967). 'Transmutation and Immutability: Newton's Doctrine of Physical Qualities.' *Ambix, 14*, 69-95; McGuire, J.E. (1968). 'Force, Active Principles, and Newton's Invisible Realm.' *Ambix, 15*, 154-208; McGuire, J.E. (1973). 'Newton and the Demonic Furies: Some Current Problems in the History of Science.' *History of Science, 11*, 21-48; McGuire, J.E. (2000). 'The Fate of the Date: The Theology of Newton's *Principia* Revisited.' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* (pp. 271-295). Cambridge.

[8] See for example: Clericuzio, A. (1990). 'A Redefinition of Boyle's Chemistry and Corpuscular Philosophy.' *Annals of Science, 47*, 561-589; Clericuzio, A. (1993). 'From Van Helmont to Boyle. A Study of the Transmission of Helmontian Chemical and Medical Theories in Seventeenth-Century England.' *British Journal for the History of Science, 26* (303-334); Principe, L.M. (1990). 'The Gold Process: Directions in the Study of Robert Boyle's Alchemy.' In Z.R.W.M. von Martels (Ed.), *Alchemy Revisited Proceedings of the International Conference on the History of Alchemy at the University of Groningen, 17-19 April 1989.* (pp. 200-205). Leiden; Principe, L.M. (1998). *The Aspiring Adept. Robert Boyle and his Alchemical Quest. Including Boyle's 'Lost' Dialogue on the Transmutation of Metals.* Princeton; Principe, L.M. (2000). 'The Alchemies of Robert Boyle and Isaac Newton: Alternate Approaches and Divergent Deployments.' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* (pp. 201-220). Cambridge; Newman, W.R. (1996). 'Boyle's Debt to Corpuscular Alchemy; the Alchemical Sources of Robert Boyle's Corpuscular Philosophy.' *Annals of Science, 53*, 567-585.

medicine, I shall also briefly look at the place of chemistry at Leiden university and at contemporary debates on the importance of chemistry for physic.

Under Boerhaave's teaching the medical faculty at the university of Leiden flourished.[9] Yet, by the time Boerhaave was appointed to his first lectureship at the University of Leiden in 1701, the Low Countries were over the peak of the Golden Age and were about to start their 'Age of Decline.'[10] According to Israel the year 1702, marked by the death of Stadtholder William III and the start of the war of the Spanish succession, was the beginning of the way down. On a political level the anti-Orangists had abolished the position of Stadtholder and the Low Countries entered their First Stadtholderless period. The change was followed by fierce arguments and riots between Orangists and anti-Orangists over questions of influence and power, and continued until well into the eighteenth century. In addition to the political debates the Provinces were plagued by 'unilateral, as well as collectively agreed, troop and financial cuts, massive public debt, complaints about quotas, and deteriorating co-operation between the provinces.'[11] Internationally the Dutch, although still a nation to be reckoned with until the 1750s, faced the rising importance of other nations, such as Britain.

Not only politically, but economically as well the Low Countries became less important. During the 1720s the Dutch overseas trade started to falter and took the industries and fisheries with it. In agriculture the downwards trend which had begun in the 1660s intensified, especially with the outbreaks of cattle epidemics. As a result the urban population declined, most noticeably in the manufacturing towns of Leiden, Haarlem and Delft. The de-urbanisation, in turn, led to a decrease of the wealth of the middle class, which formerly had been the source of the general welfare of the nation. However, although there was less employment and the conditions were harder, there was no significant increase in poverty. Since many people left the towns, the

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[9] Boerhaave's teaching was very popular, even though the general list of the enrolment of students at Leiden University shows a decline from 1650. See: Israel, J. (1995). *The Dutch Republic. Its Rise, Greatness, and Fall, 1477-1806*. Oxford: 901.

[10] J. Israel, in his extensive discussion of the Low Countries in the early modern period, has called the years between 1702 (death of William III) and 1806 (collapse of the Batavian Republic), the 'age of decline.' Israel. (1995). *The Dutch Republic*. In the discussion on the Low Countries in the early eighteenth century I rely heavily on the work of Israel. See also: Jacob, M.C., & Mijnhardt, W.W. (1992). *The Dutch Republic in the Eighteenth Century*. New York. For an overview of the Dutch Golden Age see also: Price, J.L. (1998). *The Dutch Republic in the Seventeenth Century*. New York; Davids, K., & Lucassen, J. (Eds.). (1995). *A Miracle Mirrored. The Dutch Republic in European Perspective*. Cambridge; Schama, S. (1987). *An Embarrassment of Riches. An Interpretation of Dutch Culture in the Golden Age*. London.

[11] Israel. (1995). *The Dutch Republic*: 986.

people who remained could retain their living standards. Moreover, a new elite of rich regents, nobles and descendants of mercantile families, without an active economic role, appeared. Israel has argued that the Republic 'was still an affluent society compared with neighbouring countries. But it was a society in which the middle strata were being squeezed and wealth becoming more polarised than had been the case in the Golden Age.' [12]

By compensation, the intellectual life of the early eighteenth century was firmly rooted in the success of the seventeenth century, and its decline only started in the 1730s. Schaffer has argued that the stable political situation in the seventeenth century had enforced peace in learning. He repeats after an anonymous commentator in the 1690s that 'a prudent and balanced ''original system of government'' explained why the Dutch had so spectacularly '''Triumphed over Nature.''' [13] Cook has similarly argued that 'the social, economic, political and educational structures of the Low Countries [in the seventeenth century] provided the foundation of an intellectual revolution.' [14] In short, the seventeenth century political stability, relatively religious tolerant climate and thriving economy allowed Dutch natural philosophy to develop and flourish until well into the next century.

Boerhaave was very much a child of his time. Although the political and social-economic situation became increasingly difficult, Boerhaave worked in the intellectual arena as a natural philosopher, which means that the changes did not affect him very much. His earnings for private and university teaching as well as patient treatment fees, allowed him to lead a comfortable life. It can be said that Boerhaave was one of the new rich and he could afford to buy the estate Oud Poelgeest near Leiden, in addition to his house at the Rapenburg. Boerhaave was never much into politics. Given Boerhaave's disdain for the royal court, he presumably was not an Orangist. [15] This conclusion seems to be justified since Boerhaave also repeated after the anti-Orangist Gerard Noodt that religion should be free from the control of the magistracy. [16] Boerhaave was one of the last remnants of the seventeenth century intellectual Golden Age.

By the time Boerhaave started teaching in 1701, the major tensions in

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[12] *Ibid.,* 1017.

[13] Schaffer, S. (1989). 'The Glorious Revolution and Medicine in Britain and the Netherlands.' *Notes and Records of the Royal Society, 43*, 167-190: 168.

[14] Cook, H. J. (1992). 'The New Philosophy in the Low Countries.' In R. Porter & M. Teich (Eds.), *The Scientific Revolution in National Context* (pp. 115-149). Cambridge: 116. See also Hackman, W.D. (1975). 'The Growth of Science in the Netherlands in the Seventeenth and Early Eighteenth Centuries.' In M.P. Crosland (Ed.), *The Emergence of Science in Western Europe* (pp. 89-109). London.

[15] *Commentariolus*: XVII.

[16] Boerhaave to Cox Macro, 22 June 1710, *Correspondence 1*: 19.

Dutch academic life had faded away. Israel has argued that in the first decades of the century the differences in religion became less important in the widespread campaign against the followers of Spinoza, who were regarded as equivalent to free-thinkers. Israel states:

> Although the Republic resembled England, during the first two decades in the eighteenth century, in being a country where deism, and rejection of revealed religion, were commonly perceived to be widespread phenomena, Dutch society was unique in mounting such a sustained anti-deist and anti-atheistic offensive. [17]

Spinozism became an underground movement in the so-called 'Radical Enlightenment,' while at the same time 'physico theology' was the accepted natural philosophy in the Low Countries. The main aim of 'physico theology' was to show the works of God in the creation and the overthrowing of Cartesianism. Two major works at the time were Bernard Nieuwentijt's (1654-1718) '*Het Regt Gebruik der Werelt Beschouwingen,*' ('The Right Use of Contemplating the Works of the Creator,' 1715) and the '*Gronden van Zekerheid*' ('Grounds of Certainty,' 1720), in which he rejected the philosophies of Spinoza and Descartes and argued that a revealed God is evident in the details of nature. [18]

In the beginning of his career, Boerhaave himself was a victim of the witchhunt against Spinozists as he was accused of being a follower of the controversial philosopher. However, the allegations were partly unfounded and if it is at all possible to assign Boerhaave to a certain side in the debate, his natural philosophical investigations must be placed in the camp of the 'physico theologists.'

Boerhaave's Calvinism dictated the way he studied nature in two ways. Firstly, Boerhaave aimed at showing the wisdom of God in the divine works of creation and providence. Secondly, Boerhaave contrasted the power of God with the littleness of man and he emphasised the limitations of the human mind on every occasion. A combination of these two factors is particularly visible in Boerhaave's chemistry. For Boerhaave the peculiar powers of bodies show the active hand of God in nature, while at the same time chemical experiment and observation keep man from trying to understand the infinite height of the divine. In other words Boerhaave put great emphasis on

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[17] Israel. (1995). *The Dutch Republic*: 1041. For the controversies concerning the philosophy of Spinoza see also Israel's most recent work on the Radical Enlightenment: Israel, J.I. (2001). *Radical Enlightenment. Philosophy and the Making of Modernity 1650-1750*. Oxford.

[18] *Ibid*., 1014. For Nieuwentijt and physico-theology in the Low Countries see also: Vermij, R. (1991). *Secularisering en Natuurwetenschap in de Zeventiende en Achttiende Eeuw: Bernard Nieuwentijt*. Amsterdam; Vermij, R. (1999). 'Science and Belief in Dutch History.' In K. v. Berkel, A. v. Helden, & L. Palm (Eds.), *A History of Science in the Netherlands. Survey, Themes and Reference* (pp. 332-347). Leiden.

particular occurrences rather than general theory, for in the details of nature he could see God's active government of the creation. Moreover, the individuality of natural phenomena made him realise that trying to understand the works of God via the (Cartesian) method of mathematical reasoning was not only too ambitious, but also entirely impossible. Boerhaave considered God's divine works too great and too complex to fit into the enclosure of the human mind.

Boerhaave was not unique in emphasising the peculiar characteristics of bodies. The Dutch attention for detail is a striking characteristic of Dutch early modern natural philosophy, recently recognised by historians. Cook has argued that this natural philosophy was not particularly directed towards constructing a mechanical world view, but can be characterised as the exploration of detail.[19] Ruestow has done extensive research on the influence of the microscope upon Dutch intellectual life. He has argued that 'the microscope testified to an evermore intricate complexity in nature and a pervasive and continuing unexpectedness.' Unlike telescopic observations, which quickly got assimilated into general mathematical theory, microscopy 'underscored nature's capacity for endless surprise and for images that challenged the limits of the imagination.'[20] The attention for detail was not restricted to natural philosophy, for the arts, especially Dutch painting, reveal a great attention for details. Alpers has argued that Dutch art differs from Italian art. The latter is narrative. A painting represents another world and is based on prior texts or poems. Dutch art on the contrary is descriptive, and provides 'a portrait of [the Dutch] themselves and their country – its cows, landscape, clouds, towns, churches, rich and poor households, its food and drink.'[21] It is part of a visual rather than a textual culture, which according to Alpers also explains why the Dutch pay a lot of attention to experiment and observation.

Neither Alpers nor Cook have paid much attention to the importance of religion in the Dutch approach. Alpers has left Calvinism out of her account because in her view the picturing of the world is contrary to the Protestant emphasis on the Scriptures.[22] Cook has stated that strong claims on the relationship between 'science' and Protestantism must be treated 'with the same scepticism with which the 'Merton thesis' is treated by historians of English science.'[23] Rather than pointing to Calvinism, Cook has followed Hooykaas in stating that Catholic, Jewish and Protestant natural philosophers were uni-

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[19] Cook. (1992). 'The New Philosophy': 116.
[20] Ruestow, E.G. (1996). *The Microscope in the Dutch Republic. The Shaping of Discovery*. Cambridge: 4.
[21] Alpers, S. (1989 (1983)). *The Art of Describing. Dutch Art in the Seventeenth Century*. London: xvii.
[22] *Ibid.,* xxvi.
[23] Cook. (1992). 'The New Philosophy': 141.

ted in a Biblical humanism. This brings us to the question of how much of Boerhaave's thought was specifically Calvinistic and how much was part of a general Christian attitude towards studying nature? In other words, can we not say that Boerhaave only referred to God on numerous occasions because the convention of the time told him to do so and he wanted to make his ideas acceptable? This question is related to the question of how different Boerhaave's Calvinist God was from the God of other denominations?

Ever since the publication of Weber's *The Protestant Ethic and the Spirit of Capitalism* (1904), historians have been studying the relationship between Protestantism and the rise of science.[24] They have argued that the doctrine of predestination was of crucial importance in the creation of a particular work ethic in the seventeenth century in which science could flourish. Historians have argued that the idea of predestination created so much uncertainty about the state of man in the eyes of God, that the believer sought for signs of election in the fruits of his work. The rigid work ethic created a climate in which capitalism could flourish and in which the sciences could develop.

However, rather than the theory of predestination, which is not peculiar to Calvinism only, ideas on creation and providence are responsible for the rise of natural philosophy in the Low Countries. Calvinism distinguishes itself from all other confessions in its presentation of a God who determines absolutely everything on earth; from the life of plants and animals, to the origin of ideas in the human mind. Calvin had argued that man is entirely subjected to the will of God. As a result of the Fall he cannot do any good out of himself, but he entirely depends upon God's grace. Man is obliged to study the creation firstly out of thankfulness towards God who created him and secondly so that he can detect God's divine will in the nature of things.

Luther differed from Calvin in the sense that he had not been very interested in constructing a natural theology.[25] Luther argued that although God is immanent in the world, in the eucharist of the bread as well as in other things, yet His presence is inaccessible. Human sin has transformed all creatures into 'masks' of God, which means that God is 'hidden outside his revelation.'[26] Moreover, Luther regarded the existence of religion as sufficient

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[24] Weber, M. (1971 (1904-5)). *The Protestant Ethic and the Spirit of Capitalism* (Parsons, Talcott, Trans.). London; Merton, R. (1987). *Science, Technology and Society in Seventeenth Century England*. New York; Webster, C. (1975). *The Great Instauration. Science, Medicine and Reform 1626-1660*. London; Webster, C. (1982). *From Paracelsus to Newton. Magic and the Making of Modern Science*. Cambridge. Recently published is a set of essays edited by M. Osler, discussing the relationship between religion and the rise of natural philosophy. The essays not only look at protestantism, but also at other denominations. See: Osler, M.J. (Ed.). (2000). *Rethinking the Scientific Revolution*. Cambridge.

[25] Steinmetz, D.C. (1995 (1986)). *Luther in Context*. Michigan: 24.

[26] *Ibid.*, 24-25.

proof for the existence of God. This means that Luther points to the Scriptures rather than to the creation as the source of knowledge of God, while in the Dutch Calvinist creed, the creation is mentioned even before the Word as a means to know God. It must be said that the Lutherans, under the influence of Philip Melanchton did present a Lutheran natural philosophy, based on the idea of divine providence. [27] I shall discuss the difference between Lutheran and Calvinist natural philosophy at a later stage.

While Luther did not think about nature in the first place as a means to come to know God, Isaac Newton, on the other hand believed that 'there is no way to come to a knowledge of the Deity except by revelation or by the 'frame of nature.' [28] Yet, although Boerhaave probably read Newton's reflections on the omnipotence of God in the *Principia* and the *Opticks* with Calvinist eyes, Boerhaave's Calvinist God differed significantly from Newton's God. Newton's belief was anti-trinitarian and he also denied the immortality of the soul and the existence of spirits and the devil. [29] Snobelen has argued that Newton was eclectic in his beliefs and that he combined ideas from 'Anglicanism, Calvinism, Judaism, fourth-century Arian sects, seventeenth century radical theologies and his own exegetical innovation.' [30] Nevertheless I want to single out the influence of Arianism upon Newton's beliefs, for this shows particularly well how Boerhaave's God is different from Newton's.

Newton repeatedly said that 'the supreme God does nothing by Himself that He can do by others.' [31] This statement relates to the Arian belief that God is not concerned with the 'moment-to-moment movements of all particles of matter in the universe.' Instead God needs 'an intermediary for intercourse with the world.' [32] Hence Newton introduced an 'alchemical spirit' or 'universal vital activator' as the intermediary hand of God in His governance of the world. Moreover, the active principle of alchemy was closely related to

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[27] Kusukawa, S. (1995). *The Transformation of Natural Philosophy. The Case of Philip Melanchton*. Cambridge. See also Barker's recently published essay on Lutheran religion and its influence upon Lutheran scientific thought. Barker, P. (2000). 'The Role of Religion in the Lutheran Response to Copernicus.' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* (pp. 59-88). Cambridge.

[28] Dobbs. (1991). *The Janus Faces of Genius*: 255.

[29] Snobelen, S. (1999). 'Isaac Newton, Heretic: The Strategies of a Nicodemite.' *British Journal for the History of Science, 32*, 381-419: 386-387. See also: Force, J.E. (1994). 'The God of Abraham and Isaac (Newton).' In J.E. Force & R.H. Popkin (Eds.), *The Books of Nature and Scripture* (pp. 179-200). Dordrecht. For a discussion of Newton's religious views see also Manuel, F.E. (1974). *The Religion of Isaac Newton*. Oxford; Force, J.E. (2000). 'The Nature of Newton's 'Holy Alliance' between Science and Religion: From the Scientific Revolution to Newton (and Back Again).' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution*. Cambridge.

[30] *Ibid.,* 416.

[31] Newton in: Dobbs. (1991). *The Janus Faces of Genius*: 213.

[32] Dobbs. (1991). *The Janus Faces of Genius*: 213-214.

Newton's concept of mechanical ether, gravity, electricity and later to the Arian Christ. Newton believed that the true knowledge of God and His will has been lost and he considered natural philosophy as the first step towards the restoration of truth. [33]

Boerhaave differed widely from Newton in this respect. He believed that God directly works in nature, not using a universal medium, but via the powers peculiar to individual bodies. Boerhaave's Calvinism had taught him to approach the creation with a humble mind and never to aim at the wisdom of God Himself. Hence Boerhaave emphasised the infinite variety of nature and the individual powers of all things as results of a first cause which remains hidden from man's eyes. Man can never fully disclose God's operating hand in nature, but he can only admire its working. Moreover, it is impossible to completely restore true knowledge, for man cannot even understand or perfect the structure of a simple hair. [34]

It can be said that although the study of the works of the creation was a recurring theme in all Christian theology alike, Calvinists placed an extra emphasis on the *obligation* of man to study God's creation. This is perhaps a reason why natural philosophy could flourish in a country were Calvinism was the state religion. This can also explain why Cartesianism could develop in the Low Countries. Although theologians turned away from Descartes' metaphysics, they at the same time allowed his mathematics and physics to be taught in the universities, for they must have seen it as a useful means to study nature.

The Calvinism of Boerhaave and of many contemporary 'physico-theologists,' also emphasised that the human mind is blinded by sin. Ruestow has argued that Calvinists were 'striving to recognise a revelation of God hidden not by the secretiveness of nature but by the moral depravity of man.' [35] Boerhaave expressed a Calvinist viewpoint when stating that man cannot come to true knowledge out of himself, but he depends upon God, who imprints true knowledge upon his mind. Thus man should not adopt a general theory of matter and motion in order to explain the world around him. Instead he should concentrate on chemical experiment in order to show the latent peculiar powers of bodies, which is the endless variety of the working of God's divine will in nature.

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[33] *Ibid.,* 247.
[34] *CCP*: 168.
[35] Ruestow. (1996). *The Microscope*: 78.

No-one seems to have studied Boerhaave's chemistry in detail with respect to his medicine.[36] Yet by 1718, when Boerhaave accepted the chair of chemistry, he regarded chemical skill and practice as one of the keystones of his whole medical approach. He gave an annual course of lectures, covering the history, theory and practice of chemistry, and in the practical part he discussed the medical use and application of virtually all the chemical preparations he taught. Moreover, in his teaching and writings on the powers of medicines and on *Materia medica* (1719), he makes much reference to the use of chemical preparations as drugs. These chemical works were very popular, being published in unauthorised editions by his students, and in authorised ones by Boerhaave himself. They were translated into several languages, and appeared in many editions.[37] Pupils of Boerhaave set up chemical teaching following the methods of their teacher, so the chemical approach to medicine that Boerhaave taught was very influential. However, it is not my purpose to discuss the impact of Boerhaave's ideas upon his students, for that would be the topic of another book. As said before I am more concerned with the contemporary ideas and questions shaping Boerhaave's natural philosophy.

In Boerhaave's day the proper relation of chemistry to medicine was a matter of keen dispute, with some eminent physicians and medical theorists, such as Georg Ernst Stahl in Germany, claiming that it had no role, others, especially the Helmontians, that it was crucial to medicine. In France and Britain the early seventeenth century witnessed fierce debates between Galenists and chemists. Traditional physicians protected their university courses against modern influences which meant that chemistry developed and flourished

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[36] For works looking at the relationship of chemistry and medicine in Boerhaave's work see: Gibbs, F.W. (1963). 'Boerhaave and the Place of Chemistry in Medicine.' In F.N.L. Poynter (Ed.), *Chemistry in the Service of Medicine*. London; Lindeboom, G.A. (1972). 'Boerhaave's Impact on the Relation between Chemistry and Medicine.' *Clio Medica, 7*, 271-278. For works on Boerhaave's contribution to the discipline of chemistry see: Metzger, H. (1930). *Newton, Stahl, Boerhaave et la Doctrine Chimique*. Paris; Gibbs, F.W. (1949). *The Life and Work of Herman Boerhaave. With Particular Reference to his Influence in Chemistry*. Unpublished Ph.D., London; Jevons, F.R. (1962). 'Boerhaave's Biochemistry.' *Medical History, 6*, 343-362; Partington, J.R. (1961). *A History of Chemistry*. New York: ii, 740-759; Cohen, E. (1919). *Herman Boerhaave en Zijne Betekenis voor de Chemie. Met een Vertaling van Boerhaave's Natuurwetenschappelijke Redevoeringen en Verhandelingen door Dr. Margaretha Renkema*. De Nederlandse Chemische Vereniging in Samenwerking met de Vereniging voor Geschiedenis der Genees-, Natuur-, en Wiskunde; Christie, J.R.R. (1994). 'Historiography of Chemistry in the Eighteenth Century: Herman Boerhaave and William Cullen.' *Ambix, 41*, 4-19. For a general survey on the importance of chemistry for medicine in the seventeenth and early eighteenth century see: Debus, A.G. (2001). *Chemistry and Medical Debate. Van Helmont to Boerhaave*. Canton, MA. For a history of medicine in the eighteenth century see the work of L. King: King, L.S. (1958). *The Medical World of the Eighteenth Century*. Chigago; King, L. (1963). 'Rationalism in Early Eighteenth Century Medicine.' *Journal of the History of Medicine, 18*, 257-271.

[37] See Lindeboom, G.A. (Ed.). (1959). *Bibliographia Boerhaaviana*. Leiden.

mainly outside the universities in newly founded learned societies like the Royal Society in London and the *Jardin des Plantes* in Paris.[38] Only slowly did chemical remedies become accepted among Galenic physicians but iatrochemistry never really got a place in the official medical curricula. As a result the main function of chemistry for medicine was pharmaceutical. Chemistry proved to be a great help in the preparation of cures, but it was looked upon with suspicion in the explanation of bodily processes. Alan Debus has suggested that this was mainly due to the popularity of the mechanical philosophy, which ruled out chemical theory.[39] Especially under the influence of the works of the Italians Borelli and Bellini, the mechanics of motion of the fluids became a central concern in medical theory.

Although the debate between iatrochemists and traditional physicians raged in Britain and France, it did not so much affect the Low Countries. Under Franciscus dele Boë Sylvius, who was elected to the chair of medicine at the university of Leiden in 1658, medical teaching flourished. Sylvius advocated a chemical medicine that went back to the iatrochemistry of Paracelsus and Van Helmont. He tried to explain all physiological and pathological processes in the body through the interaction of acid and alkali, which he named the fundamental principles of nature.[40] This means that he classified the classic humours according to their acidity; saliva is neutral, the pancreatic juice slightly acid and bile is alkaline. Illness results from an upset balance of the humours and a cure consists in neutralising the condition of acridity, i.e. the excess of either acid or alkali in the body.[41] The strong chemical tradition at the University of Leiden continued with the building of a chemical laboratory in 1669. The director, Carel de Maets (Dr Desmatius), became the first professor of chemistry, followed by Jacob le Mort in 1690. However, by that time chemistry had declined from a most important basis to not more than a help to medicine. For Le Mort, an apothecary's son, chemistry was only useful in the preparation of drugs.[42] The chemical laboratory declined under his

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[38] For debates in France see: Debus, A.G. (1991). *The French Paracelsians. The Chemical Challenge to Medical and Scientific Tradition in Early Modern France*. Cambridge. For England see: Jones, R.F. (1961). *Ancients and Moderns. A Study of the Rise of the Scientific Movement in Seventeenth Century England*; Clericuzio. (1993). 'From Van Helmont to Boyle.' See also: Debus, A.G. (1987). *Chemistry, Alchemy and the New Philosophy, 1550-1700*. London.

[39] Debus. (1991). *The French Paracelsians*: 154.

[40] Beukers, H. (1982). 'Mechanistische Principes bij Franciscus dele Boë, Sylvius.' *Tijdschrift voor de Geschiedenis der Natuurwetenschappen, Wiskunde en Techniek, 5* (1), 6-15.

[41] Hannaway, O. (1965). *Early University Courses of Chemistry*. Unpublished Ph.D., University of Glasgow, Glasgow: 197-198.

[42] Lindeboom. (1968). *Herman Boerhaave*: 110.

care, so that Boerhaave, who succeeded Le Mort in 1718, had to ask the curators of the university for many new utensils and materials.

It can be said that when Boerhaave started his private lectures in chemistry in 1702 his bed was already made. Hannaway has argued that 'the chemistry laboratory at Leyden should be seen as part of an overall educational pattern to train professional people in practical skills useful to the community.' [43] As chemistry was an accepted part of medical teaching, Boerhaave did not have to fight his position, nor did he have to choose between the viewpoints of the iatrochemists who explained all bodily processes in chemical terms, and the opinion of others, who claimed that chemistry had no place in medicine at all. Boerhaave was in the fortunate position of being able to study chemistry for medicine and develop a system that might look like a golden mean between two extreme views, as Lindeboom has suggested, but which was in fact a unique system, a 'new method of chemistry.' [44]

One of Boerhaave's contemporaries in the Low Countries was Johann Conrad Barchusen (1666-1723), university professor of chemistry in Utrecht from 1694 until 1723. According to Lindeboom, Barchusen preceded Boerhaave by almost a decade in promoting a chemistry which was not only ancillary to medicine but also had an independent status. [45] For Barchusen the primary aim of chemistry remained the preparation of medicines, but he also used chemistry in the investigation of the nature and qualities of bodies. [46] Barchusen, just like Boerhaave, warned against the chemists 'seeking to grasp faith and reason with their own hands,' thereby referring especially to Cartesian chemists promoting subtle ether theories. [47] Nevertheless Barchusen adopted Cartesian matter theory as well and he speculated about the sizes and shapes of the traditional Aristotelian elements salt, oil, water, and earth. He sought to understand the theory of chemistry behind the processes themselves and he 'is always trying to rationalise the chemistry of his preparations and draws on corpuscular and mechanistic theories to make them intelligible.' [48]

Boerhaave was an eclectic. He developed his own unique system by adopt-

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[43] Hannaway. (1965). *Early University Courses*: 209.

[44] Lindeboom, G.A. (1972). 'Boerhaave's Impact on the Relation between Chemistry and Medicine.' *Clio Medica, 7*, 271-278: 273. Shaw named his translations of Boerhaave's lectures *A New Method of Chemistry.*

[45] Lindeboom, G.A. (1972). 'Boerhaave's Impact on the Relation between Chemistry and Medicine.' *Clio Medica, 7*, 271-278: 214. See also Lindeboom, G.A. (1970). 'Barchusen and Boerhaave.' *Janus, 57*, 30-41.

[46] Hannaway, O. (1967). 'Johann Conrad Barchusen (1666-1723). Contemporary and Rival Of Boerhaave.' *Ambix, 14*, 96-111. See also Hannaway. (1965). *Early University Courses.*

[47] Barchusen in Hannaway. (1965). *Early University Courses:* 219-220.

[48] *Ibid.,* 242.

ing many ideas from contemporary chemists. In this book I shall discuss the influence of British natural philosophy upon Boerhaave's chemistry. At this point I shall briefly discuss the importance of French chemistry. Boerhaave not only often referred to the work of French chemists, but the changes in French chemistry show particularly well how Boerhaave's chemistry was at the same time different from and similar to the work of contemporaries.

In the seventeenth century the work of French chemists was very influential. In particular Nicholas Lémery's (1645-1715) *Cours de Chimie* (1675) was one of the most important chemical textbooks at the time.[49] According to the historian Hélène Metzger the popularity of Lémery'sJohann Conrad textbook was due to the fact that Lémery openly described chemical preparations that chemists and charlatans had kept secret before. His chemistry was also understandable by laymen as Lémery omitted all obscure language and theory, thereby presenting a straightforward chemistry.[50] Metzger states that:

> Lémery, like most of the thinkers of the time, accepted only mechanical philosophy; declaring any other interpretation of chemical phenomena, any addition to mechanism, absurd, the professor had no goal other than to give an intelligible explanation of the facts.[51]

Lémery presented a static chemistry in which he emphasised the constituent principles of nature. His main object was the separation of the purer substances of mixed bodies.[52] Consequently he spent most time explaining chemical operations. This is visible in his chemistry course as well as in his textbook. Normally Lémery spent only one day out of thirty four explaining the theory of chemistry and showing his furnaces, vessels and instruments. The biggest part of the course, which translates into 52% of his textbook, is devoted to the explanation of the operations on minerals. This is not surprising as according to Lémery the five chemical principles water, spirit or mercury, oil or sulphur, salt and earth are most difficult to find in the mineral kingdom. Lémery, unlike Boerhaave as we will see later, be-

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[49] For an extensive discussion on Lémery see: Bougard, M. (1999). *La Chimie de Nicolas Lémery.* Turnhout. For the emergence of textbook chemistry see: Hannaway, O. (1975). *The Chemists and the Word. The Didactic Origins of Chemistry.* Baltimore/London. For a discussion of Hannaway's thesis see: Christie, J.R.R. & Golinski, J.V. (1982). 'The Spreading of the Word: New Directions in the Historiography of Chemistry 1600-1800.' *History of Science, 20*, 235-266.

[50] Metzger, H. (1969 (1923)). *Les Doctrines Chimique en France du Début du XVIIe à la Fin du XVIIIe Siècle*. Paris: 32; Metzger, H. (1991 (1930)). *Chemistry* (Colette V. Michael, Trans.). West Cornwall, CT: 31-32.

[51] Metzger, H. (1991 (1930)). *Chemistry* (Colette V. Michael, Trans.). West Cornwall, *CT*: 32.

[52] Lémery, N. (1686). *A Course of Chymistry. Containing an easy Method of Preparing those Chymical Medicines which are Used in Physick with Curious Remarks and Useful Discourses upon each Preparation, for the Benefit of such who Desire to be Instructed in the Knowledge of this Art.* (Harris, W., Trans.). London: 1.

lieved that the substances resulting from a chemical experiment existed in the mixed body before. He calls these substances the principles of chemistry. However, they are only principles in respect to man since he cannot divide natural bodies any further. Nevertheless they come close to the true principles of nature and they 'will give us a very great idea of nature, and the figure of the first small particles which have entered into the composition of mixt bodies.' [53]

Lémery's chemistry in essence went back to the iatrochemistry of Sylvius. He defined the active principles, i.e. salts, sulphurs and spirits, according to the figure and shape of their particles. Moreover he divided the salts into acids and alkalis. Acids consist of pointed particles set in motion. Alkalis have porous parts so that the acid points can enter the composition and divide whatever opposes their motion. As a result of the acids breaking the resistance of the alkalis a violent ebullition occurs. This means that they can indicate each other's presence when combined together. Gradually Lémery's theory was widely accepted and it was believed that all substances, even the metals, were composed of acids and alkalis.

In Lémery's time the acid-alkali hypothesis was widely accepted and only changed after Robert Boyle argued that some substances are neither acid nor alkali, but are neutral. In order to show the presence of acids or alkalis he developed a colour indication test, which means that the presence of effervescence upon combining an acid and an alkali was no longer sufficient to prove the nature of a particular substance. Boyle showed that the combination of a particular substance with syrup of violets turns red if it is an acid and blue or green if it is an alkali. [54] By the time Boerhaave wrote his *Elementa Chemiae*, Boyle's ideas were widely accepted and Boerhaave strongly encouraged his students to read Boyle on the subject.

Unlike Lémery, Boerhaave presented an active chemistry based on the principle of motion. In that sense, Boerhaave's chemistry was closer to the chemistry of Etienne François Geoffroy (1672-1731), who is best known for his table of affinity in which he categorised natural bodies according to the strength of the forces of attraction between them. Geoffroy worked in the *Jardin Royal des Plantes Médicinales* (founded in 1640, in order to educate physicians and apothecaries). Although chemistry started off being part of the medical curriculum, it became gradually more independent in the beginning of the eighteenth century. From 1718 the focus of the *Jardin* moved away from

[53] *Ibid.,* 6.

[54] Boas, M. (1956). 'Acid and Alkali in Seventeenth Century Chemistry.' *Archives Internationales d'Histoire des Sciences, 9*, 13-28.

medicine to natural philosophy (*sciences naturelles*) and physico-chemical studies. The name changed accordingly into *Jardin Royal des Plantes*. [55]

Geoffroy advocated a Newtonian dynamic chemistry in which the principle of motion determined the nature of a particular substance. He divided chemical actions into fermentation and corruption or dissolution, either of which is caused by a particular kind of motion. If the motion is directed to unifying particles he speaks of fermentation and if it leads to destruction or dissolution of bodies he speaks of corruption. According to Geoffroy, nothing is more promising for the advancement of physic than knowledge of motion and change.

Geoffroy argued that only three principles are absolutely simple, i.e. the passive principles of water and earth and the active principle of fire. Salts result from a combination of these three principles, and are therefore called the most simple of all bodies. Sulphurs arise from a combination of the three principles and salt. Geoffroy mentioned fire as the first principle through which all bodies receive their activity. In doing so he moved away from the traditional opinion of the universal spirit being the first principle. For example, Lémery still believed in a universal spirit diffused through all bodies, even though he states that the principle is 'a little metaphysical' and therefore beyond discussion. [56]

As we shall see later, Geoffroy's definition of fire is similar to Boerhaave's. Geoffroy states that it 'is a simple and most subtle body in a continual swift motion filling and easily permeating the pores of all other bodies.' [57] The force of this fire is in proportion to the quantity of the substance in which it is found, which means that the fire is most active in the sun. The extreme subtlety and activity of the principle make it impossible for the chemist to produce fire in its purest form so that it always remains united with water and earth and in salts and sulphurs. The action of fire determines the character of water and earth, and therefore the nature of all bodies.

Alan Debus has traced the seventeenth century emphasis on the study of motion to the chemistry of Van Helmont and contemporaries, who believed that the principles of motion and life resulted from the divine will. So the study of motion essentially was seen as the study of God and His providence. [58] In

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[55] For a history of the *Jardin des Plantes* see: Laissus, Y. (1986). 'Le Jardin du Roi.' In Y. Laissus & J. Torlais (Eds.), *Le Jardin du Roi et le Collège Royal dans l'Enseignement des Sciences au* XVIIIe *Siècle* (pp. 287-341). Paris.

[56] Lémery. (1686). *A Course of Chemistry*: 3.

[57] Geoffroy, E.F. (1736). *A Treatise of the Fossil, Vegetable, and Animal Substances, that are made use of in Physick*. London: 9-10.

[58] Debus, A.G. (1973). 'Motion in the Chemical Texts of the Renaissance.' *Isis, 64*, 5-17.

recent years Debus has emphasised the importance of vitalistic principles in French chemistry. [59] Moreover, historians are becoming increasingly aware of the importance of non-mechanistic principles in the work of seventeenth and early eighteenth century chemists, leading up to the chemistry of Lavoisier and Black. [60] We shall see that Boerhaave's chemistry was also based on non-mechanic principles and that Boerhaave was no exception in valuing the works of Van Helmont highly, while investigating the effects of the principle of motion in the seeds of things.

The book has four chapters. In the first chapter I shall discuss the incident on the canalboat in which Boerhaave was accused of being a Spinozist. While looking at the question of how much truth was in the allegation I shall also look at Boerhaave's education, the influence of his teachers and on a more general level at the debates over Spinozism and Cartesianism in Dutch society and academia at the time. We shall see that Boerhaave was horrified by the theological consequences of Spinozism, but that at the same time he was attracted by Spinoza's ideas on freedom of thought.

The second chapter is devoted to a discussion of Boerhaave's Calvinism. Calvin's own work, in particular the *Institutes of the Christian Religion* (1559), will be the startingpoint of an investigation into Calvinist ideas on creation, providence and the question of how man can come to true knowledge. In turn this forms the basis of an evaluation of Boerhaave's Calvinist views concerning God's divine will visible in the creation as well as his views on the human mind. Boerhaave's ideas appear to be remarkably similar to those of Calvin.

The third chapter is about the practical application of Boerhaave's Calvinism in his chemistry. I shall pay attention to Boerhaave's definition of chemistry and how he presented a 'reformed' chemistry as distinct from the corrupt chemistry of the so-called false chemists and alchemists. Just as Calvin had argued that God diffused His divine energy in the creation, so Boerhaave introduced occult qualities in his chemistry as the agents of God's providence and divine will. Finally, Boerhaave's emphasis on the limitations of observation and experiment reflects his belief in the inability of man to achieve certainty about the first principles in natural philosophy.

Last but not least I shall look at Boerhaave's chemistry for medicine. Since Boerhaave's medicine changed over the years, an important part of the final chapter is devoted to a discussion of Boerhaave's intellectual development. The *Orations*, which Boerhaave gave at turning points in his career, show

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[59] Debus. (1991). *The French Paracelsians*: 207-208.

[60] See for example the work of Clericuzio on Boyle: Clericuzio. (1990). 'A Redefinition of Boyle's Chemistry;' Clericuzio. (1993). 'From Van Helmont to Boyle.'

how Boerhaave changed from a doubtful Cartesian into a chemist and physician very much concerned with the peculiar non-mechanical powers of bodies. For Boerhaave chemistry became increasingly more important in showing the individual characteristics of natural bodies and at last chemistry even subjected physics and mechanics to itself and became of crucial importance in medicine. The end of the chapter is devoted to the practical medical application of Boerhaave's chemistry of living bodies.

The book is mainly based on printed sources: Boerhaave's textbooks on chemistry and medicine, the academic orations and the few autobiographical notes found after his death. My intention is to stay as close to Boerhaave's own words as possible. However, I shall also use the commentaries and translations of contemporaries.

When starting the research I also planned to study the so-called Kirov manuscripts in St. Petersburg among which are lecture notes in Boerhaave's own hand, notes on chemical experiments and correspondence. Unfortunately I was unable to see the papers. Officials of the library of the military medicine academy, where the manuscripts are held, were faced with many problems concerning the collection and decided to refuse me entry. After much negotiating and the signature of a four-star-general, I was allowed to see the catalogue of the collection for a short while and after yet more talk the manuscripts themselves for a few hours. The librarians allowed me just enough time to make a list of important manuscripts on chemistry and alchemy, which is added as an appendix at the end of the book. Fortunately Lindeboom in the 1950s found a more lenient head of the academy and he was allowed to bring microfilms of the collection to the University Library in Leiden. However, Lindeboom mainly focused on Boerhaave's medicine and decided not to ask for films of all the chemistry and alchemy manuscripts. I have looked at the Leiden microfilms, but did not find much useful material on chemistry.

It can be said that Boerhaave was the most important medical teacher after Galen. His fame reached all over Europe and further afield. The story goes that a letter from China addressed to 'Mr. Boerhaave, Physician in Europe' was delivered to Boerhaave in Leiden.[61] Boerhaave himself never travelled further than Harderwijk, but at the same time corresponded with many people all over Europe. In the letters, Boerhaave not only gave medical advice, and discussed medical and chemical problems, but he also asked for seeds and

[61] For the origin of this story see: Marx, O.M. (1968). 'M. Boerhaave en Europe: The Origins of an Anecdote Explained.' *Journal of the History of Medicine, 23.*

plants in order to enrich the botanical garden in Leiden. His friends and colleagues were much obliged to him and apparently on a mountain somewhere in southern Europe is a memorial with the inscription: 'Though suffering from gout, Bassand has officially climbed to this point in order to gather plants for Boerhaave.' [62]

Boerhaave's name still lives on in the Netherlands. In Leiden we find the Boerhaave History of Science Museum, a statue opposite the hospital, a chemist called after the famous physician, and even an abortion clinic bearing Boerhaave's name! Almost every respectable town in the country has a street called after Boerhaave and in orthodox Calvinist circles the name Boerhaave stands for the only real Christian doctor the Dutch have ever known. Herman Boerhaave deserves the attention of historians and this book is an attempt to understand the driving motives of some of Boerhaave's intellectual endeavours.

[62] *SAC*: 231.

On every occasion he [Boerhaave] professed that the teaching expressed by Jesus Christ, by His words and Hislife, alone gives peace of mind. To his friends he always declared that peace of mind is scarcely to be found save only in the great precepts of Moses concerning a sincere love of God and man, if well observed; and that nowhere outside the Holy Scriptures is there to be found anything which calms the mind.

BOERHAAVE, *Commentariolus*: XVIII

1. Herman Boerhaave: Spinozist?

To begin the story of Boerhaave's Calvinist chemistry for medicine we have to start by looking at Boerhaave's youth and early career. This will not only tell us what Boerhaave learned as a young man, but it will indirectly give insight into the man he became. The family he was born into, his studies and most of all the controversies over the philosophies of Descartes and Spinoza and the theology of Cocceius determined the way Boerhaave studied the creation. Moreover, his natural philosophical approach based on the Calvinist beliefs of his early years made him into the most important physician after Galen and the most well known medical teacher of his time, the *communis europae praeceptor*, as his pupil Albrecht von Haller called him. [1]

We shall start by looking at Boerhaave's family and his theological education at the Latin School and later at Leiden University. Next we shall investigate the so called incident on the canalboat in which Boerhaave was accused of being a Spinozist. The last part of the chapter deals with a second incident in which Boerhaave was again suspected of Spinozism and scepticism. In this chapter we shall examine how much truth was in the accusations. This means that we also have to look at Boerhaave's position in the contemporary theological and philosophical debates. Finally the incidents clarify why Boerhaave chose to study the creation and how he approached natural philosophy.

The most important sources upon which I base my argument are Boerhaave's early disputations and orations. These reflect Boerhaave's ideas in his early career and also give a good insight into the way he approached contemporary debates. Another source are the autobiographical notes in Boerhaave's own hand found after his death, the *Commentariolus de familia, studiis, vitae cursu,*

[1] Haller, A. v. (1774-76). *Bibliotheca anatomica*. Zürich: 1, 756-757. Lindeboom argued that although Von Haller probably was only referring to the number of foreign students who attended Boerhaave's lectures, we can perhaps also take it to mean that Boerhaave's influence stretched over the whole of Europe. Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and his Work*. Leiden: 355.

&c. propria Boerhaavii. These notes not only tell us about the moments in Boerhaave's life that he thought important enough to leave to his posterity, but also about his theological and political views.

Boerhaave's early career

Herman Boerhaave was born in 1668 in Voorhout, a small village not far from Leiden. He was the eldest son of Hagar Daalders and Jacobus Boerhaave, who was the pastor of the local Dutch Reformed church. Herman was born into the theological branch of the Boerhaave family, which started with his uncle, Marcus Boerhaave who was a pastor in Medemblik and who also wrote some theological treatises. [2] The young Herman himself was also destined to be a pastor in the Dutch Reformed Church. From an early age his father started teaching him Greek and Latin, using the grammar of Vossius. His father also explained the dialogues of Erasmus and the comedies of Terence. He made his son study the New Testament, and he added history to his studies. Moreover, he gave his son the work *Schoutoneel* (theatre) of Christian Matthias. The result of Herman's studies was that when he was eleven years old he could translate from Latin into Dutch with the same ease as from Dutch into Latin. He also got a good understanding of the origin and deeper meaning of words and expressions. [3] Boerhaave greatly admired his father, as is apparent in Boerhaave's oration upon resigning the office of *Rector Magnificus* in 1729 as well as from the notes found after his death. [4] According to Boerhaave's friend Albert Schultens, the wish of Boerhaave's father for his son to become a theologian was engraved in the heart of the young Herman which made him readily prepared to obey his father's wish. [5]

Due to a painful ulcer on his left thigh Boerhaave moved to Leiden in 1682 in order to get better medical treatment. The care he received was not very successful and ultimately the pain wore him out so much that he treated himself with a mixture of salt and his own urine. In Leiden Boerhaave entered the third class of the Latin grammar school in order to continue the educational path his father had set out for him. At the age of fifteen Herman started his theological and philosophical studies at the University of Leiden. Unfortu-

[2] For more information on Boerhaave's descent see: Lindeboom. (1968). *Herman Boerhaave*: 12-13, appendix 2.
[3] *Commentariolus*: III.
[4] *Ibid.*, I; *SAC*: 224-225.
[5] Schultens, A. (1988 (1739)). *Academische Redevoering van Albert Schultens ter Gedachtenisse van den Groten Herman Boerhaave. Uitgesproken 14 november 1738* (Schultens Jan Jacob, Trans.): 28-29.

nately his father had died the year before, which meant that the financial means of the family were limited. In order to finance his studies Herman was granted a free scholarship by the University. From its foundation in 1557, the university awarded these scholarships, made available by the States of Holland, to talented students in order to train clergymen. Even though financially the study of theology was perhaps the only option after the death of his father, we can say that the young Herman was meant to become a minister.

Boerhaave matriculated in the faculty of philosophy as well as in the faculty of theology. In a resolution of 1690, the curators called him a *theologiae et philosophiae studiosus* and they decided that his first degree should be in philosophy. Boerhaave pursued his studies with great zeal and he won the affection of Jacobus Trigland (1652-1705), professor of divinity and grandson of the Jacobus Trigland who had played a dominant role at the Synod of Dordrecht (1618-1619) where the Remonstrants were condemned. Trigland introduced Boerhaave to Daniel van Alfen Simonszoon who was one of the four burgomasters of Leiden and who had become a curator of the university in 1687. Both men advised Boerhaave in the right course of study.

Trigland and Van Alfen Simonszoon recommended Boerhaave to Wolferd Senguerd (1646-1724) who taught him 'logic, the use of the globes, natural philosophy, metaphysics, and ethics.' [6] From 1689 Boerhaave also attended the lectures of Burchard de Volder (1643-1709) on 'the geometric synthesis of the ancients' and 'the analysis of the moderns.' [7] Possibly Boerhaave also went to demonstrations in De Volder's *laboratorium physicum*, the first university laboratory for experimental physics, set up in 1675. [8] The teaching of Senguerd and De Volder made a deep impression on the mind of the young Boerhaave, so in order to understand Boerhaave's intellectual development we have to look at the ideas of these two Leiden professors.

Both Senguerd and De Volder were well disposed towards Cartesian natural philosophy, which attempts 'to reduce natural phenomena to quantitative descriptions of arithmic and geometry.' [9] However, Senguerd and De Volder were also critical of the French philosopher. Senguerd leaned more towards Gassendi's version of Epicurean atomism. [10] De Volder, as we shall see later, also adopted some other philosophical ideas. Senguerd started teaching in

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[6] Burton, W. (1743). *An Account of the Life and Writings of Herman Boerhaave*. London: 7; *Commentariolus*: VI.

[7] Burton. (1743). *An Account*: 8; *Commentariolus*: VII.

[8] Burton. (1743). *An Account*: 8; *Commentariolus*: VII; Lindeboom. (1968). *Herman Boerhaave*: 22.

[9] Audi, R. (Ed.). (1999). *The Cambridge Dictionary of Philosophy*. Cambridge: See Cartesian science and dualism, 226.

[10] *Orations*: 20.

Leiden University in 1676, upon being appointed full professor of peripatetic philosophy. His appointment was meant to be a countermeasure against Cartesianism in the University and it was supposed to calm the emotions. Unfortunately, Senguerd did not intend to teach the 'silly dogmas of the scholastics,' but he promoted a Cartesian philosophy of matter and motion. [11]

More than Senguerd, De Volder had a profound influence on Boerhaave's mind. De Volder had studied medicine and philosophy in Amsterdam, but he took his degree in Utrecht. He had also taken classes in Leiden where, under the influence of Franciscus dele Boë Sylvius, he abandoned Aristotelian philosophy in favour of Cartesianism. After getting his doctoral degree he set up a medical practice in Amsterdam, but his reputation called him to Leiden in 1670. The curators of the university offered him the chair of logic if he would give up his Mennonite faith, upon which De Volder, who was keen to move to Leiden, changed to the Walloon church. Like Senguerd, De Volder was supposed to teach the classics. However, after teaching the prescribed programme he also added mathematics and physics to his teaching. After a visit to England in 1674, where De Volder learned about the new experimental philosophy, he started teaching experimental physics and he set up a physical laboratory (*theatrum physicum*). Moreover the curators of the university enlarged his duties with the chair of mathematics. In his inaugural oration *Oratio de conjungendis philosophicis et mathematicis disciplinis* (1682) De Volder argued for an integration of mathematics and physics. He continued promoting a smooth integration and in his oration *De rationis viribus et usu in scientiis* upon resigning his office as *Rector Magnificus* in 1698 he also suggested applying mathematics and physics to medicine.

It has been said that De Volder was more of a Cartesian than Senguerd, but in the later years of his life, De Volder became critical of Cartesianism. [12] Only a few historians have paid attention to the ideas of the Leiden professor of logic. Thijssen-Schoute in her extensive work on Cartesianism in the Netherlands has called De Volder a critical mind as she discussed De Volder's Cartesianism and his critical attitude towards the ideas of the French philosopher. [13] Similarly De Pater has discussed De Volder's Cartesianism and he ascribed De Volder's later criticism to the influence of the English natural philosophers Boyle and Newton on De Volder's thought. [14] More recently Klever has compared the writings of De Volder and especially his negative comments on the

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[11] Senguerd in: Pater, C.d. (1975). 'Experimental Physics.' In T.H.L. Scheurleer (Ed.), *Leiden University in the Seventeenth Century. An Exchange of Learning* (pp. 308-327). Leiden: 319.

[12] *Orations*: 20.

[13] Thijssen-Schoute, C.L. (1954). *Nederlands Cartesianisme*. Amsterdam.

[14] Pater. (1975). 'Experimental Physics.'

philosophy of Descartes to the ideas of Spinoza and he concluded that De Volder was a crypto-Spinozist. [15]

Moreover, Klever has argued that the mechanical medicine of Boerhaave, De Volder's most influential pupil, was founded upon the *Ethics* of Spinoza. [16] This argument seems to be justified since Boerhaave found himself being accused of having Spinozist sympathies on two occasions. For this reason it is important to look into De Volder's and Boerhaave's supposed Spinozism. We can ask whether it is a coincidence that both Boerhaave and De Volder were suspected of having heretical views? Or was it normal for natural philosophers to be accused of Spinozism at some point in their careers?

At the time De Volder taught Boerhaave, the major tensions about Cartesianism in the university of Leiden had faded away. In 1647, the Curators, desperate for peace in the academic community, had forbidden the use of the name of Descartes and his ideas in lectures and disputations. [17] Nevertheless the new ideas continued being propagated and it must be said that the Curators themselves reinforced the situation through appointing Cartesian professors. In 1676, after criticism by members of the theological faculty, the Curators passed another resolution in which they forbade the arguing of twenty Cartesian propositions. [18] De Volder, who must have recognised his own views in the propositions joined in the protest, but to no avail. His colleague Abraham Heidanus took the blame for the protests and got fired from his office. De Volder kept a low profile and could stay on as before. As before, Leiden professors were not allowed to openly express Cartesian views. Yet, the Curators turned a blind eye to the teaching of Cartesian physics. [19] The

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[15] Klever, W.N.A. (1988). 'Burchard de Volder (1643-1709), a Crypto-Spinozist on a Leiden Cathedra.' *Lias-Sources and Documents Relating to the Early Modern History, 15* (2), 191-241; Klever, W. (1997). 'Het onversneden rationalisme van Burchard de Volder.' In W. Klever (Ed.), *Mannen rond Spinoza (1650-1700). Presentatie van een emanciperende generatie* (pp. 185-227). Hilversum.

[16] Klever, W.N.A. (1994). 'Herman Boerhaave (1668-1738) oder Spinozismus als rein Mechanische Wissenschaft des Menschen.' In Delf von Wolzogen, H. *Spinoza in der Europäischen Geistesgeschichte*. (pp. 75-93). Berlin. Klever mainly refers to the structure of the *Institutiones Medicinae*, which show a resemblance to the defined mathematical structure of Spinoza's *Ethics*. However, the structure of Boerhaave's work also resembles Hippocrates *Aphorisms*, which is a more likely explanation since Boerhaave was a great admirer of the Greek philosopher.

[17] Molhuysen, P.C. (1920 (1682-1725); 1921 (1725-1765)). *Bronnen tot de Geschiedenis van de Leidsche Universiteit*. (Vol. iv, v). 'sGravenhage: III, 5-6; Sassen, F.L.R. (1970). 'The Intellectual Climate in Leiden in Boerhaave's Time.' In G.A. Lindeboom (Ed.), *Boerhaave and his Time* (pp. 1-16). Leiden. For the controversies about Cartesianism in Leiden University in the seventeenth century see: Verbeek, T. (1992). *Descartes and the Dutch. Early Reactions to Cartesian Philosophy 1637-1650*. Carbondale and Edwardsville; McGahagan, T.A. (1976). *Cartesianism in the Netherlands, 1639-1676. The New Science and the Calvinist Counter-Reformation*. Unpublished Ph.D., University of Pennsylvania, Pennsylvania.

[18] Molhuysen. (1920 (1682-1725); 1921 (1725-1765)-a). *Bronnen*: III, 320.

[19] McGahagan. (1976). *Cartesianism in the Netherlands* : 347ff.

debate between the curators and the professors centred mainly around the theological consequences of Cartesianism, such as issues of universal doubt, the nature of God, the role of philosophy in interpreting the Scriptures and the nature of the will. Mechanism was not an issue in so far as it did not touch upon the nature of the soul. This meant that De Volder could continue his teaching programme without a major revision.

Although the debates on Cartesianism had more or less calmed down in Boerhaave's time, Spinozism was still a controversial issue, even though the impact of Spinoza's ideas on philosophers at the time is said to have been limited. [20] Even so, people often had wrong perceptions about natural philosophy and were readily prepared to mark someone a Spinozist, which to them was the same as an atheist. [21] This means that Klever's recently raised suspicion of De Volder and Boerhaave being Spinozists is worth looking into.

First of all Klever argues that De Volder's sympathy for Spinoza was known among contemporaries, even though De Volder always denied his connections with the philosopher. Klever compares the situation to the betrayal of Peter (I don't know the man [Jesus]), a white lie, for Spinozism was not an acceptable belief in the Low Countries. [22] Klever argues that De Volder, when he was still working in Amsterdam, was a member of the same Mennonite church as many of Spinoza's friends and that together with Johannes Hudde and Spinoza he was a welcome guest at meetings to discuss mathematics and physics. [23]

Klever argues that De Volder's suspected Spinozism was not ill-founded, but that De Volder's views are indeed very similar to Spinoza's philosophy. De Volder publicly declared that the main mistakes (*Haupt-Irrtümer*) of Spinoza's philosophy were:

– the "absolute fatality" in the universe, in which everything is causally predetermined,

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[20] Klever. (1988). 'Burchard de Volder': 191. For the reception of the philosophy of Spinoza in the Low Countries see: Siebrand, H. J. (1988). *Spinoza and the Netherlanders. An Inquiry into the Early Reception of His Philosophy of Religion*. Assen.

[21] Klever. (1997). 'Rationalisme van B. de Volder': 209.

[22] *Ibid.,* 226. The most important evidence for De Volder's Spinozism is the correspondence between De Volder and Leibniz in which Leibniz accused De Volder of having the same views as Spinoza. For another discussion on the correspondence between De Volder and Leibniz see: Russell, L. J. (1928). 'The Correspondence between Leibniz and De Volder.' *Proceedings of the Aristotelian Society. New Series, 28*, 155-177. Russell does not mention Leibniz accusations of De Volder being a Spinozist.

[23] In 1676 a certain P. Baers wrote to C. Huygens that while in Amsterdam he 'in many delightful meetings heard speaking with much praise of your [Huygen's] excellence in mathematics and physics, especially by Johannes Hudde, Benedictus de Spinoza and dr. De Volder, professor of philosophy in the university of Leiden.' Klever. (1997). 'Rationalisme van B. de Volder': 206.

– the identity of mind and body,
– God's existence; his transcendence above finite creatures and his immanence in the world as a whole, by which extension may be called an attribute of God,
– the disproportion between God and man, which forbids the acceptance of the central dogma of the incarnation. [24]

Klever argues that the expression *Haupt-Irrtümer* were the words of Gottlieb Stolle and a certain Hallman, German theologians who visited De Volder and asked him about Spinoza's ideas. Klever states that 'they came to him with the prejudice that Spinoza's philosophy is pernicious and could not contain any truth. It was quite natural to them, therefore, to baptise the central themes, mentioned by De Volder, as *Haupt-Irrtümer*.' [25] In a fascinating account Klever argues that De Volder in some way or another subscribed to the above mentioned ideas, although maybe not the last one. He argues that De Volder in his office of professor made Spinozean thought acceptable in Leiden University and that hence 'Spinoza stood at the root of the revival of science in Leiden. De Volder was the mediator.' [26]

However, we can ask whether De Volder's denial of the contemporary accusations was more than a white lie. From the evidence provided by Klever it seems that De Volder did not publicly express any Spinozean ideas on the controversial issues of the nature of God and the truth of the Scriptures. It would be interesting to find out whether De Volder's ideas that Klever ascribed to the influence of Spinozism can also be traced back to the writings of Newton, as, especially in his later years, De Volder was impressed by the works of the English natural philosopher. Maybe De Volder's biographer and intimate friend, J. le Clerc, was right to ascribe De Volder's moving away from Cartesianism to either his own meditations or the influence of English empirical philosophy. [27] After all, if De Volder's Spinozism was so obvious, why then was it not apparent to his close friend? Klever only mentions Newton in the context of De Volder's denial of occult qualities and Newtonian *actio in distans*. [28] Yet De Pater has observed that, although De Volder did not mention Newton in his last oration upon resigning his professorship in 1705, the Leiden professor was nevertheless under the influence of the English natural philosopher. In 1697 in his oration *De rationis viribus et usu in scientiis* De Volder promoted the works of Newton.

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[24] Klever. (1988). 'Burchard de Volder': 195.
[25] *Ibid.,* 195.
[26] *Ibid.,* 233.
[27] Clerc, J.l. (1709). 'Eloge de feu Mr. De Volder,' *Bibliothèque Choisie* (Vol. XVIII, 379-380). Amsterdam.
[28] Klever. (1988). 'Burchard de Volder': 206.

Since in his [De Volder's] opinion all events in the human body take place in accordance with the laws of mechanics, which we cannot understand without knowledge of mathematics, as is quite evident, so he declares, from the works of Huygens and Newton on the motion and forces by which bodies are governed in nature. De Volder holds that the success of the geometrical method in optics, architecture, and navigation should stimulate us to apply this method in medicine as well, although he admits that sense-perception cannot be dispensed with. [29]

More research needs to be done in order to determine De Volder's Newtonianism. We now have to move on to the question of whether De Volder's supposedly Spinozean message was taken up by Boerhaave, his most influential pupil? Answering this question does not only involve us looking at Boerhaave's writings, but it also requires a discussion of the controversies surrounding Cartesianism and Spinozism.

In 1709 Boerhaave edited De Volder's *Oratio de novis et antiquis*. In the preface he praised De Volder's sharpness of mind (*acerrimam ingenii aciem*) by which he exceeded everyone else. [30] We cannot be sure whether Boerhaave knew about the accusations of De Volder being a Spinozist. Yet, whether he knew it or not, the ideas of De Volder as well as those of Senguerd were audible in Boerhaave's early disputations. In 1687 Boerhaave held his first public disputation under the supervision of Senguerd on the cohesion of bodies, the *De cohaesione corporum*. [31] As we shall see in chapter three, Boerhaave partly adopted Cartesianism in explaining the cause of cohesion. In the following academic year Boerhaave delivered another three orations on the human mind, the *De mente humana*. In the next chapter on Boerhaave's Calvinism I shall deal with Boerhaave's ideas on the mind as distinct from the body as well as with the question of whether Boerhaave was or was not influenced by Cartesianism/Spinozism. Boerhaave's disputations not only give insight into the philosophical ideas of the young Boerhaave, but also show the position Boerhaave took in the major theological controversies of his time. I shall discuss this aspect in various places later in this chapter.

In Boerhaave's first academic oration, the *Oratio de bene intellecta Ciceroni sententia Epicuri de summo hominis bono* (1689), we meet a Boerhaave who is very

[29] De Volder in: Pater. (1975). 'Experimental Physics': 318.
[30] H. Boerhaave in: Volder, B.d. (1709). *Oratio de novis et antiquis*. Leiden: preface. De Volder delivered the oration on conferring the doctor's degree on the English natural philosopher John Gale.
[31] Before graduating every student had to hold at least two public disputations. The student would occupy the professoral *cathedra* while the professor acted as chairman. Lindeboom. (1968). *Herman Boerhaave*: 21.

critical of the philosophy of Spinoza.[32] Boerhaave sided with De Volder in condemning Epicurean philosophy.[33] In the oration we hear a Calvinist Boerhaave speaking against the consequences of the materialist philosophy. Boerhaave was horrified by Epicurus' theory that both the body and mind are built of particles. According to Boerhaave this doctrine would lead to a denial of the doctrine of divine providence and the immortality of the soul. Moreover, it would promote sensual pleasures, since the only way man could achieve tranquillity of mind would be through the senses and thus through avoiding pain and seeking bodily pleasures. Boerhaave turned against the French philosopher Gassendi who had argued that Cicero, while discussing the ideas of Epicurus, followed prejudices against Epicurus rather than the authentic doctrine. Instead, Boerhaave states that Cicero represented the true Epicurean ideas and that Epicureanism fully deserves its bad reputation. In Boerhaave's eyes, Epicurean atheism paved the way for the philosophers who reduced the working of nature to matter and who denied the working of God in the world. Although Boerhaave does not mention any names, following the custom in delivering academic orations, he must have been referring to the philosophies of Spinoza and Hobbes. Boerhaave argued:

> It [the doctrine of Epicurus] has, as it were, been recalled, from the realm of Hell by most sinful men, who boast that they have achieved enormous progress in philosophy; who have given up the holy tenets of the Jewish [Spinoza] or Christian [Hobbes] religion (...) Unblushingly and brazen-faced, they do not hesitate to teach that perpetual happiness consists in progressing from one desire to the next. This is also evident from the fact that they accept and admit nothing but a single substance: body. (...) And not even God Himself is sacred anymore; so the sweetest hope of future salvation is abolished, because not the slightest hope of happiness to come remains, once the mind has been set free from the earthly body.[34]

In December 1690, Boerhaave took his philosophy degree. Boerhaave defended a thesis on the distinction between the mind and the body, the *De distinctione mentis a corpore,* after which De Volder promoted him to the title of *magister*. In his disputation Boerhaave once again was very critical of the materialist philosophies of Epicurus, Hobbes and Spinoza. It seems as if De Volder's Spinozism did not affect the young Boerhaave. After delivering the two public orations one would think that Boerhaave was free of Spinozean imputations. However, when Boerhaave was just about to commence his

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[32] An oration was a much higher distinction than a disputation. The orator had to apply to the university authorities who, after considering the subject, would grant him permission to deliver the oration. *Ibid.,*: 22-23.

[33] *Orations*: 20.

[34] *Epicurus*: 51-52. The annotations in the text are the translators.

theological career with an oration on the question 'why so many converts to Christianity were made by the unlearned, while nowadays so few are made by the most learned men,' Boerhaave was involved in an incident in which he became accused of Spinozism; an incident that dramatically changed the course of his life. [35]

The incident on the canalboat

Not long after obtaining his medical degree, while travelling on a canalboat, Boerhaave overheard a discussion on the philosophy of Spinoza. His fellow travellers condemned the philosopher and called him a 'subtle mathematical forsaker of God.' [36] However, Boerhaave suspected that the passengers did not really know what they were talking about and that no-one knew much about Spinoza's work. After a while Boerhaave got so irritated that he asked one of the passengers whether he had ever read any of Spinoza's books. In the silence that followed one of the passengers, who had not participated in the discussion, asked his neighbour the name of Boerhaave and he wrote it down. From that moment on Boerhaave was suspected of Spinozism. In the Seven Provinces this was a heavy accusation, for being publicly seen as a Spinozist meant to be generally known as an atheist. As a result Boerhaave decided to give up the pulpit and he changed to the practice of physic. [37]

In order to give up a long cherished dream, something dramatic must happen. For Boerhaave the incident on the canalboat was such a turning point. He thought the incident and its consequences so important that he wrote it down in his scanty biographical notes and his friend Albert Schultens mentioned it in his funeral oration. The question remains why Boerhaave spoke out when he must have known that it would be considered a defence of the most controversial philosopher of the time?

It could be argued that Boerhaave in his early twenties was not as well able to control his temper and that he spoke before he thought, but it still means that something must have been said in relation to Spinoza that was particularly bad in the eyes of Boerhaave. [38] What had been said that made Boerhaave

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[35] *Commentariolus*: XV, XVI.

[36] Schultens, A. (1738-1739). *Oratio academica in memoriam Hermanni Boerhaavii*:: 21. 'In navicula assidente Nostro, inter quosdam sermo coortus de Spinosae sententiis Religionem omnem funditus eruentibus. Ibi non *vera adversus subtilissimum illum & mathematicum*, ut videri vult, Atheum argumenta promi, sed maledicta tantum ac convicia ingeri, quae Zelum proderent ignoranti unice armatum.'

[37] *Commentariolus*: XVI; Schultens. (1988(1739)). *Funeral Oration*.

[38] Lindeboom praised Boerhaave's 'olympian calmness' as the result of 'quiet confidence in God to whom he prayed every day for placidity of mind.' Lindeboom. (1968). *Herman Boerhaave*: 262-263.

so annoyed that he stood up in defence of Spinoza and that made him risk his most important future ideal? In order to answer the question we need to discuss Spinoza's philosophy in more detail and compare Spinoza's views with Boerhaave's *Commentariolus*.

Boerhaave's question to the man on the canalboat if he had ever read Spinoza's books indicates that Boerhaave himself was not guilty of judging the philosopher without reading his work. Moreover he owned a copy of Spinoza's most controversial book, the *Tractatus theologico-politicus*, in which Spinoza argues, on religious grounds, that every man should be free to think what he likes and to say what he thinks. [39] Boerhaave even referred to the book in a letter to his friend and former pupil Cox Macro. After Boerhaave had expressed his regret about an accident and loss, he tells Cox Macro that several writers examined the matter in a way that pleased him very much.

> I do not know whether you have seen what Spinoza wrote on this subject in the last chapters of his theologico-political treatise; or whether an anonymous treatise, *De jure ecclesiasticorum*, has come under your notice. Also on this subject the oration of my best friend Gerard Noodt, concerning religion being free by the right of the nations from the control of the magistracy, has pleased me wonderfully. [40]

Boerhaave did not mention the nature of the accident and loss, but probably he was replying to a letter telling him that Cox Macro's only son had died while serving as a soldier abroad. [41] Also the connection with the main argument in Spinoza's book is not clear. It is, however, apparent that Boerhaave liked Spinoza's opinions on the freedom of the mind which probably gave him a nuanced view on Spinoza's philosophy.

Boerhaave read the works of Spinoza as a young man after the large theological controversies between the Remonstrants and Contra-Remonstrants had calmed down and had been settled in the synod of Dordt. Moreover, the controversial views of Descartes and Cocceius were banned from all public disputations in the universities. As a result Calvinistic theology was largely based upon dogma, and this resulted in a climate that was not as tolerant for

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[39] Spinoza's *Tractatus theologic-politicus* is mentioned in the auction catalogue of Boerhaave's library. (1739). *Bibliotheca Boerhaaviana, sive catalogus librorum instructissimae bibliothecae viri summi D. Hermanni Boerhaave*. Leiden: Libri Prohibiti, u. Boerhaave also possessed Spinoza's *Opera posthuma* (1677): Libri Prohibiti, t.

[40] Boerhaave to Cox Macro 22 June 1710. *Correspondence 2*: 19. Gerard Noodt, legal scholar and anti-Orangist wrote a critique of curruption in criminal justice and was especially opposed to the corruption of William III's *baljuws*. In general Noodt was a fervent advocate for religious toleration. See: Israel, J. (1995). *The Dutch Republic. Its Rise, Greatness, and Fall, 1477-1806*. Oxford: 674, 962-963.

[41] *Dictionary of National Biography*: Cox Macro.

clergymen as it was for laymen who could more or less confess to the church or sect they wanted. Spinoza, although his works were banned, could still live and work in peace. He was never ordered to leave his house in twenty-four hours, as happened to several ministers of the reformed church, who apparently preached ideas the governors did not like. This could be either political criticism or dissenting opinions on established church doctrines.

For everything, the *regenten*, who governed the country from 1650 until 1672, and later on Willem III, who became stadtholder of the seven united provinces in 1672, wanted to maintain the stable religious situation reached at the Synod of Dordrecht in 1619. The wars of the past years had shown that good ecclesiastical government should lead to a peaceful society. [42] Also the theologians of the so-called *Nadere Reformatie* (Further Reformation), of the seventeenth century, of which Gijsbert Voetius, Willem Teelinck and Abraham van de Velde are most well known, carefully kept the religious situation stable. They did not tolerate new challenges to orthodoxy that could eventually lead to new discords. But their very strict ideas about how one should explain the Bible led to new dissatisfactions. [43] As before, theologians discussed dogmas rather than biblical doctrines and, as both Spinoza and Boerhaave observed, they got entangled in their own theories. In their zeal to preach the only true religion they passed over a biblical understanding.

In his *Tractatus theologico-politicus* Spinoza states that churches had become theatres, where the preaching was not directed towards teaching but much more towards convincing people in a rhetorical way. He observed that this state of things necessarily stirred up an amount of controversy, envy, and hatred, which led him to the conclusion that of the old religion nothing survived but its outward forms. If any Divine light were in the preachers, he states, it would appear from their doctrines. However, he could not find anything but speculations of Platonists and Aristotelians to which they made the Scriptures conform. [44] Boerhaave developed a similar argument when he wrote in his biographical notes that

He [Boerhaave] greatly regretted that the interpretation of Holy Scripture was sought for among the sects of the Sophists; and that the metaphysical reflections of Plato, of Aristotle, of Thomas Aquinas, of Scotus, and – in his own time – of

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[42] Blom, J.C.H., Lamberts, E. (eds.). *Geschiedenis van de Nederlanden*. Rijswijk; Jacob, M.C., & Mijnhardt, W.W. (1992). *The Dutch Republic in the Eighteenth Century*. New York.

[43] For the reception of Spinoza's *Tractatus theologico-politicus* among Dutch Calvinists see: Wall, E. v.d. (1995). 'The Tractatus Theologico-Politicus and Dutch Calvinism, 1670-1700.' In H.d. Dijn, Mignini, F., Rooden, R. van (Ed.), *Spinoza's Philosophy of Religion* (Vol. II, pp. 201-266).

[44] Spinoza, B.d. (1951). *A Theologico-Political Treatise and a Political Treatise* (Elwes, R.H.M., Trans.). New York: 7.

Descartes, were considered as laws according to which the views of god expressed in the Holy Scriptures should be amended. He experienced bitter differences of opinion, and [understood] that from these are born and fostered the most passionate disputes, and the hatreds and ambitions, of the most acute minds, so much in contrast to peace with God and man. [45]

Both Boerhaave and Spinoza urged their listeners to know the Scriptures through reading the Scriptures only and not so much through listening to dogmatic preaching. As Boerhaave states, the Bible should, although it speaks in a human way, be understood in 'a sense worthy of our notions of the Deity.' The content of this divine sense has to be determined by all individuals 'according to the tenets of their own metaphysics.' [46] Therefore Boerhaave deplored that the prevalent theologians prescribed the path and the rules of orthodoxy only according to the assertions of the metaphysicians and not of the Sacred Writings. As for himself, Boerhaave wished to understand about God 'only that which God understands about Himself. Satisfied by that, he did not search further, lest he should stray into idolatries.' [47]

At this point it must be said that Spinoza's interpretation of Biblical stories was very controversial in the Low Countries. He argued that the narratives of the bible should be understood in the light of its history. His main argument is that biblical prophesies varied according to the personal opinions, the imagination and the physical temperament of the individual prophets. Since all people are different, God reveals himself in accordance with the understanding and opinions of each individual. As assurance of truth the prophets, whose minds were turned to what is just and good, normally received some sign. Thus, in this respect, Spinoza states, "prophetic knowledge is inferior to natural knowledge which needs no sign, and in itself implies certitude. Moreover, Scripture warrants the statement that the certitude of the prophets was not mathematical but moral." [48] As a result, Spinoza warns against the danger of regarding anything in the Scriptures as true before examining it first.

Spinoza's ideas were perceived as an attack on the new translation of the Bible, the *Statenbijbel*, that was finished in 1637. Spinoza however, does not deny the holiness of the Bible, for, as he states, Scripture is sacred, and its words Divine so long as it directs mankind to devotion towards God. But if "it be utterly neglected as it formerly was by the Jews, it becomes nothing but paper and ink, and is left to be desecrated or corrupted." [49] And this was

[45] *Commentariolus*: IX.
[46] *Ibid.,* IX.
[47] *Ibid.,* XVIII.
[48] Spinoza. (1951). *TTP*: 28.
[49] *Ibid.,* 168.

exactly what Spinoza and also Boerhaave saw happening in the Seven Provinces.

Although both Spinoza and Boerhaave emphasised the freedom of every individual to examine the Scriptures in a responsible way, they also gave rules as to how far this freedom should go. They defined this in their definitions of the aim of faith. For Spinoza the keyword is obedience, leading to a peaceful society, whereas Boerhaave stressed 'peace of mind' as the ultimate end. [50] According to Spinoza the sole aim and object of the Bible is to teach obedience. He used Moses as an example because Moses did not try to convince the Jews by reason, but he bound them by a covenant and by oaths. Moreover, he threatened the people with punishments should they break the law. The New Testament is a mere continuation of the law, for it contains the doctrine to believe in God, to honour him and to love one's neighbour, which is, according to Spinoza, the same as obeying Him. Faith therefore consists in a 'knowledge of God, without which obedience to Him would be impossible, and which the mere fact of obedience to Him implies.' [51] Spinoza points to this obedience as the sole solution to the theological controversies that afflicted the churches.

> To the universal religion, then, belong only such dogmas as are absolutely required in order to attain obedience to God, and without which such obedience would be impossible; as for the rest, each man (...) should adopt whatever he thinks best adapted to strengthen his love of justice. If this were so, I think there would be no further occasion for controversies in the Church. [52]

As for Boerhaave the Bible was more than just a book with stories showing obedience to God, the Scriptures gave him a glimpse of God's wisdom and power and would help the believer to align himself to His will. Thus following the words and considering the life of Christ alone would give peace of mind. To his friends he often declared that

> peace of mind is scarcely to be found save only in the great precepts of Moses concerning a sincere love of God and man, if well observed; and that nowhere outside the Holy Scriptures is there to be found anything which calms the mind. [53]

During his lifetime Boerhaave 'rested in the will of God in such a way that no

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[50] A. Cunningham has argued that the key to Boerhaave's success was the desire for 'peace of mind' linked with an eirenic medicine. Cunningham, A. (1990). 'Medicine to calm the Mind. Boerhaave's Medical System and why it was adopted in Edinburgh.' In A. Cunningham & R. French (Eds.), *The Medical Enlightenment of the Eighteenth Century* (pp. 40-66). Cambridge.

[51] Spinoza. (1951). *TTP*: 184.

[52] *Ibid.,* 186.

[53] *Commentariolus*: XVIII.

account at all of Him was to be sought. This alone', he said, 'is the highest of all laws, and that it should be respected completely and deliberately embraced.' [54] Undoubtedly Boerhaave would point to the concept of 'peace of mind' to solve the problems within the churches. After all, with a calm mind there would not be much reason to fight about the 'simplest of doctrines.' [55]

The last chapters of Spinoza's political-theological treatise, that apparently pleased Boerhaave, are about the freedom of mind, not only with respect to the right of every individual to choose the foundations of his creed, but also for the benefit of the state. This toleration followed from Spinoza's stress on the absolute separation of philosophy and theology. Each speaks as it were different a language, whereby the function of theology is not to give philosophical information, but rather to impel people to adopt certain lines of conduct. Apart from that people should be free in choosing the foundations of their creed. (The separation of theology and philosophy will be discussed later.)

Spinoza states that every individual has the sovereign natural right to do all that he can, which means to live and act according to his or her natural conditions. Nevertheless man also wants to live securely beyond the reach of fear, which will be impossible when everybody does what he likes under the reign of passions and desires. Spinoza therefore states that every individual should hand over his power to those who represent and defend him, so the body politic will then possess sovereign natural right over all things, and all men remain as they were in the state of nature, as equals. However, it is impossible to hand over natural rights entirely, for some things necessarily follow from human nature. It is, for instance, impossible to forbid men to do the things they like. But apart from this, subjects are bound to the laws of the state, and ideally a democratic state.

One of the main features of this rationally organised society would be religious toleration. Since God rules the earth through the instrumentability of earthly government, man also has to hand over his spiritual rights in so far as they are concerned with outward observances of piety and the external rites of religion. Spinoza explains this by saying that Moses also had the sovereign power, and acted in between God and man. Even the highpriest had to listen to him. However the inward worship of God and piety in itself are in the sphere of everybody's natural right, and any government that tries to control these faculties is tyrannical. For no one can freely give up his natural right of free reason and judgement. The sole object of government therefore is

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[54] *Ibid.,* XVIII

[55] *Ibid.,* IX.

not to change men from rational beings into beasts or puppets, but to enable them to develope their minds and bodies in security, and to employ their reason unshackled (...) in fact the true aim of government is liberty. [56]

Spinoza shows in an example that the prosperity of Amsterdam lasted as long as religion and sect were not important for the people in 'trusting their goods to a fellow citizen.' [57] But as soon as the religious controversies between Remonstrants and Contra-Remonstrants started to be important as a political issue, it ended in a schism. Spinoza observed that the fights did not originate in a love for truth, which is marked by gentleness and courtesy, but rather in a desire for supremacy. Spinoza ends his treatise by saying that

it is clearer than the sun at noonday, that the true schismatics are those who condemn other men's writings, and seditiously stir up the quarrelsome masses against their authors, rather than those authors themselves, who generally write only for the learned, and appeal solely to reason. [58]

Ironically Spinoza himself became the victim of such a general condemnation. And this is exactly what might have annoyed Boerhaave, who read Spinoza's work thoroughly, so much so that he risked his future career on the canalboat. Boerhaave, who always stimulated his students to think for themselves, did not so much speak up in defence of Spinoza, but much more as a protest against an uncritical adoption of ideas. For Boerhaave the freedom of thinking was so important that on numerous occasions he refused to become court physician of King William III. The offer of 'attractive conditions' and even more 'attractive promises' could not convince Boerhaave to give up his

free life, far from the crowd, altogether devoted to the continuation of his studies, where he would not be forced to say some things that he did not feel, and to feel some things that he had to conceal, and to be influenced and dominated by the inclinations of his moods. [59]

It is thinkable that Boerhaave was disappointed by the actual practice of the rather unfree situation of the pulpit, that he had serious doubts whether he should take up the ministry. Whatever his reasons might have been to speak out on the canalboat, we can conclude from his career that, although he devoted himself to natural philosophy alone, he did not give up his theological ideals altogether. As we shall see later Boerhaave through studying chemistry

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[56] Spinoza. (1951). *TTP*: 259.
[57] *Ibid.,* 264.
[58] *Ibid.,* 264.
[59] *Commentariolus*: XVII.

and medicine, studied the works of the creation and sought the will of God in the nature of things.

In order to better understand Boerhaave's precarious position regarding the philosophy of Spinoza we have to examine the period in which Boerhaave lived. Above all we have to look at the controversies that had faded away just before Boerhaave started lecturing in 1702, but which still left traces in the learned world. A particular debated topic in seventeenth and early eighteenth century Dutch society was the need for a distinction between theology and philosophy. We can see this worry in Boerhaave's work and in particular in his zeal to free theology from chemical explanations, as we shall see in chapter three. Not only was Boerhaave very concerned about the mingling of disciplines, but his worries and the desire to set the boundaries, were shared by many contemporary theologians and philosophers. In order to understand why the separation of the two disciplines became so important we have to look in more detail at the agitation around the philosophies of Descartes and Spinoza as well as at the theological controversies stirred up by the Leiden Cartesian theologian Johannes Cocceius. Therefore we also have to look at the organisation of the Dutch Reformed church, and most importantly at what was understood by philosophy and what by theology.

We can take the struggle between Cartesians and the Voetians about the mechanistic world-view from the 1640s as the starting point of the major controversies that troubled Dutch intellectual life thereafter. Orthodox theologians, who followed in the footsteps of Gijsbertus Voetius, looked with horror upon Descartes' method of universal doubt, which would lead to scepticism and unbelief. [60] To them abandoning the principles of Aristotelian philosophy meant the start of atheism. Cartesian rationalism would, they feared, overturn the established relation between reason and revelation. Van Ruler has recently argued that the debate centred round the issue of causality. Voetius and his followers after him wrote against the so-called 'New Philosophy' because 'it could not aptly describe the relation between God, the Creator and Nature.' [61] Both the Cartesians and the Voetians searched for causes in order to explain the 'driving forces' behind natural phenomena. However, the

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[60] Ruestow, E.G. (1973). *Physics at Seventeenth and Eighteenth-Century Leiden: Philosophy and the New Science in the University*. 's Gravenhage: 34-35. For the controversies around Cartesianism in the Netherlands see: Israel. (1995). *The Dutch Republic*; Verbeek. (1992a). 'Descartes and the Dutch.' ; McGahagan. (1976). *Cartesianism in the Netherlands*. ; Thijssen-Schoute, C.L. (1954). *Nederlands Cartesianisme*. Amsterdam. My brief explanation of the conflict between the Cartesians and the Voetians is based on the work of J. Israel.

[61] Ruler, J.A. van (1995). *The Crisis of Causality. Voetius and Descartes on God, Nature and Change*. Leiden: 3.

Voetians believed in a much more direct working of God in nature through internal principles of action, than the Cartesians, who argued that God works through mechanical laws of nature. In chapter three we shall see that Boerhaave adopted the Voetian/Calvinist point of view in introducing internal principles of motion. In any case, the Voetians could not prevent the introduction of Cartesian natural philosophy into the universities. During the 1650s the authorities of the universities of Leiden and Utrecht did not oppose the spread of Cartesianism. As a result most students reading for a philosophy degree were Cartesians as well as some of their university lecturers.

According to the historian Jonathan Israel the centrality of the intellectual conflict in Dutch life and culture 'stemmed from Voetius' insistence that Cartesianism subverted all established religion, philosophy, and science.' [62] This was exactly what the Dutch Cartesians denied. They were members of the Dutch Reformed church and they believed that Descartes had detached philosophy from theology, leaving the structure of faith and theological doctrine intact. However, to the Voetians this separation was not so obvious. One of the claims that outraged them in particular was the opinion that parts of the bible should be interpreted in their historical context instead of being taken literally. They argued that Cartesianism was poison for the minds of lay people and they were afraid that university controversies would turn into public discussions. With horror they imagined discussions on the question whether God really turned Moses' staff into a serpent or whether God really made the sun stand still in the sky for an hour, only because Joshua asked Him.

That the Voetians did not see any good in a separation of theology and philosophy originated in their belief that Aristotelian philosophy was a useful tool in the study of theology. Voetius insisted that the bible is a source of natural as well as ethical and religious knowledge. He wrote:

> If these things [i.e. the secrets of nature] are taught in the academies and schools, what else does one do but explain the Scriptures and take from it the doctrines of things natural? Moreover, if a student of physics examines many things in such a science and aims to become experienced in it, what else is he doing but admiring and considering the works of almighty God, and at the same time lending a helping hand to the theologian and indeed to all readers and lovers of Holy Writ (who, night and day, find their meditation and joy therein) in order to understand even better so many of its chapters and proverbs. [63]

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[62] Israel. (1995). *The Dutch Republic*: 891. In discussing contemporary debates in Dutch society I rely on the work of J. Israel.

[63] Voetius in Van Ruler (1995). *The Crisis of Causality*: 26.

It follows that 'the introduction of a new and independent [Cartesian] philosophy could not but damage theological doctrine.' [64]

The Voetian theologians thought the situation so alarming that they urged the States of Holland to do something to stop the undermining of the Scriptures. Johan de Witt (1625-1672), pensionary of Holland from 1653-1672, treated the complaints with seriousness because the fierce discussions could cause serious damage to the peace of the nation. For this reason he wished to 'preserve freedom to philosophise, and philosophers, from the censorship of preachers and synods; but took the view that to achieve this the state needed to enforce the separation of philosophy and theology implied in Cartesian teaching.' [65] By compelling theologians and philosophers to disengage, and moderate their polemics, De Witt had defeated the attempts to ban Cartesian philosophy and restrict freedom to philosophise in the universities. Moreover, he had ensured that the Cartesian controversy would enter a quieter phase.

However, with the overthrowing of the regime of De Witt and the installation of stadtholder Willem III in 1672, the hard-line Calvinists became more influential and the Cartesians were out of favour. What happened was that the Cartesians under the existing pressure, attacked radical Cartesians and Spinozists in order to turn away the anger of the orthodox Calvinists. Spinoza complains about this in a letter to Oldenburg in September 1675.

> while I was negotiating (about the publishing of the Ethics), a rumour gained currency that I had in the press a book concerning God, wherein I endeavoured to show that there is no God. This report was believed by many. Hence certain theologians, perhaps the authors of the rumour, took occasion to complain of me before the prince and the magistrates; moreover the stupid Cartesians, being suspected of favouring me, endeavoured to remove the aspersion by abusing everywhere my opinions and writings, a course which they still pursue. When I became aware of this through trustworthy men, who also assured me that the theologians were everywhere lying in wait for me, I determined to put off publishing till I saw how things were going (...) but matters seem to get worse and worse and I am still uncertain what to do. [66]

Here Spinoza, like the Cartesians, can be seen as a victim of the intolerance of the hard-line Calvinists. The Voetians had to accept, because of the law, that dissenting churches had the freedom to practice their beliefs and that Roman Catholic services, as long as attendances were not too large, could still be held

[64] Van Ruler (1995). *The Crisis of Causality*: 10.
[65] *Ibid.,* 893.
[66] Spinoza. (1955). *Ethics*: 296.

in private homes. But they drew the line at doctrines which according to their opinions undermined the principles of the Christian faith. Those who denied the divinity of Christ, the Trinity, and original sin, were accused of atheism. The best example of this is Spinoza, whose writings were widely banned and with whom nobody wanted to be associated. Especially under Willem III, the orthodox views restricted intellectual and political freedom. Although the Netherlands were freer than other European countries of the time and more tolerant to dissenting churches, 'they adhered to a censorship which created a real and formidable barrier to the expression of certain kinds of religious and philosophical ideas.' [67]

The system was policed through the organisation of the Reformed Church into Synods, Classes, and Consistories, a form of organisation which still exists nowadays. [68] Every province had a Synod that met every year to control the affairs of the church within the province and co-ordinate policy and activity between the provinces. This would proceed under the supervision of the National Synod meeting every three years, of which the Synod of Dordrecht of (1618-1619) is a well known example. Under the provincial synod came the regional classes, the gatherings of town pastors in each area. Their aim was to inform the village preachers about the wider developments as well as co-ordinating education and welfare in the regional churches. The most fundamental institution of the Dutch Reformed church was the church counsil, or *kerkenraad*. It met frequently to regulate the affairs of the church within the community. Unlike the classes which consisted of theologians only, the consistories were dominated by lay people and included lay elders, lay deacons and ministers. They closely supervised the life of the congregation and matters of life-style, as well as church affairs and the work of the ministers. [69]

There was no official relationship between the town councils and the consistories, although it was often the case that members of the order of sheriffs, the *vroedschap*, were also members of the consistory, in many respects its ecclesiastical equivalent. Consequently it can be said that whenever the consistories were dissatisfied with aspects of civic life, they were very well able to put pressure on the burgomasters and *vroedschap*, and therefore they not only interfered in ecclesiastical affairs, but they influenced all aspects of civic life as well. Boerhaave experienced this during the incident on the canalboat. The person that took his name could very well have been a member of a consistory or at

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[67] Israel. (1995). *The Dutch Republic*: 915.

[68] For a good overview of the organisation of the Dutch Reformed church in its early years see: Deursen, A.T. v. (1998(1974)). *Bavianen en Slijkgeuzen. Kerk en Kerkvolk ten tijde van Maurits en Oldebarnevelt*. Franeker.

[69] Israel. (1995). *The Dutch Republic*: 367-368.

least someone with a close relation to one of the members. Through the structure of the Church, the mentioning of Boerhaave's name at the lowest level, guaranteed that his reputation as an adherent of Spinoza, whether true or false, would be widely known.

Returning to the question why the separation of theology and philosophy became so important we can now give an answer. Under the regime of Johan de Witt the separation of the two disciplines helped in the creation of a more peaceful and tolerant society, in which there was relative freedom of religion. However, as soon as the regime of Johan de Witt came to an end, the Voetians reversed the situation and did everything in their power to influence all aspects of life, which included intellectual life. This is perhaps the reason that philosophers such as Spinoza and Boerhaave pleaded for a separation of philosophy from theology in order that every man should be free to think what he likes and to say what he thinks.

Boerhaave, as we saw, regretted that the Scriptures were explained according to the philosophies of 'Plato, Aristotle, Thomas Aquinas, Duns Scotus and even Descartes,' and was keen to separate philosophy from theology.[70] Considering that Boerhaave was a Calvinist, it seems strange that he apparently followed the Cartesians and not the Voetians in his plead for a separation. However, as we shall see in the end of the chapter, Boerhaave promoted a programme, which was far from being Cartesian.

The question remains why Boerhaave was keen to separate theology and philosophy. It is likely that Boerhaave thought back to the Cocceian controversies that plagued Leiden's intellectual life in the second half of the seventeenth century. Johannes Cocceius (1603-1669), who initiated the conflicts, belonged to a group of liberal theologians, who applied Cartesianism to theology. The resulting conflict with the Voetians lasted until well into the eighteenth century.[71] The publication of Lodewijk Meyer's *Philosophia Sanctae Scripturae interpres* (1674) further stirred the emotions. Meyer argued that Christians should come to unity of exegesis of Scripture and he proposed Cartesian philosophy as the perfect tool. The Voetians feared the introduction of universal doubt and even a systematic doubt of the existence of God in theology

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[70] *Commentariolus*: IX.

[71] Wall, E. v.d. (1993). 'Orthodoxy and Scepticism in the Early Dutch Enlightenment.' In R.H. Popkin & A. Vanderjagt (Eds.), *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries* (pp. 121-141). Leiden, New York, Köln: 121. For Cocceianism see also: Sassen, F.L.R. (1970). 'The Intellectual Climate in Leiden in Boerhaave's Time.' In G.A. Lindeboom (Ed.), *Boerhaave and his Time* (pp. 1-16). Leiden; Wall, E. v.d. (1990). 'Profetie en Providentie: De Coccejanen en de vroege verlichting.' In e.a. P. Bange (Ed.), *Kerk en Verlichting* (pp. 29-37). Zwolle.

and they prohibited Meyer's book in 1674, the same year as Spinoza's *Tractatus theologico-politicus* was put on the black list.

However, church historian Van der Wall has argued that the Cocceians were as concerned about irreligion as the Voetians. The Cocceians saw in Cartesian doubt a way to certitude and a way to convince atheists of the truth of Christianity. They interpreted the Cartesian *dubitare* as the suspension of judgement. Doubting the existence of God was seen as a result of the Fall. The cure of universal doubt was not a blind accepting of God's existence without good reason. This would create more doubt instead of solving the problem. On the contrary 'man could only be helped by searching for solid grounds in order to assent to the truth of God's existence with a sagacious judgement.' Only this would lead to true religiosity, comfort and certainty for man's soul.[72] The Voetians saw in doubt the opposite of faith. Belief, they argued, does not require any proof and they called for an uncritical embracing of the truth of traditional dogma.

The debate of the adoption on universal doubt within theology was still an issue in Boerhaave's time. In the disputations on the human mind Boerhaave sided with the Voetians. He defended these corollaries:

I. I reject the universal doubt of anything.
II. Since I state, that, if innate ideas are rejected, the existence of God cannot be made plausible to an atheist.[73]
III. I see it not proved, even though I wish for it, that you can convince the stubborn atheist to accept the idea of Deity (*Numen*), let alone of the idea of God (*Deus*) impressed upon the human mind.[74]

It is interesting to note that in the third statement Boerhaave distinguished between *numen*, the abstract idea of a presiding deity, and *Deus*, the Christian God. It is likely that Boerhaave identified the God of the Cartesians and Cocceians with *numen*, while the Voetians were speaking about *Deus*. To Boerhaave the aim of proving the existence of God must have been a precarious project, for it meant trying to understand more about God than God allows man to know.[75] In Boerhaave's view the existence of God cannot be proved but rests upon an inner conviction of the believer. Hence Boerhaave could

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[72] Wall, V. .d. (1993). 'Orthodoxy and Scepticism': 135-136.
[73] Boerhaave, H. (1687). *Disputatio pneumatica de mente humana prima*. Leiden: Corollaria I, II. 'I. Dubitationem generalem, de omnibus rejicio. II. Sepositis enim veritatibus innatis Atheo DEI existentia non probabitur.'
[74] Boerhaave, H. (1688). *Disputatio pneumatica de mente humana secunda*. Leiden: Corollarium III. 'III. Ex idea DEI insculpta menti, pertinaci Atheo demonstrari existentiam Numinis, ita ut convincatur, nondum probatum video, tamen idem desiderans.'
[75] *Commentariolus*: XVIII.

accept Spinoza's ideas on tolerance and liberty, while at the same time, as we shall see later, rejecting Spinoza's idea of God.

It can be said that Spinoza's call to separate faith and philosophy was a reaction against the zeal of the seventeenth century Voetian theologians who fought against all opinions that differed from orthodoxy. He heavily criticised the claim of the Churchmen that they had the final word in interpreting the Scriptures on all human affairs, including political matters. In their holy war against unbelief the Voetians were so keen that they mixed up theology and faith with philosophy and reason. Whereas Spinoza understood theology and faith as the knowledge of God and nature as it really is and really operates on the one hand, and the manner of human living so as to exhibit the work of God within it on the other hand. Most important was the loving obedience to God's command through faith. [76] It was when the theologians started to speculate and philosophise about the meaning of the Scriptures that damage was done.

Spinoza stressed that it cannot be proved by reason whether the basis of theology, which is the salvation of man through obedience, is true or false. Therefore the certainty of theology is moral, whereas the certainty of philosophy is mathematical. It is a truth that satisfies the intellect. But the object of both philosophical and theological knowledge is the existence and properties of God. Therefore the issue is not about the separation of God from His creation, but about different approaches in searching the nature of God.

There yet remains the question to what extent Boerhaave was influenced by Spinoza's writings. We know that he liked Spinoza's opinion on freedom of the mind, but it was also widely known that Boerhaave refuted Spinozism. Moreover, in 1690 Boerhaave got his doctoral degree in philosophy after defending his *Disputatio inauguralis*, in which he publicly criticised the philosophy of Spinoza. Moreover, Lamettrie, who attended Boerhaave's lectures, stated that his teacher was a materialist and that 'personne ne fut moins Spinoziste.' [77] Boerhaave cannot possibly have agreed with Spinoza since Spinoza's definition of God and His creation differed considerably from the views preached in the Calvinist church. The general opinion in those circles was that Spinoza, the 'bearer of the myth of atheism, had to be expelled.' [78] It is in this area that the opinions of Boerhaave and Spinoza differed considerably.

Boerhaave's God was the Calvinist God the Creator, Maintainer and Ruler

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[76] Fox, A.C. (1990). *Faith and Philosophy. Spinoza on Religion*. Nedlands, W.A.: 28.

[77] Lamettrie in Lindeboom. (1968). *Herman Boerhaave*: 265.

[78] Siebrand, H.J. (1988). *Spinoza and the Netherlanders. An Inquiry into the Early Reception of His Philosophy of Religion*. Assen: 214.

of the world, the omnipotent God, the just Judge and the merciful Father of mankind. Looking upon His greatness Boerhaave was deeply convinced of the littleness of man. Deeply convinced of his insignificance, Boerhaave depended wholly on the grace of his God, who would dispose everything well for mankind. In chapter two I shall discuss Boerhaave's Calvinism at greater length. For now it is sufficient to know that Boerhaave's religious conviction reflects the Calvinist creed, written down in the *Belijdenis des Geloofs* and in the *Dordtse Leerregels*, the doctrines of the Reformed Church established during the Synod of Dordt (1618-1619). It was stated there that the knowledge of God is twofold. It is implanted in the heart of man and it is manifest in the structure of the world, since God governs his creation. Human knowledge and reason alone are insufficient for an accurate knowledge of God and His creation. Man needs God's Word, which is offered in the Old and the New Testament. The authority of the Scriptures is evident from the working of the Holy Spirit in the heart of man. Illuminated by the holy Spirit man believes that the Scripture is God-given and he believes this with a faith that makes any form of proof superfluous. In other words, man needs revelation to attain knowledge of the true God.

Spinoza's image of God differed widely from the Calvinist notion. He denied the most fundamental principles of Calvinism; the transcendence of God, the Creation as one single act, and the resurrection of Christ.[79] Moreover, Spinoza tried to capture the essence of God, or *Numen* in Boerhaave's view, in philosophical reasoning. In the *Ethics* Spinoza gave a precise definition of God. He stated that God is 'a being absolute infinite, that is, a substance consisting of infinite attributes, each of which expresses eternal and infinite essence.'[80] Substance he defined as 'that which is in itself and is conceived through itself', which means that its essence involves its existence. An attribute is that which the intellect perceives of substance as constituting its essence. It follows from these definitions that wherever we are considering God, we are considering him under an attribute.[81] God's infinite essence involves his infinite being, which means that all being exists in and through God. Therefore Spinoza did not distinguish between God and nature and speaks about 'God or Nature', *Deus sive Natura*. In Spinoza's philosophy

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[79] The correspondence between Spinoza and the Calvinist theologian Blijenbergh is a good example of the controversy about Spinozism in the Dutch Reformed Church. See: Klever, W. (1993). 'Blijenberghs Worsteling met het Kwaad en Spinoza's Reactie.' *Tijdschrift voor de Filosofie, 55* (2), 307-329.

[80] Spinoza. (1955). *Ethics*: def. VI.

[81] For a discussion on Spinoza's concept of substance compared to that of Descartes see: Woolhouse, R.S. (1993). *Descartes, Spinoza, Leibniz. The Concept of Substance in Seventeenth-Century Metaphysics*. London/New York.

God cannot be separated from nature since if there were substances other than God, God would not be infinite. Therefore 'whatever is, is in God, and nothing can exist or be conceived without God.' Therefore all finite beings are modifications of God. Moreover, God possesses an infinity of attributes, of which only thought and extension are known to us.

Spinoza strongly differentiated between imaginary and intellectual knowledge. The ideas of imagination are ideas derived from sense-perception. They do not spring from the active power of the mind, but reflect bodily changes and states produced by other bodies. This means that imaginary ideas spring from sense perception when an individual person is affected in some way or another. The individual becomes aware of something outside itself, but only knows that it is there without having any adequate knowledge of its nature or essence. Going from the first to the second, or intellectual level of knowledge, one passes from logically unrelated impressions and confused ideas to logically related and clear propositions and adequate ideas. Knowledge of this second kind is necessarily true. The concreteness of the sense perception of the first level is replaced with the abstract generality of mathematics and the other sciences. We can even say that the *Ethics* itself can be seen as an example of the second level of knowledge, for Spinoza sets out his system in geometrical order.

The difference between the two kinds of knowledge is important for the understanding of Spinoza's account of the emotions and the intellectual love of God. Usually the emotions were considered as something different from the human body, as something apart from the natural world. Spinoza, however, did not make such a distinction and he proposed to treat man as part of nature and to regard human actions and desires exactly as if he were dealing with lines, planes and bodies (III Preface). The interaction between body and mind was no problem for Spinoza as he saw mind and body 'as one and the same thing, which is conceived now under the attribute of thought and now under the attribute of extension' (III Prop. 2 Note). A result of this definition is that mental activities are as determined as bodily activities.

One of the basic principles of the working of body and mind is the endeavour of man to exist in his own being. Man therefore strives towards a greater perfection and as he succeeds, the experience is reflected in the consciousness as 'pleasure', while the transition to a lower state is experienced as 'pain.' All other emotions are derived from these basic forms. When the idea of an external thing becomes associated in the mind with pleasure, that is with the heightening of vitality or the drive to self-preservation, one can be said to love that thing, and call it good (III Prop. 57). Yet not all emotions are passive. All actions that follow from the emotions as far as the mind is active or understands, Spinoza refers to as courage and nobility. Moral advance, therefore,

consists for Spinoza in the liberation of passive emotions and in changing them to active emotions. In other words, moral advance is parallel to intellectual advance. Understanding, living under the guidance of reason, therefore is the path to the freedom of uncontrolled passion.

However, the ultimate virtue of the mind is 'the knowledge of God, and the greatest virtue of the mind is to know God' (IV Prop. 28). For the more a man understands God, the more he loves Him. Conceiving the things as contained in God and nature, means conceiving them 'under the species of eternity', which means conceiving them as part of the logically connected infinite system. As a result knowing God means for man, to conceive himself under God's infinite attributes. From this knowledge arises pleasure, which is, accompanied by the idea of God as the eternal cause, the 'intellectual love of God', and this love is 'our salvation, blessedness or liberty' (V Prop. 32).

It can be stated that Spinoza's intellectual love towards God differed widely from the personal relation Boerhaave had with his God. It is directed to the pleasure of mental satisfaction accompanying the satisfaction of being able to explain nature, rather than having a relationship. Boerhaave's God, however, transcends His creation, and His fatherly hand acts in the world. Therefore, in order to know God, reason alone is not enough but has to be accompanied by experience and revelation. Boerhaave must have been horrified by the idea, expressed by Spinoza, that the human mind was as mortal as the body.

Thus the Calvinist Boerhaave could not have possibly agreed with Spinoza's *Deus sive Natura*. However, Boerhaave was pleased with Spinoza's ideas on the freedom of thinking as described in the *Tractatus theologico-politicus*. It could be said that Boerhaave had a nuanced view on Spinoza's philosophy. The question remains to what extent Boerhaave was charmed by the philosophy of Spinoza. For both Boerhaave and Spinoza the starting point of looking at nature was to know God through His creation. Both also stated that we cannot fathom nature to the fullest. Even their methods of investigating natural phenomena show similarities. Keeping in mind that for both Boerhaave and Spinoza their Gods were the starting points of their philosophies, we should take, in comparing the philosophers, their natural reasoning as starting point. We now see a practical application of the separation of philosophy and theology. Boerhaave could agree with Spinoza on philosophical grounds as far as mathematical certainty was concerned. However, he stayed away from Spinoza's doctrines when it came to images of God and moral certainty. Ultimately it was in the work of Newton that Boerhaave found the natural philosophy he was looking for, a philosophy that did not lead to Spinozism or Cartesian materialism, but that also steered clear of Scholastic Orthodoxy.

Years later, well into his medical career, Boerhaave's orthodoxy was called into question again. A few years after giving the rectoral address, *De comparando certo in physicis* (1715), the professor of divinity and philosophy in the Friesian university of Franeker attacked Boerhaave's oration. Ruurd Ruurds (1665-1727), calling himself Andala after his birthplace Andalahuizen, accused Boerhaave of endangering church doctrines and he stated 'that the introduction of Scepticism and even Spinozism would be the consequence of undermining the Cartesian system by such a profest ignorance of the principles of things.' [82] Andala's attack caused a great sensation especially because controversies constantly threatened the stable religious situation in the Republic. Under all the commotion Boerhaave remained calm and showed no reaction whatsoever. The Curators of the university of Franeker were embarrassed by the situation and they demanded that Andala should withdraw his accusations. Boerhaave accepted the apologies and he replied to the curators that he did not wish any more trouble for the theologian on his behalf.

The 'Affair Andala', as it came to be called, shows a totally different Boerhaave than the man we met before. The enthusiastic young man on the boat seems to be replaced by a lethargic man who thinks his fame cannot be damaged. It almost seems as if Boerhaave did not care what people said about himself and his teaching. Did Boerhaave learn from the canalboat incident that replying to false accusations would lead to nothing but damage to his career? Was there maybe some truth in the accusation? Or was the accusation so absurd that Boerhaave did not even bother to reply? In order to answer the questions we have to look at the oration that excited the feelings of the Friesian theologian. The speech gives a clear picture of the natural philosophy and medicine that Boerhaave taught and promoted.

Boerhaave in his oration on the achievement of certainty in physics criticised Cartesian natural philosophy, and he argued that it is impossible to know the first principles of things. Boerhaave also is more inclined to adopt Newton than Descartes. This is remarkable for Descartes had had such an influence on Dutch natural philosophy that academic life in Leiden was soaked with Cartesian thought. We have already seen that Boerhaave's teachers De Volder and Senguerd were influenced by Cartesianism. Moreover, the early disputations show that Boerhaave himself was not entirely free from

[82] Burton. (1743). *An Account*: 34-35. About twenty years before Andala was well known for his criticism of the Amsterdam theologian Balthasar Bekker (1634-1698), who had argued in his 'World Bewitch'd (*De Betoverde Weereld*) that it is impossible to prove the existence of any spirit other than the soul with help of the Bible. See also: Fix, A. (1993). 'Balthasar Bekker and the Crisis of Cartesianism.' *History of European Ideas, 17* (5), 575-588.

Cartesianism. The question remains why Boerhaave, living in an environment full of Cartesians, was attracted to Newton's ideas?

We do not know when Boerhaave first made acquaintance with Newton's views, but according to his biographer Lindeboom, it must have been shortly after the publication of the *Principia* in 1687. [83] At that time Boerhaave was still reading philosophy and, in the year of the publication, he also started his mathematical studies. Boerhaave had a chance to look at the *Principia* during his job in the University Library of Leiden. He got entrusted with the job of checking and cataloguing the thirty-four cases of books containing the library of Isaac Vossius, the son of the famous Gerard Vossius, bought by the university for 33,000 Dutch guilders. Among the books that went through Boerhaave's hands was a first edition of Newton's *Principia*. Moreover in the catalogue of books sold after Boerhaave's death we find all four editions of the *Opticks* as well.

However, even though Boerhaave adopted some of Newton's ideas, he was not a straightforward Newtonian when he resigned his office of *Rector Magnificus* of the university in 1715. [84] I shall discuss how Boerhaave modified Newtonianism in chapter four. For now the most important thing is that the main theme of the 1715 oration is the hidden nature of the first principles of nature. Boerhaave defined the principles as 'these things (...) through which, once they have come into being, all changes that happen in the universe are effected with inherent necessity.' [85] Boerhaave stated that anyone who understands the nature of a cause understands all its potential effects. [86] In theological terms this means that once man knows God, the ultimate cause of all existence, he knows God's will with the world.

Boerhaave's opinion on the inherent necessity of nature brought him onto a slippery slope again. It smacks of Spinozist determinism. Orthodox theologians believed that 'to subject nature to mechanics amount to a restriction of God's actions by the rules of an essentially human craft.' [87] However, according to Boerhaave the inherent necessity of nature would not restrict the omnipotence of God. Already in 1688, while speaking about the unbroken, eternal and necessary truth of axiom's Boerhaave had referred to the unity of God, and he states that it wrong to say that God's power makes possible

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[83] Lindeboom. (1968). *Herman Boerhaave*: 268.

[84] *Orations*: 145. The office of *Rector Magnificus* can he compared to the position of Vice Chancellor and is still the highest office in a Dutch University.

[85] *CCP*: 157.

[86] *Ibid.,* 156.

[87] Verbeek, T. (1993). 'From 'Learned Ignorance' to Scepticism. Descartes and Calvinist Orthodoxy.' In R. Popkin, H. & A. Vanderjagt (Eds.), *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries* (pp. 31-45). Leiden, New York, Köln: 43.

what is contrary to His reason.[88] In 1715, Boerhaave avoids the argument whether everything in nature happens out of an inherent necessity, but he tackles the question whether man can or cannot fathom the first principles. This resulted in the argument that nature works according to rules laid down by God. However, it would be unforgivably arrogant for man to presume that 'the universal causes in physics can be compressed in the tiny enclosure of the human mind.'[89]

Thus Boerhaave's argument contradicts Cartesian rationalism. Descartes defined philosophy as the study of wisdom, which included a perfect knowledge of all things. He believed in the existence of innate ideas, which led him to the conviction that man can come to a true knowledge of things by the use of reason. All truths together would form a system in which the mind can pass from fundamental self-evident truths to other evident truths which are contained in the former. Descartes argued that all branches of natural philosophy are similar. Thus they can all be examined according to the same mathematical method. The roots of philosophy are on the one hand the certainty of the existence of the finite self (Descartes' famous *cogito ergo sum*) and on the other the criterion of truth which is the existence of God and the material world. The roots feed the trunk and the branches of the tree, which are physics and the other practical disciplines. It is clear that Descartes did not begin his philosophy with God, but with the human finite self. Boerhaave's oration on the contrary is based on a deep-rooted respect for the Creator through Whom all things came into being and whose government determines the working of all things. To the highly religious Boerhaave, who grew up as the son of a minister and who wanted to be a minister himself, Cartesian philosophy was true horror for it pretended to know the working of nature from a few principles. Boerhaave called Cartesian speculation unforgivably arrogant for it was 'aiming at the wisdom itself of God.'[90]

Instead of Descartes, Spinoza might have offered Boerhaave a more attractive approach in the sense that Spinoza made the definition of God central to his philosophy. According to Spinoza the proper order of philosophical argument should start with that which is logically and ontologically prior, namely with the divine essence of nature. Only so could Spinoza rule out contingency in nature and develop a philosophy based on a true solid system, for

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[88] Boerhaave, H. (1688). *Disputatio pneumatica de mente humana secunda*. Leiden: Corollarium 1. '1. Inconcussa, aeterna & necessaria est axiomatum veritas; non enim potest existere causa eas mutatura; neque hinc coactio DEO imponitur, nam frustra posse per omnipotentiam dicitur, quod ejus sapientiae repugnat.'

[89] *CCP*: 158.

[90] *Ibid.,* 157.

if the causal dependence of all things on God is the same as logical dependence, there is no place for free creation, nor for contingence in the world of material things, nor for human freedom. However, Spinoza found the belief in a personal transcendental God, who created the world, philosophically untenable. For Spinoza God is an ontological cause of existence, a view that must also have been horrible in Boerhaave's eyes. Newton's philosophy, based on the belief in a God who created and maintains the earth, offered Boerhaave a way out of the theological consequences of Spinoza's philosophy. In other words, in the works of Newton, Boerhaave found a 'Godly' natural philosophy in accordance with his Calvinist beliefs, for Newton's God is actively involved in the actions of the world. In chapter three and four we shall examine the similarities and differences between the ideas of Boerhaave and Newton.

We can now return to the question why Boerhaave was not too bothered about the criticism of the Friesian theologian. The accusation that Boerhaave's moving away from the principles of things would lead to scepticism and Spinozism is absurd. Boerhaave was as horrified by the theological implications of Spinozism as he was by Cartesianism for that matter. The accusation that Boerhaave's oration would endanger church doctrine was out of place for the one thing Boerhaave did in the disputation was to present a natural philosophy which was entirely in accordance with the Reformed faith.

The Voetians clung to Aristotelian-scholastic philosophy, while the Cocceians adopted the new philosophy of Descartes. This meant that all new philosophy quickly became associated with irreligion and unbelief. Boerhaave found both the peripatetic philosophy and Cartesianism unacceptable. In Newton's ideas he found a new philosophy in accordance with the orthodox theology of the time. Thus it can be said that Boerhaave, through adopting a third philosophy managed to bridge the gap between orthodox theologians and adherents of the new philosophy. Boerhaave's natural philosophy must have been a blessing for the orthodox Calvinists, who so far had been plagued with the unbelief of Cartesians and Spinozists. Most people, and even the curators of his home university, disregarded Andala's accusations. At the same time Boerhaave, who was at the height of his fame, could afford not to be too worried about random accusations in the north of the country.

Did Boerhaave take over De Volder's Cartesian / Spinozean message? In other words, was Boerhaave a 'crypto-Spinozist' like his teacher? The answer has to be that to a certain extent he was. However, we have to be very careful in calling Boerhaave a Spinozist. As we saw, Boerhaave disagreed with Spinoza on the main points of his philosophy and in the theological controversies surrounding Spinoza's philosophy Boerhaave nearly always sided with the

orthodox theologians. On the other hand Boerhaave's opinion of Spinoza was a lot more nuanced than that of many of his contemporaries. Although Boerhaave was horrified by the theological consequences of Spinoza's *Deus sive Natura*, he agreed with Spinoza on political issues of freedom of the mind. Even some of Boerhaave's natural philosophical ideas smack of Spinozism, like the determinism of the inherent necessity of the first principles of things.

It can be stated that all the Spinozean ideas, acceptable to Boerhaave, fitted in with his Calvinist beliefs. Boerhaave's plea for freedom of thinking was directed at the rigid attitude of church theologians who felt more strongly about their interpretation of the bible than about the actual content of the Scriptures. Also Boerhaave's 'determinism' fits with his Calvinist beliefs. Even though Boerhaave did not adopt Newtonianism as an all encompassing theory, the natural philosophy of Newton, more than Spinozism or Cartesianism, agreed with Boerhaave's Calvinism and offered Boerhaave a way out of the controversies surrounding Cartesianism and Spinozism. In other words Newtonianism gave Boerhaave a chance to say farewell to the theological battleground and get on with his work, the study of God and His creation.

We know Him in two ways. In the first place through the creation, preservation and government of the whole world: For this is like a beautiful book, before our eyes, in which all creatures, big and small, are like letters, which show us the invisible things of God, namely his eternal power and Godhead, like the apostle Paul says in Rom. 1:20; so that they are without excuse. Secondly, He makes himself known even more clearly and completely through His holy and Godly Word, namely as much as we need in this life, to His glory, and the salvation of His people.

Dutch creed, Article 11

11. Herman Boerhaave: Calvinist

Just after Boerhaave's death in 1738, Fontenelle (1657-1757), secretary of the *Académie Royale des Sciences* in Paris wrote an account of Boerhaave's life. Most of the biography repeats what others had already written about Boerhaave and it is largely based on Albert Schulten's funeral oration. However, there is one thing that only Fontenelle mentions. Apparently Boerhaave raised his hat every time he pronounced the name of God.[1] Whether this story is true or not it indicates that among contemporaries Boerhaave had the reputation of being a highly religious man. A man *vere christianus*, as Albrecht von Haller called him.[2] In raising his hat, Boerhaave must have showed his reverence for God, as normally the Dutch kept their hats on, as a sign of liberty, even during meals and in church.[3]

The raising of the hat also indicates that Boerhaave's life was soaked with Christian thought. He started his days spending an hour in meditation and Schultens said in the funeral oration that even though Boerhaave was a quick-tempered man, he had conquered this evil by continuous prayer and daily meditation.[4] Calvinism not only characterised Boerhaave's way of living, but it was also the starting point of his natural investigations. Medicine, botany, mathematics, physics and most of all chemistry gave him the necessary means to find God in His creation.

Hitherto historians of science have not paid much attention to Boerhaave's religious views and their influence on his natural philosophy. They have mainly emphasised Boerhaave's mechanistic approach to investigating nature and, concerning chemistry, they have praised him for being one of the first to

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[1] Fontenelle. (1738). *Éloge de M. Boerhaave. Histoire de l'Académie Royale des Sciences de l'Année MDCCXXXVIII:* 108.

[2] Haller, A. v. (1774-76). *Bibliotheca anatomica*. Zürich: 1, 757.

[3] Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and his Work*. Leiden: 262, n. 4.

[4] Schultens, A. (1988 (1739)). *Academische Redevoering van Albert Schultens ter Gedachtenisse van den Groten Herman Boerhaave. Uitgesproken 14 november 1738* (Schultens Jan Jacob, Trans.): 72.

free it from religious and alchemical notions.[5] However, I shall argue that Calvinist theology had a profound influence on the way Boerhaave studied natural philosophy.

Unlike most modern scientists Boerhaave did not consider nature as an entity independent from God. Nature, for Boerhaave, was God's creation, in which minerals, plants, animals, and man himself are creatures obeying the will of the Creator. For this reason we cannot simply ignore Boerhaave's references to God and say that Boerhaave referred to his Creator because the convention of the time obliged him to do so. Saying this would be a form of contempt on our part, for we would not be taking Boerhaave's words seriously. However, when we place Boerhaave's work in the context of his Calvinist beliefs we see that Boerhaave's speaking of God the Creator reflects the faith of a deeply religious man. Moreover, insight into Boerhaave's Calvinism will give us a better understanding of his chemistry and medicine.

It is not new to argue that there is a relationship between Calvinism and natural philosophy.[6] In the historiography of science we can distinguish between two main streams of historians explaining the influence of Protestantism on the rise of science in the seventeenth century. On the one hand the Weber/Merton theses gave rise to a stream of publications discussing the doctrine of predestination as a main cause of the rise of science.[7] On the other hand we find historians who emphasise the Protestant doctrine of creation as the main reason.[8]

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[5] See for example: Brock, W.H. (1992). *The Norton History of Chemistry*. New York/London Other historians of science have also separated Boerhaave's natural philosophy from his Calvinism or do not mention Boerhaave's religious ideas at all. See: Lindeboom. (1968). *Herman Boerhaave*. Cohen, E. (1919). *Herman Boerhaave en Zijne Betekenis voor de Chemie. Met een Vertaling van Boerhaave's Natuurwetenschappelijke Redevoeringen en Verhandelingen door Dr. Margaretha Renkema*. De Nederlandse Chemische Vereniging in Samenwerking met de Vereniging voor Geschiedenis der Genees-, Natuur-, en Wiskunde; Jevons, F.R. (1962). 'Boerhaave's Biochemistry.' *Medical History, 6*, 343-362. Partington mentioned that Boerhaave was trained as a theologian, but he distinguished Boerhaave's theology from his natural philosophy. Partington, J.R. (1961). *A History of Chemistry*. New York: ii, 740-759.

[6] For an overview see: Grell, O.P. (1992). 'Protestantism, Natural Philosophy, and the Scientific Revolution.' In *Studies in the History and Philosophy of Science, 23, 3,* 519-527.

[7] Weber, M. (1971 (1904-5)). *The Protestant Ethic and the Spirit of Capitalism* (Parsons, Talcott, Trans.). London; Merton, R. (1987). *Science, Technology and Society in Seventeenth Century England*. New York; Webster, C. (1975). *The Great Instauration. Science, Medicine and Reform 1626-1660*. London.

[8] Klaaren, E.M. (1977). *Religious Origins of Modern Science. Belief in Creation in Seventeenth-Century Thought*. Michigan; Foster, M.B. (1969). 'The Christian Doctrine of Creation and the Rise of Modern Natural Science.' In D. O'Connor & F. Oakley (Eds.), *Creation. The Impact of an Idea* (pp. 29-53). New York; Oakley, F. (1969). 'Christian Theology and the Newtonian Science: The Rise of the

Hooykaas has observed that the doctrine of predestination is not specifically Calvinistic, and that 'the clever constructions of sociologists fail to prove any link between Calvin's idea of predestination and either capitalism or modern science.' Instead, he states that the central theme of reformed theology was the glory of God the Creator, and the duty of glorifying God involved the study of nature. [9] I agree with Hooykaas. Boerhaave's case shows that God's assignment for man to read the 'Bible of Nature' was a much more important stimulus for investigating nature than the theology of election.

With Hooykaas several historians have argued that until the eighteenth century the reformation belief in divine creation was the main motif for natural investigations and thus the reason for the rise of science. They distinguish two fundamental approaches to God and his creation, i.e. intellectualism and voluntarism. Both theological approaches stress the omnipotence of God, but the intellectualists mainly emphasise God's intellect, while the voluntarists stress God's freedom of will. Among the intellectualists, we find Thomas Aquinas, who held that God created natural laws freely and arbitrarily, but that these laws embody a necessity which determines the course of particular events. The voluntarists on the contrary perceive the intellectual approach as limiting God's freedom. Instead of stressing God's *potentia ordinata,* they stress His *potentia absoluta.* [10] They argue that God acts immediately on the creation, which means that natural laws represent God's power of command rather than His wise and rational sovereignty. This means that the chief mark of law is obligation rather than a relatively immanent built-in regularity. [11] As

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Concept of the Laws of Nature.' In D. O'Connor & F. Oakley (Eds.), *Creation. The Impact of an Idea* (pp. 54-83). New York; Hooykaas, R. (1972). *Religion and the Rise of Modern Science*. Edinburgh/London.

[9] Hooykaas. (1972). *Religion and the Rise of Science*: 105-106.

[10] Muller defined *potentia ordinata* as 'the power by which God creates and sustains the world according to his *pactum* with himself and creation. In other words, a limited and bounded power that guarantees the stability and consistency of the orders of nature and of grace.' *Potentia absoluta* on the other hand refers to the absolute power and 'omnipotence of God limited only by the law of noncontradiction' which means that 'God can effect all possibility, constrained only by his own nature.' However, 'things which are by nature evil and either impossible or noncompossible things (like square circles) fall outside of the realm of God's power.' Muller, R.A. (1985). *Dictionary of Latin and Greek Theological Terms. Drawn principally from Protestant Scholastic Theology.* Carlisle: 231-232.

[11] Klaaren. (1977). *Religious Origins of Modern Science*: 36-37.

God is free to change any observed regularities as He likes, any knowledge of the creation must be based on observation. [12]

Klaaren has described Calvin's theology as a strong version of voluntarist theology. He states that the radical contingency of creation was a central point of Calvin's doctrine of providence. As a result Calvin 'portrays a remarkably enigmatic power-filled picture of the world.' [13] According to Klaaren, the direct relationship between God and His creation in Calvinism shows that Calvin was not concerned 'with degrees or kinds of being and causality' as was Thomas Aquinas. 'Creation was an open book, not an outer garment or extension of God Himself.' [14] A direct result was that Calvin stressed practical virtues and disciplines rather than a life of contemplation. [15]

Foster has argued along the same lines. He states that the Reformation 'carried the implications of Christian doctrines beyond the sacred into the profane sciences.' [16] Although the medieval philosopher believed in the creation, he adopted an Aristotelian approach to investigating nature. He mainly searched for final causes, properties and essences. The 'reformed' natural philosopher, on the contrary, would only describe natural substances and not define them. This meant a change from an intellectual approach to an approach that was based on sense-perception. Foster argued that the change is a result of reformed theology; that God the Creator is essentially distinct from His creation. The emphasis on God's transcendence and His direct involvement in creation overrules the intellectualist idea that God created the laws of nature, so that nature can regulate itself. Oakley pursues the same argument as Klaaren and Foster and uses the voluntarist/intellectualist distinction in order to explain the differences between the English puritans and the philosophy of Descartes.

A problem with the histories of Klaaren and Oakley is that they fail to explain how studying the creation would bring the believer closer to under-

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[12] Margaret Osler has summarized the differences between the voluntarist and intellectualist approach in Osler, M. (1983). 'Providence and Divine Will in Gassendi's Views on Scientific Knowledge.' *Journal of the History of Ideas, 44*, 549-560. For the relationship between divine will and the ideas of Gassendi see also: Osler, M. J. (1991). 'Fortune, fate and divination: Gassendi's voluntarist theology and the baptism of Epicureanism.' In M. J. Osler (Ed.), *Atoms, Pneuma, and Tranquility. Epicurean and Stoic Themes in European Thought* . Cambridge; Osler, M. J. (1994). *Divine Will and the Mechanical Philosophy: Gassendi and Descartes on Contingency and Necessity in the Created World*. Cambridge.

[13] Klaaren. (1977). *Religious Origins of Modern Science*: 40.

[14] Klaaren seems to use a wrong expression since Calvin does compare the creation to the clothes of God the creator in Calvin, J. (1847). *Commentary on the Book of Psalms* (Anderson, James, Trans.). Edinburgh: IV.

[15] Klaaren. (1977). *Religious Origins of Modern Science*: 40-42.

[16] Foster. (1969). 'The Christian Doctrine of Creation': 36.

standing its Creator. In other words they do not pay much attention to the relationship between God and man, so the ultimate reason for studying the creation remains unexplained. A related problem is that they overlook the importance of the differences in Protestant religion. They only distinguish between English puritans and continental Christians. Klaaren does not even distinguish between Roman Catholicism, Lutheranism and Calvinism on the continent. Hooykaas is the only historian who recognises the differences, but unfortunately he fails to work them out systematically. I shall argue that Boerhaave presented a specifically Calvinist natural philosophy. His case shows that the belief in a Calvinist God reinforced the obligation to study nature. His natural investigations were directed towards gaining knowledge of God the Creator. Moreover, Boerhaave's emphasis on observation and experiment directly resulted from his Calvinist belief that the human intellect is fallen and corrupted by sin to such an extent that it is not a trustworthy tool in the search for true knowledge.

In the first part of the chapter I shall discuss Boerhaave's religious ideas in the context of Dutch Calvinist theology. Then I shall argue that Boerhaave's ideas on nature can be traced back to the Calvinist belief in God the Creator and Maintainer of the earth. This allows us to understand how Boerhaave came to think of nature as the 'Bible of Nature.' The third part of the chapter addresses the question of how Boerhaave could achieve true knowledge in natural philosophy given the Calvinist emphasis on the fallen state of the human intellect and the inability of man himself to gain true knowledge. This will also bring us to the question of how Boerhaave separated the mind from the body as well as how this reflects a particular Calvinist approach.

A Dutch Calvinist life

In 1934 the Dutch pastor J.W. Gunst published a collection of biographical essays on Herman Boerhaave, resulting from articles he had already written for several church newsletters in Leiden and its surrounding villages. The essays reflect the view of many orthodox reformed church people in the Netherlands, i.e. that Boerhaave was not only a very good medical doctor, but also that he was a 'strict and positive Christian,' the only Christian doctor the Dutch had ever known. [17] Gunst called Boerhaave a true child of the covenant who, like the Biblical Obadiah, observed the will of God from the days of his

[17] Gunst, J.W. (1934). *Herman Boerhaave. Biografische Schetsen* Leiden: 6. Among strict Calvinists in the Netherlands the name Boerhaave stands for good Christian medicine. Moreover his name is mentioned in various church newsletters and bible diaries.

youth.[18] Moreover, he considers Boerhaave's ideas as resulting from the theology of the Further Reformation (*Nadere Reformatie*) of which Theodorus à Brakel, Jacobus Koelman and Herman Witsius were the main spokesmen. The question is whether Boerhaave was as orthodox a Calvinist as Gunst wants his readers to believe. Considering that Leiden was a breeding ground of new revolutionary ideas in theology, we can ask whether we can call Boerhaave an orthodox Calvinist? Could he not have been influenced by remonstrant and Cocceian ideas? I shall argue that Boerhaave was an average Calvinist. His way of life shows the characteristics of a regular Calvinist life. Moreover, he did not like the liberal ideas of the Cartesians and Cocceians. In order to demonstrate Boerhaave's Calvinism, I shall first discuss what an orthodox reformed Calvinist in Boerhaave's time believed and how he lead his life. In order to explain what I understand to be particularly Dutch Calvinist I shall first briefly examine the development of the reformed belief in the Low Countries. Then I shall discuss how Dutch Calvinism at the time distinguished itself from other protestant positions, such as Lutheranism and English Puritanism. The last point to be considered is how we can recognise the impact of Calvinism upon the natural philosophy of the Republic in the early eighteenth century.

According to Jonathan Israel the distinctive character of early Dutch Protestantism, which also retained its force in later Calvinism, was its 'dogmatically pluriform and radically decentralised' nature. He calls it 'a bewildering plethora of doctrines and standpoints with the lines between them continually fluid.' In other words, he talks about a 'fluid Protestantism.'[19] In the 1550s, with the impetus of French, British and German Calvinism, Dutch Protestantism became more structured. In particular Calvin's *Institutes*, first published in 1536, with its clear and systematic explanation of the creed, provided the necessary orderly dogmatic system to counteract the fragmentation.[20] In these years the Reformed Church was not as orthodox as it would become in the years after the Synod of Dordt. Although from the end of the sixteenth century the Dutch Reformed Church saw a steady growth, mostly because of support from the secular authorities, in its beginning years, the reformed church, did not have many confessing members. For instance in 1619 in a big town like Haarlem not more than twenty percent of the population were confessing members of the Reformed church – and Haarlem was known

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[18] *Ibid.*: 25.

[19] Israel, J. (1995). *The Dutch Republic. Its Rise, Greatness and Fall 1477-1806.* Oxford: 85. Even today, we can speak of 'fluid Protestantism' in the Netherlands. The saying goes that if you meet ten Dutchmen, together they will represent at least eleven Protestant churches.

[20] *Ibid.*: 103.

as a popular parish. [21] Only with the battle between the Remonstrants and Contra Remonstrants over the doctrine of predestination, and the ensuing Synod of Dordt (1618-1619) was the Dutch Reformed church transformed into a bastion of reformed orthodoxy.

Yet, for some Counter Remonstrants the theological issues were not settled satisfactorily during the Synod and they pleaded for a further purification of religious life and society. In the movement of the *Nadere Reformatie* (Further Reformation) they advocated a shift from purely doctrinal concerns to *theologia practica*, a reformation of life style and morals. They fought in particular against 'adultery, prostitution, drunkenness (…) all frivolity, ribaldry, and ostentation, as well as (…) "amorous books," violation of the sabbath, and "superstitious festivals," including the widely popular St. Nicholas Day feast celebrated in December.' [22] In the 1630s and 1640s the message was taken up in many towns in Zeeland, Holland and in Utrecht. Church and state worked hard on moral and social reform which would, so they hoped, 'transform the conduct not only of the Reformed community, but of society as a whole.' [23]

The peace in Dutch theology did not last long. As we have seen, from the 1650s the ideas of the Leiden theologian Johannes Cocceius challenged the reformed orthodoxy of the Voetians. Cocceius advocated a liberal approach to theology, which was against the view of the Voetians who 'rejected liberal tendencies in theology, as well as Cartesianism in science and philosophy.' [24] The conflict centred largely around the issues of sabbath observance and the interpretation of the bible. According to the Voetians the Cocceians diluted the meaning of the Scriptures and in doing so they challenged faith through subordinating theology to Cartesian (natural) philosophy. Eventually the debate spilled over into the public sphere and according to Israel, 'the rift became fundamental not only in the church and academic spheres but in the body politic and the whole edifice of Dutch Golden Age culture.' Moreover, Israel states that, compared to the more bitter conflict between the Remonstrants and the Contra Remonstrants, the Cocceian-Voetian dispute pervaded the Dutch scene for much longer – down until the middle of the eighteenth century. [25]

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[21] Deursen, A. Th. van (1998 (1974)). *Bavianen en Slijkgeuzen. Kerk en Kerkvolk ten tijde van Maurits en Oldebarnevelt*. Franeker: 133.

[22] Israel (1995). *The Dutch Republic*: 475. On the distinction between Reformed Orthodoxy and Further Reformation see also: Spijker, W. van 't (1993). 'Orthodoxie en Nadere Reformatie.' In: T. Brienen, K. Exalto, C. Graafland, B. Loonstra, W. van 't Spijker, *Theologische Aspecten van de Nadere Reformatie* (pp.11-27). Zoetermeer.

[23] Israel (1995). *The Dutch Republic*: 477.

[24] *Ibid.*: 662.

[25] *Ibid.*: 664.

It was into this scene of theological dispute that Boerhaave was born, and which he must have overheard while growing up in the reformed parsonage of Voorhout. However, we do not know which side the Boerhaave family chose, if either. Thus we do not know the theological tendency of Boerhaave's father nor of his brother Jacob. Moreover, Boerhaave himself hardly wrote about his theological beliefs. This does not mean that he did not have any, but it is probable that he did not find it necessary to write about what was obviously known and generally accepted. We do know that Boerhaave despised doctrinal disputes. He pleaded for a return to the Scriptures, because only 'the teaching of Christ gives peace of mind,' thereby echoing Calvin who had earlier stated that tranquil peace cannot be found elsewhere but in the Gospel. [26] Boerhaave seems to side with the Orthodox Calvinists in the Republic at the time. However, before we can draw this conclusion we have to further examine the Calvinist belief at the time and compare it to Boerhaave's life and writings.

First it must be noted that there is a marked difference between Calvin and Calvinism. The church historian McGrath has argued that although Calvin arranged his *Institutes* systematically, he did not, as in later Calvinism, present a theological system in which all religious ideas are systematically derived on the basis of a leading speculative principle. [27] It was mainly under the influence of Theodorus Beza (1519-1605), colleague and successor of Calvin in Geneva, that Calvin's theology, which was based on the event of Jesus Christ and its implications for mankind, was transformed into an internally coherent and systematic theology based on Calvin's doctrine of predestination.

Calvin's doctrine of predestination is part of the doctrine of grace, and it holds that 'God, by His eternal and immutable counsel determines once for all those whom it was His pleasure one day to admit to salvation, and those whom, on the other hand, it was his pleasure to doom to destruction.' [28] Although the theme of election has dominated reformed theology from 1570, it was by no means central to Calvin's own thought. It only appears in the third book of the *Institutes* and it is part of the doctrine of redemption in Christ. For Calvin its main object is to show the sovereignty and graciousness of God. Therefore 'it is not the object of human speculation, but a mystery of

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[26] Boerhaave, H. *Commentariolus*: IX, XVIII; Calvin, J. (1982(1552)). *Concerning the Eternal Predestination of God*. (J.K.S. Reid Trans.). Cambridge : 113

[27] McGrath, Alister E. (1999). *Reformation Thought. An Introduction*. 3rd Ed. Oxford: 140. For the difference between Calvin and Beza see also: Muller, R.A. (1986). *Christ and the Decree: Christology and Predestination in Reformed Theology from Calvin to Perkins*. Durham.

[28] Calvin, J. (1997(1559)). *Institutes of the Christian Religion*. Michigan: III, xxi, 7.

divine revelation.' [29] Moreover, it relates to Christ, who is the mirror in which man may see the fact of his election. [30] McGrath has argued that for Calvin

> the primary function of the doctrine of predestination is to explain why some individuals respond to the gospel and others do not. It is an *ex post facto* explanation of the particularity of human responses to grace. Calvin's predestinarianism is to be regarded as *a posteriori* reflection upon the data of human experience, interpreted in the light of Scripture, rather than something which is deduced *a priori* on the basis of preconceived ideas concerning divine omnipotence. [31]

Thus the purpose of predestination for Calvin is twofold. First it is directed at the glory of God, for the salvation of the elect is the work of God only. Secondly, since man cannot do anything to influence his state, the doctrine of predestination demands a humble attitude towards God.
In the late sixteenth century Calvin's successors, confronted with the need to systematise theology, rigorously imposed Aristotelian logical structures upon the thought of Calvin and they made the doctrine of predestination central to their theology. [32] McGrath has distinguished four characteristics of the new theological approach:

> 1. Human reason was assigned a major role in the exploration and defence of Christian theology.
> 2. Christian theology was presented as a logically coherent and rationally defensible system, derived from syllogistic deductions based on known axioms. In other words, theology began from first principles, and proceeded to deduce its doctrines on their basis.
> 3. Theology was understood to be grounded in Aristotelian philosophy, particularly Aristotelian insights into the nature of method; later Reformed writers are better described as philosophical, rather than biblical, theologians.
> 4. Theology was seen as being concerned with metaphysical and speculative questions, especially as these relate to the nature of God, His will for humanity and creation, and above all the doctrine of predestination. [33]

Theodorus Beza was one of the most important theologians emphasising the doctrine of predestination. However, Beza's view on predestination differs from Calvin's. Beza transformed the doctrine of predestination through emphasising election instead of Christ. As a result a dogmatic and causal order of salvation replaced the centrality of justification by faith. Moreover, the

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[29] McGrath (1999). *Reformation Thought*: 138.
[30] Calvin (1997(1559)). *Institutes*: I, ii, 2; III, xxi, 1-2.
[31] McGrath (1999). *Reformation Thought*: 138.
[32] *Ibid.*: 135.
[33] *Ibid.*: 141.

certainty of one's election became of central importance in the life of the believer. Beza, like Calvin, believed that Christ is the mirror of election. However, he emphasised a different aspect. Of primary importance is not the act of believing itself, but the believer's conclusion that he believes. This means that the believer has to investigate himself through a faithful and introvert rationalisation of his religious experience. Thus Beza transformed Calvin's reference to Christ in order to get certainty about one's election into the inner experience of man himself.

The centrality of the doctrine of predestination in Calvinism is particularly visible when compared to the importance of the doctrine in Lutheranism. Where the followers of Calvin made the doctrine central to all theology, later Lutheranism marginalised Luther's insights into divine predestination. Luther had argued that God justifies sinners even though they are unworthy of such a privilege. However, 'for later sixteenth century Lutheranism, ''election'' meant a human decision to love God, not God's decision to elect certain individuals.' Thus where Calvinism emphasises 'a sovereign divine election of specific individuals,' Lutheranism 'preferred to work within the framework of a free human response to God.' [34] The most important difference between Lutheranism and Calvinism follows: for Lutherans justification by grace through faith is central to the doctrine, whereas Calvinists emphasise the sovereignty of God, predestination and the sanctification of life.

Even within Calvinism, Calvinist systematic thought based on the doctrine of predestination worked out differently according to the specific circumstances of a given community or country. For example, among English puritans, the emphasis on the doctrine of predestination caused a new interest in the 'covenant of grace' between God and his chosen people, which replaced the Old Testament covenant between God and Israel. The English saw themselves as the new Israel, a feeling which got a higher meaning in particular among Puritans as soon as their religious brothers entered the promised lands of America. The seventeenth century eschatological belief that the time of suffering for the new Israel was nearly over, affected all aspects of life. On the political level the fight against the Anti-Christ demanded for abolition of the Anglican church and caused civil war. The end of all efforts, the establishment of the New Jerusalem, would guarantee religious renewal, intellectual progress and the improvement of social life. Charles Webster in his *Great Instauration* (1975) has argued that the puritans, while referring to Daniel 12:4, had an unlimited belief in the possibilities of the human intellect. In order to establish heaven on earth, puritans saw it as their task to investigate and reveal

[34] *Ibid.*: 142-143.

the hidden nature of all natural things. Only then could the pure knowledge, which Adam had lost with his transgression, return, and only then could man restore his dominion over nature. [35] I shall come back to natural philosophy later. For now it is important to know that, although Puritans were sympathetic towards orthodox doctrine, they focused much more on pastoral theology. Most well known is the work of Richard Baxter, who envisioned every day Christian life in the *Reformed Pastor* (1656) and in his *Christian Directory* (1673). [36]

The question remains how a Dutch Calvinist led his life and how did he distinguish himself from, for example, his English brothers? The most striking difference is that in the Low Countries, orthodox Calvinist believers did not aspire to know the hidden nature of things. As we shall see their reverence for the omnipotent God, made them feel extremely little. Instead of trying to know as much as Adam before the Fall, they called for a humble mind. They recognised that they could see the wisdom of God in the smallest details of nature, but at the same time they were convinced they could not even try to understand the first principles of things. This would be the same as trying to understand God's mind, and nothing could be more arrogant. Moreover, the puritan restoration of the dominion of man over nature does not occur in Dutch Calvinist thought. After all this would rob God of his power, which would be unforgivable. The theme of humility often occurs in the writings of Boerhaave and of many of his orthodox contemporaries. I shall discuss this in more detail at a later stage.

The Dutch Calvinist emphasis on the omnipotence of God also called for a sanctification of life and work. This sanctification was grounded in the doctrine of predestination. The *Dordtse Leerregels*, prescribing the rules of orthodoxy after the synod of Dordt, link the Christian life style to a moment of conversion in the life of the believer. All his life the believer searches for a confirmation of his elected state. This confirmation is to be found in experiencing the living faith of Christ. The *Dordtse Leerregels* state that man has to strive for such an experience all his life. Moreover, the believer should not give up, for he can rely on the biblical promise that 'a bruised reed shall He not break and the smoking flax shall He not quench.' [37] Even if he does not

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[35] See: Webster, C. (1975). *The Great Instauration. Science, Medicine and Reform 1626-1660*. London. See also Merton, R. (1987). *Science, Technology and Society in Seventeenth Century England.* New York. Daniel 12:4 reads: 'But thou, O Daniel, shut up the words, and seal the book, even to the time of the end: many shall run to and fro, and knowledge shall be increased.'

[36] McGrath, A.E. (1994 (2000)). *Christian Theology. An Introduction.* 2nd Ed. Oxford: 79.

[37] *Dordtse Leerregels. Zijne de Vijf Artikelen tegen de Remonstranten*: 1, 16. The text is taken from Isaiah 42:3. Until these days strict Calvinists in the Netherlands are called '*gekrookte rieters*' (bruised reeds), after the text in Isaiah.

experience anything yet, he should not fear nor count himself among the damned, but he should continue longing for the grace of God and expecting the same with respect and humility. So the believer has nothing to fear as long as he has the earnest desire to be converted to God and as long as his actions are directed at the glorification of God. However, those who deliver themselves to the temptations of the world are lost as long as they do not desire to be converted. This means that the believer, whether he is converted or not, out of thankfulness towards God, who can save him from his damned state, is obliged to live an impeccable life. [38] So, a Calvinist life style does not so much, as Max Weber has argued, originate in the belief that the fruits of labour would prove one's election, but much more in thankfulness towards the Creator. [39]

The rules for a Calvinist life are prescribed in the *Dordtse Leerregels*. First and foremost man should humble himself before his God and continuously worship Him in prayer. Secondly he should keep the commandments and he should not give in to carnal desires. [40] Even the converted Calvinist is still under the temptation of sin. Therefore he should watch his every step and continuously pray for forgiveness and perseverance. [41] Thus, the rationalised Calvinist life involves a constant comparing of life and doctrine, whereby the Calvinist considers his system of belief intrinsically interwoven with the content of the Bible. This means that, for a Calvinist, the doctrine becomes the practical application of Biblical commandments and thus a life style according to the doctrine is considered a biblical life.

A second important aspect of the Calvinist life style, which follows the former, is that the life of the believer should be under the constant observation of man's own conscience. A good example of this are the traditional church formulas read during the communion service. Most striking is that the Calvinist is strongly advised to search his conscience and to ask earnestly whether he is prepared to show thankfulness towards God and to live according to God's commandments. The seriousness of the advice is obvious since the formula states directly afterwards that people contaminated with sin, who cannot turn away from their bad ways, should not come to the Lord's table, in order not to increase the severity of their judgement.

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[38] *Dordtse Leerregels*: I, 15.
[39] Weber, M. (1971 (1904-5)) *The Protestant Ethic and the Spirit of Capitalism*. London.
[40] *Dordtse Leerregels*: I, 13.
[41] *Ibid.*: V, 4.

In addition to man's own conscience, the life of every Calvinist is also subjected to the scrutiny of the *Kerkenraad*, or the ecclesiastical police.[42] They were responsible for the moral standard of the church and in the case of communion, they would make sure that every person going to the table would be carefully questioned on his life and manners in a *censura morum*.[43] The *Kerkenraad* was not only important in relation to communion service, which happened only four to six times a year. They also had to keep an eye on the life of church members and they had to judge whether new members were morally fit to enter the church. Usually they questioned people on the catechism and sometimes they even asked for references from neighbours. It also happened regularly that prospective members were put on probation.[44] So, not only his own conscience but also the church would control the life of the Calvinist. Yet, it must be said that Dutch Calvinists followed Calvin in stating that man can enjoy the gifts of God. They argued that he who, like the Puritans, believed that he could use worldly goods only if absolutely necessary, moves onto a slippery slope, for then he regards his own conscience more highly than the Word. In 1621 an English minister even had to defend himself against the accusation of being a puritan before the *classis* of Dordrecht.[45] Still, sanctification of life, which involved a rigid life style, is as much part of Calvinism as the doctrine of predestination. In summary, the most important characteristics of a Calvinist life are the centrality of church doctrine and discipline, a rigid and sober lifestyle, introspection and continuous prayer and reading of the Scriptures.

Boerhaave's way of life is a good example of the Calvinist lifestyle. Evidence is scarce, but we can assume that Boerhaave was an active churchgoer. Boerhaave's name cannot be found in the church archives of the *Pieterskerk*, where Boerhaave most likely attended the Sunday services. However, these archives only go back to 1700 and it is likely that Boerhaave's name was inscribed before that time. In any case, Boerhaave's children were baptised in the Pieterskerk and although parents did not necessarily have to be church members, they were still asked to subscribe to the doctrine of the church. Boerhaave's father in law, Abraham Drollenvaux, his brother Jacob, who was at the time pastor in Leiden and his sister Margaretha witnessed the bap-

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[42] *Belijdenis des Geloofs der Gereformeerde Kerken in Nederland overgezien in de Synode Nationaal laatst gehouden te Dordtrecht en uit last derzelve uitgegeven om voortaan in de Nederlandse Kerken alleen voor authentiek gehouden te worden*: Article 30: 'Wij geloven, dat deze ware Kerk geregeerd moet worden naar de geestelijke politie, die ons onze Heere heeft geleerd in Zijn Woord.'

[43] Van Deursen (1998): *Bavianen en Slijkgeuzen*: 196-200.

[44] *Ibid.*: 195-196.

[45] *Ibid.*: 193.

tisms. [46] The presence of Jacob in particular makes it unlikely that Boerhaave was not a member of the church. Moreover, Schultens, in the Funeral Oration, said that Boerhaave, following the wish of his father, had not only zealously devoted himself to God but also to the church. [47]

Although Boerhaave was never very explicit about his religious views, we can assume that he subscribed to the generally accepted doctrines. In a Calvinist society, like the Republic at the time, where the Reformed Church had such an enormous controlling power over the people, it would have been far more remarkable if Boerhaave's views would have been out of the ordinary. In that case we would have certainly found references to Boerhaave's so called heretical views in the testimonies of his friends. On the contrary, time after time, we find Boerhaave's friends praising his religious devotion. More importantly, Boerhaave's *Commentariolus* can be read as testimony of faith. Boerhaave presumably wrote these notes at the end of his life, and they can be read a defence or justification of his way of life.

The first striking feature of Boerhaave's *Commentariolus* is that Boerhaave was aware of God's omnipotence and the insignificance of man. Man is, he believed, no more than a soap-bubble in the sight of God, a speck of dust in the hand of Jehova. [48] Boerhaave also believed that because of sin he could not be righteous before God. Of accused persons, who were sentenced to death, he said 'who will say whether they are not better than I?' He believed that if he were any better this 'must not be attributed to my [Boerhaave's] responsibilities, but to God who bestows so abundantly.' [49] Boerhaave knew himself dependent upon the will of God and therefore in all he did he sought to do the will of his Maker. He wrote:

> The God, who is, he [Boerhaave] worshipped piously. He wished to understand about God only that which God understands about Himself. Satisfied by that, he did not search further, lest he should stray into idolatries. Thus he rested in the will of God in such a way that no account at all of Him was to be sought. He asserted that this alone is the highest of all laws, and that it should be respected completely and deliberately embraced. [50]

Boerhaave did not spell out his way of life, but since he praised the virtues of his parents, we can see what he valued most in a Christian life. He calls his father 'a straightforward, honest, and simple man: an excellent head of the

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[46] Baptismal registrars of the Dutch Reformed Church in Leiden. Gemeente Archief Leiden.
[47] Schultens, A. (1737). *Academische Redevoering van Albers Schultens ter gedachtenisse van den grooten Herman Boerhaave (…) uitgesproken 14 November*, 1738. Trans. J.J. Schultens. Leiden: 28-29.
[48] Boerhaave to Bassand, 23 July 1733, *correspondence 2*: 322-323
[49] *Commentariolus*: XX.
[50] *Ibid.*: XVIII

family, by virtue of his love, care, industriousness, frugality and his practical wisdom.' He admired his mother because of her 'saintly wisdom' and he praised the 'loveable disposition of his stepmother,' who equally divided her love and attention between all the children. [51] It can be said that it is the Calvinist integrity and self-denial of his parents that Boerhaave admired most. It is not surprising we find the same characteristics in Boerhaave's own life. His friends and pupils praised him for his mildness, industry, patience, honesty and faith. [52] Lindeboom has argued that, although Boerhaave was wealthy 'the famous professor lived very plainly; he detested all unnecessary luxury.' [53] Indeed, it can be said that although Boerhaave's many requests to the Curators of the university for an increase of salary do show a certain desire for money, yet he spent and invested his wealth carefully. [54] However, even though Boerhaave detested unnecessary luxury, he never denied himself the pleasure of certain worldly goods. He particularly liked musical evenings, playing the lute and going outdoors on foot or on horseback. [55]

Introspection, the third important characteristic of Calvinism, was also part of Boerhaave's life. Like all Calvinists of his time, he searched for the signs of election (the true faith in Christ, a child-like fear of God, sadness because of sin, and longing for justice) in his life. [56] The need for searching his life and conscience made Boerhaave feel uncomfortable when realising that he was so busy that he did not have time to meditate on death and consequently on his state before God. He wrote in a letter to Bassand:

> The one misfortune I daily regret is that I am so well known and honoured everywhere (...) but that I shall die all too unknown to myself, unless God hears my prayers and gives me the so desired and necessary time to meditate on death. [57]

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[51] *Ibid.*: 1 and 11.

[52] Scultens, A. (1737). *Academische Redevoering van Albers Schultens ter gedachtenisse van den grooten Herman Boerhaave (…) uitgesproken 14 November*, 1738. Trans. J. J. Schultens. Leiden: 2. See also: Burton, W. (1743). *An Account of the Life and Writings of Herman Boerhaave*. London.

[53] Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and His Work*. Leiden: 254.

[54] See the numerous references in Molhuysen, P.C. (1920 (1682-1725); 1921 (1725-1765)). *Bronnen tot de Geschiedenis van de Leidsche Universiteit*. (Vol. iv, v). 'sGravenhage.

[55] Burton (1743). *An Account*: 62-63.

[56] Se for the signs of election: *Dordtse Leerregels*: 1, 13.

[57] Boerhaave to Bassand, 23 July 1733, *Correspondence 2*: 322-323.

It turned out well, for Schultens, in the Funeral Oration, assured his listeners that Boerhaave had experienced the living faith during his last illness. Three weeks before he died, Boerhaave told his friend that in severe pain, he had experienced the Christian faith, hope and charity in such a way that 'he could kiss God's fatherly hand and subject himself to God's almighty will.' [58] Although the style of the Funeral Oration is very lofty, we cannot deny the sincerity of Schulten's words. The Reformed Church was not a liberal, multiform church, but a church where everyone's life was under careful scrutiny. In other words, everyone knew almost everything about the ways of others. Therefore, what Schultens said about Boerhaave's life had to be in agreement with what his listeners knew to be true. Moreover, the question on every Calvinist mind was the state of the deceased in the sight of God, and Schultens used his intimate conversation with Boerhaave in order to reassure his audience of Boerhaave's faith.

Finally, prayer, bible reading and meditation were of supreme importance in Boerhaave's life. Every morning he got up early, at four o'clock in summer and at five in winter, in order to spend an hour in prayer and meditation. [59] This was not unusual at the time, for the students of the States College were also awakened at five in summer, and six in winter for an hour of devotion. [60] According to Schultens, for Boerhaave, the prayers of this hour were the source of his Christian virtues. [61] The reading of the Bible was so important for Boerhaave's life, that, in the relatively short *Commentariolus* he mentioned it no less than four times. Boerhaave even reveals himself as a follower of Calvin in identifying the Scriptures with the doctrine of his faith. In Boerhaave's view, all doctrinal debate averts from the right doctrine and is no longer directed at the sincere love of God and man, but at the clever intellect of the interpreter himself. In short, Boerhaave is a good example of a Calvinist who showed that the Calvinist doctrine is 'not an affair of the tongue, but of the life.' [62]

After having seen that the Calvinist themes (the centrality of church doctrine and discipline, a rigid and sober lifestyle, introspection and continuous

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[58] ' … in de zwaarste toevallen van wringende smerten (…) niet bezwijkende, ja zelfs door inwendig gevoel van Geloove, Hoope, en Liefde, die onbezwekene gronden onzer Godsdienst zo verhelderd, dat hij Gods vaderlijke hand altoos had kunnen kussen, en zich eene stille gerustheid zijnen Allermagstigsten en teffens Allerbesten wille onderwerpen.' Schultens, A. (1737). *Academische Redevoering van Albers Schultens ter gedachtenisse van den grooten Herman Boerhaave (…) uitgesproken 14 November*, 1738. Trans. J.J. Schultens. Leiden: 84.

[59] Lindeboom (1968). *Herman Boerhaave*: 262

[60] Israel (1995). *The Dutch Republic*: 679.

[61] Schultens (1738). *Funeral Oration.*: 81-82.

[62] Calvijn. (1997(1559)). *Institutes*: III, vi, 4.

prayer and reading of the Scriptures) are central elements in Boerhaave's life, we can safely conclude that he was a Calvinist. In Boerhaave's time Johannes van Marck (1655-1731), Voetian professor of theology at Leiden University, as well as the mainly Cocceian Leiden *kerkenraad* were keen to temper the debates between Voetians and Cocceians. Yet, Boerhaave rejected the application of Cartesian doubt in theology, which means that he must have disliked Cocceianism too. [63] So we can conclude not only that Boerhaave was a Calvinist, but also that he tended towards the orthodox side of Calvinism.

Before explaining how Boerhaave's natural philosophy was grounded in his Calvinism, I shall first examine the Calvinist idea of nature. I shall mainly use Calvin's own works, for, as we have seen, while the theological debates in Dutch Academia centred mainly around the doctrine of predestination, the explanation of the Scriptures and the introduction of Cartesian doubt into theology, they did not so much affect the original Calvinist doctrine of creation. If anything, the later Calvinist stress on the doctrine of predestination reinforced Calvin's ideas on creation, providence, humility and responsibility.

The Bible of Nature

Calvinism, like all theology, starts with an image of God. Calvin's God, as we have seen, is an almighty God, the Creator and Sustainer of heaven and earth. He does not sit idly in heaven, watching over what is taking place in the world, but he holds the helm and rules over all events. [64] Man, on the other hand, is part of the creation and his knowledge and power are limited by his Creator. Since man's existence is entirely dependent upon God, he is obliged to spend his days in thankful contemplation of the works of His Creator.

The contrast between God's omnipotence and man's insignificance is a recurring theme in Calvinist theology and is summarised in the opening sentence of the last edition of Calvin's *Institutes of the Christian Religion* (1559) where Calvin states that wisdom consists almost entirely in knowledge of God and of ourselves. [65] Calvin argued against the Deists, who studied nature without considering her Maker and against theologians studying God without looking at His works. He states that the world should 'become our school if we rightly desire to know God.' [66] Man cannot know himself without turning his

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[63] Boerhaave, H. (1687). *Disputatio pneumatica de mente humana prima*. Leiden: Corollaria 1.
[64] Calvin, J. (1997 (1559)). *Institutes of the Christian Religion* (Beveridge, Henry, Trans.). Michigan: 1, xvi, 4. See also: Parker, T.H.L. (1969). *Calvin's Doctrine of the Knowledge of God*. Edinburgh.
[65] Calvin. (1997 (1559)). *Institutes*: 1, i, 1.
[66] Calvin, J. (1847). *Commentaries on the First Book of Moses called Genesis* (King, John, Trans.). Edinburgh: 60.

thoughts towards God 'in whom he lives and moves.' So all knowledge should start with knowledge of God the Creator. This will result in confidence in God and serious fear of God, coupled with the believer's acknowledgement of God as just judge, merciful father and master over all things. For this reason, studying the works of God the Creator is the beginning of Calvinist theology. In this sense Boerhaave, while studying chemistry and medicine, was continuing his studies in divinity. We should not of course forget that knowledge of God the Redeemer was necessary for salvation, but for the moment I shall mainly address the question of what the creation could teach a true Calvinist about its Maker. [67]

God first and foremost shows Himself in the creation. The expanded heavens, Calvin argued, are like God's royal tent, for God,

'layeth the beams of his chambers in the waters, maketh the clouds his chariot, and walketh upon the wings of the wind,' sending forth the winds and lightning as his swift messengers. And because the glory of His power and wisdom is more refulgent in the firmament, it is frequently designated as His palace. [68]

For this reason the visible world is an image of the invisible, the elegant structure of the world serving as a kind of mirror, in which man can behold God. [69] Even man himself is a structure in which innumerable operations of God are carried out. Therefore, man, in contemplating his own nature, should remember that there is 'one God who governs all natures, and, in governing wishes us to have respect to Himself, to make Him the object of our faith, worship and adoration.' Nothing is more arrogant than enjoying the divine gifts and at the same time neglecting the donor. [70]

It follows that the first and most important sin of man, through which he fell out of God's grace was his unthankfulness towards his Creator. In striving

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[67] For secondary works on Calvinism, creation and natural philosophy see: McLelland, J. (1965). 'Calvin and Philosophy.' *Canadian Journal of Theology, 6* (1), 42-53; Stauffer, R. (1978). *Dieu, la Création et la Providence dans le Prédication de Calvin*. Bern/Frankfurt am Main/Las Vegas; Kaiser, C.B. (1988). 'Calvin's Understanding of Aristotelian Natural Philosophy: Its Extent and Possible Origins.' In R.V. Schnucker (Ed.), *Calviniana. Ideas and Influence of John Calvin* (pp. 77-92); Schreiner, S.E. (1991). *The Theatre of His Glory: Nature and the Natural Order in the Thought of John Calvin*. Michigan.

[68] Calvin. (1997 (1559)). *Institutes*: 1, v, 1. Calvin quoted from Psalm 104. Calvin does not explain why he compared the creation to God's tent, but it is likely he was referring to the tabernacle, God's royal tent at the time when the Israelites were moving from Egypt to Israel. God's presence is represented as a pillar of cloud during the day and a pillar of fire during the night (Exodus 13:21-22). After finishing the tabernacle God moved into the temple and the cloud and the fire filled the temple with God's glory (Exodus 40:34-38). After Salomo built the temple the cloud similarly filled the temple with the glory of the Lord (1 Kings 8:10-11).

[69] *Ibid.,* 1, v, 1. Calvin is referring to Hebrews 11:3 and Romans 1:20.

[70] *Ibid.,* 1, v, 6.

to know as much as God, man robbed God of His omnipotence and honour. Therefore, as Calvin claims, man's ingratitude is the beginning of all sin and the reason for the Fall. In the commentary on Paul's epistle to the Romans Calvin states that

> in so excellent a workemanship, they [mankind] did not acknowledge the workemaster: yea when they were constrained to acknowledge Him, they did not worthily honour his majestie, but prophaned & violated the same with their vanitie. So all men are proved guiltie of impietie (...) [and] are fallen from the Lorde (...) [but] we are justified by faith. [71]

This brings us to providence, the second class of God's works in which He shows Himself. After the creation, God did not leave the world to its own devices, but He is constantly involved in running its affairs. Arguing against the deists and against those who believe that everything happens by chance, Calvin states that God is continually creating and governing the world. He states that:

> there is no random power, or agency, or motion in the creatures, who are so governed by the secret counsil of God, that nothing happens but what He has knowingly and willingly decreed. [72]

So, God's providence does not only involve foreknowledge of all events, but more importantly consists in action. Not only does God maintain and preserve the order of nature, but he 'holds and continues a peculiar care of every single creature that He has created.' [73] It is wrong to state that God only gave 'an impulse and general movement to the machine of the globe' without 'specifically directing the action of every creature.' For in that way man creates a partnership with God in which God impresses his energy on man so that he can voluntary regulate his own actions. [74] Those who are of this opinion harm God's omnipotence and deny that He rules the world by decree.

On numerous occasions Calvin states that God governs the universe by His 'Divine energy' and that 'all the parts of the world are invigorated by the secret inspiration of God.' [75] This does not mean that God introduced a

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[71] Calvin, J. (1583). *A Commentary upon the Epistle of Saint Paul to the Romans* (Rosdell, Christopher, Trans.). London: The argument.

[72] Calvin. (1997 (1559)). *Institutes*: 1, xvi, 3. For Calvin and providence see also: Davies, H. (1992). *The Vigilant God. Providence in the Thought of Augustine, Aquinas, Calvin and Barth*. New York.

[73] Calvin, J. (1856 (1558)). 'A Defence of the Secret Providence of God.' In H. Cole (Ed.), *Calvin's Calvinism*. London: 4.

[74] Calvin. (1997 (1559)). *Institutes*: 1, xvi, 4.

[75] *Ibid.,* 1, ix, 4; 1, xvi, 1. 'Divine energy' is translated from the French 'la vertue de Dieu' and 'la vigueur,' secret inspiration comes from 'inspiration secrete de Dieu.'

general principle of confused motion and then left the creatures to themselves, but it means that He regulates all individual and specific motions of animate and inanimate objects. In this way every creature is turned into an instrument in which God constantly 'infuses what energy he sees mete, and turns and converts to any purpose at his pleasure.' [76] So the directing hand of God ensures that 'the elements and their separate particles should not cease to perform their appointed functions; in a word, that the fecundity of nature should never be worn out nor fail.' [77]

Calvin mentions the sun as an example of how all things are steered through God's providence.

> For, besides illuminating the whole world with its brightness, how admirably does it foster and invigoreate all animals by its heat, and fertilise the earth by its rays, warming the seeds of grain in its lap, and thereby calling forth the verdant blade! [78]

Not only the working of the sun, but also the moment of its creation provides us with a good example of how God is in charge of all things. At first sight it seems strange that God created light and darkness before he created the sun and the moon and that he created grass, herbs and fruit trees before he created lights in the firmament of heaven. However, Calvin argues that God in the order of creation shows that He does not depend on secondary causes, but that He is entirely free to act as He pleases. Calvin states that God permits man 'to perceive the efficacy which He infuses into them [the sun and the moon].' but because man tends to forget that the natural properties of matter derive their power from a divine cause, it was necessary that 'the vigour which the sun and the moon now seem to impart to the earth should be manifest before they were created.' [79]

The matter of secondary causality was taken up in later years by Voetius, the most important interpreter of strict Calvinism in the Low Countries. According to Van Ruler Voetius opposed the mechanical philosophy of Descartes, who had argued that 'God's act of keeping the world as it is, is identical to the act by which he created it.' Descartes believed 'nature is guided by a divine concurrence, "to operate as it normally does,"' an opinion which, according to Voetius did not leave much space for divine intervention and

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[76] *Ibid.,* I, xvi, 2.
[77] Calvin. (1856 (1558)). *A Defence*: 4.
[78] Calvin. (1997 (1559)). *Institutes*: I, xvi, 2.
[79] Calvin. (1847). *Commentaries on Genesis*: 82. For secondary causality see also: Bouwsma, W.J. (1988). *John Calvin: A Sixteenth Century Portrait*. Oxford/New York and Schreiner. (1991). 'The Theatre of His Glory.'

therefore restricted God's free will. [80] He argued that God or 'the prime cause "concurs" with the secondary cause by a direct "physical predetermination" of the secondary causes.' Thus if you boil a pot of water, God first has to activate the fire for it to warm the pot. This theory was challenged by theologians who denied predetermination. They argued that God instead of working through secondary causes, acts simultaneously with a secondary cause. [81] This means that God would work in co-operation with secondary causes, an option which was unacceptable for orthodox Calvinists. They reduced the importance of secondary causes and they believed that as Van Ruler says:

> God also directs (*influit in*) the secondary causes themselves and not only their effects. With regard to medicine, this would mean that God activates the natural powers of medicaments every time they are applied by man in order for them to produce the desired effect; whereas, according to the non-premonition account, the result only depends on God's willingness to guarantee the coming-into-being of the effect; the effect itself, however, being produced by the natural power working of its own accord. [82]

In chapter three and four we shall see that Boerhaave expressed the orthodox Calvinist point of view that God works through secondary causes and actively uses them as His instruments to rule the world. [83] Moreover, we shall see that the basis of Boerhaave's particle theory was essentially Calvinistic.

Returning to Calvin, we can see that the examination of God's creation and maintenance of the world had direct relevance for man's spiritual state of mind as he cannot do otherwise but admit that he depends upon God as his sole benefactor. Only when man realises that God holds and governs him in such a way that he cannot move even one of his fingers without accomplishing the work of God, can he 'adopt any counsel consistent, or in harmony, with His counsel, or in accordance to His will.' [84] Thus Calvin describes the obligation of man towards God as follows:

> For how can the idea of God enter your mind without instantly giving rise to the

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[80] Ruler, J.A. v. (1995). *The Crisis of Causality. Voetius and Descartes on God, Nature and Change.* Leiden: 272-273.

[81] Ruler, J.A. v. (1991). 'New Philosophy to Old Standards. Voetius' Vindication of Divine Concurrence and Secondary Causality.' *Nederlands Archief voor de Kerkgeschiedenis, 71*, 58-91: 64. See also: Ruler, J.A. van (1995). *The Crisis of Causality. Voetius and Descartes on God, Nature and Change.* Leiden.

[82] *Ibid.,* 65-66.

[83] Schreiner also explains that Calvin maintained that 'nature is an instrument to which God directly imparts effectiviness.' Schreiner. (1991). *The Theatre of His Glory* : 31.

[84] Calvin. (1856 (1558)). *A Defence*: 18-19.

thought, that since you are his workmanship, you are bound, by the very law of creation, to submit to his authority? [85]

Moreover, Calvin states that 'The reason why the thinge formed, ought not to strive with his former [is] because the Maker doth nothing but by his right or authority.' [86] Thus, the creation being the revelation of God's will is set before the eyes of man, so he can learn about and align himself to God's will.

Not only does the Calvinist image of God oblige man to study the works of his Creator, it also determines the way man should look at the creation. Man is not entirely free to investigate nature as he likes, but he is bound to a set of rules. In the first place, man has to adopt a humble mind when studying the creation. It would be unforgivably arrogant to presume that man can penetrate into the very essence of natural bodies. Instead, he should always bear in mind that he can never know God to the fullest, since that would mean that he can bind God's free will to the bounds of his reasoning. In other words, in thinking man can know everything, he lifts himself up to the transcendental height of the divine, thereby denying God's omnipotence. Calvin compared the creation to the clothing of the Creator. The fabric can be seen, but the body remains hidden under layers of cloth. Calvin states:

If men attempt to reach the infinite height to which God is exalted (...) they must fail in the midst of their course. Those who seek to see Him in His naked majesty are certainly very foolish. That we may enjoy the sight of Him, we must come forth who view Him in His clothing; that is to say, we must cast our eyes upon the very beautiful fabric of the world in which He wishes to be seen by us, and not to be too curious and rash into searching His secret essence. [87]

So, instead of minutely discussing the essence of God, man should contemplate and adore Him in His works. Calvin states:

We see, indeed, the world with our eyes, we tread the earth with our feet, we touch innumerable kinds of God's works with our hands, we inhale a sweet and pleasant fragrance from herbs and flowers, we enjoy boundless benefits; but in those very things of which we attain some knowledge, there dwells such an immensity of divine power, goodness and wisdom, as absorbs our senses. Therefore let men be satisfied if they obtain only a moderate taste of them, suited to their capacity. [88]

The theme of humility returns in the debate between the Voetians and

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[85] Calvin. (1997 (1559)). *Institutes*: I, ii, 1.
[86] Calvin, J. (1583). *A Commentary upon the Epistle of Saint Paul to the Romans* (Rosdell, Christopher, Trans.). London: commentary on Rom. 9:21, p.127.
[87] Calvin, J. (1847). *Commentary on the Book of Psalms* (Anderson, James, Trans.). Edinburgh: IV.
[88] *Ibid.,* I, 57.

Cartesians. Voetius argued against the Cartesian claim of the possibility of achieving perfect knowledge via the method of universal doubt. He introduced the term 'learned ignorance' (*docta ignorantia*) in order to avoid restricting God's action to human understanding. [89] Voetius promoted natural philosophy as one of the means to achieve 'learned ignorance.' for it would enlarge 'the awareness of our ignorance and the insight that some things are unknown or cannot be known' which means that 'the more we learn, the better we become aware of our ignorance.' [90]

Secondly, man cannot see the invisible Godhead unless he is 'enlightened through faith by internal revelation from God.' [91] Even though 'creation exhibits so many bright lamps lighted up to show the glory of its Author,' they are insufficient in themselves to lead man onto the right path. Sin causes spiritual blindness so that man himself cannot perceive God's wisdom, righteousness and goodness in His creation. It is man's sinful self more than the temptations of the world that leads him away from God and which also makes man responsible for his own deeds. It follows that not nature, but the human self sets limits to the knowledge of the creation. Therefore, as a modern commentator has argued, 'the difficulty is not with what is shown to fallen human reason through the natural order; the difficulty is with human misperception because of sin.' [92] However, faith can cure human blindness and enable man to view creation as a reliable way to coming to knowledge of God.

This brings us to the third rule that leads man to knowledge about God. Since God represents Himself in His Word in the same manner as in His creation, the Scriptures are indispensable in order to understand and recognise the works of God's providence. [93] Every part of the Scriptures speaks about God's paternal kindness towards his believers. Moreover, Calvin states that the knowledge of God set out in the Scriptures serves the same purpose as that which is visible in the creation, namely, 'that we may thereby learn to worship Him with perfect integrity of heart and unfeigned obedience, and also to depend entirely on His goodness.' [94]

Thus a humble mind, faith and reading of the Scriptures are the three conditions for a just understanding of God's creation. Bearing these rules in mind, man is fit to investigate the 'energy' through which God sustains His

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[89] Verbeek, T. (1993). 'From 'Learned Ignorance' to Scepticism. Descartes and Calvinist Orthodoxy.' In R. Popkin, H. & A. Vanderjagt (Eds.), *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries* (pp. 31-45). Leiden, New York, Köln.

[90] Voetius in *Ibid.,* 39.

[91] Calvin. (1997 (1559)). *Institutes*: 1, v, 14.

[92] Steinmetz, D.C. (1995). *Calvin in Context*. New York/Oxford: 29.

[93] Calvin. (1997 (1559)). *Institutes*: 1, x, 1.

[94] *Ibid.,* 1, x, 2.

creation. Moreover, as man is obliged to serve his God, he cannot do otherwise than to study the creation because it will teach him God's will and it will lead him continually higher towards his Creator.[95] For this reason Calvin looks with some envy upon astronomers, physicians and natural philosophers who are 'enabled to obtain a deeper insight into the secret working of divine wisdom.'[96] We shall see later in chapter three that Boerhaave's chemistry fits exactly with his Calvinism. In particular his concept of fire shows remarkable similarities with Calvin's divine energy.

From an early age Boerhaave was familiar with the idea that God reveals Himself in the creation as well as in the Scriptures, so when he changed from the study of theology to the study of natural philosophy, he changed his method of study rather than the topic under investigation. Whether Boerhaave studied how God reveals Himself in His Word or how he shows Himself in the creation, the ultimate Calvinistic end of study remained the knowledge of God and of man himself.

Boerhaave's Calvinist natural philosophy is nowhere more evident than in his last academic work, the editing and publication of the works of the Calvinist natural philosopher Jan Swammerdam (1638-1680), under the title '*Bijbel der Natuure*' or the *Bible of Nature*. Swammerdam is well known for his work on the smallest animals in nature. He not only dissected and engraved them, but he also preserved them in a cabinet of natural history. Most notably he discovered the method of preserving which was later adopted by Frederik Ruysch, whose anatomical preparations still exist today. Swammerdam died relatively young and left all his manuscripts and drawings to his friend Melchizedec Thévenot, who was supposed to publish them. However, before Thévenot could complete the task, he died himself. The drawings, which had already been engraved, drifted about in France for a while before Boerhaave traced them. He spared no time and money to purchase them for publication. The usually economical Boerhaave even spent 1500 écu's to buy the engravings from the French anatomist Du Verney, who, because engravings can be easily plagiarised, bought them cheaply for 50 écu's.[97] Boerhaave also managed to trace the manuscripts and he also got hold of a collection of letters Swammerdam had written to Thévenot.

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[95] Calvin, J. (1993 (1574)). *Sermons on Job*. Edinburgh: 414. b. 40.
[96] Calvin. (1997 (1559)). *Institutes*: 1, v, 2. The French original (*Institution* (1566)) reads: 'Je confesse bien que ceux qui sont entendus & experts en science, ou les ont aucunement goustees, sont aidez par ce moyen, & auancez pour comprendre de plus pres les secrets de Dieu.'
[97] Boerhaave to Bassand, 9 September 1735 in *Correspondence 2*: 340-343.

We can ask the question why Boerhaave was so keen to publish Swammerdam's work? Boerhaave surely must have been impressed by the minuteness and precision of the drawings, but I shall argue that there was more to it than just that. For Boerhaave, Swammerdam's work represented a Calvinist guide for reading the works of the creation. Just as the Scriptures tell man about God and His plan with mankind, the *Bible of Nature* tells about the Creator and His will for the world. In editing Swammerdam's writings Boerhaave sometimes decided to leave out Swammerdam's religious reflections. This means that Boerhaave's edition of Swammerdam's work tell us indirectly about Boerhaave's religious beliefs.

Boerhaave decision to publish Swammerdam's work under the title *Bible of Nature*, was inspired by a letter Swammerdam wrote to Thévenot. He wrote:

> See, so astonishing is God, concerning these small animals, that I dare say that in the insects lie sealed God's innumerable wonders, which seals open, while leafing through the book of nature, the Bible of natural divinity, in which God's invisibility becomes visible. [98]

Swammerdam also mentioned the 'Bible of Nature' concerning his friend Steno, who converted to the Roman Catholic religion. He wrote to Thévenot: 'I wish he [Steno] were still like he was when he sought God in the Bible of Nature; then he would not be so opiniated in his religion and he would love all men.' [99]

Swammerdam very often wrote about the divine wisdom visible in the complex structure of small insects. [100] For instance when speaking about the visibility of God's finger in the anatomy of lice, he stated that the intestines of the small animals reflect the structure of the universe. No-one, but God Himself, can comprehend it all. Hence the natural philosopher can only examine nature through God's grace. Swammerdam wrote that 'God who has painted Himself in nature, is almighty to do what His divine wisdom likes to show the creatures endowed with intellect who move and live in Him.' [101]

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[98] Swammerdam, J. (1737). *Bijbel der Natuure. Met een Voorreden, waarin het Leven van den Auteur Beschreven is door Herman Boerhaave*: 1, 394. Note the adoption of the expression 'making God's invisibility visible' of Rom. 1:20 and article 11 of the *Dutch Creed*.

[99] Swammerdam to Thévenot, January 1678. Translated from the Dutch by Lindeboom in Lindeboom, G.A. (Ed.). (1975). *The Letters of Jan Swammerdam to Melchisedec Thévenot.* Amsterdam: letter 14.

[100] For a discussion on Dutch Calvinism and the emphasis on studying the smallest creatures see also: Ruestow, E.G. (1996). *The Microscope in the Dutch Republic. The Shaping of Discovery.* Cambridge: 56-60.

[101] Swammerdam to Thévenot, Autumn 1678. in: Lindeboom. (1975). *Letters of Swammerdam*: letter 27.

So, nature reveals God's wisdom and providence to the natural philosopher. The ultimate aim of the work was to show that the world is created and steered by an intelligent Being and that man cannot do otherwise but admire, love and fear the Almighty wisdom of the Creator. Swammerdam referred to the biblical story in Exodus of the third plague affecting the people of Egypt in order to make clear that even the magicians at Pharaoh's court had to admit that it was the finger of God that caused the dust of the land to transform into lice. [102] Swammerdam accompanied almost all his explanations of insects with a reflection on God's wisdom and the way man can climb up to a better understanding of the divine Architect through examining the 'Bible of Nature.'

Swammerdam's religious thoughts become more numerous and mystical in nature towards the end of the book (and also Swammerdam's life). At some point, Boerhaave even decided to leave out Swammerdam's religious reflections in the nature of the mayfly. He states that as far as he is concerned they are irrelevant and he refers anyone who feels up to reading it to the original booklet still available on the market. Boerhaave states:

> Although it is true that the author wrote about the mayfly in order to give man a reflection of his miserable life, and to caution him to look forward to and observe higher things; even so, we do not think that anyone can reprimand us for leaving out these reflections. [103]

It can be said that Boerhaave represents a fairly straightforward 'rational' Calvinism. He does not seem to be very charmed by mystical reflections which turn the mind away from nature itself towards the heavenly kingdom. This is not surprizing as the centres of the radical mystical theology of the so called Further Reformation (*Nadere Reformatie*) were in Utrecht and Zeeland and not in Leiden, which was, as we saw, a breeding ground for Cartesianism and Cocceianism. Boerhaave does not take Swammerdam's mystical turn very seriously as he ascribed Swammerdam's stay with Antoinette de Bourignon, a mystic prophetess, to his suffering from melancholy and persistent fevers. [104] Fairly recently Lindeboom has presented a more nuanced view of Swammerdam's state of mind. He claimed that although Swammerdam was spiritually unbalanced during his acquaintance with Antoinette de Bourignon, it is impossible to explain Swammerdam's religious zeal only as resulting from a depressive psychosis. Swammerdam wrote most of the commentary on the mayfly before he had even heard of Antoinette de Bourignon. Moreover,

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[102] Swammerdam. (1737). *Bijbel der Natuure*: 1, 85.
[103] *Ibid.,* 1, 343.
[104] Boerhaave in *Ibid.,* foreword.

Lindeboom argues that Swammerdam's use of metaphorical language was generally accepted during the seventeenth century. [105]

Boerhaave, like Swammerdam, reflected on the state of his soul in the sight of God, but that did not make him turn away from the natural world. Unlike Swammerdam who abandoned his work on insects, Boerhaave tirelessly pursued his natural philosophical investigations. Just as the Scripures taught Boerhaave about God and His love for the world, so the 'Bible of Nature' taught him about God the Creator. Swammerdam was concerned that he studied nature for his own pleasure and fame only, and so he renounced the world and joined a religious commune. For Boerhaave, on the contrary, natural philosophy was absolutely necessary for man to feel totally dependent upon his Creator and to feel the need of salvation in Christ. Schultens in Boerhaave's funeral oration praised Boerhaave's search for knowledge in the same sentence as his awareness that he could not find eternal life in his earthly life. [106] In doing so Schultens directly linked Boerhaave's natural philosophy to his knowledge of the divine. In fact, Boerhaave believed that resting in the will of God is the highest of all laws. Only this would be a basis for gaining true knowledge about God and His creation. [107] Boerhaave's view is well summarized in a letter written to Ruysch. He wrote:

> A hundred thousand thanks for the demonstrations of valuable learning which I recently recieved in your incomparable *theatrum* (*schouwtoneel*) which presents even new, so far never known instruction, to the wisest and most experienced mind. How far assidiousness, love of truth and God's favour brings man in the exploration of the creature! Go on, use your fresh old age, your thoroughly practised judgement, and your still excellent talents to God's honour, to the enlightenment of man and your happy pleasure! [108]

God, experience and truth

At this point it must be noted that God's involvement in His creation is a recurring theme in all Christian theology. This means that Boerhaave's references to nature as God's creation, although consistent with Calvinism are not

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[105] Lindeboom, G.A. (1980). *Ontmoeting met Jan Swammerdam*. Kampen: 37-38.

[106] Schultens. (1988 (1739)). *Begrafenisrede*: 15. The Dutch reads: De wakkere jongeling (...) van gloeiende ijver naar geleerdheid blakende, en in het leven het leven niet vindende...

[107] *Commentariolus*: XVIII.

[108] Boerhaave to Ruysch, date unknown, in: *Correspondence 3*: 4-5. According to Lindeboom, Boerhaave, when speaking about the *theatrum* was referring either to Ruysch's book *Museum anatomicum Ruyschianum* or Ruysch's anatomical work in the *Thesaurus animalium primus*. The use of the word *schouwtoneel* or *theatrum* is also interesting because Calvin used the term to denote the creation.

in themselves enough to establish that Boerhaave's natural philosophy was specifically Calvinistic. Historians of science have for example similarly argued that Newton's thoughts on the aether are imbedded in his theology of creation and yet Newton's religion is very different from Boerhaave's Calvinism. [109] In order to determine the Calvinist nature of Boerhaave's investigations we have to turn to Calvin's ideas on truth and knowledge. [110]

Man, Calvin argues, 'consists of a body and a soul; meaning by soul, an immortal though created essence, which is his [the body's] nobler part.' [111] He states that contrary to animals, who do not possess a sense that goes beyond the objects presented to them, human beings conceive attributes of the invisible God. This shows that there must be an essence, a soul, separated from the human body. The soul is not enclosed by space. Yet it 'occupies the body as a kind of habitation, not only animating all its parts, and rendering the organs fit and useful for their actions, but also holding the first place in regulating their conduct.' [112]

The soul not only invigorates the body, but it also has a religious meaning. Following Gen.1:27, which states that man is created in the image of God, Calvin argues that, although the body displays divine glory, the soul is the proper seat of God's image. Since the soul is the only essence in which the nature of man surpasses all other created beings, it necessarily has to be the part on which God impressed His likeness. Accordingly the 'image of God' corresponds to the integrity of Adam before the Fall, 'when his intellect was clear, his affections subordinated to reason, all his senses duly regulated, and when he truly ascribed all his excellence to his Maker.' [113] After the fall sin corrupted the soul, but traces of its original perfect state are still visible. Man still has a 'sense of divinity', through which he can recognise what is good. It is like a cart track in the snow; the cart itself has disappeared, but its traces are still visible.

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[109] There are numerous studies on Newton's religion in relation to his natural philosophy. Most fundamental are: Metzger, H. (1938). *Attraction universelle et religion naturelle chez quelques commentateurs anglais de Newton*. Paris; McGuire, J.E., & Rattansi, P.M. (1961). 'Newton and the Pipes of Pan.' *NRRS, 21*, 108-143; McGuire, J.E. (1968). 'Force, Active Principles, and Newton's Invisible Realm.' *Ambix, 15*, 154-208; Dobbs, B.J.T. (1991). *The Janus Faces of Genius. The Role of Alchemy in Newton's Thought*. Cambridge.

[110] See: Ruestow, E.G. (1996). *The Microscope in the Dutch Republic. The Shaping of Discovery*. Cambridge: 77-79.

[111] Calvin. (1997 (1559)). *Institutes of the Christian Religion* (Beveridge, Henry, Trans.). Michigan: 1, xv, 2.

[112] *Ibid.,* 1, xv, 6.

[113] *Ibid.,* 1, xv, 3.

The separation of soul and body is a Calvinist trademark, which distinguishes Calvinism from Lutheranism. Luther believed in the real presence of Christ in the eucharist, in the same way as he also saw the divinity of God, in the bodily suffering of Christ on the cross. [114] According to Kusukawa, 'for Luther it was in the physical things (…) that spirituality existed.' [115] Accordingly, for Luther and his follower Philip Melanchton, the soul cannot be distinguished from the body. Both are the subject of grace. Melanchton even went so far as to claim that knowledge of human anatomy is necessary for understanding the Christian soul and he returns to the Galenic/Platonic division of the soul into a raional, sensitive and nutritive part. [116]

Calvin's definition of the soul encloses intellect and will. The office of the intellect is to 'distinguish between objects, according as they seem deserving of being approved or disapproved.' The will has 'to follow what the intellect declares to be good, to reject and shun what it declares to be bad.' [117] The intellect governs the will in such a way that the will cannot do otherwise than follow what the intellect dictates. In this sense Calvin does not clearly distinguish between the two, but refers to the intellect as being the most important office of the soul.

In defining the soul in terms of intellect and will, Calvin refutes the opinion of former ecclesiastical writers (he does not give names), that the soul consists of intellect, sense and appetite or will. It was believed that the intellect is endowed with reason and has to rule the inferior movements of the senses. The will, having an intermediary position in between, is possessed of full power and freedom to either choose to obey reason and virtue or to degenerate into lust. In the second instance we do not speak of will anymore but of appetite. Free will was said to consist of the ability 'to discern between good and evil' and of the power 'to choose the one or other.' [118] Again Calvin has another opinion than his Lutheran colleague, Melanchton. The latter also argued that the rational soul is divided into intellect and will, but he also believed that the will is a 'pre-eminent power, supreme and freely acting on an object indicated by the Intellect.' [119] Yet, the object of sound will, should always be the knowledge of God.

Calvin observed that classical philosophy of the soul crept into theology

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[114] Kusukawa, S. (1995). *The Transformation of Natural Philosophy. The Case of Philip Melanchton*. Cambridge: 76-77.
[115] *Ibid.*: 77.
[116] *Ibid.*: 88, 90.
[117] Calvin (1997 (1559)). *Institutes*: I, xv, 7.
[118] *Ibid.,* II, ii, 4.
[119] Melanchton in Kusukawa (1995). *The Transformation of Natural Philosophy*: 95.

and 'the common dogma came to be, that man was corrupted only in the sensual part of his nature, [but] that reason remained entire and will was scarcely impaired.' [120] Roman Catholic theology on the nature of the soul still resembles the old opinion that the sensual part of the soul is fallen, but that reason and will are still free to either act or abstain from action. Moreover, Roman Catholic theologians argue that human will is inclined to do the right thing, but the surroundings threaten good intentions. [121]

Calvin heavily criticised the ecclesiastical writers, with the exception of Augustine, for reconciling the doctrine of Scripture with the philosophical ideas on the mind. Instead of arguing that the human intellect and will survived the Fall almost unaffected Calvin states that as a result of the Fall the faculties of the soul are so corrupted that they cannot do any good and are incapable of righteous desire. Yet, man still has a limited power of discerning between good and evil, through which he understands and judges. Calvin states that

> in the perverted and degenerate nature of man there are still some sparks which show that he is a rational animal, and differs from the brutes, inasmuch as he is endued with intelligence, and yet, that this light is so smothered by clouds of darkness, that it cannot shine forth to any good effect. In like manner, the will, because inseparable from the nature of man, did not perish, but was so enslaved by depraved lusts as to be incapable of any righteous desire. [122]

Calvin especially writes against the belief that man can deserve heaven through performing good works. Calvin states that

> the understanding of the soul in divine things, that is in the knowledge and true worship of God, is blinder than a mole; good works it can neither contrive nor perform. In human affairs as in the liberal and mechanical arts, it is exceedingly blind and variable. Now the will, so far as regards divine things, chooses only what is evil. So far as regards lower and human affairs, it is uncertain, wandering, and not wholly at its own disposal. [123]

It follows that man cannot show any good-will out of his own nature, but that he needs the assistance of divine grace. For this reason Calvin states that seeking God is the beginning of wisdom. [124]

Thus Calvin does not deny that man has will, but he states that man is deprived of soundness of will. To will the wrong thing is part of man's corrupt nature, to will well results from grace. Calvin argued that

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[120] Calvin (1997 (1559)). *Institutes*: II, ii, 4.
[121] *The Catholic Encyclopedia* vol. VI on Free Will.
[122] Calvin (1997 (1559)). *Institutes*: II, ii, 12.
[123] *Ibid.,* Aphorisms II, 18.
[124] *Ibid.,* II, iii, 2.

the soul, in some strange and evil way, is held under this voluntary, yet sadly free necessity, both bond and free; bond in respect of necessity, free in respect of will; and what is still more strange, and still more miserable, it is guilty because free, and enslaved because guilty, and therefore enslaved because free. [125]

Thus free will does not consist in a free choice between good and evil, but in man acting voluntarily and not by compulsion; 'man is not forced to be the servant of sin, while he is, however, (...) a voluntary slave; his will being bound to the fetters of sin.' [126] The appetite is not a movement of the will, but a natural inclination to move towards a condition in which the individual feels comfortable. In this sense free will proceeds more from instinct than from intellectual deliberation. Calvin concludes that 'the natural desire of happiness in man no more proves the freedom of the will, than the tendency in metals and stone's to attain the perfection of their nature.' [127]

Divine grace provides the correction and cure of natural corruption. The cure starts with the conversion of the will. Calvin states that through faith God 'begins the good work in us by exciting in our hearts a desire, a love, and a study of righteousness, or (...) by turning, training, and guiding our hearts unto righteousness.' [128] For this reason faith consists in knowledge of God, Christ and the divine will. [129] The Calvinist call for studying the creation must be seen in this light, since it guides the believer to knowledge of God and His will. This means that when Boerhaave speaks about 'the love of God' as the end of all his studies, he is expressing a thoroughly Calvinist thought. [130]

Like Calvin, Luther held that the human will is fallen and corrupted by sin. The will, unless enlightened by faith, is inclined to do wrong. Thus 'free will after the Fall exists only in name and as long as a man "does what in him lies," he is committing mortal sin.' [131] Yet man has a sort of freedom in respect to the 'things beneath him', which means that he can choose between the things regarding his temporal life. He can even choose to behave or not according to the divine law. However, man can never have a freedom of choice in relation to "the things above him" such as eternal salvation and perdition. Man also

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[125] *Ibid.,* II, iii, 5.
[126] *Ibid.,* II, ii, 7.
[127] *Ibid.,* II, ii, 26. Note that Calvin believed in a proces in nature that causes the metals to grow towards more perfection, an opinion we also find in the alchemy of Boerhaave. We cannot say that Boerhaave was directly influenced by this statement, but it shows that it was an accepted opinion in Calvinism.
[128] *Ibid.,* II, iii, 6.
[129] *Ibid.,* III, I, 2.
[130] *Commentariolus*: XVII.
[131] Steinmetz, D.C. (1995 (1986)). *Luther in Context*. Michigan: 66.

has a freedom of responsible reaction to the things above him. Luther states that it is man's own fault if he does not believe in God, but prefers to stay under the guidance of Satan. [132]

With respect to knowledge, Lutheran theologians believed that man is not entirely under the guidance of sin. They argue that the natural knowledge of God, that is the knowledge of God's will and not of His hidden nature, is implanted in the human mind. This knowledge is prior to reason and sense perception. The natural knowledge has been partly obscured by sin, which has weakened human nature such that it rejects or abuses the implanted knowledge. Thus 'the natural knowledge of God serves only to render fallen human beings inexcusable.' [133]

Calvin was more radical than Luther in stating that all the thoughts proceeding from the human mind are 'foolish, frivolous, perverse, and insane.' [134] This leads to the question how the Calvinist believer can achieve true knowledge? According to the modern historian David Steinmetz, Calvin, unlike Lutheran theologians, does not focus on knowledge itself, but on the knowing subject. [135] Steinmetz has argued that Calvin disagreed with the Lutherans, who held that man can know God through an innate knowledge of His will. Although man still has traces of God's image engraved on his heart, he needs the creation to convince him of God's existence. [136] However, the creation, although it shows God's existence, it does not show His essence. The creation shows a knowledge of God which is adapted to the limited capacity of the human intellect, for man's perception is corrupted by sin. Steinmetz writes:

> The thrust of his [Calvin's] argument, however, is that while human beings know that God exists, they misperceive His self revelation in nature because of the noetic consequences of human sin. Since sin is a condition that is not natural to the human race, but a consequence of Adam's fall, the misperceptions of the revelation of God in nature are inexcusable. [137]

In the debates over Cartesianism just before Boerhaave matriculated at Leiden University, the distinction between innate and manifest knowledge once

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[132] Rupps, G.E., Marlow, A.N., Watson, P.S., & Drewery, B. (Eds.). (1969). *Luther and Erasmus: Free Will and Salvation.* (Vol. xvii). London.
[133] Steinmetz, D.C. (1995). 'Calvin and the Natural Knowledge of God,' *Calvin in Context* (pp. 23-39). New York/Oxford: 28. See also pp. 26-27.
[134] Calvin. (1997 (1559)). *Institutes of the Christian Religion* (Beveridge, Henry, Trans.). Michigan: II, iii, 1.
[135] Steinmetz. (1995). Calvin and the Knowledge of God: 29.
[136] *Ibid.,* 29.
[137] *Ibid.,* 29-30.

again was at stake. Boerhaave's teacher Jacob Trigland and his colleague Jacob Revius had argued against Adriaan Heereboord (1614-1661), professor of logic, and they had stated that the knowledge of God is manifest and what is manifest should not be doubted. Heereboord wanted to replace Aristotelian logic with a philosophy based on Cartesian reasoning. However, Trigland and Revius argued that natural reason may be used to acquire knowledge, but the philosopher has to bear in mind that it is impossible to prove *a priori* that there is a God. God's existence has no cause and can only be proved *a posteriori*, starting with the effects visible in the creation. [138]

Calvin states that although the human intellect is fallen and corrupted by sin, yet man, godly and ungodly alike, has a certain desire to find truth. For Calvin all true knowledge relates either to the knowledge of God or to the knowledge of what God is in relation to man. [139] Most of the time man gets lost on the path leading to truth, but history proves that he made some progress. Calvin argues that the findings of natural philosophy, medicine and mathematics show that God has left many good things in the possession of human nature, even though it is despoiled of the true good. [140] It follows that the desire to know the truth is God-*given* and all true knowledge is communicated to man by his Creator in the same way as 'He fills, moves, and invigorates all things by the virtue of the Spirit (...) according to the particular nature which each class of beings has received by the law of nature.' [141] This means that the foundation of true knowledge is that which dictates itself upon the intellect from the outside and man depends upon God's grace for being able to recognise the truth.

Calvin distinguished between an intelligence of earthly things and an intelligence of heavenly things. [142] The first category consists of things which do not directly relate to God and His kingdom, but are connected with the present life, such as matters of policy and economy, all mechanical arts and liberal studies. By heavenly things Calvin refers to the pure knowledge of God, the method of true righteousness and the mysteries of the heavenly kingdom; in other words the knowledge of God and of His will, and the means of framing one's life in accordance with them. [143]

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[138] Verbeek, T. (1992). *Descartes and the Dutch. Early Reactions to Cartesian Philosophy 1637-1650*. Carbondale and Edwardsville: 40-42.
[139] Calvin. (1997 (1559)). *Institutes*: II, ii, 18.
[140] *Ibid.,* II, ii, 15.
[141] *Ibid.,* II, ii, 16.
[142] This seems to be a similar distinction as between Lutheran freedom of the will with respect to the things beneath him and the limitations of choice regarding the things above him.
[143] *Ibid.,* II, ii, 13

Through distinguishing earthly from heavenly knowledge Calvin enables man to use the achievements of profane authors. Since all true knowledge is God-given it would be an insult to reject the truth, wherever it appears. However, this does not mean that man can develop natural philosophy independently from God. He has to bear in mind that all true knowledge comes from his sole benefactor, which means that his intellectual achievements are worth nothing if they are not based on a solid foundation of truth. [144] So earthly knowledge is linked to heavenly knowledge in such a way that 'the more a man studies to approach God, the more he proves himself to be endued with reason.' [145]

The Calvinist emphasis on the fallen state of the human intellect, also dictates the way a Calvinist should study the creation. We have already seen that man has to adopt a humble mind, he has to be enlightened by faith and he has to read the Scriptures at the same time. Most important, however, is that he should not rely on his intellect to come to true knowledge. Calvin states that human reason is corrupt and exposed to many forms of delusion and therefore is not a very good guide to true knowledge. He argues that 'the human intellect is very seldom mistaken in the general definition or essence of the matter; but that deception begins as it advances farther, – namely, when it descends to particulars.' [146] Man then forgets the rule he laid down in the general case and he falls into error. Calvin compared the situation to an adulterer who condemns sleeping with someone else's wife in public, but he commits the crime in his thoughts. Calvin mainly referred to universal judgements distinguishing between good and evil, so that man cannot be held inexcusable. However, in later years Dutch Calvinists adopted Calvin's theory of knowing and applied it to all aspects of human knowledge. In their debate against the Cartesians they argued that deductive arguments are not reliable beyond a certain point. This means that empirical investigation is a more reliable method to achieve true knowledge. [147] Thus the Calvinist emphasis on the fallen state of the human mind can explain why Calvinists were so much opposed to the deductive method of reasoning and why they relied much more on experiment and an inductive method based on sense perception to come to true knowledge. It remains a problem how man can adopt an inductive method of reasoning when his intellect is corrupt. In the next chapter we

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[144] *Ibid.,* II, ii, 16.
[145] *Ibid.,* I, xv, 6.
[146] *Ibid.,* II, ii, 23.
[147] Verbeek, T. (1993). 'From 'Learned Ignorance' to Scepticism. Descartes and Calvinist Orthodoxy.' In R. Popkin, H. & A. Vanderjagt (Eds.), *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries* (pp. 31-45). Leiden, New York, Köln: 37.

shall see that Boerhaave moved around the problem through concentrating on the individual observable particulars and powers of bodies without trying to formulate general theory.

Having discussed how Calvin defined the human soul we can now proceed to show how Boerhaave betrays himself a true Calvinist in defining the nature of the soul as well as in the way he prescribes the rules to come to true knowledge. Not many historians have looked at Boerhaave's ideas on mind and body even though it was an important part of Boerhaave's thought. Not only did he start his academic career discussing the distinction between mind and body in the early disputations but he also ended it lecturing on the nature of the mind while speaking about the nervous system.

Most recently John Wright has written about Boerhaave's ideas on minds and mental diseases. However, he does not pay any attention to the importance of religion. [148] The historian De Groot, on the contrary, has mentioned the importance of religion for Boerhaave's ideas on body and mind, but unfortunately does not say much more about it. [149] I shall show that Boerhaave's ideas on the mind and the method to come to true knowledge were embedded in his Calvinist beliefs. The sources for Boerhaave's ideas on body and soul are his early disputations, his *Institutiones medicinae* (1708), and the lectures on the nervous system (1730s). As the basic outlook of the ideas does not show much variation, I shall discuss them as being complementary rather than as representing the development of a particular set of ideas.

In his early disputations Boerhaave defined the soul as the principle of life in man, as well as the beginning of thinking, conscience and will. The soul is a thinking entity and although it is closely connected to the body, it is distinct from the body. It is the principle which makes man a reasonable animal. [150] Boerhaave seems to use the words soul (*anima*) and mind (*mens*) arbitrarily. Yet, he must have had a clear understanding of a difference between the two. Soul

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[148] Wright, J.P. (1990). 'Boerhaave on Minds, Human Beings, and Mental Diseases.' *Studies in Eighteenth Century Culture, 66* (1), 118-120.

[149] Groot, J.V. d. (1917). 'Boerhaave's Beschouwingen over de Ziel,' *Denkers over Ziel en Leven*. (pp. 166-210). Bussum-Amsterdam.

[150] Boerhaave, H. (1687). *Disputatio pneumatica de mente humana prima*. Leiden: corollarium IV: 'Anima est in nobis vitae principium;' Idem: thesis I: 'dicendo mentis nomine nobis venire, meliorem illam, & hominis digniorum partem, vitae in eo, ratiocinationisque principium, quod ad constituendum animal rationale concurrit;' Boerhaave, H. (1688). *Disputatio pneumatica de mente humana tertia*. Leiden: thesis XIX; the soul is defined 'substantia cogitare prona, unita corpori personaliter.'see also: Boerhaave, H. (1690). *Disputatio philosophica inauguralis de distinctione mentis a corpore*. Leiden: cap. I.

in his view encompasses mind, but is more than that. It is the dwellingplace of the principle of life, which moves the body as well as the mind. Man shares the animating principle with animals, but the faculties of the mind makes man what he is, a rational animal. Accordingly, the soul animates the body as a whole, while the Creator connected the mind to the cerebrum, cerebellum and nervous system. In his medical works, Boerhaave mainly speaks about the mind, as this can be clearly linked to and also effects the constitution.

Boerhaave states that man consists of body and mind. The body is extended in three dimensions, has a form, and it accommodates motion and rest. The essential nature of the mind is to be conscious, or to think. [151] Boerhaave agreed with Descartes that since the faculties of the mind can only be perceived by the individual person himself, we should talk about the mind in the first person. So:

– That which thinks is called mind.
– Thinking is the first thing that is known by the mind. Or is it the mind itself?
– Thus thinking is not dependent upon anything else, which can be known earlier, nor is it defined by anything else. [152]

Boerhaave further argues that the mind transcends the material level of the body as it can think about immaterial objects like universal truths, God, axioms, virtues and mathematical knowledge. [153]

The different natures of body and mind was the reason for the historians Schulte and Wright to investigate to what extent Boerhaave adopted Cartesian dualism. While Schulte argues that Boerhaave adopted Cartesian ideas, Wright states that Boerhaave's ideas clearly went beyond Descartes' philosophy. Wright has argued that mind and body are united in such a way in Boerhaave's medical system that it is dubious whether we can speak of a strict dualism. Wright suggests that adopting a sort of dualism kept Boerhaave free of theo-

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[151] Boerhaave, H. (1745). *Praelectione's academicae in proprias institutione's rei medicae edidit, et notas addidit Albertus Haller*. Göttingen: I, 79. Haller, A. v. (Ed.). (1742). *Dr. Boerhaave's Academical Lectures on the Theory of Physic. Being a Genuine Translation of his Institutes and Explanatory Comment, collated and adjusted to each other, as they were dictated to his students at the University of Leyden*. London: I, 66.

[152] Schulte, B.P.M. (1959). *Hermanni Boerhaave Praelectione's de Morbis Nervorum 1730-1735. Een Medisch-Historische Studie van Boerhaave's Manuscript over Zenuwziekten*. Leiden: praelectio 47, 23 March 1733, pp. 216-217. 'Cogitare est primum, quod scitur a mente. an ipsa men (s?) [sic.]. Ergo non pendet ab ullo alio, prius scito: nec definitur. In ea cogitatione est cogitans, est res cogitata.'

[153] Boerhaave. (1687). *De mente humana prima*: thesis III-IV; Boerhaave, H. (1688). *Disputatio pneumatica de mente humana secunda*. Leiden: theses XII-XVII; Boerhaave. (1690). *De distinctione mentis a corpore*: cap. II-IV.

logical controversy, for he was never 'suspected of irreligion.' [154] I shall argue that Boerhaave's ideas might look Cartesian, but that they effectively resulted from his Calvinist conviction.

Contrary to Descartes, Boerhaave does not see an unbridgeable gap between mind and body. He argued that body and mind are united in such a way that the mind forms ideas of pleasure and pain if the body is affected and vice versa that the body obeys the action of the mind under particular circumstances. [155] The exact nature of the connection of body and mind is unknown, and can only be explained as a harmony established by God, which is beyond man's understanding. Just before his death Boerhaave told his friend Schultens that in times of severe illness he felt the immortal independent nature of the soul better than he ever understood it through reason. Experience made him realise that the soul encompasses the eternal principle of thinking, which functions independently from the body, but yet is linked to the body in a way that is beyond human understanding. [156]

Boerhaave not only disagreed with Descartes on the nature of body and soul, but he also opposed Spinoza's views. Boerhaave believed in the immaterial origin of the mind. Thus the mind is essentially different from the body, which means that an idea is necessary different from the object or sense perception exciting the idea. Spinoza on the contrary considered body and mind as modes of extension and thought, both of which he defined as attributes of God. They influence each other, but because they are both conceived in God it is unnecessary to define the exact nature of their relation. Since both body and mind are conceived in God, an idea and the object of the idea must be necessarily the same. [157]

Boerhaave explains that the function of the body is to generate motion and resistance and it is subject to attraction and gravitation. The mind is fit to perceive appearances of external objects, to judge and compare and to will anything. In other words the human mind consists of intellect and will. Just as Calvin argues that intellect and will resemble the 'image of God' imprinted on the soul when God created man in his likeness, so Boerhaave states that intellect and will together form the mind and that both are entirely and inti-

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[154] Wright. 'Boerhaave on Minds': 292. See also: Schulte, B.P.M. 'The Concepts of Boerhaave on Psychic Function and Psychopathology' in: Lindeboom, G.A. (Ed.). (1970). *Boerhaave and his Time, Papers read at the International Symposium in Commemoration of the Tercentenary of Boerhaave's Birth. Leiden, 15-16 November 1968.* Leiden: 98-99.

[155] Boerhaave in Haller. (1742). 'Academical Lectures': I, 66.

[156] Schultens. (1988 (1739)). *Begrafenisrede*: 3.

[157] Spinoza, B. (1995). *Ethics*: Part II, Prop. VII; Haller. (1742). *Academical Lectures*: IV, 238.

mately linked to God. [158] Moreover, Boerhaave describes the mental faculties as a gift of the Creator, which sets man apart from animals. [159]

In describing the process of thinking Boerhaave closely followed Calvin and he links the human mind to God, the fountain of all things that can be thought. Boerhaave is undecided about the question whether thinking is the beginning of consciousness or the other way around. Thinking requires a thinking subject and a thought object. These two aspects are necessarily different for the thinking subject cannot be thought as a thought object. In other words the thinking subject is conscious, and as such does not have an idea of itself through which it can know itself. [160] Similarly, thought objects or ideas are different from the thinking subject. Ideas are formed in the mind and change every moment. In this sense the thinking subject remains the same, while every moment it thinks about another object. The constant stream of ideas indicates that the human intellect cannot generate ideas, but that something outside it imprints ideas on the mind. Therefore ideas are always and everywhere the same, even though many people can think them. It follows logically that the ideas must be caused by an entity that is always and everywhere the same, namely 'Yahweh, the God who is, who was and who will be, the alpha and omega.' [161] Boerhaave in his lectures argued that

All people therefore perceive almost the same idea from the same object. But in such a common idea there is nothing truly belonging either to the acting object or the affected organ; nor do our ideas arise from a knowledge of the figure, bulk, &c. compared with the figure, bulk, &c. of the object; though these changes of the sensitive organ are at present acknowledged by everyone to be different from the ideas which they excite, except Spinoza and the Epicureans. What light is, re-

[158] Schulte. (1959). *De morbis nervorum*: prae. 56, 7 May 1733, 236-237: 'Hoc intelligere, et velle, constituit, mentem, ejusque perfectione's, distinctas a corporeis. quae optimae, si ambae, sine aliquo medio, unitae DEO intime, integrae.'

[159] *Ibid.,* prae. 47, 23 March 1733, 216-217; Boerhaave states about animals that they feel, but don't think in: Boerhaave, H. (1688). *Disputatio pneumatica de mente humana tertia.* Leiden: thesis V: 'Bruta sentiunt. Non cogitant.'

[160] *Ibid.,* prae. 47-48, 24 March 1733, 216-217. 'Id quod cogitat, mens dicitur. Cogitare est primum, quod scitur a mente. an ipsa men (s?) [sic.]. Ergo non pendet ab ullo alio, prius scito: nec definitur. In ea cogitatione est cogitans, est res cogitata. Cogitans non scitur ut cogitatum, sed est primum, simplex, ipsum, semper idem, immutabile, nullam ideam sui habens, qua se cognosceret, vix successivum, consciu (m) res cogitata, idea, est in cogitante, cum conscientia.'

[161] *Ibid.,* prae. 48, 24 March 1733, 218-219.

mains a mystery to every mortal, and what the eye is, but few are acquainted with; and yet the husbandman sees as well as the philosopher (...) Sensation, therefore, is nothing either in the object, or the nerve affected; but a certain idea which God has determined or assigned to each particular change in the corporeal sensory. [162]

It can be objected that Boerhaave's denial of the possibility of knowing the things themselves leads to scepticism. Indeed Boerhaave did not think it possible to achieve certainty about first principles, but in his lectures he moved away from the question of sure knowledge to the imperfection of human judgement. He argued that man can perceive things that do not relate to the things themselves. For example if we see a painting of a nose, we immediately think of someone whose nose it might be, without that particular person being present. This means that:

> All our sensations therefore are owing to that disposition of the mind which was given to it by the Creator, who has so ordered it, as not to be capable of seeing the object which the eye sees , and yet that it should form the same judgement as it would if it had or collected the luminous rays themselves. But yet our senses do not deceive us (...) but all our errors arise from the hastiness of our judgement. [163]

Thus man can see things without perceiving or understanding the thing in itself. Boerhaave compared the way God imprints ideas upon the mind to a beam of light. We do not know what light is, but we know that it is not a body. It makes objects visible and excites the mind to think. So the mind can think many new things. Hence the process of thinking is called enlightenment. [164]

Just as the thinking subject cannot be known via the thought object, God, the cause of all things, cannot be fully understood by His creatures. Otherwise God, the first cause of everything could be understood by His creatures, the thinking subjects. [165] Boerhaave argues, using Euclidean mathematics, that many confusing ideas can usually be reduced to one clear and simple idea, in the same way as man can understand the immortal, unchangeable and body-independent nature of the human mind because it is connected

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[162] Haller. (1742). *Academical Lectures*: iv, 238. These are not Boerhaave's own words, but are derived from lecturenotes. However, we can trust Von Haller's records. In the manuscript version we find short references in the margin referring to stories reported by Von Haller in full. See: Leningrad MS XIII 10, Leiden MF F699, *Chemica opera*.

[163] *Ibid.,* iv, 240-241.

[164] Schulte. (1959). *De morbis nervorum*: prae. 50, 23 April 1733, 222-223. 'Et modus, quo Causa cogitantis et cogitati agit in cogitans, et cogitata, a similitudine vacatur illuminatio.'

[165] *Ibid.,* prae. 48, 24 March 1733, 216-219.

with the Creator. Boerhaave concludes that knowing this is the simplest of all doctrines. [166]

Contrary to the faculties of the intellect, Boerhaave does not devote much time to describing the character of the will. He describes it as a faculty that is so much anchored in the mind that it seems like the mind consists entirely of willing. Unlike ideas that are present only for a certain period of time, the will is ever present. Boerhaave closely follows Calvin in stating that the impression of an idea first and foremost instructs the will to act. [167] Just like Calvin, Boerhaave denies that an intellectual judgement can be reduced to an act of the will. [168] Instead he argues that man 'cannot help forming a judgement in accordance with the way the (...) impressions are formed in the brain.' [169] In other words, the idea or representation of an object 'excites something more than the bare representation, which is not a simple idea or perception, but a determination of the will with respect to the idea.' [170]

This means that if the will, being instructed by the intellect, wants to keep an idea, it fills the mind with joy, hope and pleasure and vice versa, if the will wants to get rid of the idea, it fills the mind with pain and sorrow. This in turn will incite the body to action. The feelings of love and hate operate upon the body from the common sensory (*sensorium commune*), that part of the brain where all the nerves terminate. This means that man's intellect and hence humanity have a corporeal cause as well since they depend upon the healthy disposition of the common sensory of the brain. [171]

Unlike Calvin, who devoted much time to explaining that the will is held under a voluntary necessity, Boerhaave leaves the question of free will aside and devotes much more time to the question how the human mind can assemble true knowledge. This question was urgent for Boerhaave, being a Calvinist, believed that man, in body, soul and mind, is fallen and of himself cannot do any good. The Calvinist emphasis on man's fallen state is particularly visible in funeral orations. For example Schultens in the funeral oration for Boerhaave told his audience not to mourn for Boerhaave, because he states that his soul was freed from all earthly troubles. Boerhaave himself similarly argued in the funeral oration for Bernhard Albinus (22 September 1722)

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[166] *Ibid.,* prae.51, 24 April 1733, 224-225.
[167] *Ibid.,* prae. 56, 07 May 1733, 236-237.
[168] Boerhaave. (1688). *De mente humana secunda*: cor. IV: 'Judicum ad voluntatem referendum nego.'
[169] Wright. 'Boerhaave on Minds': 293. Wright paraphrased Haller. (1742). *Academical Lectures*: iv, 263-264.
[170] Haller. (1742). *Academical Lectures*: iv, 242
[171] *Ibid.,* iv, 246-247. Wright has also noticed the correlation between mental events and changes in the brain, which makes him think that dualism maybe is not a useful term to describe Boerhaave's system. Wright. 'Boerhaave on Minds': 292.

that one should be glad for God freed Albinus's soul from all sinful blemish, so that he could enter the kingdom of God. [172]

True knowledge, Boerhaave states, is 'what results from observation, or what follows of consequence from the facts or observations, so evidently, that no skilful and unprejudic'd person can refuse their assent.' [173] Boerhaave believed that human reasoning is corrupt, so that man should rather rely on observation. Truth is to be found outside the human intellect. In the same way as God imprints ideas upon the human mind He imprints true characteristics on his creatures. So in botany 'the kinds and true characteristics which have been imprinted on plants from their origin by the Creator, never suffer any changes.' [174] Boerhaave argued that reason explains what is known already, but does not discover anything. This means that man does not need the arguments of reason, but understands through contemplation. [175] Boerhaave argued that man can perceive the essence of things, but as soon as he starts interpreting what he sees, he falls into error. In the case of botany this means that the 'virtues and arbitrary characteristics given them [botany] by man, (...) frequently vary and deceive us.' [176]

Not only do thoughts originate from outside, they also arise from internal causes, through the faculties of memory and imagination. Man's humanity and consciousness depend upon his God-given ability to recollect what has happened before. Just as the mind is connected to the brain, the faculty of memory is intimately linked to the disposition of the body. This explains that when someone is ill it affects his perception and sound reasoning. Madness arises when you remove the connection, for ideas start leading a life of their own. [177] Imagination largely depends upon the memory, for it is the arising of ideas without an external cause being present. This means that the imagination or fancy affects the nerves, spirit and brain in the same way as the external senses cause ideas, without the external cause being necessarily present. [178] However, a delusion can only be overcome by sense-perception for the faculty of reason is unable to convince man of truth. The man who believed his legs were made of straw, could not be convinced by his friends that his legs were flesh and blood. Only when they set up a coach robbery and the

[172] Schultens. (1988 (1739)). *Begrafenisrede*: 3; Boerhaave, H. (1721). *Oratio de vita et obitu Bernhardi Albini*. Lugd. Bat: 44-45.
[173] Haller. (1742). *Academical Lectures*: 1, 43.
[174] *Ibid.,* 1, 44.
[175] Schulte. (1959). *De Morbis Nervorum*: prae. 52, 27 April 1733, 230-231.
[176] Haller. (1742). *Academical Lectures*: 1, 44.
[177] *Ibid.,* iv, 255-257.
[178] *Ibid.,* iv, 257.

man had to flee the coach in a hurry did he believe his legs were steady enough to walk on. [179]

In order to achieve true knowledge, Boerhaave states that the natural philosopher should first and foremost found his knowledge on accurate observation followed by just reasoning. [180] This means that he has to ban all speculations, hypotheses and preconceived opinions from his mind and start his investigations as if he is ignorant of the phenomena. In this way the natural philosopher can make the experiment speak for itself, while 'the mind adds nothing to the appearance, but barely the perception of it.' [181] In short Boerhaave states that

> He that desires to learn truth, should teach himself by facts and experiments; by which means he will know more in a year, than by abstract reasoning in an age. Proper experiments have always truth to defend them; also reasoning join'd with mathematical evidence, are founded upon experiment, will hold equally true; but should it be true, without those supports it must be altogether useless. [182]

Boerhaave's ideas on the mind and the intellect show similarities with the ideas of the English empiricist John Locke (1632-1704). [183] Just like Boerhaave, Locke was a strong advocate of experience and sense perception as the fountain of all ideas. [184] However, unlike Boerhaave, Locke denied all innate ideas and he argued that there is no consent about the truth of any principle, not even moral judgements. As we have seen, Boerhaave's Calvinist conviction led him to believe that man has the the innate ability to judge between good and evil, but he is generally deceived when he descends into particulars. This means that Boerhaave's way of observation is a passive activity of the mind, because it is God who imprints true knowledge upon the senses. Locke's sense perception on the other hand is an active movement of the mind. As soon as a simple idea enters the mind, the mind starts interpreting, combining and comparing in the construction of complex ideas of modes, substances and of relations. The truth of a particular idea consists of

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[179] *Ibid.,* iv, 266.

[180] Boerhaave. (1688). *De mente humana tertia*: cor. 1: 'Clara & distincta perceptio, sensu explicata sano, in naturalibus veritatis norma certissima est.'

[181] Haller. (1742). *Academical Lectures*: 1, 60.

[182] *Ibid.,* 1, 74. See also Boerhaave. (1688). *De mente humana tertia*: cor. 1; Boerhaave, H. (1741). *A New Method of Chemistry* (Shaw, P., Trans.). (2 ed.). London: 1, 207, 379; Haller. (1742). *Academical Lectures*: 1, 57.

[183] It is uncertain whether Boerhaave knew about the ideas of Locke. His catalogue of books does not show any work of Locke. (1739). *Bibliotheca Boerhaaviana, sive catalogus librorum instructissimae bibliothecae viri summi D. Hermanni Boerhaave*. Leiden.

[184] Locke wrote about the origin of ideas in: Locke, J. (1689). *Essay concerning Human Understanding.* London.

the agreement between ideas and can be shown through intuition, mathematical demonstration and sensitive knowledge based on memory. In Locke's system, the idea of God is a complex idea made up of the simple ideas resulting from sense perception, and depends upon the intuitive knowledge of man's own existence. Boerhaave would never agree with Locke, since he believed that man is almost always mistaken in the interpretation of the observations he makes, which would mean that his idea of God is the result of corrupt human reasoning.

In Boerhaave's view the will of the Creator is the cause of all true knowledge.[185] It necessarily follows that freedom cannot be found in the intellect nor the will. For the mind, when it is not convinced of a certain idea, is indifferent to decide, which is essentially the same as the unfree state of the mind when it is instructed to accept truth.[186] Thus, man does not have freedom of choice over what to believe, but truth dictates itself from outside upon the senses. True knowledge, which consists of knowledge of God and His creation cannot be found within man himself, but lies in the creation. Keeping to experiments and sense perception also prevents the natural philosopher from searching after God, the primary cause. For example man can see the laws of motion, but experiment can never explain the origin and communication of motion. He simply has to accept that God is the origin of motion without trying to explain how and why. In his *Elementa chemiae* Boerhaave wrote:

> We are struck with admiration, when, from these instances we see what powers the Creator has given to the human mind; whereby, when duly cultivated, we can discover the laws he established in framing the world. Certainly we owe the greatest veneration and thanksgiving to that Being, which impressing his own image on our minds, gave us a disposition to understand, study, and love the truth.[187]

Boerhaave's quest for true knowledge and his urge to study the Creation is a recurring theme in his academic orations. Moreover, studying the orations in the order Boerhaave delivered them, the Calvinist nature of his natural philosophy becomes more and more obvious. In chapter four we shall see that Boerhaave's orations also mark important turning points in his natural philosophy. Most striking is that Boerhaave moved from a mechanistic point of view to a natural philosophy based on vitalistic principles. Moreover, as the

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[185] Boerhaave in Haller. (1742). *Academical Lectures* : iv, 263.

[186] Boerhaave. (1690). *De distinctione mentis a corpore*: cor. 11: 'Indifferens ad assentiendum mens nondum convicta; persuasa ubi veritas ad assensum determinata; unde quum hoc in casu non minus quam in illo libera sit, indifferentia non est de essentia libertatis.'

[187] Boerhaave. (1741). *A New Method*: 1, 363.

non-mechanical principles become increasingly more important in Boerhaave's thoughts, Boerhaave also spoke more boldly about his Calvinist beliefs. At this point I shall discuss how Boerhaave emphasised man's obligation to study the creation and his awareness that God Himself is the source of all true knowledge.

Boerhaave delivered no less than nine orations. This is remarkable, for in Leiden University it was customary to deliver an oration upon accepting and resigning a chair, after resigning the office of *Rector Magnificus*, and after the funeral of a distinguished member of the academic community, solemn occasions which normally would not happen very often in the life of one man. We can read Boerhaave's orations as important moments in his academic career, in which he tells his audience about his natural philosophical programme. We also see Boerhaave changing from a young and enthusiastic academic to a much more moderate scholar, something that Boerhaave noticed himself for in 1729 he wrote:

> When we feel old age coming on and then examine ourselves, we must indeed acknowledge with Petrarch, that our present personality has nothing in common with our previous way of being as a young man. [188]

Instead of the youthful boldness in approach of his early years, Boerhaave observed he had become much more cautious and judicious with respect to his chances of success. Moreover, in his old age he felt that 'the course of his life has almost been run, and that his feet approach the finish.' For this reason he wanted to concentrate more upon 'preparing for his last journey and composing his mind for a peaceful departure from the body.' [189] Thus we see that with the years Boerhaave's emphasis on a Calvinist study and contemplation of the works of the creation became increasingly more important. [190]

In the general introduction to their translation of the orations E. Kegel-Brinkgreve and A.M. Luyendijk-Elshout argue that Boerhaave's orations must be seen in the light of a particular rhetorical tradition dating from Antiquity. They state that like the citizens of the Greek city-state, Boerhaave presented closely knit arguments, using the ancient rules of rhetoric, in order to convince his audience of the truth of his words. In this sense Boerhaave's search for truth is the presentation of his ideas before a court of reason in

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[188] *SAC*: 222.

[189] *Ibid.*: 223.

[190] Luyendijk-Elshout and Kegel-Brinkgreve have also argued that the orations reflect the various stages of Boerhaave's career. However, they do not link the changes to Boerhaave's theological reflections. *Orations*: 13-14.

which he has to persuade a jury of experts and laymen. [191] However, Boerhaave's search for truth was more than just a rhetorical form. In Boerhaave's case the rhetoric of the classics is embedded in a Calvinist tradition where truth is unambiguous and in a sense beyond human reasoning. For the Greeks the truth was the outcome of arguing. It was a prize awarded to the winner in a debate, so that whoever had the most convincing argument could claim to know the truth. On the contrary, in the Christian tradition truth is no longer defined by the most persuasive reasoning, but it is an independent criterion and should be the undoubted outcome of any debate. For the Calvinist in particular, truth is to be found outside corrupt human reasoning in the teaching of Christ. So when Boerhaave used the rhetorical form of reasoning his aim was not only to present a convincing argument, but more importantly to also take his listeners unto 'the heights of truth.' [192]

Boerhaave's lifelong search for truth was not unusual. Betty Jo Teeter Dobbs in her *Janus Faces of Genius. The Role of Alchemy in Newton's Thought* (1991), has argued that the assumption of unity of truth was one of the most common assumptions at the time. She states that since God's attributes are not only recorded in the Bible, but also reflected in the creation, true knowledge must necessarily be knowledge of God. For this reason natural philosophy had direct theological meaning. [193]

Leaving aside the funeral oration for Albinus, the *Oratio academica de vita et orbitu viri clarissimi Bernhardi Albini* (1721), Boerhaave's orations can be divided into four parts corresponding to four periods of his academic life. The first oration, the *Oratio de bene intellecta Ciceroni sententia Epicuri de summo hominis bono* (1689), like the early disputations reflects the thoughts of an inexperienced but promising student in theology and philosophy. The orations *De commendando studio Hippocratico* (1701) and the *De usu ratiocinii mechanici in medicina* (1703) show the enthusiastic confidence of a starting academic. In the third period Boerhaave delivered the *Oratio in qua repurgatae medicinae facilis asseritur simplicitas* (1709), the *Sermo academicus de comparando certo in physicis* (1715) and the *Dissertatio de chemia suos errores expurgante* (1718), in which he appears to be more reserved about the endless possibilities of natural philosophy. In Boerhaave's last orations, the *Sermo academicus quem habuit quum hone'sta missione impetrata botanicam et chemicam professionem publice poneret XXVIII Aprilis 1729* and the *Sermo academicus*

[191] The notion of bringing ideas before a 'court of reason' is derived from the philosophy of Immanuel Kant.

[192] *Epicurus*: 31.

[193] Dobbs. (1991). *The Janus Faces of Genius*: 6. For a discussion on the search for truth while faced with a wide range of ideas see P.O. Kristeller on the 'Unity of Truth' in: Kristeller, P.O. (1979). *Renaissance Thought and its Sources*. New York

de honore medici servitude (1731), we meet an aged scholar stepping back contemplating the aim of his pursuits. [194]

The oration and disputations of Boerhaave's student years reflect the thoughts of a young man who learned Calvinism at his mother's knee. His first academic oration is directed against all philosophers deviating from the truth. As we saw before, Boerhaave, like his orthodox contemporaries, is horrified by the Epicurean idea that the human soul, like the body, consists of atoms and is mortal. In this opinion, man did not have to fear death or life after death anymore and is left to physical pleasures as his highest good. This idea, together with the denial of an omnipotent God ruling the world through His providence, stands for all anti-Calvinist doctrine that Boerhaave grew up with. Boerhaave is most appalled by philosophers 'who hold horrible opinions on God and the human soul' as well as by those who follow Aristotle who held 'that the world never knew a beginning but always existed by itself through the eternity of ages.' This, Boerhaave argued, 'is wholly alien to sound reason.' [195] After setting out all the consequences of Epicurean philosophy that are contrary to Calvinist theology, Boerhaave asked his listeners: 'How could they believe with a truly unyielding spirit that no deity rules our human affairs according to His will, that nothing exists, apart from the bare body and its properties?' In Boerhaave's view these philosophers held on to a 'heinous and sinful opinion that robs us of all that is divine and eminently desirable.' Instead, Boerhaave argued that 'it were better to adopt the view of the most noble men, and to regard a quiet obedience to the laws set down by nature, and the incredible joy of a tranquil conscience will arise from this, as a solid good.' [196]

Twelve years separate Boerhaave's Epicurus Oration from his second oration. Soon after 1689, Boerhaave graduated in philosophy and medicine. Until his first academic post as Reader in Medicine in 1701, Boerhaave spent most of his time studying mathematics, medicine, chemistry and physics. He came out of this period of studying as a confident academic, setting up the teaching programme of medicine that would prove to be so popular that it earned for him the title of *communis europae praeceptor*.

The most striking element of the 1701 and 1703 orations is Boerhaave's constant referring to true principles upon which medicine should be built. These true principles are revealed to man through sense-perception and only he 'who is free from all sectarianism, unfettered by any preconceived ideas, devoid of all leanings towards prejudice; he who merely learns, accepts

[194] See also *Orations*: 13-14.
[195] *Epicurus*: 32.
[196] *Ibid.*, 52.

and relates what he actually sees.' is able to follow nature as his sole guide when investigating the 'true occurrences in reality.' [197] If students take this into account in their studies, Boerhaave argues, 'we shall eventually have at our disposal a medical science which is more reliable, not subject to phantasy, not continually changing, but eternal.' [198] In fact if man would be able to perceive the actual nature of truth, he would find that nothing is more simple. For this reason simplicity is the most reliable guide in the pursuit of true knowledge. Boerhaave appears to be confident that man, in studying the creation in the right manner, can approach truth quite closely.

In the six years between his oration on the adoption of the mechanical method in medicine (1703) and his oration on the simplicity of purified medicine (1709), Boerhaave develops a more cautious attitude towards the possibility of unveiling truth. Upon accepting the position of *Rector Magnificus* of the University in 1709, Boerhaave discussed how man can achieve certainty in physics without falling into the common error of claiming to know the first principles through pure reasoning. Being aware of the threat that Cartesianism posed to a Calvinistic way of studying nature, Boerhaave disapprovingly referred to philosophers who 'almost seem to think themselves able by mere meditations to find in their own thoughts the ways and means by which the whole universe holds together and moves.' However, 'the first principles of nature are wholly hidden from us' and 'only from the observation of our senses can knowledge of their properties be gained.' [199] Boerhaave closely followed Calvin, who prescribed the adoption of a humble mind in all natural investigations. Boerhaave addressed his listeners and he asked them:

> I would now like to ask anyone whether he understands all this? whether he comprehends in his mind the immense thing that is the universe? (...) We would feel ashamed to find anyone so lacking in self-knowledge, so destitute of modesty, as to take this upon himself. For then we would in monstrous stupidity be aiming at the wisdom itself of God, and equal the Giants in arrogant pride. [200]

The 'arrogant pride' is exactly what damaged chemistry in the past and Boerhaave argued in 1718, upon accepting the chair of chemistry, that only chemists themselves can restore the fault by knowing the boundaries of their discipline. In chapter three I shall discuss how Boerhaave defined his Calvinist chemistry.

Boerhaave's Calvinist insistence on humility and the impossibility of know-

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[197] *CSM*: 69-70.
[198] *URM*: 112.
[199] *CCP*: 155.
[200] *Ibid.*, 157.

ing first principles, distinguished him from the English puritan natural philosophers who believed that natural philosophy could restore the fallen state of man. [201] They argued that knowing the world meant to master the world and in the end to come to know God. Harrison traced this opinion to the late medieval opinion that knowing the world is to become like God, for 'the investigation of nature could [again] lead to knowledge of the mind of God.' [202] Boerhaave, on the other hand did not believe in redemption via natural philosophy. The study of nature is necessary for man to acknowledge his sinful nature and his need for God's grace, but can never serve to reconcile man with God.

Boerhaave's orations of 1729 and 1731 are of a contemplative nature as Boerhaave discusses the nature of truth. Especially in the last oration Boerhaave most clearly links his concept of truth to his religious conviction. He starts his oration by repeating Calvin's distinction between knowledge of heavenly and knowledge of earthly things in stating that 'All things that come within the range of human thought relate either to God or the physical universe.' However, all true knowledge relates to God the Creator. Boerhaave argued:

> If we now look more closely at this earth of ours, a true planet, we learn that it is composed of living beings, plants and minerals; fire, air and water; and that all this is again subject to the firm rule and unassailable maxims of the Creator of Nature; everything obeys His commands. And so, people who have studied these matters more deeply have gained the noble insight that all things are created and directed by a Single Being, essentially differing from these created things, existing before and above and outside them; a Being who by one single decree of efficient wisdom has called the whole and each single phenomenon in it into existence and rules over this universe.' [203]

Boerhaave's last orations are a plea for man to examine nature, being God's creation, to bring man to a closer understanding of the Creator, the only source of truth. Moreover, it will help man to align himself to God's will.

> Indeed the study of nature also forms and creates habits and moral characteristics which are noted and admired in our leading botanists by those who know them well. I may state on the best authority and opinion that an imperturbable calm resides in their hearts, and a life which does not know deceit. [204]

Boerhaave's Calvinist approach was not unique, for we also find the 'Calvinist

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[201] See: Webster. (1975). *The Great Instauration*; Harrison, P. (1998). *The Bible, Protestantism and the Rise of Natural Science*. Cambridge; Bono, J. (1995). *The Word of God and the language of Man*. Cambridge

[202] Harrison, P. (1998). *The Bible, Protestantism and the Rise of Natural Science*. Cambridge: 170-171.

[203] *HMS*: 248.

[204] *SAC*: 227.

characteristics' (humble approach and an emphasis on the limitations of the intellect linked to an experimental approach) in the work of Boerhaave's comtemporaries. I shall briefly look at the work of the Dutch natural philosophers Bernard Nieuwentijt (1654-1718) and Willem Jacob 's Gravesande (1688-1742). Both natural philosophers advocated a specific approach, which was in many respects very similar to Boerhaave's.

Nieuwentijt was one of the most well known advocates of 'physico theology' in the early eighteenth century Republic. His two influential books, written against Spinozist and 'atheist' tendencies in Dutch academia, advocate an empirical approach for the study of nature. This means that his work can be read as a defence of the Calvinist natural philosophical method. According to Israel, 'Nieuwentijt's importance lies not in his originality (…) but rather in his lasting impact on Dutch culture. For (…) Niewentijt's comfortable conjunction of questioning empiricism with an unquestioning faith which avoided the challenging issues raised by Spinoza, Huygens, Bayle and Bekker continued to dominate the whole of Dutch mainstream Enlightenment.' [205]

W. J. 's Gravesande was a pupil of Boerhaave and is known as the first systematic teacher of Newtonianism at the University of Leiden. Like Nieuwentijt, he warned against the 'dangerous' philosophy of Spinoza, who, in his eyes, had abused the mathematical method. Like Boerhaave, 's Gravesande had international fame. Voltaire called both Boerhaave and 's Gravesande the leading men in Dutch natural philosophy. [206] Moreover, 's Gravesande advocates a humble experimental (Calvinist) approach very similar to those of Boerhaave and Nieuwentijt.

We have seen that Boerhaave advocated a humble approach in natural philosophy. Nieuwentijt and 's Gravesande also adhered to this view. In their eyes the arrogance of man in assuming that he can know everything through the power of his intellect had damaged natural philosophy. In particular the work of Nieuwentijt can be seen as a lifelong crusade against rational philosophy. He emphasised experiment and observation (*ondervinding*) as the only basis of true knowledge. Moreover, he made the increase of true knowledge dependent upon the will of God. He argued that the first step of natural research should always be a prayer to God for the enlightenment of the intellect in order to recognise God's hand in the works of nature. [207] This same sentiment is also visible in Boerhaave's life. Schultens said in the funeral oration:

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[205] Israel, J. (1995). *The Dutch Republic. It's Rise, Greatness and Fall, 1477-1806.* Oxford: 1041-1042.
[206] *Ibid.*: 1043.
[207] Nieuwentijt, B. (1717). *Het Regt Gebruik der Wereltbeschouwingen ter Overtuiging van Ongodisten en Ongelovigen.* Amsterdam: 37.

The Christian humility (…) he [Boerhaave] embraced as the flower and honour of all virtues: and [he] acknowledged that she is not the result of a noble nature, but of Grace, to be obtained only through continuous prayer. [208]

This brings us to the second characteristic of Dutch Calvinist natural philosophy: the great emphasis on experience and experiment. It can be argued that, since we also find a promotion of the experimental method in, for example, the writings of French and British scholars, we cannot call it specifically Dutch Calvinist. However, as we saw before Dutch Calvinist natural philosophers, unlike other natural philosophers, explicitly link the experimental method to a religious theory about the limitations of the human intellect.
In this sense it is particularly interesting that there is a remarkable similarity in the way Dutch Calvinists speak of the certainty of natural knowledge through experiment and experience on the one hand and the certainty of one's election through a religious experience on the other. Nieuwentijt is most explicit about the link. In reply to the philosophy of Spinoza he argued that it is impossible to gain accurate knowledge of *all* the characteristics of things through abstract reasoning. On the contrary, a mathematical method based on experiment and experience would lead to true knowledge. Spinoza's big mistake, according to Nieuwentijt, was that he adopted imaginary mathematics in order to prove the existence and characteristics of natural as well as metaphysical truths. Nieuwentijt was particularly offended by Spinoza's mathematical proof for the existence of God, based on rational argument *without* the certainty of (sense) experience. [209] This experience, which according to Nieuwentijt contains the certain knowledge of things, is important for investigating religious truths as well as natural bodies. [210] Just as for a strict Calvinist a religious experience is necessary for the certainty of his salvation, so experience and observation are necessary for discovering true knowledge about the nature of things. Moreover, true knowledge gained through experience is indisputable, so that in theology as well as in natural philosophy there is no need for argument. [211]

Finally, Dutch Calvinist natural philosophy has to be in the service of the people. Although Calvinists believe that the natural order is fallen and under the rule of sin, yet they also believe that they have a calling to work in the world. In the sixteenth century, Calvin had argued against the Anabaptists, who distinguished between the baptismal community and the heathen world,

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[208] Schultens (1988 (1739)). *Begrafenisrede*: 101.
[209] Nieuwentijt in Vermij, R. (1988). *Bernard Nieuwentijt. Een Zekere, Zakelijke Wijsbegeerte*. Geschiedenis van de Wijsbegeerte in Nederland, vol. 12. Baarn: 112.
[210] *Ibid.*: 116.
[211] *Ibid.*: 121.

that the state is a divinely willed order. [212] The Anabaptist considered a civic government only useful in order to regulate the Christian world. Calvin, however, argued that the believer always remains a sinner and therefore cannot escape the worldly government.

> Imperfection and disorder rendered the created, civic order neither dispensable nor evil. (…) Christians must be willing to live in a world infected with disorder; they have to take sin seriously precisely because they cannot escape from it. [213]

Furthermore, Calvin argued that the believer lives side by side with the wicked. Moreover, he lives in a Fallen world infected by sin. This asks for an active attitude of the believer. Rather than turning away from the world 'Christians must face the nature of the world and properly understand and take responsibility for that world.' [214] In this sense anarchy is a constant treat to human society. He argued that man is prone to follow his own desires and ambitions and so destroy the community of people. In order to avoid this situation he argued that every citizen has to follow his vocation and stay in the rank of society which God preserves for every believer. Moreover, Calvin believed that the formation of government is a natural instinct still present in the fallen soul. He argued that man was formed to be a social animal and that therefore people have an impulse to care for the human race. This means that, in Calvin's view, murder as well as marriage are contrary to the order of nature. In short:

> Calvin believed that God preserves society because he continues to love his image in the human being. Also, however, the conscience and natural reason contribute to the order and stability of the civil reign. (…) Nature, according to Calvin, causes us to propagate the race, raise our children, and even to recognise the image of God or a common human nature in our neighbor. (…) Calvin's God did not reject His creation but continued to exercise providence over the "work of his hands" and to reveal his glory in His earthly "theatre" (…) Calvin insisted on a Christian realism about societal life. This realism required both a respect for the threat of chaos and an appreciation for and activity in the world. [215]

Later Dutch Calvinism did not divert from Calvin's views. Also after the Synod of Dordt the worldly government was considered to be a divinely willed order. All subjects were obliged to obey the laws, unless the government

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[212] Schreiner, S. (1991). *The Theatre of His Glory. Nature and Natural Order in the Thought of John Calvin.* Michigan: 83.
[213] *Ibid.*: 85.
[214] *Ibid.*: 84-85.
[215] *Ibid.*: 95.

would not act according to divine command. Individually all Calvinists were called to help building a Christian society.

It is not surprising that in the works of both Boerhaave and Nieuwentijt we find references to the use of natural philosophy in service of the Republic. Yet, 's Gravesande's *Rede over de ware, nooit misprezen filosofie* (Oration on the true, never disdained philosophy) best expressed this sentiment. Instead of turning away from the created order, he argued that true philosophy is aimed at the good life. 's Gravesande believed that society was installed by God and that it is His will that people live happily together in the service of each other. He expressed the Calvinist opinion that a true philosopher directs his thoughts towards God, he follows his vocation and so lives according to God's will. [216] Since God reveals His will in His works, the natural philosopher is particularly privileged in seeing the goodness of God towards mankind. So studying nature, although it cannot bring man to true wisdom on its own, is an important tool for man in order to recognise the divine order of nature so that he can align himself to God's will. 's Gravesande argued:

> As soon as one recognises his duties towards the Ruler and Lord of the world, he will see that his most important duty is to follow His will in his life. Then he also will not doubt that he has to keep, protect and maintain the bond of society of the whole human race, since God used this to bind all people together. [217]

Boerhaave, as we shall see, uses the same argument in his chemistry and medicine, for it would bring man to a closer understanding of God's will with the world. Moreover, Boerhaave also stresses the importance of natural philosophy for the prosperity of the nation. For example, the introduction of his chemistry textbook consists mainly of a description of the use of chemistry in disciplines relevant for the building of the Republic, such as the mechanical arts, medicine and natural philosophy. Furthermore, in his praise of Hippocrates, he states that Hippocrates did not theorise medicine, but he applied it in practice, in service of the people of Athens and Thessalia, who were suffering from the plague. [218] Boerhaave also directly linked the work of the physician to the work of Christ when stating:

> The usefulness of Physic in a Republick is both well known and esteem'd, especially as it is so extensive as to touch the life and health of every individual member; the

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[216] Pater, C.d. (1988). *Willem Jacob 's Gravesande. Welzijn, Wijsbegeerte en Wetenschap.* Geschiedenis van de Wijsbegeerte in Nederland, vol. 13. Baarn: 66-67.

[217] *Ibid.*: 69.

[218] Boerhaave in Haller. (1742). *Dr. Boerhaave's Academical Lectures on the Theory of Physic. Being a Genuine Translation of his Institutes and Explanatory Comment, collated and adjusted to each other, as they were dictated to his students at the University of Leyden.* Göttingen: i, 28.

esteem for it has always been so great, that people afflicted with diseases had rather apply themselves to any ignorant person, than be without physic; but it is very evident, that those who know anything of physic will not inconsiderately commit themselves to the rashness of pretenders. (…) Our Saviour is a remarkable instance in this respect, who being invested with divine Power, also made it His particular care to relieve the bodily disorders of mankind. [219]

In chapters three and four we will see more of the effects of Calvinism on Boerhaave's natural philosophy. For now it is important to note the Calvinist theology called for a humble, experimental and serviceable approach. The historian Kusukawa has claimed that Calvin, unlike Luther and Melanchton, who believed that spirituality lies in material things, 'saw no need for a natural philosophy, nor did he see a valid foundation for such a discipline.' In her view, for Calvin 'there could not be a natural philosophy based on pagan philosophy and directed towards a Christian purpose,' precisely because Calvin 'insisted that human reason is so impaired by sin that it misperceives God's revelation.' [220] However, I shall show that in the case of the Calvinist Boerhaave this was by no means true.

The following chapters show that in the case of Boerhaave, Calvinism provided a cultural framework that not only determined Boerhaave's life, but also the way he thought about natural philosophy. Calvinism preached the total dependence of man and the creation upon God the Creator. In this sense there is no real difference between God steering all the operations in nature and the way He inspires the mind with true knowledge. The Calvinist emphasis on the corrupt state of the human mind, led Boerhaave to a natural philosophy based on experiment and observation. Only then would it be possible to obtain true knowledge about the Creation and about God Himself, her Creator. Boerhaave first and foremost was a Calvinist. When he gave up a career in the church, he did not give up studying theology after all, for in the Scriptures as well as in the Bible of nature Boerhaave could see the works of God. In the following chapters we shall see how Boerhaave promoted his Calvinist experimental approach and the way he applied Calvinist theology to his chemistry and chemistry for medicine.

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[219] *Ibid.*: i, 57.

[220] Kusukawa (1995). The Transformation of Natural Philosophy: 205

O Lord my God, thou art very great; thou art clothed with honour and majesty.
Who coverest Thyself with light as with a garment: who stretchest out the heavens
like a curtain: who layeth the beams of His chambers in the waters:
who maketh the clouds His chariot: who walketh upon the wings of the wind:
who maketh His angels spirits; His ministers a flaming fire.

Psalm 104:1b-4

III. Herman Boerhaave: Calvinist chemist

Boerhaave's chemical career started at a young age, when he started experimenting with his brother Jacob. The experiments were the start of many hours in the chemical laboratory.[1] Boerhaave dedicated his *Elementa chemiae* (1732) to his brother Jacob in memory of their shared moments in the chemical laboratory, while Jacob was studying medicine and Boerhaave's mind was still directed towards theology.[2] Ironically enough it turned out that of the brothers Jacob became the minister and Herman the most well known physician of the time. Yet, even after Boerhaave gave up a career in theology and devoted himself to the study of natural philosophy, he did not renounce his theological studies altogether. In the funeral oration for Boerhaave his friend Schultens did not only tell his audience that Boerhaave still wanted to follow in his father's footsteps but also that Boerhaave throughout his life zealously devoted himself to God and the church.[3]

Why did Boerhaave start performing chemical experiments while he was studying theology? Was it simply because he was curious enough to join his brother who did them as part of his medical studies, or was it perhaps because Boerhaave thought about chemistry in a theological way? This brings us to the question whether in Boerhaave's case we can make a clear distinction between the Calvinist theology of the time and Boerhaave's chemistry, or whether both are sides of the same coin; the coin being the study of God and His creation. I shall suggest that Boerhaave never moved away from his original aim and that his chemistry shows a particular Calvinist way of studying nature. In his chemical laboratory he was still a theologian, searching for the will of his Creator in the nature of things.

The chapter has three sections. In the first section I shall discuss Boerhaa-

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[1] Boerhaave. (1968). *Commentariolus*: XIII. 'Chemiam dies noctesque exercuit.'

[2] Boerhaave, H. (1732). *Elementa chemiae*. Leiden: praefatio.

[3] Schultens, A. (1988 (1739)). *Academische Redevoering van Albert Schultens ter Gedachtenisse van den Groten Herman Boerhaave. Uitgesproken 14 november 1738* (Schultens Jan Jacob, Trans.): 28-29.

ve's presentation of a reformed method of chemistry in which he freed chemistry from false theological notions. Secondly, I shall look in more detail at Boerhaave's chemical theories which are based on his belief in the Calvinist God who is constantly involved in running the affairs of the world. I shall especially pay attention to Boerhaave's introduction of occult qualities working as agents of God's providence and divine will. The third and final part of the chapter deals with Boerhaave's chemical experiments, in which he carefully applied the Calvinist rules for obtaining true knowledge.

The basic source for Boerhaave's chemistry is his chemical textbook, the *Elementa chemiae*, published in 1732. Boerhaave wrote his textbook in reaction to illegitimate publications of lecture notes under the name *Institutiones et experimenta chemiae* (1724). Boerhaave was so annoyed about the publications that he threatened in the local newspaper to prosecute anyone who published anything under his name without his consent.[4] He even signed all the copies of the *Elementa chemiae* himself to prove their authenticity. In addition to Boerhaave's textbook, I shall also use Boerhaave's correspondence as well as notes of his experiments.

In explaining Boerhaave's chemistry I shall use the 1741 translation of Boerhaave's lectures by the English physician Peter Shaw (1694-1736), rather than the official translation of Boerhaave's chemistry textbook by Timothy Dallowe (1735).[5] According to Christie, Shaw's 1741 translation 'is as reasonable as Dallowe's: they can both be claimed equally to reflect whatever it was Boerhaave's Latin expressed.'[6] I agree. Although Shaw sometimes qualified Boerhaave's language, most of the time his translation is accurate.

This cannot be said of Shaw's extensive commentary upon Boerhaave's ideas in the footnotes to the text. Recently, Principe has argued that Shaw's translation of the works of Robert Boyle is not very trustworthy. Not only did Shaw cleanse Boyle's writings of alchemical taints, he also Newtonised Boyle whenever he saw the chance.[7] Other historians have also recognised Shaw's Newtonian enthusiasm, even though paradoxically Shaw seemed to

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[4] *Leidsche Courant*, 09/10/1726.

[5] In 1727 Shaw had already translated the edition of Boerhaave's work that provoked Boerhaave's anger under the title *A New Method of Chemistry*. This edition should not be confused with the translation that came out in 1741 under the same title. The former is a publication of lecture notes taken by students, while the latter is a translation of Boerhaave's own work.

[6] Christie, J.R.R. (1994). 'Historiography of Chemistry in the Eighteenth Century: Herman Boerhaave and William Cullen.' *Ambix, 41*, 4-19: 7.

[7] Principe, L.M. (1998). *The Aspiring Adept. Robert Boyle and his Alchemical Quest. Including Boyle's 'Lost' Dialogue on the Transmutation of Metals*. Princeton: 15.

have favoured Stahlian chemistry in the end of his career. [8] Golinski has suggested that Shaw's success in his time was largely due to the fact that his texts were answers to current intellectual fashions in society. [9] Thus, with the publication of the unauthorised edition of Boerhaave's chemical lectures in 1727, Shaw was aiming at trading-chemists and gentleman-amateurs. [10]

Shaw's main concern with chemistry was to make it more serviceable to the arts and trades. He states that the aim of his chemical lectures is 'to enlarge the bounds of chemistry by applying it to the advancement of natural philosophy, the illustration and improvement of the known arts, and the discovery of new ones.' For this purpose, Shaw thought it necessary to have a 'summary of all that is hitherto known and done in chemistry, concisely drawn up, to show the present state of the art.' [11] Shaw understood that there were numerous writers, but he aimed only at 'the original experimental writers, who (...) are few in comparison of the speculative theorists, plagiarists and transcribers.' [12] Boerhaave, Stahl, Boyle, Bacon and Hoffmann fell into the category of respectable chemical writers, whose works should be made known to the world. Shaw aimed at giving an overview of the prevalent opinions among the most important and well-known chemists of his time for the sake of the people. In doing so he did not favour one system above the other. He praised Stahl for his 'solidity of judgement, and true attachment to observation, experiment, and geometrical reasoning, in the sublimer chemistry,' and Boerhaave for showing that 'the rational art of medicine has an entire dependence upon chemistry.' [13]

Comparing the 1727 translation to the 1741 translation of Boerhaave's lectures we can see that Shaw became more careful over the years. In his early translation Shaw happily Newtonized Boerhaave's work, and more importantly Shaw and Chambers took out almost all the Calvinism. Although

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[8] Thackray, A. (1970). *Atoms and Powers. An Essay on Newtonian Matter-Theory and the Development of Chemistry*. London: 119, 184; Donovan, A.L. (1975). *Philosophical Chemistry in the Scottish Enlightenment. The Discoveries of William Cullen and Joseph Black*. Edinburgh: 31; Schofield, R.E. (1970b). *Mechanicism and Materialism. British Natural Philosophy in an Age of Reason*. New Jersey: 211-212, 145; Shapiro, A.E. (1993). *Fits, Passion and Paroxysms. Physics, Method, and Chemistry and Newton's Theories of Coloured Bodies and Fits of Easy Reflection*. Cambridge: 224.

[9] Golinski, J.V. (1983). 'Peter Shaw: Chemistry and Communication in Augustan England.' *Ambix, 30* (1), 19-29: 20-21.

[10] *Ibid.,* 59-60.

[11] Shaw, P. (1755). *Chemical Lectures, Publickly Read at London, in the Years 1731 and 1732; and at Scarborough in 1733*. London: 1; Shaw in Stahl, G.E. (1730). *Philosophical Principles of Universal Chemistry* (Shaw, P., Trans.). London: advertisement.

[12] Shaw in Boerhaave, H. (1741). *A New Method of Chemistry* (Shaw, P., Trans.). (2 ed.). London: ii, 353.

[13] *Ibid.,* ii, 377.

they kept the references to the biblical narrative they did not mention many of Boerhaave's references to the Creator. By stating that a person who knows how to use the powers of nature can produce endless surprising effects, Shaw and Chambers define the use of chemistry in terms of its usefulness for man, rather than acknowledge that the aim of studying chemistry should be the knowledge of God the Creator.[14] It is likely that this was the reason that Boerhaave was outraged by the publication of his lectures. While for Boerhaave it was most important to realise that man is obliged to acknowledge and glorify his Maker, his words were quoted as if he did not mention God at all. Boerhaave must have been annoyed about the neglect of the religious side of his teaching, for unbelief formed a danger for the teaching of church and university. Moreover, as we shall see in chapter four, Boerhaave was not as Newtonian as Shaw made him to be. For these reasons it is not surprising that Boerhaave felt obliged to bring out an authorised version of his chemical teaching to make sure that his chemistry would be seen in the right perspective.

Shaw's translation of 1741 is much more trustworthy. Although Shaw sometimes qualified expressions of occult qualities, he tried to stay close to the original text as much as possible, only referring to books and natural philosophers of direct importance. In any case, where he was not happy with Boerhaave's chemistry, he wrote a comment in the footnotes rather than changing the original text. For example, Shaw did not like Boerhaave's alchemy and in the footnotes he wrote:

> The elements of chemistry, perhaps, should rather be kept clear of these Cabalistic conceits, for fear of giving a wrong turn to the mind at its first setting out in this practical science; tho' they may have their use in reading the alchemical authors.[15]

Shaw's 1741 translation, but not his commentary in the footnotes (!), was quite close to Boerhaave's original. So when quoting from Boerhaave's work I shall use Shaw's translation and where necessary I shall add the original Latin in the footnotes.

Boerhaave's reformation of chemistry

Shaw's concern about distinguishing true chemists from 'speculative theorists, plagiarists and transcribers' was a general worry among the natural philosophers of Boerhaave's time. Modern historians have generally translated this concern of seventeenth century chemists into a desire to separate the

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[14] Shaw, & Chambers. (1727). *A New Method of Chemistry.* London: 213.
[15] Shaw in Boerhaave. (1741). *A New Method*: 1, 68.

dark secrets of alchemy from the true principles of chemistry.[16] However, recently Newman and Principe recognised the historiographic mistake in this approach. They argue that to separate alchemy, the pursuit of making gold out of base metals, and chemistry, a discipline resembling the modern science of chemistry, in early modern times is Whiggish and originates from 'a-historical interpretations of alchemy advanced by nineteenth-century occultists and twentieth-century partisans of analytical psychology.' The terms chemistry and alchemy did not refer to two distinct sets of practice, but 'the terms were not used with any consistent difference of meaning and [that] the boundaries between what we retrospectively call "alchemy" and "chemistry" were extremely diffuse at best.'[17]

Boerhaave's work also shows that we cannot speak of a strict separation of alchemy and chemistry, but that we have to distinguish between true alchemists and chemists on the one hand and vagabond alchemists and modern chemists on the other hand. Boerhaave valued true chemists on the same level as 'such philosophers as endeavour to explain chemical experiments upon just principles.'[18] On the other hand, he accused modern chemists – and Boerhaave is mainly referring to the iatrochemists of his day – of trying to fit all phenomena into general conclusions, thereby unjustly simplifying the complicated nature of chemistry.[19] The 'old true alchemists' understand the doctrine of Paracelsus and Van Helmont. Vagabond (contemporary) alchemists on the other hand can only produce gold through selling a fake method of making gold.[20] Following Bacon, Boerhaave compared the (al)chemists of his time to the lazy sons of a father, who on his deathbed told his children that he had buried a treasure in the garden. After his death the sons went digging and 'tho' they missed their aim, for in reality there was none hid,

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[16] Newman, W.R., & Principe, L.M. (1998). 'Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake.' *Early Science and Medicine, 3* (1), 32-65. Principe and Newman refer to the distinctions between chemistry and alchemy made by Metzger, Boas-Hall, Dobbs and Beretta. See: Metzger, H. (1969 (1923)). *Les Doctrines Chimique en France du Début du XVIIe à la Fin du XVIIIe Siècle*. Paris: 94, 133-138; Boas, M. (1958). *Robert Boyle and Seventeenth Century Chemistry*. Cambridge: 48; Dobbs, B.J.T. (1975). *The Foundations of Newton's Alchemy. Or 'the Hunting of the Greene Lyon.'* Cambridge: 44, 176-177; Beretta, M. (1992). 'The Historiography of Chemistry in the Eighteenth Century: A Preliminary Survey and Bibliography.' *Ambix, 39* (1), 1-10; Beretta, M. (1993). *The Enlightenment of Matter. The Definition of Chemistry from Agricola to Lavoisier*. Uppsala.

[17] Newman, W.R., & Principe, L.M. (1998). 'Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake.' *Early Science and Medicine, 3* (1), 32-65: 35, 33.

[18] Boerhaave. (1741). *A New Method*: 1, 501.

[19] *Ibid.,* 1, 567.

[20] *Ibid.,* 1, 570; Boerhaave, H. (1919 (1734)). *De mercurio experimenta*. Tranlated by M. Renkema in Cohen, E. *Herman Boerhaave en Zijne Betekenis voor de Chemie*. De Nederlandse Chemische Vereniging in Samenwerking met de Vereniging voor Geschiedenis der Genees-, Natuur-, en Wiskunde: 132.

yet they sufficiently enrich'd themselves, by the large crop, which the ground, in consequence of this tillage produced.' [21] Boerhaave does not say who is the dying father, nor what he means by the treasure. Presumably the father is the representation of the alchemists who suspected there was something out there to discover. The non-existing treasure must have been the secret of making gold, for Boerhaave was not entirely convinced of the possibility of transmutation. However, the offspring of the true alchemist enriched themselves by keeping the legend alive and selling fakes and lies.

Boerhaave was not the only one seeking to separate true chemistry from its dark counterpart. Recently Principe has argued that Robert Boyle in his *Sceptical Chemist* (1661) was not writing against the alchemists, but against the vulgar chemists such as cheats, laborants (distillers, refiners, dyers, apothecaries) and the writers of textbooks. Boyle distinguished a higher order of chemists who, like the traditional alchemists can transmute metals and are searching for secret arcana like the alcahest or universal solvent. [22]

In Boerhaave's view alchemy is a respectable part of chemistry, concerned with metals. [23] From the early days of his chemical career Boerhaave was concerned with alchemical experiments aimed at purifying metals. [24] His high admiration for the old alchemists is clear in Boerhaave's correspondence with Cromwell Mortimer, secretary of the Royal Society. The existing correspondence consists of eight letters, six in the hand of Boerhaave and two written by Mortimer. They were written between July 1733 and September 1738, the last letter being written by Boerhaave two weeks before his death. The main topics of the letters are Boerhaave's experiments with mercury, which I shall discuss at a later stage, and the related issue of the trustworthiness of alchemical writings.

Boerhaave's letters to Mortimer show Boerhaave's highly critical attitude towards the pretensions of obscure alchemical writings. Boerhaave was especially wearied with the use of obscure language by the 'foolish who scribble down in an utterly incompetent fashion (all manner of things) concerning the most difficult subjects, while they are ignorant of the most elementary matters.' [25]

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[21] Boerhaave. (1741). *A New Method*: 1, 203.

[22] Principe. (1998). *The Aspiring Adept*: 32-33. See also: Principe, L.M. (1990). 'The Gold Process: Directions in the Study of Robert Boyle's Alchemy.' In Z.R.W.M. von Martels (Ed.), *Alchemy Revisited* (pp. 200-205).

[23] Newman and Principe have recognised the difficulties in separating chemistry and alchemy and they have suggested to call early modern chemistry *chymistry*, which includes both chemistry and alchemy. Newman, W.R., & Principe, L.M. (1998). 'Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake.' *Early Science and Medicine, 3* (1), 32-65.

[24] See Leningrad MS XIII 6 /Leiden MF Q 249, *Notae chemiae, 1694-1702*.

[25] Boerhaave to Mortimer, 8 April 1734, in *Correspondence 1*: 211.

The old writers (*veteres auctores*), on the contrary, write with brevity and lucidity about what Boerhaave considered to be the truth. For this reason, Boerhaave warns the natural philosophers of his day not to pigeonhole all the ancient adepts under the same name.

Three years later, Mortimer wrote to Boerhaave on exactly the same subject. He wrote:

> When reading books on chemistry it has occurred to me that it is more difficult to distinguish the real princes of the art from the spurious imitators of knowledge (*scientiae simulatoribus*) in this study than in the pursuance of any other study.

Mortimer even gave a motive for the deceptions as he wrote that he was

> persuaded that ninety-nine out of a hundred alchemical writers have plundered their books out of jealousy and not out of any love for knowledge (*scientia*): since they had wasted money, time and labour in useless experiments, they were ashamed to have to admit their lack of results; but in order that their friends would believe that they were the adepts of true knowledge (*scientiae adeptos*) they described in an obscure style, experiments that were either faked or invented for some hypothesis or other, and a truly insane doctrine. [26]

Boerhaave agreed with Mortimer and in reply to Mortimer's letter he answered that Mortimer 'judged the writers on chemistry wisely.' [27] In the same letter Boerhaave also pitied the alchemists, emperors, kings and princes whose hopes of transmutation he had destroyed while experimenting on mercury. The historian Snelders has taken this letter to mean that although Boerhaave did not reject alchemy, he lost interest in the alchemical project. [28] However, the letter does not speak about Boerhaave's disappointment with alchemy as a whole, for he referred mainly to the work of false alchemists. Boerhaave continued his letter confessing 'but I am overwhelmed with work, and despite this I never flee from my amiable folly,' thereby referring to his investigations into the properties of metals. Moreover, Boerhaave's experimental notebooks show that he continued his experiments as before.

Boerhaave considered the distinction between true and false chemistry and alchemy so important that in 1718, upon accepting the chair of chemistry, he devoted his inaugural oration to the development of a chemistry based on true principles. In doing so he explained the errors of chemistry and how they could successfully be wiped out. Boerhaave argued that chemistry suf-

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[26] Mortimer to Boerhaave 26 April 1737, in *Ibid.,* 217. I have used Lindeboom's translation of the letter with a slight alteration. I have translated *scientia* as 'knowledge' instead of 'science.'

[27] Boerhaave to Mortimer 10 May 1737, in *Ibid.,* 219.

[28] Snelders, H.A.M. (1993). *De Geschiedenis van de Scheikunde in Nederland. Van Alchemie tot Chemie en Chemische Industrie rond 1900.* (Vol. 1). Delft: 59.

fered two major faults. In the first place the false (al)chemists forged chemistry out of lack of results. They fled into obscure language in order to cover their failures. The effect of this was not only visible in chemistry, but in medicine as well. For example the metaphorical and heirogryphic manner of writing gave rise to the calling of imperfect metals by the name of sick men and gold by the name of a sound, lively and healthy man. Likewise the means to purify metals were called medicines. In turn this lead to the opinion that imperfect metals and sick bodies could be cured by one and the same medicine, the Philosopher's Stone. As a result of the confusion the chemists extended their influence over the whole field of medicine. However, Boerhaave found that 'this new notion [of the Philosopher's Stone] was (...) vain, empty and destructive; and the boasts of the chemists appeared to rest only on their own pride.' [29] According to Boerhaave many physicians made the mistake of rejecting Galen, the Peripatetics and the Arabs without having an alternative medicine. They were readily prepared to adopt chemistry, impressed by the results of mercury in the treatment of syphilis. However, they were too eager in their praise of chemistry as a basis for medicine.

The second mistake of chemists, which Boerhaave considered worse than the universal application of obscure chemistry in medicine, was the usage of false chemistry in theology. Of all natural philosophical investigations, Boerhaave thought that chemistry was best capable of revealing the secrets of nature and coming to know God, through His creation. However, the chemists of his day had turned it around and used the word of God in their own interest. Rather than glorify God, in the pursuit of His creation, they explained the Bible in terms of chemical principles and elements in order to find the secret of gold and to enrich themselves. Boerhaave states that

> These people (...) defiled one and all with their commentaries (...) so much so that everything which may be read in the Holy Scripture, however clear, unambiguous, and plain, was distorted by these trifling fools into an inapposite meaning. Eventually they went to such lengths in their madness that – who would believe this? – they ended up by converting the Sacred History itself, the very miracles by means of which the Holy Authors supported the truth of their teaching, into maxims of alchemy. [30]

False chemistry, according to Boerhaave, was largely based on a misreading of the Bible. Boerhaave especially mentioned the desire to transmute metals which gave rise to a misreading of the books of Moses, Solomon's writings and the Revelation of the apostle John which were regarded as descriptions of

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[29] Boerhaave. (1741). *A New Method*: 1, 36.

[30] *CSEE*: 197.

the art of making gold. Moreover, Boerhaave prefers not to talk about the 'heinous and abominable interpretations' of the Holy Trinity and of other recondite religious mysteries.[31] In the first chapter of his *Elementa chemiae* Boerhaave gives more examples of how the alchemists up to his time saw the Scriptures as proof for their claims. He describes in detail how Zosimus, the Panapolite, who lived in the fifth century, thought that chemistry was first taught by demons to the daughters of men, in exchange for certain favours. This idea comes from a misreading of the words of Moses, 'that the sons of God saw the daughters of men, that they were fair; and they took them wives of all which they chose.'[32]

It is remarkable that Boerhaave was more concerned about theology corrupted by chemical notions than vice versa. Boerhaave considered theology the queen of all knowledge and wisdom. There is no other discipline, Boerhaave argued, that is more important for man's welfare. For this reason man has to be on his guard against 'the danger that something profane might steal into the most sacred sanctuary of this wisdom.' Boerhaave argued that

> Anyone (...) who mingles what is sacred with baseness, who seizes upon the reverence that ought to be offered up to the Single Lord, in order to devote it to the most loathsome idols – such a man should be considered guilty of the most wicked and accursed sacrilege.[33]

Boerhaave blamed the arrogance of man as the reason for the reckless search into the mysteries of revealed religion. In other words, the false (al)chemists broke the first Calvinist rule in their search for true principles. They did not adopt a humble mind, but they presumed they could rise up to the heights of God and understand His creation to the fullest.

The wise (al)chemists, according to Boerhaave, founded their knowledge upon truth and experiment. He wrote to Mortimer:

> There must be frankness concerning experiments: nothing should be simulated or concealed; I report on my experiments and their results simply and without verbosity (...) I do not wish to include anything that is not born out of result. Consequently my work can offend no one, except perhaps those who are fighting for a preconceived opinion.[34]

Boerhaave especially praised the efforts of Bacon and Boyle, who distinguished between superstition and Godly knowledge of nature. Of Bacon, Boerhaave stated that 'he distinguished flawlessly between the most holy se-

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[31] *Ibid.,* 197.
[32] Genesis 6:2.
[33] *CSEE*: 195.
[34] Boerhaave to Mortimer 10 May 1737 in *Correspondence 1*: 219.

crets of piety and wanton fancies of a giddy mind, between death of the body and the heavenly origin of the soul, between Nature and God.' Boyle similarly distinguished 'in the most prudent manner between the principles of religion and the whole field of natural and chemical sciences.' Boyle's writings appealed to the Calvinist Boerhaave for Boyle wrote 'on the style that prevails in the holy scriptures, on the love of God, on the design of God the Creator; on the duty of gratitude and reverence, to be rendered by man to the Almighty God, his Redeemer.' Boerhaave is especially impressed by the 'Boyle Lectures in Defence of the Christian Religion.' Boyle left a bequest for lectures to be given after his death in which 'the love of God and the design of the Creator' would be defended against atheists and enemies of the Christian doctrine. Boerhaave states that 'more could be added on this point, but (...) it is sufficiently clear that the errors with which wayward chemistry has defiled holy subjects, have been most happily erased by the wisdom of the chemists themselves.' [35]

Boerhaave followed Bacon and Boyle and he promoted a chemistry based on a true understanding of the Bible. In other words, he wanted to understand the Bible in its original sense and at the same time save chemistry from its secret and hidden nature. He therefore presented a straightforward, plain, and we might even say reformed chemistry.

Boerhaave's reformation of chemistry did not only consist in the presentation of a chemistry worthy of his God, but it is also visible on a practical level. The reformation ideal of the priesthood of believers, reflects itself in the set-up of Boerhaave's textbook of chemistry, the *Elementa chemiae*. In the same way as every man should be able to read the Bible and be responsible for his own belief and conduct, the chemist should understand the theory of chemistry rather than follow a set of prescriptions. Boerhaave, unlike contemporary textbook writers like Lefebvre, Lémery and Geoffroy, extensively explained the theory and operations of chemistry rather than the preparations of the art. This effects the outlook and content of his whole chemistry. Instead of presenting a set of recipes, he aimed at the understanding of the elements or basic principles of the art. He encouraged his readers not to just follow formulas, but to think about what chemistry is and does. Ultimately this knowledge would enable his pupils to study chemistry independently and so improve the art. In the last part of the chapter we shall see how Boerhaave prescribed the rules for performing chemical experiments and formulating chemical theory.

Boerhaave's educational aim is visible throughout the whole work. In the

[35] All quotes in the paragraph are from *CSEE*: 198-199.

preface he states that he wants 'to teach the first rudiments, and exhibit a few examples of the art.' [36] In doing so, he takes his reader from simple theory and experiment to the most complex chemical processes. Boerhaave similarly stated in his *Materia medica* (1714) that 'the purpose of the book was chiefly to deliver rather the method than materials for treatment of diseases.' [37] The educational, rather than prescriptive character of Boerhaave's chemistry made his chemistry unique among contemporaries and it is not surprising that Shaw called his translation of Boerhaave's *Elementa chemiae*, *A New Method of Chemistry*, for he argued that 'the author's [Boerhaave's] aim is not to improve the matter, but only the manner of the science: that is to dispose the materials of it in a more natural and more useful order, than had ever been done before.' [38]

I shall now discuss the 'first rudiments' of Boerhaave's chemistry and show how chemistry is rooted in his Calvinist faith.

The Elements of Chemistry

Boerhaave definition of chemistry reads:

> Chemistry is an art which teaches the manner of performing certain physical operations whereby bodies cognizable to the senses, or capable of being render'd cognizable, and of being contain'd in vessels, are so changed, by means of proper instruments, as to produce certain determined effects; and at the same time discover the causes thereof; for the service of various arts. [39]

Partington has argued that Boerhaave's definition would be as valuable for cookery as for organic chemistry, even though Johnson adopted it in his *Dictionary* (1755). [40] However, it is not my purpose to discuss whether Boerhaave's definition of chemistry is of any use in understanding early eighteenth-century chemistry. I shall concentrate on the aspects of matter and motion, the two pillars of Boerhaave's chemistry, as both aspects most clearly show the Calvinist nature of Boerhaave's chemistry.

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[36] Boerhaave. (1741). *A New Method*: the author to the reader. Boerhaave also stated that it was his aim to express himself 'in the fewest, as well as the clearest words possible,' which is ironic considering the length of his chemical textbook.

[37] Boerhaave, H. (1741 (1714)). *Materia medica: or, a Series of Prescriptions adapted to the Sections of his Practical Aphorisms concerning the Knowledge and Cure of Diseases.* London: preface.

[38] Shaw comenting on Boerhaave in Boerhaave. (1741). *A New Method*: 1, the author to the reader.

[39] *Ibid.,* 1, 65. 'Chemia est ars docens exercere certas Physicas operationes, quibus corpora sensibus patula, vel patefacienda, vasis capienda, mutendtus, per propria instrumenta: ut definiti & singularis, quidem effectus producti innotescant horumque causae ipsa per effecta pateant, in varios diversarum artium usus.' Boerhaave, H. (1732). *Elementa chemiae*. Leiden: 1, 37.

[40] Partington, J.R. (1961). *A History of Chemistry.* New York: ii, 746.

In 1687 Boerhaave devoted his first public disputation to the subject of cohesion. This was not an unusual topic for in Boerhaave's time the manner of cohesion between particles was a matter of keen dispute. Some philosophers adopted the mechanical theory of Descartes, who held that an external pressure of the surrounding subtle matter keeps up the internal pressure of the particles so they cohere together. Others followed Gassendi and the atomists in arguing that the particles cohere together in a hook and eye construction. Bacon ascribed cohesion to spirits or 'pneumaticals' shaping matter into forms and qualities.[41] In later years, Newton, like Bacon, introduced non-mechanical agents into his system.

In his *De cohaesione corporum* (1687) Boerhaave addressed the problem of cohesion of the parts of a natural body. Boerhaave's explanation is not very clear. I understand that Boerhaave is dissatisfied with the Cartesian explanations of cohesion. Boerhaave states that we cannot ascribe the cause of cohesion to the pressure of an outside air of ethereal particles nor to hook and eye constructions only, but cohesion is the result of another cause.[42] Later in the oration Boerhaave suggests that this cause is the structure of matter. Experiments had shown Boerhaave that particles having a spherical figure repel each other and do not cohere together very well. This is visible in for example mercury, which easily breaks up into innumerable small spherical particles. Sharp pointed particles similarly do not cohere together very well.[43] This means that the more common are points of contact between particles, the stronger particles cohere together.[44] Boerhaave also spoke about the concept of por-

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[41] Dobbs, B.J.T. (1991). *The Janus Faces of Genius. The Role of Alchemy in Newton's Thought*. Cambridge: 21. See also Freudenthal, G. (1990). *The Problem of Cohesion between Alchemy and Natural Philosophy. From unctuous moisture to phlogiston*. In Z.R.W.M. von Martels *Alchemy Revisited. Proceedings of the Internationl Conference on the History of Alchemy at the University of Groningen, 17-19 April 1989*. Leiden: 107-116.

[42] Boerhaave, H. (1687). *Disputatio de cohaesione corporum*. Leiden: LXIX. 'In praecedentibus disputationibus demonstratum dedimus, quod, etiamsi corporum durorum, quaeve firmiter sibi mutuo agglutinatae sunt, partes juxta se invicem quiescant, aut saltem diverso in motu non sint constitutae; et quamvis ramosa partium figuratio apta satis existat ad eas sibi invicem implicandas, valideque connectendas; nec non aëris, aetherisque pressio, particularum separationem, ac divortium utcunque avertere possit; quod tamen neque partium juxta se invicem quies, neque earum ramositas, nec aëris, aetherisve gravitas, pondus, aut pressio, ut prima duritiei, & firmae cohaesionis partium causa admitti queat; hinc aliud illius phaenomeni, vel affectionis corporae principium, & causam quarendam [sic.] esse.'

[43] *Ibid.,* LXXI.

[44] *Ibid.,* LXXIII. 'Ea propter, cum corpora illa quae se invicem paucioribus in punctis contingunt, firmiter non cohaereant; illa vero inter quae frequentior partium contactus intercedit, magis consolidari, & arctius uniri queant, concludendum videtur ad duritiem corporumque cohaesionem, plurimum conferre corum multis in punctis contactum, adeoque ab illa rationem, ac causam aliqualem duritiei, & firmitudinis corporum defumendam esse.'

osity in order to show that the more cavities there are in between particles, the less the parts cohere together. However, Boerhaave does not explain exactly what he means by porosity. It is not unthinkable that he was still influenced by the Cartesian idea that all matter is divided into small parts and that the gaps and pores in between them are filled with an etherial subtle matter. [45] Yet, Boerhaave's suggestion that the more pores the less cohesion, runs against the Cartesian opinion. Boerhaave also seems to imply that cohesion is not entirely mechanical, for at the end of his dissertation he argued for the existence of occult qualities. [46] Boerhaave does not further elaborate on the matter, but, as we shall see later, Boerhaave, after reading Newton, was able to come up with a better explanation.

Thus in 1685, we see a Boerhaave who has moved away from the Cartesianism of his teachers Senguerd, who supervised Boerhaave at that time, and De Volder. Both men taught that nature works through a mechanical interaction of bodies. In their view the extended parts of bodies are inert and conserve the movement they have. De Volder saw no need for the introduction of non-mechanical powers, like elasticity, discontinuities and actions at a distance in order to explain physical phenomena. He argued that the cause of motion in a body always has to be looked for in another body. This means that De Volder's definitions of gravity and cohesion, are entirely different from the Newtonian interpretation of later decades. De Volder showed experimentally in his *Theatrum physicum*, and he argued in his *questiones academicae*, written as a syllabus for the students, that gravity is the result of the pressure of the fast moving subtle particles of water or air, which removes the bigger parts to the periphery. We find this opinion in Boerhaave's disputation as well when he states that it is contrary to reason and experience that a small body cannot move a bigger one. [47] However, while De Volder's world picture was entirely mechanical, with only extended matter and modes to account for, Boerhaave did believe in the existence of occult qualities.

Not long after his graduation in 1690, after having read the first edition of Newton's *Principia*, Boerhaave started explaining his *affectionis corporae principium* and *occultae qualitates* in terms of Newtonian forces. In the preface to Newton's *Principia* Boerhaave read:

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[45] For a discussion on the influence of Cartesian matter theory in Dutch natural philosophy see: Ruestow, E.G. (1996). *The Microscope in the Dutch Republic. The Shaping of Discovery.* Cambridge: 40-41.
[46] Boerhaave.(1687). *De cohaesione corporum*: adj.II. 'Dantur occultae qualitates.' Boerhaave also added this statement to his first disputation on the human mind. Boerhaave, H. (1687). *Disputatio pneumatica de mente humana prima*. Leiden: VI.
[47] Boerhaave, H. (1687). *Disputatio pneumatica de mente humana prima*. Leiden: cor. VII. 'Corpus minus non posse movere majus, experientiae repu[g]nat, & rationi.'

I [Newton] am induced by many reasons to suspect that they [phenomena of nature] may all depend upon certain forces by which the particles of bodies, by some cause hitherto unknown, are either mutually impelled towards one another, and cohere in regular figures, or are repelled and recede from one another. These forces being unknown, philosophers have hitherto attempted the search of nature in vain; but I hope the principles here laid down will afford some light either to this or some truer philosophy. [48]

From the beginning of his University teaching career in 1701 Boerhaave, perhaps under the influence of Newtonianism, gave his particles non-geometrical properties, such as impetus, elasticity, gravity and attraction, in addition to their shape and size. In 1703, in his oration on the usefulness of the mechanical method in medicine, Boerhaave argued that 'through the effects of this art [mechanics], then, no mass is found to be immovable anymore, however small the moving forces may be.' [49] Boerhaave does not directly define the moving forces as Newtonian even though he mentioned Newton as one of the most important mechanicians in his time. In later years he explicitly referred to the Newtonian forces of attraction in order to explain cohesion. He held that Newton's force of attraction denotes an unknown cause that creates an apparently spontaneous motion through which bodies are brought into mutual contact. [50]

Boerhaave is generally known as the first to have introduced Newtonianism at Leiden University. Boerhaave himself referred often to Newton as 'the man in whom nature has revealed the acme of human perspicacity.' [51] Moreover, contemporaries praised Boerhaave's Newtonian approach to nature. Nevertheless historians of science are divided over the issue how many Newtonian ideas Boerhaave adopted. Some historians have argued that Boerhaave's ideas were mainly Newtonian in outlook, others have suggested that Boerhaave tried to make his system commensurate with Newton's ideas but that many of Boerhaave's thoughts surpassed Newton's mechanistic system. [52] In the

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[48] Newton, I. (1729). *Mathematical Principles of Natural Philosophy and his System of the World* (Andrew Motte, Trans.). London: Newton's preface to the first edition, xviii.

[49] *URM*: 95.

[50] *CCP*: 163.

[51] *CSEE*: 212.

[52] For historians arguing Boerhaave's Newtonianism see: Metzger, H. (1930). *Newton, Stahl, Boerhaave et la Doctrine Chimique*. Paris; Cohen, B. (1966 (1956)). *Franklin and Newton. An Inquiry into Speculative Newtonian Experimental Science and Franklin's Work in Electricity as an Example Thereof*. Cambridge, Massachusetts: 222-225. For historians adopting a critical attitude towards Boerhaave's Newtonianism see: Schofield, R.E. (1970). *Mechanicism and Materialism. British Natural Philosophy in an Age of Reason*. New Jersey; Shapiro, A.E. (1993). *Fits, Passion and Paroxysms. Physics, Method, and Chemistry and Newton's Theories of Coloured Bodies and Fits of Easy Reflection*. Cambridge; Hall, A.R. (1963). *From Galileo to Newton 1630-1720*. London.

next chapter we shall see that Boerhaave adopted Newtonian views in the 1700s, but that in the 1710s Boerhaave modified his views again, and he became a much more moderate Newtonian.

For now it is not so much the question whether Boerhaave gave an exact replication of Newton's theories. Instead we should be much more concerned with the question why Boerhaave initially was attracted to Newton's ideas and why Boerhaave's contemporaries thought that Boerhaave's ideas were so similar to those of Newton? I shall suggest that Boerhaave was attracted to Newtonian natural philosophy because, unlike Descartes and Spinoza, Newton presented a system that in outlook was in accordance with his own Calvinist beliefs. Newton's natural philosophy was based on the belief in God the creator, who through His providence sustains the world. It can be objected that Newton's religion held anti-Trinitarian beliefs, and is therefore entirely different from Calvinism, yet Newton mainly spoke about his religious beliefs in secret. For the eyes of the world he preached generally accepted theological ideas. [53] This means that Boerhaave did not know about Newton's heretical beliefs. He had access only to the *Principia* and the *Opticks*, which presented him with a theology which was very similar to his own.

Newton's God, like the Calvinist God, rules the earth continually. Nothing happens out of necessity, but out of God's free will. God created the world as He pleased, He designed the framework and he presides over it actively as well. Newton wrote:

> This most beautiful system of the Sun, Planets, and Comets, could only proceed from the council and dominion of an intelligent and powerful Being (...) This Being governs all things, not as the soul of the World, but as Lord over all. [54]

Newton argued that God also installed the laws of nature. Yet, there is no necessity involved, so God can change everything at any instant. For this reason it is idle to think that it is possible to figure out the structure of the world by using the intellect only. Philosophers who do so assume that the world exists out of necessity, and that natural laws follow from that same

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[53] For Newton's religion see: Snobelen, S. (1999). 'Isaac Newton, Heretic: The Strategies of a Nicodemite.' *British Journal for the History of Science, 32*, 381-419 Snobelen's article is a reconstruction of Newton's private and public religious worlds. See also: Westfall, R. (1980). *Never at Rest: A Biography of Isaac Newton*. Cambridge; Manuel, F.E. (1974). *The Religion of Isaac Newton*. Oxford; Force, J.E. (2000). 'The Nature of Newton's 'Holy Alliance' between Science and Religion: From the Scientific Revolution to Newton (and Back Again).' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* . Cambridge; McGuire, J.E. (2000). 'The Fate of the Date: The Theology of Newton's *Principia* Revisited.' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* (pp. 271-295). Cambridge.

[54] Newton. (1729). *Mathematical Principles*: 388.

necessity. True knowledge about the creation could only be based on observation and experiment. Therefore the study of nature is the starting point in knowing God. In using this premise as his starting point, Newton could develop a form of atomism free from atheism and materialism. He rejected the corpuscular philosophy based solely on the shape and motion of particles. Instead he explained the system of the world in terms of particles and invisible forces in between particles. Moreover, in the *Opticks* Newton proposed chemistry as the best means to obtain experimental knowledge of hidden forces in the invisible realm of nature. [55]

The result of Boerhaave's Calvinist reading of Newton is that Boerhaave's chemistry is influenced by Newtonian matter theory. His ultimate simple corpuscles resemble Newton's 'solid, massy, hard, impenetrable, moveable particles' created by God in the beginning. [56] Boerhaave defined particles as

> corpuscles, which when alone, are unchangeable by any cause hitherto observed; being endued by the author of nature with such a degree either of hardness, as that they are incapable of being divided into less parcels, or being changed in their figures. [57]

Boerhaave states that 'the Creator has infused a principle in things whereby certain corpuscles unite in little masses, so firmly cohering that no power implanted in nature, or to be excited by art, can divide them into less parcels.' [58] Consequently God Himself is the Author of the most simple bodies. Without pretending to know them entirely, insight into the working of the smallest parts would bring man to a closer understanding of and a higher admiration for the Creator. Hence Boerhaave's motto, *simplex veri sigillum*, simplicity is the hallmark of truth. [59]

Boerhaave distinguished between elements and these ultimate, pure particles. He states that the philosophers used to consider them the same, but that

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[55] In the thirty first Query at the end of the *Opticks*, Newton proposed many chemical experiments in order to discover the powers of attraction between bodies. See also: McGuire, J.E. (1968). 'Force, Active Principles, and Newton's Invisible Realm.' *Ambix, 15*, 154-208: 164-165.

[56] Newton, I. (1730). *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light* (4 ed.). London: 400.

[57] Boerhaave. (1741). *A New Method*: 1, 160.

[58] *Ibid.,* 1, 222.

[59] In the next chapter I shall argue that it is not unlikely that Boerhaave's motto is based on Newton's first rule of reasoning in philosophy, which says that 'nature is pleased with simplicity, and affects not the pomp of superfluous causes.' Newton, I. (1729). *Mathematical Principles of Natural Philosophy and his System of the World* (Andrew Motte, Trans.). London: 398. Luyendijk-Elshout and Kegel-Brinkgreve did research into the source of the sentence, but did not trace an unmistakable source. However, they argue that it is a well known sentence in classic writings. They mention the example 'simplex est natura veritas' as a variation on Boerhaave's motto. *Orations*: 117, n. 17.

they realised that the elements fire, air, water, earth, alcohol, mercury and the presiding spirit in every body, when absolutely simple, appear to be fine, permanent elements. However, it is unclear whether they can be obtained in their purest form.[60] Therefore, when Boerhaave speaks about the four elements fire, air, water and earth he is not strictly speaking about simple corpuscles, but about complex arrangements of primary particles. Air, for example, is a 'universal chaos, consisting of almost all kinds of corpuscles, confusedly jumbled together, and constituting one mass.'[61] Except perhaps in the case of pure fire, for 'fire may perhaps be exhibited pure and elementary, as it penetrates gold, and other of the most solid bodies.'[62] Moreover, we shall see in a later part of this chapter that in the end of his life, Boerhaave was busy trying to purify mercury.

In Boerhaave's chemistry the traditional elements fire, air, water and earth are classified as 'instruments of chemistry' being 'capable of a particular motion; which being thence apply'd to the body intended to be chang'd, produces the requisite change therein.'[63] Thus the elements serve the same purpose as utensils, vessels and menstrua. The passive matter of earth and water form the vessels in which God infuses the active principles of fire and air in order to move the bodies. Together the instruments serve the purpose of changing bodies by means of motion. The elements are as it were divine tools through which God operates His creation. In this sense God is in control of the affairs of the world in the same way as the chemist handles chemical processes in his laboratory. This means that the purpose of Boerhaave's chemistry was not to obtain knowledge about the original and pure principles of matter. Instead Boerhaave was much more concerned with discovering God's providential hand in His creation. For this reason Boerhaave stressed the impor-

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[60] Boerhaave. (1741). *A New Method*: I, 160. Boerhaave's opinion was generally accepted in his time. Boyle and N. Lémery similarly argued that principles are only principles in respect of ourselves, and that it is well possible that they can be further divided. Boyle, R. (1661). *The Sceptical Chemist. Or Chymico-Physical Doubts & Paradoxes, Touching the Spagyrist Principles.* London; Lémery, N. (1686). *A Course of Chymistry. Containing an easy Method of Preparing those Chymical Medicines which are Used in Physick with Curious Remarks and Useful Discourses upon each Preparation, for the Benefit of such who Desire to be Instructed in the Knowledge of this Art.* (Harris, W., Trans.). London. On the problem of chemical composition see also: Boas, M. (1958). *Robert Boyle and Seventeenth Century Chemistry.* Cambridge: chapter IV; Thackray. (1970). *Atoms and Powers*: 166-167; Clericuzio, A. (2000). *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century.* Dordrecht/London.

[61] Boerhaave. (1741). *A New Method*: I, 399.

[62] *Ibid.,* I, 167.

[63] *Ibid.,* I, 170. See also the article of R. Love in which she argues that Boerhaave treated fire as an element of matter as well as an instrument of chemical change. Love, R. (1974). 'Herman Boerhaave and the Element-Instrument Concept of Fire.' *Annals of Science, 31,* 347-559.

tance of knowledge of the forces of motion and change much more than he promoted a knowledge of the constituent principles of the natural body. [64]

The aim of chemistry, according to Boerhaave, is the changing of bodies by means of motion. [65] Boerhaave did not restrict the objects of change to sensible bodies only, but he also incorporated insensible objects in as far as they can be made visible either in themselves or in their effects. [66] In so doing Boerhaave incorporated invisible forces in his chemistry. Motion and change were so important in Boerhaave's chemistry that he even explained the act of Creation in terms of change and motion.

> Suppose, for instance a single corporeal mass wholly at rest; that is, all its particles mutually quiescent among themselves, such as it was in the beginning, must it not remain unchanged in all future times? (...) But if a motion be raised among the parts we must conceive an in-exhaustible variety of effects and changes producible therefrom. [67]

Boerhaave defined matter to be inert and passive, which means that motion must be derived from a metaphysical cause. In Boerhaave's eyes the Creator constantly infuses motion into matter, so that it can grow and reproduce. For this reason man can behold the works of God when doing chemical experiments.

Motion may be excited by means of fire, be suppressed when already raised, be changed in its degree, increased or diminished, the quantity of it may remain the same, or only its course and direction be changed. Boerhaave was especially attracted to Newton's *Opticks*, in which Newton explained chemical phenomena as effects of forces between particles of matter. [68] In 1718, upon accepting the chair of chemistry, Boerhaave argued that

> when he [Newton] explains the laws, actions and forces of bodies – basing himself upon the careful study of their effects – he appeals to chemistry and to nothing else; when he again relates the forces so found to other phenomena that are still to be explained he calls upon purely chemical methods, and through his illustrious example he demonstrates that if chemistry did not exist it would be impossible for even

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[64] For a further discussion on the widespread debates on the validity of analysis by fire see Debus, A.G. (1967). 'Fire Analysis and the Elements in the Sixteenth and the Seventeenth Centuries.' *Annals of Science, 23*, 127-147.

[65] Boerhaave. (1741). *A New Method*: 1, 155.

[66] *Ibid.,* 1, 66.

[67] *Ibid.,* 1, 156.

[68] Thackray has argued that 'Newton's most fundamental contribution to the development of matter theory was his replacement of the sort of 'corpuscular philosophy' favored by, say Boyle, with a view of nature based on particles and the forces in between them.' Thackray. (1970). *Atoms and Powers*: 26.

the most perspicacious of mortals to gain insight into the proper nature and forces of single bodies. [69]

It is no wonder that Petrus Musschenbroek directly linked the systems of Newton and Boerhaave when he stated that

one should have continually before one's eyes these two perfect models that the two great men of the century have left us (...) the *Opticks* of Newton and the Chemistry of Boerhaave. [70]

Boerhaave argued that in all cases the changing of bodies is directed towards finding new appearances and powers, created by God in the beginning. [71] According to Boerhaave 'chemistry is best adapted for discovering these latent peculiar powers,' which makes chemistry 'the best and fittest means of improving natural knowledge.' [72] He refers to Newton who, when explaining the laws, actions and forces of bodies, used chemistry as his sole guide. In the next chapter I shall discuss how Boerhaave's aim for chemistry, i.e. the revealing of new appearances and powers, was not so much Newtonian anymore (even though Boerhaave used Newton as his major example), but acquired a specific Dutch Calvinist meaning. For now it is sufficient to know that for Boerhaave, chemistry, of all natural philosophy, is best suited to open the 'Bible of Nature' and know God through His creation. Therefore, Boerhaave's God is implicit in every experiment he did and in every theory he developed.

Boerhaave's solution for the problem of cohesion illustrates how he incorporated God in his chemistry. Boerhaave's theory of menstrua shows most clearly how he combined mechanical ideas based on the shape and motion of particles and powers peculiar to every body in order to explain the nature of cohesion. Boerhaave defined a menstruum as 'a body, which, when artificially applied to another, divides its subtlety; so that the particles of the solvent remain thoroughly intermixed among those of the solvend. [73] It is called a menstruum because the chemists used to heat the body and the solvent for a philosophical month, which is forty days. The reason for looking at menstrua

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[69] *CSEE*: 212.

[70] Musschenbroek cited in Metzger. (1930). *Newton, Stahl, Boerhaave*; Cohen, B. (1966 (1956)). *Franklin and Newton. An Inquiry into Speculative Newtonian Experimental Science and Franklin's Work in Electricity as an Example Thereof*. Cambridge, Massachusetts; Schofield. (1970). *Mechanicism and Materialism*: 147.

[71] Boerhaave. (1741). *A New Method*: 1, 173.

[72] *Ibid.*, 1, 173.

[73] Boerhaave. (1741). *A New Method*: 1, 489.

is obvious because menstrua are used to break up parts of matter, which also means that you have to understand how the parts cohere together.

The action of a menstruum depends upon motion, for if a menstruum did not change the motion of the parts, nothing would happen. The nature of this motion is very difficult to understand as it originates from causes such as gravity, elasticity and magnetism. Boerhaave encouraged his readers to further inquire into the causes of motion 'for he who can learn the power of menstrua, will understand the whole nature of chemistry; and be able to perform all its noblest operations.' [74] Boerhaave divided menstrua into four groups according to the different ways of dissolving bodies.

The first group of menstrua acts mechanically. Boerhaave referred to a simple power common to all bodies. He observed that fire acts as a universal mechanical solvent as all natural bodies answer to the force of fire and dissolve as soon as the heat of bodies increases. Secondly, some menstrua show a repelling force. For example, lead and mercury mixed and ground together repel all matter that is foreign to both. This property makes it easy to separate impurities from the two metals. The mixture of lead and mercury also works according to the force of attraction since as soon as the repelling power has separated the heterogeneous parts, both metals attract each other and cohere together. The fourth kind of menstruum combines the three preceding ones and is most common in nature.

'The principal difficulty,' according to Boerhaave is 'to understand, by what means the solvent enters the pores of the solvend.' It is difficult since 'there are very few instances of merely mechanical solutions: whence we are obliged to make use of those wherein mechanical causes act conjointly with others.' [75] Like in his first disputation on the cohesion of bodies, Boerhaave argued that the pores between the particles of the solvent are important. If the pores are too small the particles cannot penetrate into the matter and no internal solution can happen. This means that solid bodies are poor menstrua while liquids have a much better dissolving capacity. The size and figure of the pores and of the particles are particularly important for they should fit together like a lock and its key. This means that every body has its menstruum giving it its peculiar and singular power of acting. However, very often the least particles of a menstruum insinuate themselves only partially into the pores of the solvend, which makes the surface of the solvend look like a bristle. When the particles of the menstruum are put in motion they strike with a different direction on

[74] *Ibid.*, I, 495-496.
[75] *Ibid.*, I, 507.

all sides upon the particles sticking in the surface of the solvend. In turn the particles will act like wedges breaking up the internal cohesion of the body.

Unlike the above mentioned mechanical causes, Boerhaave also introduced non-mechanical causes. Boerhaave held that mechanics cannot sufficiently explain why the particles of a fluid at rest, surrounding a solid body would penetrate the body and dissolve its parts. Hydrostatic laws would explain a compression of the fluid, and in case the solvend is soft the entering of particles into the pores, but at the same time the particles would cohere more strongly together rather than dissolve. Boerhaave argued that in addition to mechanical causes the forces of attracting, repelling, and changing in many other ways, would be needed to fully explain the action of menstrua.

Moreover, Boerhaave introduced a mystical cause in order to explain why the particles of the solvent dissociate themselves from one another and unite with the particles of the solvend, rather than remaining in their former situation. The same cause also explains why the particles of the solvend, separated by the action of the solvent, remain united with the parts of the menstruum; rather than that the dissolving and dissolved particles unite by the affinity of their own nature into homogeneous bodies. Boerhaave ascribed the cause of dissolution to a 'certain power with which the parts of a menstruum endeavour to attract the dissolved parts, rather than to repel them.' Therefore, Boerhaave states, 'we are not to imagine this is a mechanical action, or an unfriendly commotion; but rather an appetite of union.'[76] The Latin original expresses this union even stronger as a union of love or friendship.[77]

Thus, although Boerhaave described the mechanical actions of menstrua he also emphasised the limitations of a purely mechanical explanation. He argued that all different bodies have different powers, which cannot be brought back to a mechanical power. He wrote:

> I have learnd from experience, that different parts, of different properties, are mix'd in with all such bodies; whilst these parts have respectively their own peculiar powers of attracting, repelling, and changing themselves many other ways. We must not, therefore, attribute more to mechanical power, than the Author of nature has given to natural bodies; nor extend this power beyond its proper bounds, in accounting for chemical operations. This declaration is forc'd from me, by the regard I bear to truth; and may clear me from the imputation of pretending to explain chemical operations upon mechanical principles.[78]

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[76] *Ibid.,* I, 493.

[77] Boerhaave. (1732). *Elementa chemiae*: ii, 98. 'non igitur hic etiam actiones mechanicae, non propulsiones violentiae, non inimicitiae cogitandae, sed amicitia; si amor dicendus copulae cupido.'

[78] Boerhaave. (1741). *A New Method*: I, 511.

Boerhaave did not pretend to entirely understand the cause of cohesion. This can be ascribed to his Calvinist conviction that the ultimate causes of nature ultimately refer to God. They must remain hidden for man cannot climb up to a Divine understanding. Boerhaave's warning is serious as he thought that 'the true cause which makes extended and impenetrable parts thus cohere, is the order of nature, or God himself, its Author.' [79]

Invariably, Boerhaave's 'occult qualities' refer back to the working of God in His creation. My argument, although unheard of in the case of Boerhaave, is not new in general. In recent years historians of science have become increasingly aware of the influence of the theological issues of providence and divine will upon the development of natural philosophy. For example, M. Osler has argued that Gassendi's scientific knowledge originated from his voluntarist theology. [80] In the case of Newton it is by now generally accepted that his theology is of crucial importance in understanding his physics and chemistry. B.J.T. Dobbs has argued that Newton's introduction of ether solved the problem how God could work through providence in a world that was entirely mechanical, i.e. working according to the laws of matter and motion. [81] Other historians of science as well have argued that Newton's forces associated with particles, i.e. *vis inertiae*, gravity, fermentation and cohesion, are manifestations of God's presence and power in the world. [82] McGuire has also argued that for Newton all matter moves through a universally distributed force of gravitation and that God is the direct cause of this force, motion and other active principles. [83] I shall also argue that Boerhaave's occult qualities are instruments, or Calvinist secondary causes, through which God operates in an otherwise mechanical world.

Boerhaave strongly believed that the creation is wholly inspired by the Creator and that He gives every natural body its own unique character. He argued that God had lodged a *spiritus rector* or presiding spirit into all tenacious and durable matter. This spirit is so subtle that it is only perceivable by its smell or taste. It determines the peculiar character of a body and animates

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[79] Boerhaave, H. (1719). *A Method of Studying Physick* (Mr. Samber, Trans.). London: 22.

[80] Osler, M. (1983). 'Providence and Divine Will in Gassendi's Views on Scientific Knowledge.' *Journal of the History of Ideas, 44*, 549-560; Osler, M.J. (1991). 'Fortune, fate and divination: Gassendi's voluntarist theology and the baptism of Epicureanism.' In M.J. Osler (Ed.), *Atoms, Pneuma, and Tranquility. Epicurean and Stoic Themes in European Thought* . Cambridge.

[81] Dobbs. (1991). *The Janus Faces of Genius*: 33-38.

[82] Thackray. (1970). *Atoms and Powers*: 26-27.

[83] McGuire, J.E., & Rattansi, P.M. (1961). 'Newton and the Pipes of Pan.' *NRRS, 21*, 108-143: 112; McGuire, J.E. (1967). 'Transmutation and Immutability: Newton's Doctrine of Physical Qualities.' *Ambix, 14*, 69-95; McGuire, J.E. (1968). 'Force, Active Principles, and Newton's Invisible Realm.' *Ambix, 15*, 154-208

its parts.[84] The ancient adepts measured the *spiritus rector* as being always 1/8200 part of the smallest particles of the oil in which it resides.[85] They also state that it is so active that, when nourished in a warm environment and sustained by a due heat it is extremely moveable and endowed with the power of generating a spirit like itself. For this reason they call the *spiritus rector* 'the vital spark, *spiritus intus alens*, the internal nourishing spirit, and many other the like names.'[86]

Boerhaave states that some adepts claim to have seen the spirit sealed up in the sulphur of metals and fossils and that the same spirits when freed are exceedingly active, able to insinuate into any other body and of great efficacy against diseases, which was a common opinion in alchemy. Boerhaave referred to the general opinion that sulphur, or rather philosophical sulphur, was 'an abstract principle, an inherent constitutive element within matter.' In the forming of metals, mercury was said to consist of matter, and sulphur of form. In a refined form sulphur was generally symbolised by the sun, hence the mentioning of *spiritus rector* as the son of the sun.[87] Boerhaave does not discuss the alchemical notions any further. He did not deny the truth of the matter, but since he felt that he had not mastered the subject he left it to the adepts.[88]

The working of God in His creation is nowhere more evident than in Boerhaave's theory of pure fire. Unfortunately the influence of Boerhaave's Calvinism on his theory of fire has never been recognised. Already in the *Encyclopédie* Diderot and d'Alembert in their article on fire took God out of Boerhaave's ideas.[89] Until recent years historians of science have similarly ignored the importance of Calvinism for Boerhaave's views. H. Metzger has argued that the belief in a fire permeating all bodies was an established idea and can be traced back to the Cartesian doctrine of an all pervading subtle matter as also represented in the writings of the chemists Wilhelm Homberg and Nicholas and Louis Lémery.[90] R. Love has traced Boerhaave's idea of fire to the

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[84] Boerhaave described a process of natural circulation in order to explain how the *spiritus rector* lodges itself in a natural body. This process is comparable with the process of natural circulation as described by Nicholas Lefebvre in Lefebvre, N. (1664). *A Compleat Body of Chemistry*. London and by Nicholas Lémery in Lémery, N. (1696). *Cours de Chymie*. Paris.

[85] Unfortunately Boerhaave does not tell how the adepts came to their measurement of the *spiritus rector*.

[86] Boerhaave. (1741). *A New Method*: 1, 169.

[87] Abraham, L. (1998). *A Dictionary of Alchemical Imagery*. Cambridge: 193.

[88] Boerhaave. (1741). *A New Method*: 1, 170.

[89] Diderot, & d'Alembert. *l'Encyclopédie ou dictionaire des sciences, des arts et des metiers*: 599ff, article on *feu*.

[90] Metzger. (1930). *Newton, Stahl, Boerhaave*: 218-219.

classic writings in which fire is associated with divine attributes. She has argued that well into the seventeenth century the mystical symbol of fire was the representation of God's universal power and presence.[91] It is true that Boerhaave's belief in an all pervading substance was not unique. For example the Stoic concept of *pneuma* shows similarities with Boerhaave's pure fire as well as Jacob Boehme's divine substance of nitre.[92] However, Boerhaave's fire is a specifically Calvinist secondary cause through which God actively operates in the world.

Fire, according to Boerhaave, is 'an almost universal solvent, as it liquifies almost all bodies, if applied in a proper proportion to them.'[93] Moreover it is 'chief cause and principle of almost all the effects cognizable by our senses.'[94] Its minute, hard, and impenetrable particles insinuate themselves into the pores of all bodies and at length unite with them. Boerhaave argued that 'the elements of fire are found everywhere; in the most solid gold, as well as in the most empty vacuum of an airpump; being present equally and in the same quantity, in all bodies and spaces.'[95] It is this minuteness of the constituent parts of fire, penetrating into the most solid matter, that led many chemists to err, 'being so incomprehensible, by reason of its extreme minuteness, that it eludes our nicest research; so that with many it passes for a spirit rather than a body.'[96] The mistake did not only affect chemistry but also medicine. Boerhaave reminds his readers of 'the strange opinions broach'd by physicians concerning the innate heat, radical moisture, and the like matters.'[97] Boerhaave considered fire the most simple body, but at the same time he argued that even fire is an arrangement of particles, for Newton had shown that even in the most simple rays of light the greatest diversity in colour, refraction,

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[91] Love, R. (1972). 'Some Sources of Herman Boerhaave's Concept of Fire.' *Ambix, 19* (3), 157-174. Love's argument that the belief in a spiritual substance like fire was not unique is obvious when comparing Boerhaave's concept of fire to for example Jacob Boehme's divine substance saliter, which has the same qualities. However, Boerhaave's concept of fire is specifically Calvinist.

[92] Principe, L.M., & Weeks, A. (1989). 'Jacob Boehme's Divine Substance Saliter: its Nature, Origin, and Relationship to Seventeenth-Century Scientific Theories.' *British Journal for the History of Science, 22*, 53-61. See also Taylor, F.S. (1953). 'The Idea of the Quintessence.' In E.A. Underwood (Ed.), *Science, Medicine and History. Essays on the Evolution of Scientific Thought and Medical Practice written in honour of Charles Singer* (vol. 1, pp. 247-265). London. Note that Taylor's quintessence is something between matter and spirit, while Boerhaave's fire is corporeal. Osler, M.J. (Ed.). (1991). *Atoms, Pneuma, and Tranquility. Epicurean and Stoic Themes in European Thought*. Cambridge.

[93] Boerhaave. (1741). *A New Method*: 1, 502. Boerhaave did not believe in pure fire as a universal solvent, as was commonly believed, for he argued that although fire dissolves many bodies it does not dissolve all. *Ibid.,* 1, 368.

[94] *Ibid.,* 1, 206.

[95] *Ibid.,* 1, 207.

[96] *Ibid.,* 1, 206.

[97] *Ibid.,* 1, 208.

reflection and motion can be found.[98] Boerhaave's pure fire differs from vulgar fire. The former is the true element and can be seen as an all pervading spirit, whereas the latter is the fire which is generally known by its flame, smoke and ashes.

In order to estimate the presence and quantity of pure fire, Boerhaave investigated its effects. He observed that neither heat and light, nor colour, are of any help in defining the nature of fire, for they all depend upon a subjective perception. For example a hot iron, not yet red, still burns the hand and a cave having the same temperature at all times feels cold in summer and warm in winter. After long observations Boerhaave concluded that the only effect that gives insight in the nature of fire is the swelling of matter upon heating without the matter gaining any weight.[99] The reason for the swelling is that fire agitates the particles of the body, so that it expands all its parts. It likewise appears that this expansion, and the rarity of the body that follows, is successively increased, until finally the whole mass will melt. In general bodies are loosened and weakened by fire, an effect that is also visible in the human body for Boerhaave argued that sick feverish people and people living in the hot climates of Asia and Africa are lazier than healthy people and people living in cool climates.

Cold has a reverse effect on the particles of bodies, for it contracts all bodies. Since cold keeps the particles of bodies together it must be innate, or implanted in the nature of the body itself, and is similar to the force of cohesion. By contrast the expanding power of fire must consequently be extrinsic, or superadded to bodies, and therefore violent. From this it follows that the end of cold is a state of absolute rest, between coherent particles, and that the state of extreme fire is a perpetual agitation of dissolved particles. These two principles, the one contractile, the other expansive, continually work through all bodies and therefore can be said to be the cause of a multitude of corporeal actions. Thus defined, fire is acknowledged as the instrumental cause of all motion. The motion of fire itself, however, must be derived from some other higher, and more metaphysical cause for Boerhaave's fire is material and he defined matter as being inert, and passive. Although fire produces its effects by motion, Boerhaave warns that the action of fire cannot make any alteration in the elementary substance of bodies, the atoms and molecules, for it is necessary that what acts upon an object, must be out-

[98] *Ibid.*, I, 363-364.

[99] Boerhaave made the common distinction between primary and secondary qualities (although he did not call it like that). Extension is like a primary quality determining the nature of fire, while heat, light and colour are accidental or secondary qualities dependent upon individual experience.

side that object. Which means that the fire cannot penetrate the elementary parts, but only enters the pores and interstices of bodies.

Boerhaave considered alcohol the principle of inflammability that 'the Author of nature (...) has every where hid within the veins of incombustible bodies.' [100] Moreover, Strother remarked in a footnote in his translation of Boerhaave's *Elementa chemiae* that the etymology of the word alcohol is derived from the Hebrew words for *Deus* and *potens*, and thus refers back to God's omnipotence. [101] Contrary to the principle of phlogiston, which is the matter and principle of fire, introduced by Georg Ernst Stahl (1660-1734), Boerhaave's ideas on alcohol and pure fire have never received much attention among historians. The reason for this neglect is perhaps that phlogiston has generally been seen as the basis of Stahl's animism and has been considered of crucial importance in the revolutionary insights of Lavoisier. Boerhaave's system on the other hand, has always been perceived as purely mechanical without allowing for non-mechanical causes. Boerhaave, in his chemical work never explicitly referred to Stahl's phlogiston, even though he recommended Stahl's work to his students. However, Boerhaave's ideas on fire and alcohol are as important in the understanding of Boerhaave's chemistry as phlogiston is in comprehending Stahl's work.

Boerhaave had observed that alcohol upon heating turns into a pure flame, which shows all the characteristics of pure fire. Unlike other combustible bodies, alcohol is wholly inflammable and does not afford any smoke or ashes while its whole substance transforms into fire. The hard incombustible particles of water, salt and earth, intimately mixed with the combustible matter of alcohol form the second cause of material fire. When agitated by the pure flame they increase the violence of the fire through their vibration, an effect which is most visible in gunpowder. Gunpowder, when spread out in a flame does not have a great effect, but as soon as it is compressed in a cylindrical barrel its particles vibrate so violently and add so much violence to the flame that it is powerful enough to project a leaden bullet out of the barrel with great force. [102] This experiment also shows that a cause is necessary to keep a flame going, or in other words to keep the pabulum and the fire joined together. Boerhaave had observed that a fire extinguishes in a vacuum and burns more fiercely when a wind is present. This led him to the conclusion that the pressure of air applies the parts of fire together.

However, Boerhaave denied that combustible bodies, when burned and transformed into invisible parts, change into pure fire itself. Pure fire, he

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[100] *Ibid.*, I, 314.
[101] Strother, E. (1749). *Dr. Boerhaave's Elements of Chemistry*: 177.
[102] Boerhaave. (1741). *A New Method*: I, 332.

states, is 'unchangeable and perhaps void of gravity,' so it is impossible to create or generate fire *de novo*.[103] Nevertheless pure fire can be collected in one place, through for instance attrition, the parallel lines of the sun and the foci of glasses and be preserved in a suitable pabulum which is always either alcohol or oil. Accordingly Boerhaave experimented on alcohol in order to discover the manner wherein fire is contained in the fuel of combustible bodies. Boerhaave was disappointed to find that upon heating, alcohol transforms into a vapour that resembles water and no longer retains the nature of alcohol. This put an end to Boerhaave's speculations and, like his speculations on the nature of the *spiritus rector*, Boerhaave referred back to the alchemists. He argued that the pure principle of inflammability is perhaps the same as philosophical sulphur, the principle the ancient alchemists called the 'son of the sun, the issue of fire, and the internal fire of things' distributed through a large quantity of water, intimately united with its particles, that disappears on its contact with fire.[104] This brings us to the theological meaning of Boerhaave's concept of pure fire. Although Boerhaave believed that pure fire is corporeal, he is not so sure that elementary fire also possesses weight and gravity in proportion to its solidity. Since pure fire is distributed throughout the whole universe, Boerhaave is inclined to believe that God created fire 'without gravity and without any direction to a certain point.'[105] Fire is lodged in the universe by God with a power of exciting such motions in bodies as are necessary to change them. The chemist is especially privileged since although he cannot generate fire, he is best suited to study its effects and use it in his practice. Moreover, it enables him 'to understand and adore the power and wisdom of the Creator, from a clearer view of his works.'[106]

However, although it is always and everywhere present it does not always show itself in its active form. It has to be kindled by vulgar fire, rubbing, attrition or be directed by the parallel lines of the sun. Boerhaave also observed that the harder and more rigid a body appears, the stronger fire acts upon its particles. Consequently fire shows itself least in rare bodies in which the particles hardly cohere together. This means that fire depends on the action of solid bodies in order to present itself to man and also that it can freely pass throughout all space without showing any of its usual effects, like light, heat, colour, etc. Boerhaave points to the rays of the sun in order to prove his point. He states that as we ascend nearer to the sun, fewer bodies hinder the equal action of the sun's rays, but instead of it getting warmer it can be ex-

[103] *Ibid.*, I, 339.
[104] *Ibid.*, I, 320.
[105] *Ibid.*, I, 420.
[106] *Ibid.*, I, 378.

tremely cold on the tops of mountains. This made Boerhaave think that pure fire becomes of a more divine nature as it is less confined to earthly substance and the less affected by the weight of the atmosphere, i.e. the higher it ascends to the tops of the mountains. He states:

I have sometimes wonder'd upon reading what the ancient alchemists relate, *viz.* that in pure fire is the utmost silence and rest, and even that God resides therein; from whence he sends out his ministring fires to move and vivify bodies, which otherwise would die by their inactivity; thus performing the orders of the Almighty Maker. To the like effect we find testimonies among the ancient Jews and sacred writers. [107]

Boerhaave supported his idea with biblical texts mentioning the working of God through fire. He referred to the story of the burning bush through which God spoke to Moses, as well as to the description of the top of the Mount Sinai which was surrounded by smoke because God descended upon it in fire. [108] Boerhaave not only mentioned texts in which God appears in fire, but he also mentioned passages in which God works through fire. He read in numerous bible texts that God sent out His ministering fires to kindle sacrifices, and also to consume the wicked, for as Boerhaave read, 'the Lord thy God is a consuming fire.' [109] Boerhaave, like Calvin had done before him, mentioned Psalm 104 wherein the creation is depicted as the clothes of the Creator. God's ministers are like a 'flaming fire:'

O Lord my God, thou art very great; thou art clothed with honour and majesty. Who coverest *thyself* with light as *with* a garment: who stretchest out the heavens like a curtain: who layeth the beams of his chambers in the waters: who maketh the clouds his chariot: who walketh upon the wings of the wind: who maketh his angels spirits; his ministers a flaming fire. [110]

Boerhaave's chemical analysis of air, reinforced his argument of the divine nature of fire. He argued that a hidden virtue is in the air, which he called

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[107] *Ibid.,* 1, 244. The Latin original reads: 'Miratus sum, quum legerem antiquos Hermeticos retulisse nobis in suis scriptis, quod in igne puro fummum sit silentium, quies absoluta, atque in illo habitare DEUM, unde tamen emissi Ignis ministri moribunda per inertiam corpora vivicarent, moverent, facerent jussa exsequi juxta Arbitrium Omnipotentis & Omnifabri, NUMINIS liberrimum.' Boerhaave. (1732). *Elementa chemiae*: 1, 164-165. Boerhaave adopted the opinion of his teachers Senguerd and De Volder that air is heavy rather than weightless and he discussed the weight of air/atmosphere in the section on air. He argued that air weighs more close to the surface of the earth and is much lighter on tops of mountains. Boerhaave. (1741). *A New Method*: 1, 387, 420.

[108] Moses and the burning bush: Exodus 3:2-4; mount Sinai: Exodus 19:18; 24:17.

[109] Boerhaave referred to the story of Nadab and Abihu, the sons of Aaron, who were devoured by a fire sent from heaven (Leviticus 10:2). See also Hebrews 1:7; 12:29

[110] Boerhaave. (1741). *A New Method*: 1, 244. The Bible text is from Psalm 104:1b-4.

the food of life, and whose effect is possibly its elasticity. [111] Unlike his teacher De Volder, who had argued that air is heavy, Boerhaave stated that air appears to be heavy only because it contains particles of matter. [112] However, pure elastic air must be without gravity. Boerhaave stated:

> I have often been led to consider, whether God did not originally create fire and pure elastic air, without gravity, and without any direction to a certain point, but equally distributed it through the universe, and all its systems; so as that the fire should always act upon air, to keep it moving, even in the utmost degree of cold. [113]

Thus Boerhaave's concept of pure fire is intimately linked to the will of the Creator, which means that Boerhaave steered clear of the Cartesian theory of motion in which God did not play any part. Descartes had argued that, although motion is created by God, the changes in the world cannot be explained as a direct effect of God's hand in nature. Motion conserves itself and changes arise from the nature of creatures themselves. [114] Schofield has made a distinction between seventeenth and eighteenth century materialists, who defended matter's inertness, and the 'dynamic corpuscularians', who, basing themselves on the notion of God's omnipresence in the world, added immaterial forces to matter. [115] Although Boerhaave's force of fire is material his matter theory would fall into the second category, for his God actively steers the world through the force of fire.

Boerhaave's introduction of the non-mechanical cause of fire into his chemistry caused some problems for his contemporaries. Edward Strother (1675-1737), Doctor of medicine of Utrecht and Fellow of the London College of Physicians, who also translated Boerhaave's *Elementa chemiae* into English could not accept that Boerhaave's system is not entirely mechanical. Strother added in a footnote:

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[111] Boerhaave in Haller A. v. (1742). *Dr. Boerhaave's Academical Lectures on the Theory of Physic. Being a Genuine Translation of his Institutes and Explanatory Comment, collated and adjusted to each other, as they were dictated to his students at the University of Leyden*. London: ii, 113.

[112] In his discussion of air in the *Elementa Chemiae* Boerhaave discussed the nature of the particles of matter contained in the air. For De Volder's opinion on the weight of air see: Klever, W. (1990). 'Zwaarte. Een Polemiek in de Zeventiende Eeuw.' *Tijdschrift voor de Filosofie, 52* (2), 280-314: 310-311; Pater, C.d. (1975). 'Experimental Physics.' In T.H.L. Scheurleer (Ed.), *Leiden University in the Seventeenth Century. An Exchange of Learning* (pp. 308-327). Leiden.

[113] Boerhaave. (1741). *A New Method*: 1, 420.

[114] Anderson, W.E. (1976). 'Cartesian Motion.' In P.K. Machamer & R.G. Turnbull (Eds.), *Motion and Time, Space and Matter. Interrelations in the History of Philosophy of Science* . Ohio: 207-208; Ruestow, E.G. (1973). *Physics at Seventeenth and Eighteenth-Century Leiden: Philosophy and the New Science in the University*. 'sGravenhage: 65-66.

[115] Schofield. (1970). *Mechanicism and Materialism*: 15-16. See also Yolton, J.W. (1983). *Thinking Matter. Materialism in Eighteenth-Century Britain*. Oxford: 90-91.

Pray what is motion, by which Fire acts, but a mechanical affection or mode of matter? Are there not certain laws of motion, which are every day found out or better explain'd? This state or mode of matter is called *impetus* or *velocity* , and it is not a part of matter, but an effect of an impression or impulse given from an external or moral agent, which impulse continues till it meets with an obstacle; hence a projection made, when there is no medium or attraction to resist, wou'd be perpetual, let it proceed from what cause we please; now tho' fire is a natural agent, that has receiv'd its impulse from the Almighty Hand, this does not hinder us from finding out its properties, nor from calling its properties mechanical. [116]

However, not every one was sceptical about Boerhaave's explanation of pure fire. Many of his fellow natural philosophers perceived fire as an all pervading subtle matter. His Leiden colleagues, who were also his pupils, Willem 's Gravesande (1688-1724) and Petrus van Musschenbroek (1692-1761), also defined fire as an all-pervading substance. [117] In fact, the historian A. Thackray has observed that 's Gravesande, although he adopted Newton almost to the letter, did not discuss the concept of ether, but talked extensively about fire. [118]

We also find Fahrenheit (1686-1736) writing to Boerhaave on the nature of fire. The excitement of heat and cold and the expansion of warm bodies were points under special discussion. This was practically relevant because mercury easily dilates by the application of heat, which makes it suitable for use in the thermometer Fahrenheit developed. [119] It is remarkable that Boerhaave kept the letters he received from Fahrenheit, because normally he rarely kept letters from anyone. This must indicate that Boerhaave considered the topic under discussion as rather important. Fahrenheit writes to Boerhaave about fire:

we know just as little of the first commencement of heat as we know of the extreme limit of heat, for if we think of the vast spaces between the celestial bodies, that is where heat must be at its lowest level, or cold at its severest, because the rays of the heat-producing bodies are not reflected or reverberated and etherial matter or universally distributed fire is consequently at its greatest repose there. [120]

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[116] Strother. (1749). *Elements of Chemistry*: 170.

[117] 's Gravesande, W. J. (1735). *An Explanation of the Newtonian Philosophy in Lectures Read to the Youth of the University of Leyden*. (Fellow of the Royal Society, Trans.). London: 193; Musschenbroek, P. v. (1761). *Elementa physicae*. Leiden: 386.

[118] Thackray. (1970). *Atoms and Powers*: 104.

[119] Boerhaave. (1741). *A New Method*: 1, 235-236. For Fahrenheit's thermometers see: Oettingen, A. J. (1894). *Abhandlungen über Thermometrie von Fahrenheit, Réaumur, Celsius (1724, 1730-1733, 1742)*. Leibzig; Cohen, E., & Cohen-de Meester, W.A.T. (1936). 'Daniel Gabriel Fahrenheit.' *Chemisch Weekblad, 33*, 374-393; Kant, H. (1984). *G.D. Fahrenheit, R.A.F. de Réaumur, A. Celsius. Biographien hervorragender Naturwissenschaftler, Techniker und Mediziner*. Berlin.

[120] Fahrenheit to Boerhaave, 20 March 1729, Star, P. v.d. (1983). *Fahrenheit's letters to Leibniz and Boerhaave*. Leiden: 126-127.

Fahrenheit does not go as far as Boerhaave in stating that God may reside in the fire, but he is not at all sure where the fire comes from or how it acts in nature.

It is interesting that Fahrenheit directly links the universally distributed fire to an ethereal matter. This brings us back to the argument that Newton's ether works as an instrument of God's providence. However, Newton's ether and Boerhaave's fire and other latent peculiar powers are essentially different. [121] Newton's forces, working in the internal vacuities of matter were 'agents of change in phenomena and the cause of activity in matter.' [122]

> And now we might add something concerning a certain most subtle spirit which pervades and lies hid in all gross bodies; by the force and action of which spirit the particles of bodies attract one another, at near distances, and cohere, if contiguous; and electric bodies operate to greater distances as well repelling as attracting the neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies; and all sensation is excited, and the members of animal bodies move at the command of the will, namely by the vibration of this spirit, mutually propagated along the solid firmaments of the nerves, from the outward organs of sense to the brain, and from the brain into the muscles. [123]

The implication of Newton's thought is expressed by one of his disciples, David Gregory, who wrote that Newton believed 'God to be omnipresent in the literal sense.' [124]

Boerhaave's fire, likewise, fills the spaces in between particles and is the cause of motion. Moreover, it directly refers to God as Boerhaave called fire 'that wonderful cause, which the Creator has lodged in the universe.' [125] However, we must not say that in Boerhaave's view God is fire, although he saw fire as a very concrete divine means of action, since when God sends down his fire from heaven, something happens on earth; people will be consumed or a sacrifice will be kindled. Pure fire, in Boerhaave's view, is a secondary cause through which God operates in the world. Newton's forces on the other hand

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[121] Here I take a different viewpoint from Thackray. See: Thackray. (1970). *Atoms and Powers*: 111. On the influence of ether theories see the articles of Heiman and Cantor in Cantor, G., & Hodge, M. J.S. (Eds.). (1981). *Conceptions of Ether. Studies in the History of Ether Theories 1740-1900*. Cambridge. Heiman in his article *ether and imponderables'*has argued that Newton's theory of the ether paved the way for the development of other imponderable fluid theories like Boerhaave's fire and Stahl's phlogiston. Cantor in his article on *the theological significance of ether theories'*has also linked ether theories and ideas about a universally distributed fire and he has discussed the theological significance of the ideas.

[122] McGuire. (1968). 'Newton's Invisible Realm': 161.

[123] Newton. (1729). *Mathematical Principles*: 547.

[124] Gregory, 21 December 1705, in Thackray. (1970). *Atoms and Powers*: 27.

[125] Boerhaave. (1741). *A New Method*: 1, 377.

are subtle and his God the direct cause of all phenomena in nature. McGuire has argued that in Newton's view God's essence and existence are inseparable. For this reason Newton's God is 'necessarily and substantially omnipresent and "thereby able to act in all times & places for creating & governing the present universe."' [126] This means that 'Newton plainly holds that all natural phenomena – force, matter, and their qualities – are equally manifestations of God's *potentia absoluta*.' [127] The Calvinist Boerhaave, however, did not believe that secondary causes would limit the power of God, for He is free in steering the causes as he wants.

In the oration which Boerhaave delivered upon accepting the chair of chemistry in the University of Leiden, he ridiculed the chemists who argued that 'fire is not a physical phenomenon' but something 'between body and spirit', and also those who 'raised the sun and its son, fire, to the rank of the gods.' [128] Those adopting the superstitions about the divine nature of fire, Boerhaave argued, soon found themselves investigating magical phenomena such as fauns, satyrs, genii, nymphs, pygmies, demigods, the masters of woods, mountains, rivers, and of subterranean places and the air. [129] Boerhaave, however, makes a separation between God and His creation. This means that his God is not immanent, but transcends the creation. Yet, Boerhaave's God is actively steering the creation. So Boerhaave's fire necessarily has to be material. Like Calvin's 'divine energy', it does not act independently but as an instrument (secondary cause) through which God actively and directly operates in the world. Investigation of its effects will most directly tell the chemist about God. Boerhaave concluded his chapter on fire stating

> I here leave the matter, after having examin'd it with my utmost endeavours, to be further persuaded by others. There are infinite things still remaining to be discovered in it, which may afford room for sagacity and beneficence to find out and impart to mankind, in order to enable them more fully to understand and adore the power and wisdom of the Creator, from a clearer view of His work. [130]

After examining how Boerhaave's ideas on matter and motion are in essence knowledge of God and His providential hand in nature, we must now turn to the question how Boerhaave applied his Calvinist chemistry on a practical level. I shall argue that Boerhaave's Calvinist chemistry, incorporated a particular Dutch Calvinist method of experimenting.

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[126] McGuire. (1968). 'Newton's Invisible Realm': 201.
[127] *Ibid.*, 203.
[128] *CSEE*: 203.
[129] *CSEE*: 197.
[130] Boerhaave. (1741). *A New Method*: 1, 378.

The incident in the chemical laboratory

Among contemporary natural philosophers Boerhaave was known as an even-tempered man. He could control his feelings very well and his students and colleagues seldom saw him angry. Chevalier de Jacourt, one of his students, recalled a particular incident in which Boerhaave showed his self-control. A boy servant came in to stoke the fire in a furnace, but unfortunately pushed over a pot containing lead which had been being heated continuously for about twenty years. Boerhaave turned red and he told his audience in Latin that his experiment which had lasted for twenty years, was flushed away in the wink of an eye. However, at the same time he reassured his servant that it was nothing and that it would be inhuman to ask for the servant's continuous attention. [131] Boehaave had all reason to be upset for twenty years of work had been destroyed, yet he continued his lecture in the same tone as if the servant had only ruined an unimportant experiment.

The question is why was Boerhaave heating lead continuously for a period of twenty years? What did he want to prove with his experiment and what was so important about it that made him upset? These questions relate to the bigger question of why Boerhaave thought experiments were important in the practice of chemistry, which brings us to the questions of what, in Boerhaave's eyes, was a chemical experiment and how did he interpret the results?

My questions are similar to the questions raised by Shapin and Schaffer in their discussion of Boyle's experiments with the airpump in *Leviathan and the Airpump* (1985). [132] They have argued that the scientific method is a form of social organisation and a means of regulating social interactions within the scientific community. [133] In their argument Boyle's experiments with the airpump in the social environment of the laboratory show that experimental truth was a consensus between a particular group of people.

> In the official formulation of the Royal Society, the production of experimental knowledge commenced with individuals' acts of seeing and believing, and was completed when all individuals voluntarily agreed with one another about what had been seen and ought to be believed (...) The objectification of knowledge proceeded through displays of the communal basis of its generation and evaluation.

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[131] Jaucourt, Chevalier de in a biographical note on Boerhaave in Diderot, D. & d'Alembert. *Encyclopédie*: XVII, 471.

[132] Shapin, S., & Schaffer, S. (1985). *Leviathan and the Airpump. Hobbes, Boyle and the Experimental Life*. Princeton: 3.

[133] *Ibid.,* 14. See also Shapin, S. (1994). *A Social History of Truth: Civility and Science in Seventeenth-Century England*. Chicago; Cantor, G. (1989). 'The Rhetoric of Experiment.' In D. Gooding, T. Pinch, & S. Schaffer (Eds.), *The Uses of Experiment. Studies of experimentation in the natural sciences* (pp. 159-180). Cambridge.

Human coercion was to have no visible place in the experimental form of life (...) It was to be nature, not man that enforced assent. [134]

Thus, truth is a matter of agreement over the experimental matter of fact. Shapin and Schaffer point out the distinction between matter of fact and the ultimate physical causes and explanations. [135] It is not clear on what grounds Boyle distinguished between the two categories. Shapin and Schaffer state:

Boyle's criteria and rules for making his preferred distinctions between matters of fact and causes have the status of *conventions*. Causal talk is grounded in conventions which Boyle's reports exemplify, just as the construction of the matter of fact is conventional in nature (...). The ultimate justification of convention does not take the form of verbalised rules. Instead the 'justification' of convention *is* the form of life: the total pattern of activities which includes discursive practices. [136]

I shall argue that Boerhaave, like Boyle in the interpretation of Shapin and Schaffer, clearly distinguished between experimental matters of fact and ultimate causes. Both categories were grounded in his Calvinist belief that God imprints true knowledge upon the intellect as well as upon the creation. Man cannot come to true knowledge of his own accord, but truth dictates itself upon the intellect from outside. This means that the true knowledge imprinted by God on His creation, can only be revealed to man, through making nature speak for herself. In other words, through experiment and observation. However, the human intellect is fallen and blinded by sin, so man cannot perceive truth to the fullest. Moreover, he should not even try, because it would be unforgivably arrogant for man to want to know as much as his Maker. It follows that Boerhaave considered the distinction between an experimental truth and the ultimate cause of a phenomenon as a difference between the truth as shown to the limited capacities of the human intellect and the true cause of all things, i.e. God the Creator. So in Boerhaave's case the experiment was more than a social category for the construction of truth. Yes, Boerhaave did make the experiment the voice of nature and yes, the outcome of the experiment did depend upon an agreement on what could be seen. But on another level the outcome of an experiment was God-given and thus beyond the boundaries of human reason and consensus.

Boerhaave's awareness of the God-given status of true knowledge made him very cautious of general theory. He argued that the forces of nature

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[134] Shapin & Schaffer. (1985). *Leviathan and the Airpump*: 78-79.
[135] *Ibid.,* 51, 139-140. Hobbes considered the distinction un-philosophical for it is the philosophers job to find the truth or at least to approach truth as near as possible.
[136] *Ibid.,* 52.

'wholly elude the perspicacity of the human mind' and that 'only through observation of their evident effects do they become manifest to the senses, and hence they eventually become known to the mind.' [137] We saw in chapter two that Calvin held that although the human mind is generally right in the general definition or essence of matter, yet man is unable to reason from generals to particulars. Calvin only referred to man's ability to distinguish between good and evil, but Boerhaave took this one step further and applied Calvin's idea to natural philosophy. He argued:

> That the best general definition of the concept 'body' has been given by the mathematicians, I hold to be so evident that I really do not expect anybody will query the truth of this statement. From this universal definition of the geometricians, however, nobody will be able to deduce with correct and logical reasoning the individual nature of each single body as it exists in nature. [138]

Instead Boerhaave proposed to turn around the method and start with the particulars.

> Whoever desires to discover these unknown facts, then, must deduce from the particular object he wants to study the conditions which strictly determine his otherwise unbridled freedom of reasoning in exploring the nature of the object in question. And surely nobody learns to know these conditions who has not discerned, by means of sense perception, the effects to be observed in every body. For these effects are related to the properties consequent upon the particular nature of the object which is studied: every single effect therefore reveals one property and taken together they reveal, as it were, its complete nature, as far as it is open to the senses. [139]

Boerhaave's emphasis on experiment and observation is nowhere more evident than in his chemistry. Chemistry, he argued, is best suited to *observe* the changes which arise in different bodies. However, when the chemist wants to *account* for the appearances of bodies, he starts acting the part of a philosopher or of a rhetorician. [140]

Time after time, Boerhaave emphasised that the outcome of an experiment should be examined on its own, rather than viewed in a general theory of chemistry. He had observed that the interpretation of experimental observations led to disagreements among chemists. Just as the theologians of Boerhaave's time were divided over dogmatic issues, so the chemists were similarly at odds over chemical doctrine, which led to a fragmentation of chemistry

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[137] *CSEE*: 200.
[138] *URM*: 95-96.
[139] *URM*: 96.
[140] Boerhaave in Haller. (1742). *Academical Lectures*: 1, 44.

into various sects. However, in Boerhaave's view true knowledge should be unambiguous, and not a matter of debate. The chemist must not leap to hasty conclusions, but examine nature over and over in all her details. Only then would it be possible to come to true knowledge. Boerhaave stated:

> it was established by the brilliant, useful, and delightful discoveries of chemists that one needs an enormous store of observations, a most cautious scrutinity of this material, and finally, a careful mutual comparison of all data, before one is entitled to postulate a universal rule that is valid for all natural reactions. [141]

And even when formulating a law of nature, the chemist must always be able to accompany his knowledge with an experiment, 'it being the character of a chemist that his speculations pass on to effects. Thus when (...) accounting for fermentation he will at the same time produce it; his sayings will be effects; and being free from the enquiry of ultimate causes.' [142] This rule is visible throughout Boerhaave's chemistry. For instance, when Boerhaave speaks about pure fire or the force of cohesion, he shows their characteristics at the same time, without trying to understand their final cause.

In order to avoid mistakes, Boerhaave formulated four rules to be observed in chemical experimentation:

> First it should be very easy, so as not to require any great physical labour; whereby a violent corporeal force is applied to the subject. Secondly, it should be simple, or not compounded of various concurrent operations; nor require a variety of instruments. Thirdly, the change it makes should not be very remote from the nature of the subject. Fourthly, the effect produced should rather consist in a separation of the parts, such as they were originally, than be changed by the operation. [143]

Similarly the instruments of chemistry must be simple, so that their changing power is easy to understand and apply. In short, Boerhaave's rules make experiments repeatable. The results of Boerhaave's chemistry will approach truth, for if an experiment has the same result at all times it must be true. It follows that the chemist can form a judgement based on a thorough knowledge of particulars. Boerhaave argued:

> the artist will hence clearly perceive that those parts were, as they originally existed in the subject; and thence form a true judgement of its nature and the disposition of its component parts. And without this procedure we might commit great errors (...) I wish I could have found an author who has delivered his experiments in this method. [144]

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[141] *CSEE*: 202.
[142] Boerhaave. (1741a). *A New Method*: I, 173-174.
[143] *Ibid.,* II, 3.
[144] *Ibid.,* II, 3.

Boerhaave's insistence on particulars and his great caution with regard to universal rules made his approach different from Newton's.[145] Both Boerhaave and Newton start their natural investigations with the most simple causes and effects. However, Newton's method of analysing nature was directed at the formulation of general laws. He proceeds from effects to causes, from experiments and observations to general conclusions.[146] Newton states that it is impossible to understand the whole system to the fullest, but in proceeding from phenomena to causes philosophy will ultimately proceed to the First Cause of things and be able to answer questions about the design and purpose of the universe.[147] Thus, Newton was more optimistic than Boerhaave in climbing up to the heights of divine knowledge.

Boerhaave's insistence on the limits of human knowledge is not unique. We find the same attitude among his Dutch contemporaries. Recently C. de Pater has argued that the Dutch natural philosophers 's Gravesande and Musschenbroek, pupils of Boerhaave, adopted Newton's rules and embedded them in a solid metaphysical foundation, by reducing them to the will of God.[148] But 's Gravesande and Musschenbroek, although they seem to follow Newton more than Boerhaave in believing in universal laws of nature, still have the Calvinist belief that the boundaries of human intelligence are defined by God. For 's Gravesande argued:

> I think; i.e. there is something Intelligent; from thence I infer that the first Cause of this is eternal, and infinitely exceeds in Intelligence that Intelligence which it has created; upon which account I am oblig'd to attribute a Power to it by which a Mind may be form'd, i.e. infinitely exceeding all that I can frame any idea of to myself (...) It is plain then that God is *one, eternal; of infinite Knowledge*; and that his power is confin'd within no Bounds. Which Things being demonstrated, hence other Things flow that are discover'd of God (...) For it is easy to prove that all that is oppos'd to it proceeds from a Defect of Understanding, and can be only in a limited Intelligence.[149]

Thus we are here presented with three Dutch natural philosophers who base their certainty of knowledge upon God, the source of all truth. Of course we have to be cautious in generalising but the explicit linking of knowledge and

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[145] Schofield has developed a similar argument in: Schofield. (1970). *Mechanicism and Materialism*: 147-150.

[146] Newton. (1729). *Mathematical Principles*: 398-400, Rules of Reasoning in Philosophy.

[147] Newton, I. (1730). *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light* (4 ed.). London: query 31, 403-404.

[148] Pater, C.d. (1994). 'Willem Jacob 's Gravesande (1688-1742) and Newton's *Regulae Philosophandi*, 1742.' *Lias-Sources and Documents Relating to the Early Modern History, 21* (2), 256-294: 276.

[149] 'Gravesande in *Ibid.*, 265-266.

certainty to God seems to be a trademark of Dutch Calvinist natural philosophy. Moreover, Boerhaave's chemical experiments can be viewed as particular Calvinist tools for looking at the creation.

I shall now proceed to a discussion of Boerhaave's chemistry experiments with respect to metals. All Boerhaave's chemical experiments are directly or indirectly relevant to his medicine, but I shall discuss his experiments on the vegetable and animal kingdom in the context of Boerhaave's chemistry for medicine in the next chapter. The experiments with metals show how Boerhaave applied his Calvinist chemistry in practice. Boerhaave also adopted the theory and method of the true chemists and alchemists, and made them part of his Calvinist chemistry. Most importantly his experiments on mercury show that Boerhaave tried to reveal the working of at least one of the instruments of nature and so to see God in His creation.

Boerhaave's Calvinism, surprisingly, did not rule out the importance of natural magic and alchemy for chemistry. In his Bible he had read that Tubal-Cain was 'an instructor of every artificer in brass and iron,' which in Boerhaave's eyes made him the first chemist of all times. [150] The Biblical figure of Moses was also important because he was responsible for the transfer of Egyptian chemical knowledge into the Jewish culture and later on into Christianity. Boerhaave argued that Moses was 'skill'd in all the learning of the Egyptians' and that he knew the secret of making gold. His evidence is the story of the golden calf, which Moses melted and transformed into a powder that when mixed with water was fit for drinking. Boerhaave adds that the transforming of gold is 'one of the highest effects of the art, and which the greatest chemists at this day are unacquainted with.' [151] Contrary to the false (al)chemists, who transformed the Bible into a chemical textbook, Boerhaave used the Scriptures in order to justify the methodological approach of his chemistry. For Boerhaave the Bible represented the undisputed truth and rather than making biblical texts the servants of chemistry, he subjected chemical knowledge to the truth of the Word.

Boerhaave argued that chemistry in its original meaning, in the time of the Bible, simply meant the 'knowledge of natural things.' [152] Since metals are a large and constituent part of 'natural things', metallurgy and alchemy are respected parts of Boerhaave's Calvinist chemistry. Boerhaave even encouraged investigation in these unknown areas, for he had 'not met any writers on natural philosophy, who treat the nature of bodies and the manner of changing

[150] Genesis 4:22.
[151] Boerhaave. (1741). *A New Method*: 1, 14. The story of the golden calf can be found in Exodus 32.
[152] *Ibid.*, 1, 12.

them so clearly, as those called alchemists.' [153] Boerhaave argued that man tends to define unusual appearances in nature as beyond, or above the power of nature. However, man knows only little of the powers that God lodged in the creation. So that rather than running away from what seem miraculous appearances, man should adopt an open mind and investigate their effects.

Boerhaave illustrated his argument with the example of a teacher, who, using phosphor for a pencil, wrote on the end of the bed of his pupil the words 'tomorrow you will die'. Upon a light noise the boy woke up and he discovered the writing on his bed. He was so shocked that he called in his servants with candles. Naturally the letters disappeared. To the boy the appearance of the words was magic, while to his teacher it was a natural effect. Using the example Boerhaave shows that man should not refer natural magic to the field of miracles too soon, but he recommends it as 'useful to human society, agreeable to the intelligent and proper to display the glory of the Creator by the wonderfulness of his works.' [154]

Boerhaave showed much admiration for the work of the old alchemists. He wrote that:

> where ever I [Boerhaave] understand the alchemists, I find them describe the truth in the most simple and naked terms, without deceiving us, or being deceived themselves. When therefore I come to places where I do not comprehend the meaning; why should I charge them with falsehood, who have shewn themselves so much better skill'd in the art than myself? [155]

Boerhaave praised the alchemists for developing chemical theory in which they explain the nature of change without trying to know more about the powers impressed by the Creator upon natural bodies. More than anyone else the alchemists realised that man can only operate within the bounds of the creation. Even when man gains knowledge of all things, he is still not able to create anything, for the main law 'which the Creator has impressed upon His work', is that 'all things arise from other similar pre-existing ones; plants from plants, animals from animals and fossils from fossils.' [156] Boerhaave had a high veneration for the alchemist's ideas on generation and he described the process at great length in his *Elementa chemiae*. Historians of science have recognised Boerhaave's alchemical writings, but they have dismissed them as unfortunate slips of the pen. [157] However, alchemy was an important part of

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[153] *Ibid.*, I, 200.
[154] *Ibid.*, I, 193.
[155] *Ibid.*, I, 202.
[156] *Ibid.*, I, 201.
[157] Lindeboom. (1968). *Herman Boerhaave*: 348-352; Cohen. (1919). *Herman Boerhaave en Zijne Betekenis voor de Chemie*: 52

Boerhaave's chemical experiments and we cannot neglect its importance for Boerhaave's chemistry as a whole.

Although Boerhaave realised that the alchemists sometimes formulated general conclusions too quickly, he stressed that this does not mean that chemists should turn away from alchemy. So even though Boerhaave doubted the possibility of transmutation, this did not put a stop to his alchemical investigations. He firmly believed that man should never limit the possibilities of nature, for that would be the same as limiting the powers of the Creator. He argued that history proves that things are taken for impossible which are unknown by the ignorant. For example, this was proven by his theory of pure fire. He states:

> The ancient writers spoke something of a perpetual fire, which was of a solid nature, and endureth even under water, but it was exploded as an idle chimaera; though the same has since been actually discover'd (...) and many of the other things related to natural magic will appear much more incredible to those unacquainted with the experiments, than that lead should loose its natural form, and be converted into gold. [158]

Boerhaave states that the chemists have to search nature thereby following the alchemists in 'the immense pains they have been at, in discovering, and handing to us, so many physical truths.' [159]

Boerhaave believed that the metals originate from mercury and sulphur like animal and vegetable bodies are made of earth and water. [160] Thus Boerhaave defined quicksilver and elementary earth as the two fixing principles of bodies, without which all natural bodies would be volatile moving particles, or floating atoms, that are so subtle as not to be recognizable by our senses.

In the experiments on mercury, Boerhaave wrote that like all things in nature, metals grow, are being fed and multiply. However, the factor that makes metals grow is not yet known. It had been suggested by most chemists that a combination of mercury and sulphur, forms the semina growing towards a particular metal. This is also the reason why metals, when dissolved, separate into mercury and sulphur. The alchemists also suggested that the reason why different metals come into existence is because mercury hardly ever presents itself in its purest form but in most cases is contaminated with sulphur, which can hardly be separated from mercury. Repeating the alchemists, Boerhaave states that from the origin of the metals sulphur intruded into the semina and

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[158] Boerhaave. (1741). *A New Method*: I, 204.
[159] *Ibid.,* I, 203.
[160] *Ibid.,* I, 486.

is therefore indissolubly linked to mercury.[161] This original contamination causes the mercury to attach itself to other impure substances, thereby entering into a 'marriage' with an unknown agent.

The make-up of mercury is even visible in the chemical symbol for mercury (☿). The symbol of the cross denotes something sharp or corrosive, like vinegar or fire. It behaves like spiked wire and sticks around other particles. The middle is like gold (☉), perfectly round, denoting a perfect immutable, simple body without anything acrimonious or heterogeneous to it. The outer part has a silver colour. Therefore the half circle on top of the gold refers to silver (☾), defined as half gold, whose inside if turned outwards would transform the silver into gold. Finally the cross underneath points to something sharp and corrosive, the contaminating part. Boerhaave did not believe that sulphur can ever change into a metal, for it always remains the same and is not more than oil mixed with an acid.[162] It follows that when taking the sulphurous part away the chemist would be left with a purer version of mercury or maybe even gold itself.

Boerhaave, following the adepts defined the other metals in the same way. The chief part of copper (♀) and antimony (♁) is round, but it also has a large corrosive part adhering to it, which if taken away would leave the rest with all the properties of gold. Iron (♂) likewise denotes gold at the bottom, but also has a great proportion of a large corrosive adhering to it. Tin (♃) is half silver, the other half being a corrosive acid. The symbol for lead (♄) shows that almost the whole is corrosive, but there is still some resemblance with silver. However Boerhaave found it hard to believe that for example copper can transform into gold, for, as far as he could see, copper, after treatment, only transformed into a more perfect copper.[163]

The proper and specific characteristic of metals consists in their density. The weight of a metal increases with its purity, which means that gold and mercury are heavier than, for example, copper or tin. It follows that increasing the weight of a metal by condensation is the best method to turn other metals into gold, or other bodies into metals. From this it follows that the chemical operation of condensation can be defined as the taking away of the sharp particles that decrease the weight of natural bodies. According to Boer-

[161] See also a note Boerhaave copied from Bacon's *Speculum Alchemiae* stating: 'omnia mineralia in terra ex ☿ et nascuns [sic.]. ex ♁; Hic deves metalla varia.' Leningrad MS XIII 4/Leiden MS F 693, *Index eorum quae chemiam spect. alphabeticus*.

[162] Boerhaave. (1741). *A New Method*: ii, 265.

[163] The chemical symbols for the metals were also used in astronomy and astrology. However, Boerhaave denied any connection between the two realms.

haave, this operation is the most difficult of all operations as 'it requires something like a creative power' to increase the weight of a body. [164]

Boerhaave's experiments on metals show remarkable similarities to Geber's metallurgy and we can even say that his matter theory in essence went back to alchemical particle theory. Boerhaave made a thorough study of the alchemists and he closely followed Geber, when performing his experiments. [165] Moreover, he set out to demonstrate 'the truth of Geber's statement in which he [Geber] thanks Almighty God for having made mercury so simple that it is always and every where the same.' [166] Boerhaave repeated Geber in stating that metals thicken and solidify themselves within the earth (*inspissatio*). In the Geberian theory of matter this means that particles of matter form themselves into metals.

Geber viewed all mineral substances, including mercury, as being composed of tiny corpuscles, called 'minimal parts' or 'subtile parts'. These particles have a higher specific weight, due to their small size, which allows them to be closely packed, not leaving much room for big interstices. The perfection of the metals depends upon the way the particles are packed, i.e. their density, which is the way they cohere together. Silver for example, has large particles and therefore large interstitial spaces, contrary to mercury, which is a very homogeneous body wherein the particles are tightly packed and very easy to volatilise. [167] The size of the particles is also important. Mercury is

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[164] Boerhaave. (1741). *A New Method*: 1, 103. The Latin original reads that the chemist needs a 'potentiam creantem' for the operation of condensation.

[165] Newman in his recent works on Boyle and the American alchemist Starkey/Philaeletus, has similarly traced their corpuscularian theories back to the matter theories of Geber. Newman, W.R. (1994). *Gehennical Fire. The Lives of George Starkey, an Americal Alchemist in the Scientific Revolution*. London; Newman, W.R. (1996). 'Boyle's Debt to Corpuscular Alchemy; the Alchemical Sources of Robert Boyle's Corpuscular Philosophy.' *Annals of Science, 53*, 567-585. In explaining Geber's theory of matter I rely heavily on the work of Newman. For the influence of alchemical theory on corpuscularian matter theory see also the work of L. Principe and A. Clericuzio: Principe, L.M. (2000). 'The Alchemies of Robert Boyle and Isaac Newton: Alternate Approaches and Divergent Deployments.' In M.J. Osler (Ed.), *Rethinking the Scientific Revolution* (pp. 201-220). Cambridge; Principe, L.M. (1990). 'The Gold Process: Directions in the Study of Robert Boyle's Alchemy.' In Z.R.W.M. Martels (Ed.), *Alchemy Revisited* (pp. 1990); Principe, L.M. (1998). *The Aspiring Adept. Robert Boyle and his Alchemical Quest. Including Boyle's 'Lost' Dialogue on the Transmutation of Metals*. Princeton; Clericuzio, A. (1990). 'A Redefinition of Boyle's Chemistry and Corpuscular Philosophy.' *Annals of Science, 47*, 561-589.

[166] Boerhaave to Mortimer, 8 April 1734 in Boerhaave, *Correspondence 1*: 211. 'Unum id mihi in hisce propositum; sufficit si obtinui, sed simul studui asserere veritatem dicto Gebri solventis gratias Altissimo, qui creavit argentum vivum adeo simplex, ut semper & ubiq.'

[167] Newman, W.R. (1991). *The 'Summa Perfectionis' of Pseudo Geber. A Critical Edition, Translation and Study*. Leiden: 149-157.

composed of small particles, while its impurity is made up of larger ones. A gentle heat will volatilise small corpuscles easier than large ones, and carry up pure particles leaving the contaminated particles behind. [168] It follows that in order to purify mercury, its constituent corpuscles must be reduced in size and packed more tightly together. [169] Therefore, Geber believes that by continually subliming and dissolving mercury it will become more homogeneous as its particles become more closely packed and that in the end its particles will attain such minuteness that they will be able to penetrate through the pores of a base metal and transmute it into gold. [170]

For Boerhaave lead was an interesting metal, for it is the heaviest metal after mercury and yet further away from the perfection of gold than any of the other metals. Moreover he thought that it would be possible to change lead into mercury through applying a great degree of fire. [171] This can perhaps explain why Boerhaave was heating a pot of lead for twenty years. Even though he was sceptical about the possibility of transmutation, yet he kept trying for he must have thought that maybe he could condense the metal and so to transmute it into gold. [172]

After studying the works of the alchemists Boerhaave set himself to work in order to either produce pure mercury or to produce the sulphur that contaminates the mercury. At the end of his life he published his findings in the *Philosophical Transactions* of the Royal Society. However, Boerhaave started experimenting with the metals even before his academic career had begun. This is not only visible in the notes he made of his chemical experiments, but also many of the experiments lasted for twenty years or more.

Boerhaave's notebooks show that he was busy experimenting on metals as early as 27 October 1693, when he was twenty-five years old. The Kirov Manuscript Collection in St. Petersburg holds Boerhaave's chemistry notebooks in which he wrote accounts of his experiments. Only two notebooks, microfilmed and brought to Leiden, are accessible for research. The first manuscript holds experiments from 1693 until 1698. The other describes experiments from 1718 until 1737. Two other notebooks, covering the period

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[168] *Idem.,* 144.

[169] *Idem*., 155.

[170] Newman. (1994). *Gehennical Fire*: 97.

[171] Boerhaave. (1741). *A New Method*: 1, 104.

[172] At the time it was said that Helvetius had managed to transmute lead into gold after a stranger gave him a secret potion. However, the *Jo. Fred. Helvetii, vitulus aureus quem mundus adorat & orat* does not appear in the *Bibliotheca Boerhaaviana, sive catalogus librorum instructissimae bibliothecae viri summi D. Hermanni Boerhaave*. (1793). Leiden, which perhaps indicates that Boerhaave did not value the story very highly.

from 1699 until 1717, can be found in the Kirov Collection but were inaccessible for research. [173]

It is likely that Boerhaave started his alchemical experiments earlier than 1693, while experimenting with his brother Jacob. However, no notes of these experiments can be found. It is likely that the experiments starting in October 1693 represent the start of Boerhaave's chemical career. Boerhaave not only graduated in medicine, but also after the incident on the canalboat, he had turned to a serious study of natural philosophy. Until his appointment as lecturer in medicine in 1701, Boerhaave seriously studied chemistry and he did many experiments on metals. [174]

From 1698 until 1718 we do not have any records of experiments with metals. Possibly the notes in St. Petersburg will show that Boerhaave continued experimenting, but it is likewise possible that the experiments with metals were simmering as Boerhaave got more and more busy lecturing, writing and visiting the sick. During these twenty years Boerhaave wrote his major medical and botanical textbooks, the *Institutiones medicinae* (1708), the *Aphorisms* (1708) and the *Index plantarum* (1710). Moreover, Boerhaave was elected *rector magnificus* of the University in 1714. Boerhaave did not stop his chemical experiments, but under the pressure of his medical duties the direction changed. His lecture notes, and also some of the chemistry notes show that he did many experiments on plants, oils and spirits, which can be traced back to his *Formulae remediorum*. [175]

A second notebook, containing experiments on metals starts in 1718, when Boerhaave was offered the chair of chemistry in the University of Leiden. With the chair also came a laboratory and money for improvement, for Boerhaave's predecessor, Jacob le Mort, had largely neglected the maintenance of the laboratory. Boerhaave asked for new ovens and instruments as well as for more space for spectators as he had observed that the laboratory was packed with students during his private demonstrations in the preceding years. He also wanted rules for the professor for the use of the laboratory and the rebuilding of a small room above the laboratory for the use of the professor. [176]

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[173] Experiments 1693-1698: Leningrad MS XIII 6/Leiden MF Q 249, *Notae chemiae, 1694-1702*; experiments 1717-1737: Leningrad MS XIII 9/Leiden MF Q 252, *Experimenta chemica, 1720-1732*. A third notebook contains experiments from 1718 until 1735, but has not been brought to Leiden. Also a notebook entitled *Materia medica chemia* (Leningrad MS XIII 56), containing 90 chemical experiments from 1710 onwards, is similarly unavailable for research.

[174] Leningrad MS XIII 6/Leiden MF Q 249, *Notae chemiae, 1694-1702*.

[175] Leningrad MS XIII 6/Leiden MF Q 249, *Notae chemiae, 1694-1702*; Leningrad MS XIII 38/Leiden MF Q 255, *Formulae remediorum adversus hypohondriacam (a)egritudinem*.

[176] Molhuysen, P.C. (1920 (1682-1725); 1921 (1725-1765)). *Bronnen tot de Geschiedenis van de Leidsche Universiteit* (Vol. iv, v). 'sGravenhage: iv, 150. resolution of August 1718, 'Voorstel van Boerhaave aan C. en B. betr. verbeteringen in het Chemisch Laboratorium.'

Presumably Boerhaave's new laboratory facilities as well as his new teaching responsibilities gave an impulse to his chemical experiments with the metals. However, he was still very busy, and he could not devote all his time to chemistry. It is not surprising therefore that the number of entries in the notebook increased significantly after giving up his professorships in botany and chemistry in 1729. Boerhaave himself indicated that after resigning his chairs he would have time for some specific chemical experiments. He stated that

> the work of many years has ultimately led me to set aside some important questions for the leisure of my old age, if God grant this to me – successes in this field may please me more when I am less distracted by various duties (...) they [chemical experiments] will perhaps keep away the lethargy of old age, and keep up my physical condition by means of moderate exercise. [177]

Boerhaave's first experiment on 27 October 1693 is the production of a tincture through mixing and digesting sulphur and oil, soon followed in 1694 by similar experiments involving sal ammoniac, antimony and mercury. On the third of December 1695 Boerhaave wrote the first entry in which he describes how he tried to create gold out of purified mercury and sulphur. In the years between 1693 and 1718 Boerhaave must have changed his mind about the possibility of transmutation as the experiments in the second notebook mainly describe the process of purifying metals, mercury in particular. The results of Boerhaave's mercury experiments have been published in the *Philosophical Transactions*. [178] Moreover, Boerhaave wrote about them to his friends Bassand and Mortimer, who was also secretary of the Royal Society.

Before Boerhaave's retirement from the chairs of chemistry and botany Boerhaave's correspondence with Bassand was mostly about academic and medical matters. Bassand sent Boerhaave many seeds for the Leiden Botanic Garden. Sometimes he also sent him minerals, but presumably Boerhaave did not have the time to chemically investigate these before his retirement. In return Boerhaave offered medical advice to Bassand. The correspondence changed remarkably after Boerhaave's retirement. It seems as if he got more time to devote himself to the things that were most important in his life: theology and chemistry. Boerhaave not only started writing about his religious thoughts but also about his work in the laboratory. In particular this last and very personal part of the correspondence is important in order to understand Boerhaave's chemistry. They reveal that his main motive for his

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[177] *SAC*: 233.

[178] Boerhaave, H. (1733-1744). 'De mercurio experimenta.' *Philosophical Transactions of the Royal Society, xxxviii*, 145-167; Boerhaave, H. (1735-1736). 'De mercurio experimenta.' *Philosophical Transactions of the Royal Society, xxxix*, 343-359, 368-376.

tireless investigations was not to show the possibility of transmutation of metals as such, but to search for a medicine that would work upon the most essential parts of the diseased body.

Throughout the correspondence with Bassand Boerhaave speaks with admiration about the old (true) alchemists. Boerhaave is also very interested in finding a universal medicine. This became especially urgent as Boerhaave was very eager to find a means to help Bassand, who suffered very badly from gout. [179] Boerhaave's thoughts about transmutation must be seen in this context, for they are closely linked to his expectation of extracting the medicinal properties of the Hungarian copper. A medicine based upon this extract would change the constitution of the blood. [180] Presumably Boerhaave was looking for a medicine that would dissolve the sharp particles of the blood, so the blood as well as the bodily fluids originating from the blood, can move more freely through the joints. [181] In the next chapter I shall discuss in more detail Boerhaave's chemistry for medicine. For now it is sufficient to recognise that Boerhaave did use metals for medicinal purposes.

In almost all the letters written from 1732 until 1735 Boerhaave informed Bassand about his experiments concerning the medicinal properties of the first matter. In August 1732 Boerhaave wrote to Bassand about an experiment he had performed with a Hungarian copper (*volatile sulphur veneris*) that, according to Boerhaave, in sublimation, acquires a quality that is unknown to ordinary copper, but which resembles a gold tincture. Boerhaave expects that this mysterious volatile quality is valuable in medicine and therefore he asks Bassand, who is physician at the Hungarian court, to send him some more.

Boerhaave especially expected to find something in the sulphur of vitriol-copper (*sulphur vitrioli veneris*), since Van Helmont, and many other alchemists, kept referring to this substance as the best cure for diseases, for it works very powerfully upon the most essential fluids of the body. [182] Not discouraged by the few results Boerhaave carried on with the time-consuming experiments (some experiments went on for 6 months!) to extract and define the mysterious *sulphur vitrioli veneris* from the minerals that Bassand had sent him. The main problem Boerhaave had to face was that he was able to extract the *sulphur vitrioli veneris* from a first batch of the mineral and also to prepare a very powerful

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[179] Boerhaave to Bassand: 3 August 1732, *Correspondence 2*: 302-303. Boerhaave wrote to Bassand: 'You should, however, know that I have day and night been occupied with chemical experiments ever since you departed from here, in order to find the remedy that would be capable of releasing you of that obstinate full-bloodedness and relieve a terrible torment [gout].'

[180] Boerhaave to Bassand: 3 August 1732, *Correspondence 2*: 304-305.

[181] Boerhaave, H. (1979 (1741)). *Kortbondige Spreuken wegens de Ziektens, te kennen en te genezen* (Love, Kornelis Jacobz., Trans.). Alphen aan den Rijn: no. 370-399, 512-557.

[182] Boerhaave to Bassand: 21 February 1733; in *Correspondence 2*: 316-317.

medicine. However, when he tried the same procedure on a second batch of the same minerals it did not work. This strengthened his suspicion that there was some hidden unidentified quality in the first batch of minerals. [183]

In the letter of August 1732 Boerhaave not only writes about powerful medicines prepared from minerals, but he also asks Bassand if there are skilful men in the Hungarian mines, who know what the first matter of metals looks like. Boerhaave wrote:

> There is a certain fluid matter, that they [the Hungarian miners] call Gur, according to Agricola it is like fat or candlegrease, and it is formed into a mature and perfect metal by the coction of nature and subterraneous heat. Never have I been able to see or obtain that. Perhaps an investigation of it could teach us someting definite about the transmutation of metals; perhaps it contains medicinal properties which are sought so arduously in potable metals. [184]

In October 1732, Boerhaave wrote to Bassand that he had looked into the matter of transmutation a bit closer and that when all the main authors, among them Agricola, Mathesius, Paracelsus and , investigated the stone matrix they found first of all a thick and fat yellow-green coloured fluid, which the Germans call Guhr. Moreover, Boerhaave wondered whether Guhr is fluid gold and he wrote:

> I have wondered whether such primitive matter from which gold is formed could not be the true drinkable gold, which is so adorned by much praised virtues. This is the only reason why I desire to see it: for it would be easy to ascertain (the truth) by the cautious administration of it to patients. [185]

This fluid, after it is hardened through the boiling of nature, transforms into different kinds of metals. Boerhaave is determined to investigate the matter further. If this theory is true, he states, it must be untrue that metals originate from the melting together of fire and quicksilver, or from sulphur and mercury, as chemists like Homberg propose. This also means that the basic matter must be more like vitriol than mercury. [186]

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[183] Boerhaave to Bassand: 23 July 1733, 8 December 1733; 26 May 1734: *Ibid.,* 320-327, 323-333.

[184] Boerhaave to Bassand: 3 August 1732: *Ibid.,* 304-305. It is possible that Gur referred to the biblical place Ur of the Chaldees, and literally means the origin of metals. (Genesis 11:31). On 31 December 1732, Boerhaave wrote about Gur: 'On reading through the various true writers on metals, I keep finding that they write that in the hardest stone there is a thick, unctuous metal-fluid, like liquid soap and yellowish-green in colour, which, when it hardens, produces a real metal: which is thus said to be the primary matter in metal, soluble in water and called Gur by the diggers. This is worth knowing; for if it is found, would it not be easy to discover whether it has any healing power.' *Correspondence 2*: 312-315

[185] Boerhaave to Bassand: 8 December 1733, *Ibid.,* 326-327.

[186] Boerhaave to Bassand: 3 October 1732, *Ibid.,* 310-311.

In August 1735, a few months after Boerhaave had sent the results of his experiments on mercury to the Royal Society in London, he wrote to Bassand that he wanted to defend the opinion of Geber. That Boerhaave valued the ancient alchemist more than the opinion of many a chemist of his own time is obvious when he wrote:

> Another (...) paper I offered to the French, and the experiments with gold and silver will soon become public: these papers will show the firm truth of the old alchemists, as well as the unstable truth of the new men. You can feel my hints about Homberg and Boyle, who are followed by flocks of natural philosophers. [187]

It seems as if Boerhaave had changed his mind, for in 1718 he had written with praise about the efforts of Boyle to free chemistry from the errors of false (al)chemists. [188] However, Boerhaave was not opposed to the matter theory of the old alchemists, but much more to the mingling of theology and chemistry on the one hand and the generalisation of experimental observations into all encompassing theory. Moreover, in this particular quotation Boerhaave referred to Homberg and Boyle who claimed to have changed mercury into gold through insinuating particles of fire into the pores of mercury, and so increasing its specific gravity. [189] For Boerhaave the transmutation was very hard to believe. Unlike Boyle and Homberg he did not believe that igneous particles are the same as sulphur. Nor did he believe that fire is heavy, but he thought it to be without any gravity.

In fact, while writing the outcome of his experiments on mercury to the learned men of the Royal Society, Boerhaave praised the efforts of the early alchemists. He argued that the alchemists are all convinced that minerals that are not yet changed by fire contain a medicinal power that can resolve the sharpness of the fluids. Boerhaave himself does not doubt the truth of their claim as he witnessed the successful treatment of constipation and mania with medicines made from the minerals from the Hungarian mines. However, Boerhaave is not yet able to identify the medicinal power of the mineral as he is talking about the medicine he had produced from the first delivery of minerals and so far he had failed to produce the same medicine. On the ninth of September 1735 Boerhaave writes for the last time to Bassand about the experiments, stating that he would not rest until either he would find the

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[187] Boerhaave to Bassand: 20 July 1735, *Ibid.*, 338-339.

[188] *CSEE*: 202-203.

[189] Shaw in Boerhaave. (1741). *A New Method*: 101. The claim of Boyle and Homberg is based upon the opinion that gold is made of mercury and fixing igneous particles or sulphur. If you take the igneous particles away, you are left with liquid mercury.

medicinal power in the mineral or he would be able to prove that the chemists are searching in vain for a universal medicine.

In the *Mercurio experimenta* Boerhaave follows the same line of argument as he uses in the correspondence with Bassand. He speaks in very favourable terms about the hermetic philosophers in the tradition of Geber, thereby rejecting the contemporary opinion that the Heretics cannot be seen as natural philosophers because their methods and ideas were thought to be obscure and contrary to the new natural philosophy. Boerhaave, on the contrary, is convinced, after thoroughly reading the old chemists, that their method was based upon experiment as much as in his own days and that they only used obscure language as a code so the mysteries of nature would only be revealed to a small group of elect.

In order to find out more about the nature of mercury and its role in the origin of metals, or in other words to test the claims of his contemporaries, Boerhaave performed a great number of experiments. First of all he discovered that rubbing mercury with water and salt, multiple distillations, pressing mercury through leather and shaking of mercury (when poured into a bottle and put into the inner mechanism of a mill), may change the outward form of mercury but that it does not change the nature of mercury. Boerhaave also concluded that the chemists of his day were wrong in supposing that fire is the philosophical sulphur that transforms quicksilver into metals, although he does not deny the importance of sulphur as part of metals. In fact Boerhaave proved that mercury and fire cannot unite at all. The distillate of mercury, namely the red powder, transformed back into mercury as soon as it was exposed to a gentle heat. To describe the working of mercury and fire upon one another Boerhaave used an old alchemical metaphor. The snake, he writes, that had bitten itself and had died resurrected in great splendour from the death.[190] The conclusion that mercury and fire do not unite also makes it very doubtful that the warmth of mines, seldom more than 70°F, is the only responsible factor in transforming mercury into metals. Even though it has been said that this process takes a thousand years, Boerhaave wonders how a human being of such a short lifetime is to know?

In 1735, in a second paper to the Royal Society Boerhaave wrote about his experiments on lead, in which he tried to transform it into pure mercury. According to Van Helmont sr. and his son Franciscus Mercurius, it is possible to dissolve lead by using alkali and salt or oily substances to extract the sulphurous parts so a very fluid mercury stays behind. However, Boerhaave has

[190] Boerhaave, H. (1919 (1733-36)). 'De mercurio experimenta.' In E. Cohen (Ed.), *Herman Boerhaave en Zijne Betekenis voor de Chemie* :126.

to conclude after complicated and time-consuming experiments that it is not easily possible to transform lead into mercury.

After his failures with the lead experiments Boerhaave does not stop experimenting as in 1736, in a third paper to the Royal Society, he comes up with another method to produce mercury. So far the chemists thought that it was possible to burn out the spot of sulphur with the strongest fire, although strangely enough they at the same time deny this possibility. Boerhaave agreed with them for he was also not able to produce pure mercury after distilling it no less than 511 times.[191] Finally Boerhaave used menstrua for the purification of mercury.

During solution the solvent and solvend divide into such small particles that they become one fluid. The particles of the metals, when melted in the fire, fuse and become one homogeneous mass, wherein every particle holds the same proportion of a different metal as the whole. It is in this sense possible to separate gold *ad infinitum*, for if one part of gold were mixed with a hundred thousand parts of melted silver it would still be visible in the smallest particle of the whole mass. Thus we see, that the least particle of gold may be expanded through an immense mass of silver, so that every particle of the silver contains a proportional particle of gold, while at the same time the particle of gold remains unchanged amongst the unaltered parts of the silver.

The property of metal particles of mixing with other particles without losing their own characteristics means that the chemists believed that metals can only be opened by metals; that 'nothing but a metal can intimately enter and mix with another; and that the inner mercurial part of metals is a thing of infinite subtility, and always the same.'[192] Boerhaave's experiments on refining mercury with gold show the practical application of this method. He managed to purify quicksilver only through fusing it together with gold and afterwards separating it again, whence a black powder, which Boerhaave believed to the spot of sulphur, stayed behind. Boerhaave repeated the experiment and he managed to produce pure mercury out of the amalgam of mercury and gold, a finding that aroused his excitement. But he warns that he should not celebrate too early as too often his hopes proved to be idle.[193]

Boerhaave's discovery of black powder as the source of contamination is not entirely surprising. In alchemy the colour black signifies the death and putrefaction of the old metal, before the regeneration of a purer form. In

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[191] Boerhaave in Cohen (1919). 'De mercurio experimenta': 125, 146. See also Boerhaave's letter to Mortimer on 10 May 1737 in which he warned Mortimer not to waste time in trying to transform mercury in a strong fire. Boerhaave, H. *Correspondence 3*: 218-219.

[192] Boerhaave. (1741). *A New Method*: 1, 490.

[193] Boerhaave in Cohen (1919). 'De mercurio experimenta': 150.

alchemical theory the black powder staying behind in the alembic after an experiment symbolises a dead body that has to be washed and purified with the mercurial water before it can be sown and united with the seed of gold and with the spirit.[194] Moreover, before finishing the experiments on mercury he had already written in his *Elementa chemiae* that the metals dissolved in quicksilver, digested and ground together, produce a black powder. Boerhaave expects that if the experiment be repeated for years the metals will produce more of this black powder, and the metals will appear in their purest form. Boerhaave denied that the black powder is the same as elementary earth. Instead he defined the black powder as 'an extraordinary metallic production of admirable properties, richly deserving to be inquired into.'[195]

What do Boerhaave's experiments on the metals tell us about the Calvinist nature of his chemistry? The letters to Mortimer can give an insight in the matter. As we have seen already, Boerhaave and Mortimer corresponded about the distinction between true and false (al)chemists. They also spoke about the nature of mercury. Boerhaave argued against the predominant opinion that fire can change mercury into metals resistant against fire. He, on the contrary, had shown that fire does not have any effect upon mercury at all. In fact Boerhaave believed that God made mercury so simple that it could not be altered by any chemical means. In July 1732, shortly before sending his findings on mercury to London, Boerhaave wrote to Mortimer:

> When I have a moment free I shall write a brief note to the [Royal] Society on the strange properties of mercury, as I have discovered them in the very prolonged experiments; whence indeed we may agree that the alchemists said truly, albeit in execrable Latin, that *be it a subject of all wonder, the All Highest will never have created anything more wonderful in the nature of things*.[196]

Boerhaave, in calling mercury the most wonderful thing created by God, must have thought that investigation into its most simple properties would show him a glimpse of God's perfection.

In short, Boerhaave's chemistry is the key to nature, God's creation. The chemist is specifically privileged in seeing God's divine will in the order of things. He can see how God holds the creation together through the powers

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[194] Abraham. (1998). *Alchemical Dictionary*: see black, blackness, black earth: 26-27.

[195] Boerhaave. (1741). *A New Method*: I, 485.

[196] Boerhaave to Mortimer, 12 July 1733, in *Correspondence I*: 209. The original Latin text of the second half of the quotation is: '...unde equidem constabit, quod *alchemistae* vere dixerint de eo, licet minus Latine, quod *subjectum sit omnis mirabilitatis non creaverit Altissimus, mirabile magis in natura rerum*. I am grateful to Elisabeth Leedham Green for suggesting this translation of the passage, which differs entirely from the translation given by Lindeboom.

of bodies, how He defines the nature of all being and how He is the source of all movement through the force of fire. The nature of mercury in particular showed Boerhaave the wisdom of God in the nature of things. He counted mercury among the permanent simple elements, together with fire, air, water, earth, alcohol and the presiding spirit, through which God constantly creates and maintains the universe. This means that if for Boerhaave chemistry is the key to nature being God's creation, mercury which shows the perfection, simplicity and truth of the divine design, must have been one of the most important locks to be opened. Hence Boerhaave's history of chemistry in which he showed the truth of the ideas of the old alchemists, who had already argued for the absolute simplicity of mercury.

Thus, Boerhaave's experiments on mercury implicitly tell us about the Calvinist nature of his chemistry, for they were directed towards making the invisible visible, i.e. towards showing God's eternal power and Godhead. Moreover, Boerhaave's experiments on mercury show his belief in the omnipotence of God and the humble state of man, for the better he could demonstrate the simplicity of mercury the more it filled him with wonder over the divine wisdom. This is what made Boerhaave's chemistry different from the chemistry of his contemporaries. More than anything else, Boerhaave's chemistry was Calvinistic. His Calvinist understanding of God and His creation determined how he viewed the creation, how he did his chemical experiments and most importantly what he saw in his laboratory.

… no man can find out the work that God maketh from the beginning to the end (…)
I know that, whatsoever God doeth, it shall be forever: nothing can be put to it,
nor anything taken from it (…)
All go unto one place; all are of the dust, and all turn to dust again.

BOERHAAVE quoting *Ecclesiastes 3:11, 14 and 20*

IV. Herman Boerhaave: Calvinist chemist and physician

After having examined Boerhaave's Calvinism and his Calvinist chemistry, we can now turn to his Calvinist chemistry for medicine. So far historians of medicine have mainly stressed Boerhaave's mechanistic approach in medicine. Invariably their accounts focus on the way Boerhaave divided the body into solid and fluid parts and how Boerhaave ascribed life and action in the body to the motion of the bodily fluids in the tubes and vessels. In doing so the historians tend to separate Boerhaave's medicine from its wider social and cultural background. In other words they present the reader with historical 'facts', without questioning why Boerhaave developed his system the way he did. I shall argue that his Calvinist emphasis on the greatness of God visible in the creation on the one hand and the limitations of the human mind on the other were of crucial importance for Boerhaave's medicine. Moreover, late in the first decade of the eighteenth century, Boerhaave started considering chemistry of utmost importance for his medicine. Before discussing Boerhaave's chemistry for medicine I shall briefly describe Boerhaave's medical education. This will give us a better understanding why Boerhaave was keen on keeping up with all the latest works in chemistry and medicine.

Boerhaave started his medical studies in 1691, after graduating for his philosophy degree in December 1690.[1] His friend, Jan van den Berg, who at that time was secretary to the Curators of Leiden University, advised Boerhaave to do so, in order 'to make sure of his fortune in every way.' Although Boerhaave was trained to be a theologian, the study of medicine would 'secure his well-being by more than one anchor.'[2] Van den Berg's advice fell onto fertile ground for Boerhaave had already been thinking about medicine when he

[1] The exact date of the begining of Boerhaave's medical studies is not known. Lindeboom has suggested that Boerhaave started studying medicine in 1691, for Boerhaave after graduating for his philosophy degree in 1690 spent nine months working in the university library before starting his medical studies. Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and his Work*. Leiden: 28.
[2] Schultens, A. (1988 (1739)). *Academische Redevoering van Albert Schultens ter Gedachtenisse van den Groten Herman Boerhaave. Uitgesproken 14 november 1738* (Schultens Jan Jacob, Trans.).

was suffering from a huge ulcer on his left thigh when he was twelve years old. Moreover, Boerhaave was keen to become a physician of body and soul as Christ was when he healed the crippled and the blind.[3] Boerhaave graduated for his degree in 1693 in Harderwijk, where it was apparently as easy to buy a medical degree from the university as to buy a fish on the market.[4]

Boerhaave was self-taught. Just as he had studied theology by reading the bible and the works of the church fathers, so he started his medical studies by reading the works of Hippocrates and then worked his way through the standard medical textbooks of his time, such as the works of Vesalius, Faloppius, Bartholin and Sydenham.[5] Although he attended anatomical dissections, he did not attend lectures ('except for a few by the celebrated Drélincourt shortly before his death'), nor did he have much practical experience with the sick.[6] This was not unusual, for practical experience was not a necessary requirement for the exam. In Boerhaave's time a student was only asked to explain one of the Aphorisms of Hippocrates to show his theoretical knowledge of the art of medicine. As we saw before, Boerhaave never made it to the pulpit, but he set up a medical practice in Leiden shortly after his return from Harderwijk.

Boerhaave's way of studying influenced his approach to medicine all his life. After starting a medical practice he did not stop studying. On the contrary, he kept reading and the more he read the more often he changed his mind. In the first part of the chapter I shall show that Boerhaave adopted at least three different approaches in medicine. He started off a Cartesian mechanist, just as his teachers Senguerd and De Volder had been. Then, for a short while, Boerhaave was very much attracted to Newtonianism. However, after a few years he modified his view and although he still adopted Newtonian ideas, we cannot call him a straightforward Newtonian anymore. Rather than ascribing all changes in nature to Newtonian forces, Boerhaave argued that every body and every one of its individual parts have their own peculiar powers.

This chapter is divided into four parts. First I shall discuss Boerhaave's changes of mind and the growing importance of chemistry for his medicine. Related is the question what made Boerhaave's chemistry different from phys-

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[3] *Ibid.*

[4] Harderwijk University did not charge huge graduation fees, but every graduation meant some extra money for the professors. Hence it was easy to get a medical degree in Harderwijk. The Dutch even had a rhyme saying 'Harderwijk is a town of trade, there are sold bloaters, billberries and degrees' [Harderwijk is een stad van negotie, men verkoopt er bokking, blauwbessen en bullen van promotie]. Lindeboom. (1968). *Herman Boerhaave*: 40.

[5] *Commentariolus*: XI, XII.

[6] *Ibid.,* XI.

ics which I shall address in the second part. Thirdly I shall argue that Boerhaave's idea to study the body as a machine was not a first step in the development of modern 'scientific' medicine, but resulted from his Calvinist beliefs. The last part of the chapter is about Boerhaave's medical practice and how Boerhaave applied his Calvinist chemistry to medicine at the bedside.

From 'mechanical instruments' to 'threads of the warp'

In his *Elementa chemiae* of 1732 Boerhaave wrote:

> wise men observe the works of nature as they offer themselves, and then by experiments endeavour to learn the laws; which the Creator has impressed on His work and in what manner each thing according to its peculiar nature arises, is produced, or perfected; the principal of which law is that all things arise from other similar pre-existing ones; plants from plants, animals from animals, and fossils from fossils. That all power of propagating is contained in the seminal matter alone; which converts every crude thing it takes, into its own form, and assimilates it to itself. [7]

Thus all appearances in nature result from the individual power of every creature, contained in the semen of its kind, to realise itself. Moreover, God Himself endowed the seed with its peculiar power of propagating. We have already seen that Boerhaave explained the growth of metals using a theory of regeneration. I shall now show that for the older Boerhaave the seminal principles came to be of utmost importance in his medicine as well and that he proposed chemistry as the best method to know their working.

Before explaining Boerhaave's views on the seminal principles I shall briefly recapitulate Calvin's views on Creation. This will give us a better understanding of why Boerhaave emphasised the seminal principles. Calvin argued that the creation is like God's royal tent in which man can behold God. [8] Moreover, God maintains and preserves every creature through His divine energy which He constantly infuses into every being. In fact, God preserves every creature in such a way that the fecundity of nature will never fail. We have already seen that Boerhaave's fire is very similar to Calvin's 'divine energy.' In this chapter I shall argue that Boerhaave similarly believed that God implanted seeds in His Creation, so that it thus might grow, bear fruit and show the glory of God the Creator.

The seeds of things, according to Boerhaave, are eternally and everywhere the same and 'form the foundation and support for each single body existing,

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[7] Boerhaave, H. (1741). *A New Method of Chemistry* (Shaw, P., Trans.). (2 ed.). London: 1, 201.
[8] Calvin. (1997 (1559)). *Institutes*: 1, v, 1. Calvin is referring to Psalm 104:3-4.

growing, moving, maintaining itself and propagating itself by fruitful generation.' [9] The seeds have in them the origin of vegetables, animals and minerals. Boerhaave argued:

> Plant, animal, and mineral have this very same day the identical characteristics and form which they have had throughout, from times immemorial; the same alternations of birth, growth, activity, bringing forth, illness, and death. They all carry hidden in their veins prolific seeds from which similar bodies may then be brought forth (...) Surely the mind, overcome and lost in thought, is transported when it recognises even in the tiniest thing something of the infinite. [10]

Thus the seed is one of the most simple bodies in nature and yet has in itself the power to develop into a particular being. Thus the atoms of the body do not unite via blind collision, but something steers their movements. Moreover, the variety of nature cannot be brought back to universal principles, but 'each single species acknowledges principles particularly its own.' [11] The only way to know the variety of forms of bodies, is to study the creation. Boerhaave referred to Moses who revealed nature in his biblical accounts.

> This is why I confess, willingly and reverentially, that the Prince of Sages, Moses, has in few words explained and set forth the order of nature far more beautifully than the other philosophers in their enormous volumes. Listen, I beg of you, listen to wisdom's summary on the subject of physics! Accept that most energetic utterance, the effective power of which has made the world fruitful! *Let the earth bring forth the green herb, which shall yield its own seed, after its kind.* [12]

For Boerhaave the process of reproduction was proof of the divine act of creation. He starts with the Aristotelian argument that the human body can only come into being through a 'man and a woman of the preceding generation who have reached a certain age, according to a fixed law, from one particular substance, always in one and the same manner.' Thus a human being cannot come into existence through anything else but his own kin. Moreover a man and a woman have to be simultaneously present. However, he then gives his explanation a specific theological turn. Boerhaave does not believe in an eternal world, but he believes that there is a teleological process. The process shows that 'the first man owes his coming into being to a cause infinitely greater than human nature.' [13]

Although the seeds guarantee the life and existence of the creation, Boer-

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[9] *CCP*: 165.
[10] *Ibid.,* 167.
[11] *Ibid.,* 168.
[12] *CSEE*: 186. Boerhaave quotes from Genesis 1:11.
[13] *HMS*: 249.

haave also admitted that 'certain of the more simple bodies do not have seminal power, and consequently do not increase nor transmute others into their own nature.' [14] Among these Boerhaave mentioned fire, which serves to give motion to bodies, water, the nutriment of all bodies and earth, being the building stone of the body. These bodies display such a great simplicity that they exclude 'all organic structure of seed.' [15] However, Boerhaave did not define them as passive, for he argued that fire, water and earth have an innate power (*innatam facultatem*) through which they sustain and apply their nutriment and so continually propagate themselves.

Boerhaave presented a picture of the world filled with latent powers peculiar to every combination of particles. Among them are the seminal powers, the powers of fire, water and earth and many powers yet to be discovered. The question is how Boerhaave defined the powers of bodies? Given Boerhaave's admiration for the work of Newton are Boerhaave's powers the same as the Newtonian forces? What is the role of chemistry in discovering the powers of bodies and what made Boerhaave's chemistry different from his physics? Last but not least how did Boerhaave apply his theory of latent peculiar powers in his chemistry for medicine?

We have already seen in chapter three that Boerhaave in his *De cohaesione corporum* (1687) discussed the porosity of bodies with respect to the cohesion of particles. He argued that the greater the porosity of a body, the lesser the individual parts cohere together. The emphasis on porosity is not surprising, given the fact that he delivered his disputation under the supervision of one of the university's leading Cartesians, Wolferd Senguerd, and porosity was an important theme in Cartesian matter theory. However, Boerhaave did not explain the matter very clearly at the time. Only in his works of later years does the importance of porosity become clear. It can be said that Boerhaave believed that the activity in nature happens mainly in the pores in between particles. Fire insinuates itself into the cavities of even the most solid matter, giving life and motion. Water and oil similarly penetrate into the pores of matter, so as to act as a glue to keep the particles together. It must be said that Boerhaave's later explanation is not necessarily Cartesian, for in 1715 he no longer attached much value to Cartesian explanations of the behaviour of natural bodies, such as the laws of motion, the power of elasticity, the nature of the magnet and the explanations of the human body. [16]

It follows that the actions of chemistry depend upon what happens in the

[14] Boerhaave. (1741). *A New Method*: I, 201.
[15] *Ibid.,* I, 201.
[16] *CCP*: 174-175.

pores and not so much upon the individual particles themselves. Boerhaave's chemical experiments are directed towards finding new appearances and powers which appear when dissolving a compound into its most simple particles and, after examining the ingredients, mixing them again. So the individual particles are not active in themselves, but only show their powers when combined with other bodies. For example when applying the force of fire to a mixture of well dried salt of nitre and pure oil of vitriol, the chemist ends up with a liquor containing a ruddy, volatile, fiery, acid spirit. [17] The particles of salt of nitre and vitriol in themselves are quiescent, but as soon as they are brought together in the fire, they transform into another nature with other qualities.

The ultimate cause of all chemical phenomena, and thus the cause of the latent peculiar powers, is God. Boerhaave added to the above mentioned experiment:

> Thus we see an effect, the cause whereof is lodg'd by God in these bodies; yet so as that it never becomes manifest to man, except by these contrivances, precisely thus applied. [18]

For Boerhaave matter is passive and it needs another non-material God-given cause in order to give life and motion to natural bodies. On a note in the Kirov collection, which accompanied notes of chemical experiments between 1720 and 1732, Boerhaave copied some texts from Ecclesiastes, which emphasise his belief in a God who is constantly in charge of everything. God, who created the earth, remains for ever while the generations of man come and pass away in a regular cycle. [19] The Calvinist emphasis on the omnipotence of God and the littleness of man becomes particularly obvious when Boerhaave repeats after the Preacher that 'man is built of dust and shall return to the earth as it was.' [20] After death the spirit returns to God, its first origin, the God-given powers of the body fade away and the particles fall apart. Man, in his existence is entirely dependent upon God, who constantly operates the mechanism of his body via the powers caused by a collision of particles. We cannot say that it is God himself who is present in the pores of bodies, but he employs the powers of bodies as instruments in His hand.

We have already seen that Boerhaave was very enthusiastic about Newton's

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[17] Boerhaave. (1741). *A New Method*: I, 197. The experiment was originally developed by Glauber.
[18] *Ibid.,* I, 197.
[19] Kirov MS XIII 9/Leiden MF Q 252, *Experimenta chemica, 1720-1732.* Boerhaave copied Ecclesiastes 1:4 and 9; 3:11, 14 and 20; 7:10; 11:3; 12:7.
[20] *Ibid.,* Ecclesiastes 3:20; 12:7. See also *HMS*: 262. Boerhaave stated: 'Observe the act of creation through which God constructs the human body from insignificant dust, as is set out by the eminent professor who occupies this chair [of medicine] so successfully.'

ideas on the forces of attraction, which work in a similar way as Boerhaave's powers. However, at this point we have to ask how Newtonian Boerhaave really was? I shall argue that Boerhaave was carefully avoiding general theory and he strongly believed that man's knowledge of causes is very limited. For both Boerhaave and Newton the ultimate cause of everything is God. Yet Newton is more optimistic than Boerhaave in believing that man can come close to understanding God. Newton argued that 'the main business of Natural Philosophy is to argue from Phaenomena without feigning Hypotheses, and to deduce Causes from Effects, till we come to the very first cause, which is certainly not mechanical.' [21] In the same Query Newton argued that although 'every true step made in this Philosophy brings us not immediately to the Knowledge of the first cause, yet it brings us nearer to it.' [22] Moreover, in his search for knowledge, Newton wanted to eliminate as many individual causes as possible. He argued in the *Opticks*:

> To tell us that every species of things is endow'd with an occult specifick quality by which it acts and produces manifest effects, is to tell us nothing: but to derive two or three general principles of motion from phaenomena, and afterwards to tell us how the properties and actions of all corporeal things follow from those manifest principles, would be a great step in philosophy. [23]

Boerhaave, on the other hand, did not believe it possible to ever come near to knowing the first cause. He was far more interested in the individual characteristics and powers of bodies than in Newton's 'general Laws of Nature' through which the principles of motion work in the *minima naturae*. [24] Boerhaave's natural philosophy was not directed at knowledge of the divine as such, but his aim was to see God's hand in the creation. In this way he could marvel at the greatness of God (which is beyond understanding) and align himself to His will. In discussing Boerhaave's Newtonianism we have to turn to Boerhaave's early career in the 1700s. In these years Boerhaave incorporated Newtonian forces in his natural philosophy. His later change of mind defined his point of view for the rest of his life.

The difference between the early and the late Boerhaave is best visible when comparing the *Institutiones medicinae* of 1708 and the *Elementa chemiae* of 1732. The former presents a mechanistic medicine partly based on Cartesian ideas of matter and motion and the mechanics of Newton's *Principia*. Boerhaa-

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[21] Newton, I. (1730). *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light*. (4 ed.). London: Query 28, 369.
[22] *Ibid.,* 370.
[23] *Ibid.*, 401-402.
[24] *Ibid.,* Query 31, 401.

ve's chemistry textbook, on the contrary, was influenced by the chemistry of Newton's *Opticks*. Moreover, in his chemistry textbook Boerhaave on every occasion also emphasised the non-mechanical cause of all natural phenomena. My argument follows Christie's suggestion that there is a remarkable difference between Boerhaave's early mechanistic medicine of the *Institutiones medicinae* and his later chemical approach. [25]

Historians of science have always approached and studied Boerhaave's medicine starting with the *Institutiones medicinae*, written in Boerhaave's early years as a medical teacher. [26] This has reinforced their opinion that Boerhaave's medicine is a mechanistic system, in which there is no place for vitalistic principles. Both Lindeboom and Luyendijk-Elshout have argued that Boerhaave was very consistent in the use of mechanistic ideas in medicine, even though later on some of those got a vitalistic meaning. [27] Recently A. Debus has also argued that although for the later Boerhaave chemistry was important, yet 'it was clearly not to become the theoretical basis of medicine.' [28] On the contrary, I shall argue that when approaching Boerhaave's medicine from the angle of his chemistry, Boerhaave's medicine in the long term is not as mechanistic as historians have argued. In particular the introduction of powers peculiar to every body into the realm of medicine shows how Boerhaave's medicine ultimately relied upon non-mechanical principles and that Boerhaave's approach is closely related to his Calvinist beliefs. In the *Elementa chemiae*, published in 1732, at the end of Boerhaave's academic career we meet another Boerhaave for whom chemistry was at least as important as mechanics in the explanation of the working of the body.

When Boerhaave started teaching medicine in 1701, he presented a medicine mainly based on Cartesian mechanics and Newtonian hydraulics and hydrostatics. This is most visible in Boerhaave's 1703 oration in which he pleaded for the adoption of the mechanical method in medicine, something which De Volder had already suggested in 1698. Boerhaave even referred to his old teacher and he told his audience: 'You will find here a man [De Volder] who will reveal all hidden mysteries of *mathesis* with incredible ease of lucid

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[25] Christie, J.R.R. (1994). 'Historiography of Chemistry in the Eighteenth Century: Herman Boerhaave and William Cullen.' *Ambix, 41*, 4-19.

[26] According to Lindeboom, Boerhaave wrote his medical work because in the beginning of his teaching career he was aware of the need for a decent textbook. Lindeboom. (1968). *Herman Boerhaave*: 70.

[27] *Ibid.,* 272-274; Luyendijk-Elshout, A.M. (1982). 'Mechanicisme contra Vitalisme. De School van Herman Boerhaave en de Beginselen van het Leven.' *Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek, 5* (1), 16-26.

[28] Debus, A. (2001). *Chemistry and Medical Debate. Van Helmont to Boerhaave*. Canton, MA: 201.

speech, and who will show you how to apply them in medicine.' [29] Boerhaave argued that

> the human body is composed in such a way that its united parts are able to produce several motions of very different kinds which derive – fully in accordance with the laws of mechanics – from the mass, the shape and firmness of the parts and from the way in which they are linked together (...) Therefore man has a body in the sense which the mechanicians give to that term and show all the characteristics which are displayed by this clearly defined category. [30]

Under the heading of mechanics, Boerhaave counted geometry and 'the science of the liquids' as most important in revealing the 'many factors which determine the nature, the impetus and direction of the humours which circulate through our vessels.' [31]Structure is the key word in Boerhaave's early mechanistic medicine, and he points to the crucial importance of the net-like organisation of the tubes and vessels for the maintenance of life. [32] The structure of the body even determines the nature of the fluids, for the particles of the blood break according to the size of the containing vessel, so that the sanguiferous arteries contain the large red globules of the blood, the smaller serous arteries hold the yellow of serous globules and the smallest particles of the blood, the spherules end up in the lymphatic arteries. [33] Not only the blood, but also milk, semen and the other humours are produced in a mechanical way through the small tubes of the glands. In other words the parts of the body work like *mechanical instruments*, maintaining the life and motion of the body. Boerhaave summarised his argument and stated that

> the human body is a mechanism, the solid parts of which are either vessels, capable of encompassing, directing, changing, separating, collecting and secreting liquids, – or *mechanical instruments* which through their form, firmness, and through the way in which they are joined, are able to sustain other parts, or to produce certain movements. [34]

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[29] *URM*: 119.
[30] *Ibid.,* 96-97.
[31] *Ibid.,* 97.
[32] *Ibid.,* 99. A. Guerrini has similarly argued that Pitcairne derived function from structure. See: Guerrini, A. (1987). 'Archibald Pitcairne and Newtonian Medicine.' *Medical History, 31*, 70-83: 80.
[33] *Ibid.,* 100. Lindeboom gives a detailed explanation of the division of blood particles in Lindeboom, G.A. (1970). 'Boerhaave's Concept of the Basic Structure of the Body.' *Clio Medica, 5*, 203-208.
[34] *URM*: 102. My Italics.

Boerhaave believed that the fluids are ultimately built of solid particles working according to their mass, motion and shape. [35] They are distinguished one from another through 'the quality of elasticity, specific gravity, dense or thin consistency, various degrees of adhesiveness, the speed with which a fluid moves and the direction of its path.' [36] However, Boerhaave did not want to ascribe the working of the body to the particular qualities of each single particle. Instead, he emphasised the common nature of fluids, as explained by the mechanicians. [37] Life, health and even the working of remedies depend upon the mechanical motion of the fluids in the solids. Boerhaave used the Cartesian metaphor of a clock in order to explain that once the mechanician knows the working of its inner mechanism, he can correct the structure and repair its defects. [38]

Boerhaave's presentation of the mechanical method in medicine is very optimistic, for he believed that 'it is certainly a marvellous science, almost superhuman as to its results which exceed all expectations! For its most subtle and complicated discoveries are based on principles which are sure, yet very few in number and generally known.' [39] Boerhaave held that the particular nature of all bodies depend on the 'active force' and that as soon as the latter is known, the differences between bodies can be disclosed. In fact, Boerhaave argued that 'the human body is in its nature the same as the whole of the Universe which is open to our view.' [40]

The emphasis on mechanics meant that Boerhaave did not value the use of chemistry for medicine very highly. 'What need is there,' he argued, 'of elements, qualities, forms, chemical, animate, or metaphysical causes, the disposition of loving and hating – where, I say, is there room, a reason, a need, for so many fables?' [41] Chemistry is very useful for medicine for 'it yields an abun-

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[35] T. Brown has argued that Boerhaave's emphasis on the solids distinguished him from the work of Pitcairne, who mainly based his physiology on the working of the fluids. Brown, T. (1969). *The Mechanical Philosophy and the 'Animal Oeconomy.' A Study in the Development of English Physiology in the Seventeenth and early Eighteenth Century.* Unpublished Ph.D., Princeton University: 296-297.

[36] *URM*: 104.

[37] *Ibid.,* 106.

[38] *Ibid.,* 111.

[39] *Ibid.,* 95.

[40] *Ibid.,* 96.

[41] *Ibid.,* 102. See also RSM: 130. The 'disposition of loving and hating' is a metaphor used in alchemy to denote two opposites and is similar to the opposition between peace and strife, man and woman, active and passive, sulphur and mercury, hot and cold, fixed and volatile, spirit and body, form and matter. 'The alchemists were ultimately concerned with the union of substances, the reconcilliation of opposites' in the so called chemical wedding, through which the Philosopher's Stone could be produced and gold obtained. Abraham, L. (1998). *A Dictionary of Alchemical Imagery.* Cambridge: see chemical wedding, peace and strife, 35-39, 141.

dance of observed facts and provides us with an excellent compendium of methods of observation.' [42] However, Boerhaave argued that chemistry is useless in the formulation of general rules through which the physician can logically deduce some sort of theory. Boerhaave argued that

> in our body (...) more things come about through these common properties of liquids, to the examination of which the geometricians apply themselves, than through the spurious, doubtful qualities of liquids which are often artificially created by the chemists' art. [43]

However, not long after forcefully arguing for the adoption of a mechanical method in medicine, Boerhaave changed his mind. In 1709, in his oration on the simplicity of medicine, Boerhaave started moving away from a medicine which was mainly based on the laws of mechanics, hydraulics and hydrostatics and he started emphasising the individual qualities of bodies. In other words Boerhaave changed from stressing the mechanical effects of the fluids moving in the solids to explaining the nature of the humours and the blood in chemical terms. The change is particularly visible in Boerhaave's preface to Bellini's *De urinbus et pulsibus* (1717). He praised the achievement of the mechanical philosophy, but at the same time he states that chemistry is best able to investigate the nature of the humours. [44] Boerhaave's different approach is also visible when comparing his description of the humours in his medical and chemical textbooks.

In his *Institutiones medicinae* of 1708, Boerhaave stressed the general mechanical motion of the blood through the veins and arteries and how the globules of blood split according to the sizes of the vessels. He argued that all the principal functions or actions of the blood result from 'the motion of the humours through the vessels, and by the re-action of the vessels upon those humours.' [45] So this means that 'the whole mass of blood is drove forward with so great a force and again repell'd by so many great resistances in passing through a full conical, pliable and very elastic vessel.' [46] Boerhaave's description of the motion of blood in the vessels is so similar to the views of Newton in the second book of the *Principia* that we can state that Boerhaave was di-

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[42] *URM*: 105.

[43] *Ibid.,* 105.

[44] Boerhaave in Bellini, L. (1730). *De urinis et pulsibus de missione sanguinis de febribus, de morbis captis et pectoris opus Laurentii Bellini, dictatum Francisco Redi cum praefatione Hermanni Boerhaave*. Leiden: praefatio.

[45] Boerhaave in Haller. (1742). *Dr. Boerhaave's Academical Lectures on the Theory of Physic. Being a Genuine Translation of his Institutes and Explanatory Comment, collated and adjusted to each other, as they were dictated to his students at the University of Leyden*. Göttingen: ii, 255.

[46] *Ibid.,* ii, 145.

rectly influenced by Newton's ideas on the motion of bodies in resisting mediums. For example, Boerhaave's idea on the motion of blood seems to reflect Newton's propositions that when the particles of a fluid are similar and have the same given ratio of density to each other and the same motion, these particles 'will continue to move among themselves with like motions and in proportional times.' [47] This means that in an elastic vessel 'every tremulous body (...) propagates the motion of the pulses on every side straight forward.' [48] Boerhaave likewise argued that

> The blood then, being drove out of the heart in an oblique direction against the sides of the aorta, strikes and presses on them in a very acute angle (...) Hence therefore the particles of the blood will every moment receive a different motion, collision, and rotation; as also a constant attrition, attenuation, and compactness, with an abrasion or levigation of their angles, and an uniformity or similitude in each particle. From all which will arise that fluidity, heat and colour observable in the whole mass, with that division of its parts fitting them to pass through all the small vessels. [49]

By contrast, in the *Elementa chemiae*, published in 1732, Boerhaave devoted more attention to the actual nature of the blood, rather than its motion. A reason for the shift of attention is that Boerhaave believed that many illnesses are caused by putrefaction of blood stagnated in the obstructed vessel of an unhealthy person. The otherwise perfectly round and neutral particles change into an acid or alkaline nature and harm the body. This change is the result of a changing situation in which the particles normally react with one another. When stagnating the particles affect each other in a different way and so result in illness. The temperature of the body is of crucial importance in assuring a healthy circulation of the blood. Boerhaave had observed *in vitro* that a gentle heat, such as in the chemical process of digestion, resolves and volatilizes the blood. However, the body should not be too hot, for the blood will coagulate into masses, stop the circulating fluids and cause the death of the patient. An experiment worth our attention is the coagulation of blood with alcohol *in vitro*. As we have seen Boerhaave considered alcohol the *pabulum ignis*, the principle of inflammability, which means that it has the same effect as fire upon the particles of the blood, i.e. 'the liquor (...) coagulates the grosser juices of

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[47] Newton, I. (1729). *Mathematical Principles of Natural Philosophy and his System of the World* (Andrew Motte, Trans.). London: book II, prop. XXXII, theorem XXVI, 327.
[48] *Ibid.,* book II, prop. XLIII, theorem XXXIV, 371.
[49] Boerhaave in Haller. (1742). *Academical Lectures*: ii, 150.

the body like fire, and contracts the fibrous parts, rendering them hard and dry, and preserves both from spontaneous putrefaction.' [50] Hence the treatment of haemorrhages with alcohol and the violent disorders of the nerves and brain after drinking too much alcohol.

Boerhaave's *in vitro* experiment with blood and alcohol shows the action of the individual particles of the blood. For instance, Boerhaave argued that the experiment shows that the watery particles are the most volatile part of the blood, while the 'pitchy oil strongly coheres with the earth of the blood.' [51] Boerhaave argued in the same way as Newton had done in the thirty-first Query of the *Opticks*, where Newton describes many chemical experiments which show the forces and reactions of the individual particles of bodies. It can be said that Boerhaave closely followed Newton's saying that

> all the parts of Animals and Vegetables are composed of Substances volatile and fix'd, fluid and solid, as appears by their analysis; and so are Salts and Minerals, so far as Chymists have been hitherto able to examine their Composition. [52]

Why did Boerhaave change his mind? I shall argue that the widespread use of the microscope in the Low Countries at the time, the attention to detail, which is visible in contemporary Dutch paintings, and the works of naturalists like Jan Swammerdam and Frederik Ruysch had a profound effect upon Boerhaave's mind. [53] In 1709, in his oration on the simplicity of medicine, Boerhaave praised the virtues of the microscope for 'who could desire a clearer light for the scrutiny of the intestines than that which is shed by the use of the microscope?' Moreover, 'the injection of coloured liquid in the meandering vessels of the body,' a technique developed by Swammerdam and Ruysch, similarly shows that 'the tiniest and most hidden things are wholly similar to the greatest and most visible ones.' [54] Boerhaave still believed in the possibility of achieving some sort of certainty in medicine. He argued that 'the better the constitution of our body is known, the simpler it will found to be,' and he proposed to start with the study of the simplest parts of the body.

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[50] *Ibid.,* ii, 222. Boerhaave seems to contradict himself in this instance, for in his chapter on pure fire, he had argued that the effect of fire upon the particles of bodies is the loosening of bodies, rather than the coagulating of particles.

[51] *Ibid.,* ii, 223.

[52] Newton, I. (1730). *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light*. (4 ed.). London: Query 31, 385.

[53] For a discussion of the Dutch attention to detail see: Ruestow, E.G. (1996). *The Microscope in the Dutch Republic. The Shaping of Discovery.* Cambridge; Alpers, S. (1989 (1983)). *The Art of Describing. Dutch Art in the Seventeenth Century.* London.

[54] *RMS*: 134.

However, paradoxically, the microscope and most importantly chemistry had also taught Boerhaave that the simplicity of nature is more complex than he thought. Van Leeuwenhoek's microscopic observations on the globules of the blood and *in vitro* experiments on the bodily humours had shown Boerhaave that although the particles of the humours themselves are simple yet their working is different in every vessel. [55] Boerhaave stated:

> It is of course rightly maintained that each single effect depends on its own cause; but it is absolutely wrong to assume that these causes are wholly determined by the variety of the humours. For the same action of the same liquid, when it takes place in different vessels of the body, produces extraordinarily different effects. [56]

Boerhaave also stated that 'a new argument' had proved that the 'imagination had produced a greater multiplicity in them [the humours] than is actually found to exist.' [57] It is likely that Boerhaave was referring to the 'new argument' of Newton, who had published the first edition of his *Opticks* in 1704, and in 1706 the Latin edition with the Queries containing Newton's thoughts on chemistry, particles and forces. It is not unthinkable that Boerhaave's emphasis on simplicity was based on Newton's own first rule of reasoning in philosophy, published in the *Principia*, which states that 'nature is pleased with simplicity, and affects not the pomp of superfluous causes.' [58] In the *Opticks* Newton pursued his search into simplicity and discussed the smallest particles of matter and the forces in between them causing them to act.

According to Thackray's historical account of Newton's matter theory, Newton's atoms differ from the atoms of the classical authors. [59] They not only have the inherent force of *vis inertiae*, but also the active forces of gravita-

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[55] Boerhaave described his *in vitro* experiments on milk, urine and blood in part three of the *Elementa chemiae* (1732). Unfortunately the experiments are not dated. Perhaps the experiments are described in the two notebooks describing Boerhaave's chemical experiments between 1699 and 1717, which are currently unaccessible for research.

[56] *RMS*: 135.

[57] *Ibid.,* 135.

[58] Newton. (1729). *Mathematical Principles*: 398. The Latin original reads: natura enim simplex est & rerum causis superfluis non luxuriat. Newton, I. (1687). *Philosophiae naturalis principia mathematica*. London: 402. Christianson quoted from Newton's manuscripts: 'Truth is ever to be found in simplicity, & not in ye multiplicity & confusion of things (...) It is ye perfection of God's works that they are all done wth ye greatest simplicity. And therefore as they that would understand ye frame of ye world must endeavour to reduce their knowledge to all possible simplicity.' See: Christianson, G.E. (1984). *In the Presence of the Creator. Isaac Newton and His Times*. New York: 261.

[59] To avoid confusion in the terminology: Boerhaave's bodies and humours are build of corpuscles, which in turn are build of atoms or particles.

tion, fermentation and cohesion.[60] The ultimate particles themselves are immutable, but the corpuscles built of the atoms are subject to change. Chemistry employs the interparticle forces in order to change the composition of bodies.[61] In Newton's work 'force is the causal principle of motion and rest.'[62] Unlike Cartesian motion, which needed no force or cause to maintain motion, Newton, according to Westfall, held that 'the prime necessity of an operative dynamics was a conceptual unit to measure the 'external cause' of changes of motion.'[63] Hence, Newton's chemistry was directed at showing the forces between particles that cause and maintain motion, rather than any chemical properties of the particles themselves.

Boerhaave adopted this idea and from 1709 he argued that the ultimate particles of the bodily fluids are perfectly round and simple and do not have chemical properties as such. Just as in modern chemistry Boerhaave's chemistry was based on the idea that 'a chemical reaction involves two particles.'[64] Only when these are brought together do the individual powers of bodies show themselves. This means that when chemists 'bring bodies in contact with other ones' they can observe the effects and discover the properties of bodies.[65]

In 1718 Boerhaave put the same argument forward in stronger terms. He argued against the iatrochemists who presented the human body as a 'chemical laboratory, an arena in which the chemists could stage their games,' in which chemically endowed particles react with one another in processes of fermentation.[66] Boerhaave stressed that chemical experiments differ from the processes in nature and that instead of forcefully reconciling the processes

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[60] Thackray, A. (1970). *Atoms and Powers. An Essay on Newtonian Matter-Theory and the Development of Chemistry*. London: 23. It must be remarked that in the 31st Query of the *Opticks*, fermentation is a result of the forces of attraction and repulsion and not an independent force. Newton argued: 'Now the above-mention'd motions are so great and violent as to shew that in Fermentation the Particles of Bodies which almost rest, are put into new Motions by a very potent Principle, which acts upon them only when they approach one another into pieces, and vanish into Air, and Vapour, and Flame.' Newton, I. (1730). *Opticks, or a Treatise of the Reflections, Refractions, Inflections & Colours of Light*. (4 ed.). London: 380.

[61] Thackray. (1970). *Atoms and Powers*: 25, 31.

[62] Westfall, R. (1971). *Force in Newton's Physics. The Science of Dynamics in the Seventeenth Century*. London, New York: 338.

[63] *Ibid.,* 344.

[64] Nye, M.J. (1992). 'Physics and Chemistry: Commensurate or Incommensurate Sciences?.' In M.J. Nye & e. al. (Eds.), *The Invention of Physical Science* (pp. 205-244). Dordrecht: 213.

[65] *RMS*: 132.

[66] *CSEE*: 206. For a more detailed discussion on the idea of the human body as a chemical laboratory see: Clericuzio, A. (1994). 'The Internal Laboratory. The Chemical Reinterpretation of Medical Spirits in England (1650-1680).' In A. Clericuzio & P. Rattansi (Eds.), *Alchemy and Chemistry in the Sixteenth and Seventeenth Centuries*. Dordrecht.

of the body to *in vitro* chemical processes, chemistry should keep within the limits of showing the effects of chemical reactions.[67] In 1709 we can already see the first signs of Boerhaave's later opinion, for Boerhaave no longer only stressed the general mechanics of the fluids, but he started devoting attention to the working of the smallest corpuscles of the body. Moreover, Boerhaave praised the chemists in their efforts to discover the nature of the smallest particles and so to enter 'the innermost sanctuary of nature.'[68] He argued that not mechanics, but 'wearisome pharmacy and laborious chemistry hardly produce better results than simplicity.'[69]

We can now see how chemistry for medicine had also shown Boerhaave the limits of human knowledge of the simple parts of bodies. He argued:

> Now let us grant that the simplicity of this science [medicine] is accepted in as far as it is still in its infancy; we may fear that it will become difficult in a later stage when it has achieved perfection. If I am not mistaken, there is a straightforward argument that leads me to a very different conclusion. For everything has only a single nature, particularly its own. When we know this nature fully, the thing will never be seen in another light. On the other hand, the more we bring forward, the less real truth will be discovered, when it is a case of reasoning rashly about essentially unknown matters.[70]

Time after time Boerhaave argued that 'when the hidden depths of the body are most clearly revealed, our mind openly acknowledges that its science becomes less vast, the more is knows about it.'[71] This means that Boerhaave was not prepared to adopt the Newtonian forces in order to explain *all* natural occurrences.

In 1715, in his oration on the achievement of certainty in physics, the limitations of knowledge become even more clear. Paradoxically, Boerhaave's answer to the question of certainty in physics is that man cannot achieve certainty at all. Boerhaave started his oration stating that 'the first principles of nature are wholly hidden from us.'[72] He defined the 'first principles' as the things 'through which, once they have come into being, all changes that happen in the universe are effected with inherent necessity.'[73] The change in Boerhaave's mind is complete. In 1703 he had argued for the adoption of the mechanical method in medicine in order to 'have at our disposal a medical

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[67] *CSEE*: 210.
[68] *RMS*: 142.
[69] *Ibid.*, 140.
[70] *RMS*: 133.
[71] *Ibid.*, 134.
[72] *CCP*: 155.
[73] *Ibid.*, 156.

science which is more reliable, not subject to fantasy, not continually changing, but eternal.'[74] In 1715, Boerhaave is not so sure anymore and he argued that although physics is very useful in investigating nature, the universal laws of physics 'show up the imperfections of assumed first principles.'[75]

In order to show the limits of physics in explaining first principles, Boerhaave showed the impossibility of showing the essence of atoms and motion. He argued against the Cartesians who defined the nature of bodies in terms of extension because it is an impossible starting point in understanding the nature of change.[76] According to Boerhaave the void and weight are similarly useless concepts in understanding the nature of bodies. Also the forces of attraction cannot give any insight into the first principles of things. Boerhaave stated that the origin and nature of bodies cannot be known and the only thing the natural philosopher can see are the effects of a non-mechanical cause. Even attraction itself is not more than the effect of an unknown cause. Boerhaave was very much opposed to philosophers who sought to disclose the 'permanent laws and eternal covenants' and 'predict with mathematical certainty and prove each individual change that will result when bodies are brought together in collision.'[77] In doing so the philosophers made the same mistake as before for they wanted to explain all the actions of nature according to one universal principle. Instead, Boerhaave argued that

> there will be found to exist as many distinct species of attraction as there are kinds of different bodies – each of which, however, is regulated by its own laws. Is it not proved by the visible system of the world, gravity, magnetism, the force of electricity, the efficacity of salts, the action of seeds, in short, the forces of individual bodies?[78]

According to Boerhaave, even Newton, unlike his followers, was cautious in adopting the term 'attraction,' for Newton defined attraction as the effect of a hidden cause. However, 'it does not explain what this cause is, nor does it set forth in what intelligible manner it evokes such a motion.'[79] So changing motions are the only effects of attraction a philosopher can observe and, in later years, Boerhaave pointed to chemistry, rather than physics, as the best means to reveal the effects of the powers of bodies. In 1718 Boerhaave told his audience to be careful with universal doctrine, for 'each time the chemists brought some bodies in contact with others, they discovered new phenom-

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[74] *URM*: 112.
[75] *CCP*: 175.
[76] *Ibid.,* 160.
[77] *Ibid.,* 162.
[78] *Ibid.,* 163.
[79] *Ibid.,* 163.

ena, different reactions, and dissimilar effects, which refused to be encompassed by some universal common law.' [80] Boerhaave even pointed to mechanics for 'helping explore this wrong opinion, by proving that smaller units react in the same way as the larger ones.' [81]

Thus, Boerhaave did not adopt Newtonianism as an all encompassing theory, explaining all the actions of nature. Instead, he emphasised the individual powers of bodies and rather than the forces of attraction, he adopted seminal principles, or *threads of the warp* in order to explain the variety of things in the created order. Boerhaave argued in 1715:

> Yet if it now pleases us seriously to consider the method used by nature to achieve effects (...) it will then become evident that the causes of these things are not the ones usually accepted among philosophers. For, apart from the elements and motion, another enduring first principle is to be found from which each single thing depends. What I have in mind are *threads of the warp* that through no cause can be randomly loosened, that cannot be produced by any cause: these threads are entwined and woven together, so as to form the foundation and support for each single body existing, growing, moving, maintaining itself, and propagating itself by fruitful generation. You realize that I allude to the seeds of things. [82]

Boerhaave even goes as far as stating that the phenomena arising from the working of the seminal principles are the prime concern of the natural philosopher. [83] He is in no way able to recreate the seed itself, but he can only observe the powers it works in natural bodies. Thus the seminal principles stand at the beginning of all variety in nature, which means that seeds carry in them 'the creation, the nature and powers of single bodies.' [84]

What happened between 1709 and 1715 that made Boerhaave turn his attention to seminal principles? Was it because Boerhaave, after his appointment to the chair of botany in 1709, started improving the botanical garden through collecting and planting seeds? Or is the answer more trivial and do we have to ascribe Boerhaave's change of mind to the fact that he got married and that his marriage with Maria Drolenvaux was a happy one. Boerhaave dedicated the second edition of the *Institutiones medicinae* to his father in law and he apologised for taking away his daughter who was such pleasant company for him. [85] Boerhaave's marriage was blessed with four children of whom only the eldest

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[80] *CSEE*: 202.
[81] *Ibid.,* 203.
[82] *CCP*: 165. My italics.
[83] *Ibid.,* 165.
[84] *Ibid.,* 168.
[85] Lindeboom. (1968). *Herman Boerhaave*: 97-98. Boerhaave, H. (1713). *Institutiones medicinae*. (2 ed.). Leiden: preface.

daughter, Joanna Maria, born in 1712, survived. It is unlikely that Boerhaave took his marriage light-heartedly, for he was a serious man and he loved his wife and children. [86] Whatever it was that made Boerhaave change his mind, the effect was that Boerhaave no longer believed in the achievement of certainty, but he started emphasising the variety of nature and the hidden (occult) qualities of natural bodies particular to each kind. Boerhaave's reference to a 'union of love or friendship' in order to explain cohesion is but one example. [87] He used the seminal principles as a major example.

As a result, in 1715 even more than in 1709, Boerhaave expressed his fascination with the microscopic discoveries of Malpighi, Swammerdam and Leeuwenhoek when speaking about the working of the 'threads of the warp.' They had all studied the rich variety of the creation in the first beginnings of animals in female eggs and male semen. [88] Ruestow, in his historical account of the beginning of microscopy in the Low Countries has discussed the works of Swammerdam and Leeuwenhoek. He has argued that in the seventeenth century the Dutch were fascinated with 'the imagery of invisible mechanisms' and he has called the medicine resulting from this fascination the 'Cartesian physiology of invisible mechanisms.' [89] In particular in Leiden the new physiology coincided with a keen interest in the anatomy of the smallest structures of bodies. In the 1660s the lymphatic network provoked much speculation and controversy. One of the main issues at stake was whether 'the semen with its generative power came from the lymph, the blood, or the "animal spirits" of the nerves.' [90] Among the anatomists discussing the issue were Frederik Ruysch, Jan Swammerdam and Reinier de Graaf, names mentioned by Boerhaave with much praise in his 1715 oration.

In particular the work of Swammerdam on the reproductive organs of insects must have captured Boerhaave's imagination. In September 1735 Boerhaave wrote to his friend Bassand that he had been busy for some time editing the works of Swammerdam and he stated that 'among the books on natural

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[86] Boerhaave's letters to Bassand show how Boerhaave delighted in seeing his daughter grow up. See: *Correspondence 2*.

[87] See chapter three. Boerhaave, H. (1732). *Elementa chemiae*. Leiden: ii, 98. Fairly recently historians of science have devoted more attention to the importance of 'occult qualities' in natural philosophy. See: Henry, J. (1986). 'Occult Qualities and the Experimental Philosophy.' *History of Science, 24*, 335-381; Schaffer, S. (1987). 'Godly Men and Mechanical Philosophers.' *Science in Context, 1*, 55-85.

[88] *CCP*: 166. See also page 171. For a discussion on the controversies surrounding the discovery of male semen and female eggs see: Roe, S.A. (1981). *Matter, Life and Generation. Eighteenth-Century Embryology and the Haller-Wolff Debate*. Cambridge.

[89] Ruestow. (1996). *The Microscope*: 41.

[90] *Ibid.,* 44-45.

history now in existence none of those praised equal or approach this book.'[91] Swammerdam dissected insects under the microscope which allowed him to give detailed descriptions of the rich variety in nature, and to show the greatness of the Creator in the smallest details. Among other things Swammerdam was very interested in the ovaries of mayflies, bees and other insects. However, it is not clear whether Boerhaave's interest in seminal principles resulted from an interest in the work of Swammerdam, for Boerhaave only started collecting and transcribing the 'Bible of Nature' towards the end of his life. It is more likely that the microscopic observations regarding male spermatozoa of Leeuwenhoek influenced Boerhaave's thought.[92]

Ruestow has discussed that throughout the eighteenth century it was disputed what Leeuwenhoek's discovery of the spermatozoa was a discovery of? This question was also linked to the question 'what kind of life it [life visible under the microscope] was and how it impinged upon the other world of living things.'[93] Although Boerhaave used the microscope in his natural philosophy he did not consider it the main instrument for discovering the properties of living beings. Boerhaave's interest in seminal principles and the underlying cause of life might have been started by the microscopical observations of Malpighi, Leeuwenhoek and Swammerdam, but he nevertheless developed a chemistry of living things in order to discover the powers peculiar to every creature.

In Boerhaave's eyes, chemistry, of all natural philosophy, is best able to show the variety of life and motion in nature and improving natural knowledge, for 'chemistry is best adapted for discovering (...) latent peculiar powers of bodies.'[94] Boerhaave's admiration for the old alchemists is not surprising for the seminal principles were an important aspect of their work. They defined the seed as 'the interior heat, or the specific spirit, which is enclosed in the humid radical.'[95] Alchemy mainly speaks about mercury, the seed of metals. It cannot be a coincidence that Boerhaave experimented extensively on mercury towards the end of his life. Maybe he thought that insight into the

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[91] Boerhaave to Bassand, 9 September 1735, *Correspondence 2*: 340-341.

[92] For a discussion of Leeuwenhoek's microscopic discoveries see: Ruestow. (1996). *The Microscope*; Schierbeek, A. (1959). *Measuring the Invisible World. The Life and Works of Antoni van Leeuwenhoek FRS*. London, New York.

[93] Ruestow. (1996). *The Microscope*: 260-261.

[94] Boerhaave. (1741). *A New Method*: 1, 173. The Latin original is: 'Atqui prorsus proprias hasce rerum dotes chemiam longe pulchrius detegere aptando his prodendis corpora, quam aliam, quaecunque demum illa fuerit, disciplinam, palam est. Colligere jure videmur optimo, Artem nostram princeps esse scientiae rerum naturalium promovendae, maximeque aptum, instrumentum.' Boerhaave, H. (1732). *Elementa chemiae*. Leiden: 1, 79.

[95] Abraham. (1998). *Alchemical Dictionary*: seed, 180.

seed of metals would also give him a better understanding of seminal principles in general, although he must also have been aware of the limitations of such a comparison.

Boerhaave's choice to use chemistry in investigating the effects of the first principles of things is not surprising. Recently A. Clericuzio, has argued that the seminal principles were an important topic in seventeenth century atomism and chemistry, although it was not studied by Cartesians.[96] Clericuzio has argued that Boyle's adoption of the seminal principles shows that Boyle's 'mechanical philosophy' was not as mechanical as historians of science have thought, for his particles have chemical rather than mechanical properties. It is unlikely that Boyle directly influenced Boerhaave as Boyle never published his thoughts on seminal principles. Nevertheless for Boerhaave, as for Boyle, all creatures are born out of a seed and all particles have a power in them to form themselves into a body. Among the chemical authors writing about seminal principles, who possibly affected Boerhaave's views especially in later years was Van Helmont. While investigating the properties of the metals, Boerhaave grew to appreciate Van Helmont so much that in his correspondence he regularly referred to him and even called him 'Father Helmont' (*Helmontius pater*).[97] Moreover, W. Burton in his biography states that Boerhaave 'had read over carefully Paracelsus four, and Helmontius seven times: the latter was his favorite.'[98] An important aspect of Van Helmont's concept of semen is that it is religious. He held that God installed a plan of life and development in every creature and, as such, God's idea 'is enshrined in the semen of each being,' an idea we also find in the work of Boerhaave.[99]

Returning to the question of how Newtonian Boerhaave really was, we can now give an answer. We can say that Boerhaave changed from a self-assured Cartesian mechanical philosopher into a doubtful Newtonian. He did adopt Newton's ideas of the forces, and he did praise Newton's adoption of chemistry as the best means to investigate their effects, but he was at the same time

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[96] Clericuzio, A. (1990). 'A Redefinition of Boyle's Chemistry and Corpuscular Philosophy.' *Annals of Science, 47*, 561-589: 583.

[97] See Boerhaave's correspondence with Bassand. The references to Van Helmont become more and more positive towards the end of Boerhaave's life. Lindeboom, G.A. (Ed.). (1957). *Boerhaave's Brieven aan Bassand*. Haarlem; *Correspondence 2*. For the reference to 'Father Helmont see: Boerhaave to Bassand, 23 July 1733, *Correspondence 2*: 320-321.

[98] Burton, W. (1743). *An Account of the Life and Writings of Herman Boerhaave*. London. Burton also states that Boerhaave esteemed Van Helmont more as a philosopher than as a physician, for he did not find Van Helmont's remedies very effective.

[99] Pagel, W. (1982). *Joan Baptista Van Helmont. Reformer of Science and Medicine*. Cambridge: 60. See also: Pagel, W. (1986). *From Paracelsus to Van Helmont: Studies in Renaissance Medicine and Science*. Cambridge.

very careful in universally applying them to all natural phenomena. Boerhaave's later orations and the *Elementa chemiae* show his particular Dutch Calvinist approach in medicine. His religion forbade him from compressing all natural phenomena into natural laws only, which would be the same as trying to capture God into the limited capacity of the human mind. Instead, Boerhaave proposed to look at the nature and powers of bodies as resulting from seminal qualities. The seeds, more than anything else show the variety of the creation and the ingenious divine design. Just as his fellow countrymen were busy with microscopes in order to see the greatness of God in the working of the smallest animals and (seminal) principles, Boerhaave started investigating the powers peculiar to every body. Moreover, Boerhaave pointed to chemistry as the best method to discover the hidden powers of bodies and the variety of creation.

Medicine, physics and Boerhaave's chemistry of living things

Boerhaave's clear distinction between chemistry and physics makes it even more clear that the later Boerhaave was only partially Newtonian. Boerhaave not only argued that chemistry and physics are different disciplines, but he also subjected physics to chemistry and made his chemistry of living things the most important discipline upon which to build medicine. When Boerhaave accepted the chair of chemistry he argued:

> And so chemistry surpasses other disciplines in usefulness; it is now impossible for it to harm what is pure and holy through abuse (...) In physics we can be of good cheer with this guide, in medicine all possible good may be expected from it. It teaches most faithfully how the deepest secrets may be revealed, intricacies be disentangled, how hidden forces of bodies may be discovered, imitated, changed, applied, and perfected. [100]

Likewise, when he resigned his chair of chemistry, Boerhaave told his audience that 'physics may derive some benefit' from the 'important questions' he wanted to address in his old age. [101] Presumably Boerhaave was referring to his experiments on mercury, the seed of all metals which also involved extensive experiments on Guhr, the first matter of metals.

What made Boerhaave's chemistry different from his physics? Since the seventeenth century the distinction between physics and chemistry has been somewhat blurred and has been matter of debate between its respective practitioners. In the 1960s the distinction was that

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[100] *CSEE*: 211.
[101] *SAC*: 233.

"chemists love molecules, and get to know them individually, in the same way that politicians love people." In contrast (...) "physicists are more concerned with fields of force and waves than with the individual personalities of the molecules or matter." [102]

Although this characterisation is a modern one, and of course we cannot speak of molecules as such in Boerhaave's chemistry, we can use it in order to understand Boerhaave's distinction between chemistry and physics. Just as in the 1960s, Boerhaave believed that chemistry, more than physics, shows the individual characteristics of bodies, while physics is more concerned with general theory.

In the *Elementa chemiae* Boerhaave clearly distinguished between chemistry and physics. He argued:

> mechanics, and those skilled in hydrostatics and hydraulics, have explained many operations in nature by an infallible method, from the general properties common to all bodies. But from all these sciences, how much soever improved, they have never been able to account for those effects of bodies which depend on the disposition peculiar to certain kinds thereof; which the Creator has endowed therewith beyond all the rest; as those effects would never have existed, had such peculiar power or property of the body been wanting. [103]

Thus, mechanics explains the general characteristics of bodies, while chemistry is concerned with the peculiar properties. Chemistry 'resolves a compound into its simples, and having examined those ingredients separately, unites them again after a certain manner, in hopes of finding some new appearance, or power turn up.' [104] Physics, which in the Newtonian sense is synonymous with mechanics, on the contrary tries to formulate natural laws. Throughout his career Boerhaave warned against the danger of universal doctrine and he kept stressing the importance of knowledge of particulars. Chemistry, of all natural philosophy, would keep the natural philosopher within the bounds of

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[102] Nye. (1992). 'Physics and Chemistry': 217. Nye quotes the definition of Mulliken in: Mulliken, R.S. (1968). 'Spectroscopy, Quantum Chemistry, and Molecular Physics.' *Physics Today, 21*, 52-57: 55.

[103] Boerhaave. (1741). *A New Method*: 1, 173. The original Latin reads: 'Fatemur Mechanicos, Hydrostaticos, Hydraulicos, ex assumtis generalibus, omnique corpori communibus, rerum proprietatibus explicuisse, fallaci nunquam methodo, multas actiones Physicas. Attamen ex omnibus hisce, vel excultissimis, nunquam ostendere valuere eos corporum effectus, qui vere pendent ex singulari corporum effectus, qui vere pendent ex singulari corporum ingenio, proprio tantum certis quibusdam, quae CREATOR hac dote prae aliis omnibus sola dotavit: neque enim uncenam extitissent effecta haec, abfuisset, illa penitus insita suo cuique particulari corpori vis.' Boerhaave. (1732). *Elementa chemiae*: 1, 79.

[104] Boerhaave. (1741). *A New Method*: 1, 173. The original Latin reads: 'Illa compositum sua in simplicia resolvit, mox seorsum perspecta haec certo artificio adunat ea spe, ut videat, quaenam oritura sit inde rerum nova facies, quae potestas?' Boerhaave. (1732). *Elementa chemiae*: 1, 79.

what he was supposed to know, while at the same time allowing him to discover the hidden secrets of nature. Boerhaave stated:

> He [the chemist] does not regard the names of substantial forms, but sticks to the consideration of the sensible powers peculiarly found in each body; which he exhibits by effects and shews how they may be applied to the production of the noblest work. He pays no homage to occult qualities [daemons, goblins, or spirits], but discovers by his art the effects ignorantly ascribed thereto; and teaches how, when discovered, they may be brought into action. He readily confesses his ignorance as to the creation of seeds, and the peculiar structure given to each body at its first origin; but carefully attends to the appearances arising therefrom, and after noting them faithfully down, applies them directly to the working changes in things. [105]

Adopting chemistry as the 'guide' to physics and medicine would also prevent the natural philosopher from supposing that the 'universal cause in physics can be compressed in the tiny enclosure of the human mind.' [106] At the same time chemistry would give him new and wonderful insights into the marvels of God's creation.

Although Boerhaave called 'the chemical art the best and fittest means of improving natural knowledge,' Peter Shaw in the footnotes tried his hardest to change Boerhaave's chemistry into a branch of Newtonian mechanics. [107] Chemistry, he argued, is 'sublimer mechanics,' for mechanics, being the doctrine of motion, is a key to understanding chemical effects. Shaw distinguished sublimer mechanics from common mechanics, for the latter has to do with 'common laws of sensible masses,' while the latter deals with the 'more remote intestine motions of the component particles of the same bodies whereon the changes of texture, colour, properties, &c. induced by chemistry depend.' [108] Shaw argued that matter in itself 'has real power of inactivity, a *vis inertia*, which removes it even out of a state of indifference, and determines it absolutely to remain inactive.' [109] The active powers as 'gravity, whereby bodies tend towards the centre; attraction, whereby particles of bodies cohere;

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[105] Boerhaave. (1741). *A New Method*: 1, 174. The Latin for the first part of the quotation reads: 'Liber inani ultimarum causarum inquisitione praesentis dabit. Nec daemonas, lemures, spritus, invocans, sed corpora corporibus vere nata applicans opera perficiet. Non curabit formarum substantialium nomina, sed sensu perceptas potestates, quas insevit peculiari, cuique corpori, penitus singulares, per ipsa ostendet eventa, deprehensique his uti docebit ad praestanda maxime mirifica opera.' Boerhaave. (1732). *Elementa chemiae*: 1, 80.

[106] *CCP*: 158.

[107] Nye has argued that the subjection of chemistry to mechanics was common from the early seventeenth century. Nye. (1992). 'Physics and Chemistry': 207-208.

[108] Shaw in Boerhaave. (1741). *A New Method*: 1, 155.

[109] *Ibid.*, 1, 173.

the cause of elasticity, magnetism, fermentation &c.' [110] Common mechanics explains the motion of bodies while sublimer mechanics or chemistry deals with the active powers, the forces of bodies upon which all motion depends. Shaw argued that although the forces of attraction equally apply to all bodies, the motions in the *minima naturae,* acting on one another at a distance, 'flow from certain powers, or forces not reducible to any of those in the great world.' [111] Shaw states that:

> Our noble countryman [Newton] (...) has the glory of opening a new source of sublimer mechanics; which, duly cultivated, might be of infinitely more extent than all the mechanics yet known. 'Tis hence alone we must expect to learn the manner of the changes, productions, generations, corruptions, &c. of natural things; which are the great part of philosophy called chemistry. [112]

For Shaw the cause of the forces is infinitely great and beyond understanding. The philosopher can see how an impulse works its effect, but he does not know the working of the impulse itself. Nevertheless, it is extremely important to know that nothing would exist without the active principles. Shaw paraphrased Newton and argued:

> Body itself is merely passive, and needed some other principle to move it; and now that it is in motion, it needs some other principle for conserving that motion. By the tenacity of fluids, the attrition of their parts, and the weakness of elasticity in solids, the motion which we find in the world, is always dwindling and on the decay; so that there arises a necessity of recruiting it by active principles; Such are the cause of gravity (...) and such the cause of fermentation, by which the heart and blood of animals are kept in perpetual motion, the inward parts of the earth are constantly warm'd, bodies burn and shine, mountains take fire, caverns blown up, &c. 'For we see but little motion in the world, beside what is owing to these active principles: And were it not for these, the bodies of the earth, planets, comets, sun, and all things in them, would grow cold, and freeze, and become unactive masses.' [113]

Shaw, while commenting upon Boerhaave's chemistry does exactly what Boerhaave never wanted anybody to do, i.e. to fit everything into a general theory. We should not of course forget that Boerhaave was very enthusiastic about Newton's work, but Shaw made Boerhaave more Newtonian than he actually was. Boerhaave emphasised the working of individual bodies and their powers, while Newtonian physicians attempted to formulate universal rules.

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[110] *Ibid.,* I, 173.
[111] *Ibid.,* I, 155.
[112] *Ibid.,* I, 156.
[113] *Ibid.,* I, 157. Shaw paraphrased Newton. See: Newton. (1730). *Opticks*: 399-400.

In order to emphasise the distinctiveness of Boerhaave's ideas, I shall compare his medicine to the Newtonian medicine of the British physicians Archibald Pitcairne and James Keill. [114] In his oration on the usefulness of the mechanical method in medicine, Boerhaave singled out Pitcairne, among others, for his application of mechanics in medical matters. Although Pitcairne had been teaching medicine in Leiden from 1692 until 1693, it is unlikely that Boerhaave heard Pitcairne speak, for apart from some lectures of Drélincourt, Boerhaave did not attend lectures on medicine at all. [115] In the years Pitcairne was in Leiden he contested the iatrochemistry of his predecessor Franciscus dele Boë Sylvius (1614-1672) and he presented a medicine based on the mechanics of Alfonso Borelli and Lorenzo Bellini. In later years, while teaching medicine in Edinburgh he also incorporated Newtonian hydraulics and hydrostatics into his physiology.

Brown in his *The Mechanical Philosophy and the 'Animal Oeconomy'* has argued that according to Pitcairne 'the goal of *all* science, medical as well as physical, is to find the *true causes* of natural appearances by manipulating experience mathematically.' [116] For this reason he focused on fluids and forces on the one hand and matter and movement on the other. Brown has argued:

> What he (Pitcairne) really discovered by his Newtonian 'phenomenalism' were not the laws of animal behavior and function as they present themselves to the unbiased experimental investigator, but 'the Laws and Properties of the Fluids and Canals of Human Bodies,' which the mathematician in him could handle with no change of method or modification or principle. [117]

In Pitcairne's system, just as in Boerhaave's early medicine, life is a result of the constant circulation of the blood caused by the motion of the heart and arteries. [118] Moreover, all other functions of the body depend upon the free

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[114] See for British Newtonianism: Jacob, M.C. (1976). *The Newtonians and the English Revolution 1689-1720*. Hassocks, Sussex.

[115] *Commentariolus*: xi.

[116] Brown. (1969). *The Mechanical Philosophy*: 217. See also Brown, T.M. (1970). 'The College of Physicians and the Acceptance of Iatro-mechanism in England, 1665-1695.' *Bulletin of the History of Medicine, 44*, 12-30; Brown, T.M. (1974). 'From Mechanism to Vitalism in Eighteenth-Century English Physiology.' *Journal of the History of Biology, 7*, 179-216; Brown, T.M. (1977). 'Physiology and the Mechanical Philosophy in Mid-Seventeenth-Century England.' *Bulletin of the History of Medicine, 51*, 25-54; Brown, T.M. (1987). 'Medicine in the Shadow of the *Principia*.' *Journal of the History of Ideas, 48*, 629-648.

[117] Brown. (1969). *The Mechanical Philosophy*: 219.

[118] Pitcairne, A. (1745). *The Philosophical and Mathematical Elements of Physick*. London: 7. See for Pitcairne's medicine also: Cunningham, A. (1981). 'Sydenham versus Newton: The Edinburgh Fever Dispute of the 1690s between Andrew Brown and Archibald Pitcairne.' *Medical History, supplement 1*, 71-98.

flow of the blood and humours secreted from the blood through the vessels of the body. Pitcairne treated the blood like any other fluid, which meant that he adopted general mechanical laws in order to transform the body into a hydraulic system. [119] The physician was not more than a mechanic controlling 'the fluids in the body by managing the parts of them which naturally come out through the excretory channels.' [120]

In the last part of his book, Brown has argued that the Newtonian physiology of James Keill, based on the *Opticks* replaced the mathematical medicine of Pitcairne. [121] The difference between the two is visible when looking at the nature of the blood. Brown put Pitcairne in the category of medical writers who had argued that the blood breaks up into smaller parts, according to the sizes of the vessels. Pitcairne considered this operation to be purely mechanical, thereby rejecting the idea of a ferment in each organ stirring the blood and 'preparing it for the selective filtration of certain particles.' [122] Keill proposed the Newtonian forces of attraction between the different sort of particles of the blood as a better solution for the problem of secretion. Moreover the measure of attraction and cohesion could account for the differences in the humours and secretions. [123]

However, more recently Guerrini has argued that there was not an abrupt break between the mechanistic theories derived from Newtonian physics and the vitalistic theories of the later eighteenth century, but that the physiology of the late seventeenth and early eighteenth century was quasi-vitalistic. [124] This vitalism was a result of Newtonian theories of the ether. Guerrini has also mentioned Pitcairne as the first to develop a Newtonian physiology, but she takes the argument further than Brown. She argued that Newton's *De natura acidorum*, published in 1710 in John Harris' *Lexicon Technicum* 'reinforced Pitcairne's growing perception that the key to mechanistic physiology lay in a chemistry of short-range forces, just as the key to life itself was the Harveian circulation of the blood.' [125] Contrary to Brown, Guerrini has argued that

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[119] Brown. (1969). *The Mechanical Philosophy.* 229.

[120] *Ibid.,* 231.

[121] For biographical details on James Keill see also: Valadez, F.M., & O'Malley, C.D. (1971). 'James Keill of Northampton, Physician, Anatomist, and Physiologist.' *Medical History, 35*, 317-335.

[122] Brown. (1969). *The Mechanical Philosophy.* 314. See also Pitcairne, A. (1745). *The Philosophical and Mathematical Elements of Physick*. London: 35.

[123] Brown. (1969). *The Mechanical Philosophy.* 315.

[124] Guerrini, A. (1985). 'James Keill, George Cheyne and Newtonian Physiology, 1690-1740.' *Journal of the History of Biology, 18*, 147-166, Guerrini follows a similar argument in her accounts of the Scottish physicians Pitcairne and Gregory. Guerrini, A. (1986). 'The Tory Newtonians: Gregory, Pitcairne and Their Circle.' *Journal of British Studies, 25*, 288-311; Guerrini. (1987). 'Archibald Pitcairne and Newtonian Medicine.' *Medical History, 31*, 70-83.

[125] Guerrini. (1985). 'Newtonian Physiology': 250.

although Pitcairne in general proposed a mechanical physiology, he implicitly acknowledged Newtonian forces. For example, when Pitcairne argued that the blood breaks up into smaller parts, he also stated that the cohesion of the minutest parts cannot be broken by any mechanical force. [126] Pitcairne's 'chemical cohesion' between the smallest parts, Guerrini argued, 'was not mechanical in origin, but was caused by an attractive force.' [127] Unlike, his followers, Pitcairne did not work out the chemistry of forces. He did not mention the forces of attraction in his work and he stuck to hydraulics and mathematics as the key to physiology. In his inaugural lecture in Leiden he argued:

> Our knowledge of Things is confined to the Relations they bear to one another, and the Laws and Properties of Powers (*vires*), which enable them to produce changes in some things, and to become altered by other things. [128]

According to Guerrini, James Keill was the first to develop a physiology based upon the Newtonian forces of attraction. In his *Essays upon Several Parts of the Animal Oeconomy* (1717) Keill wrote on animal secretion:

> The Power by which the Particles of the Blood attract one another is the same with that which is the Cause of the Cohesion of the Parts of Matter as was first communicated to me by my brother (...), who had no sooner discovered it, but he deduced from it the cohesion of the parts of matter, the cause of the elasticity of bodies, or fermentation, dissolutions, coagulations, and many other of the operations in chymistry. And since it will appear that the whole Animal Oeconomy does likewise depend upon this Attractive Power; it seems to be the only principle from which there can be a satisfactory conclusion given of the *Phaenomena* produced by the *Minima Naturae*. [129]

Unlike Pitcairne, whose forces of attraction operate between particles and the passages in the glands, Keill spoke about the attraction between particles themselves. [130] This means that for Keill the corpuscles themselves 'were in-

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[126] Guerrini. (1987). 'Pitcairne and Newtonian Medicine': 76-77.
[127] Guerrini. (1985). 'Newtonian Physiology': 251.
[128] Pitcairne in: Guerrini. (1987). 'Pitcairne and Newtonian Medicine': 73.
[129] Keill, J. (1717). *Essays on several Parts of the Animal Oeconomy.* London: 101-102. Guerrini quotes the same passage in a shorter form in Guerrini. (1985). 'Newtonian Physiology': 256. Boerhaave possessed copies of Keill's *Account of Animal Secretion* (1708), the *Essays on Several Parts of the Animal Oeconomy* (1717) and *The Anatomy of the Human Body* (1703). It must be noted that Boerhaave only possessed the second revised edition of the last work which does not yet include the chapter on 'the Velocity and Quantity of the Blood' containing Keill's chemistry of forces, which Keill added in the seventh edition of 1723. (1739). *Bibliotheca Boerhaaviana, sive catalogus librorum instructissimae bibliothecae viri summi D. Hermanni Boerhaave*. Leiden: no. 846-848.
[130] Guerrini. (1985). 'Newtonian Physiology': 257.

animate particles of matter, and the process he described was chemical.' [131] The process is chemical because of the chemical reactivity resulting from the attractive force of acids. [132] Keill argued that his process of animal secretion was much simpler than the one proposed by the mechanists. Keill no longer needed a different sort of particle for every concretion, but only four or five different varieties of primary particles, which could conglomerate into twenty-two (twenty-six in later years) different combinations, with different sizes and shapes. In due course the particles could be strained out and pass into their proper vessel in the body. [133]

How does Boerhaave's medicine differ from the Newtonian medicine of his British colleagues? We have seen already that Boerhaave was sceptical about a universal application of the forces of attraction in the explanation of bodily phenomena. He ridiculed the natural philosophers who 'are immensely eager for glory and proudly proclaim that at last, in our time, that first principle [attraction] is discovered from which effects in nature come into being, can be learned and demonstrated.' [134] It must be this sentiment that Peter Shaw referred to when warning against a precipitate application of the sublimer mechanics. Even though Shaw considered the forces in the *minima naturae* as the key to understanding nature, yet he argued that attraction 'is such a complex thing, that it may solve a thousand different things alike (...) and till more of its properties are ascertained, it were better to apply it less, and study it more.' [135] Von Haller also commented upon Boerhaave's explanation of the nature of the blood that Keill, unlike Boerhaave, rushed into general hypotheses in which he made attraction account for the motion of the blood and the contraction of the muscles. [136]

Yet, in the development of Boerhaave's thought we can almost distinguish the ideas of Pitcairne and Keill. Boerhaave started off with presenting a mechanical medicine which very much resembled the medicine of Pitcairne, and just after the publication of Newton's *Opticks* he started devoting more attention to the individual powers of bodies. However, unlike Keill, Boerhaave moved away from Newtonianism in the early 1710s. Rather than emphasising general laws of nature, he emphasised the powers peculiar to every natural

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[131] *Ibid.,* 257.

[132] Guerrini, A. (1985). 'James Keill, George Cheyne and Newtonian Physiology, 1690-1740.' *Journal of the History of Biology, 18*, 147-166: 250. Guerrini refers to Newton's *De natura acidorum*, which resulted from Newton's chemical and alchemical experiments in the 1680s. In the essay Newton 'set forth a case for short-range attractive forces analogous to gravity.'

[133] *Ibid.,* 258.

[134] *CCP*: 162.

[135] Shaw in Boerhaave. (1741). *A New Method*: 1, 157.

[136] Haller, A. v. (1742). *Academical Lectures*: iii, 233-234.

body in every particular situation. In Boerhaave's eyes, the principles of motion, the elements and seminal principles, more than Newtonian forces of attraction, reveal the rich variety of nature. Moreover, rather than subjecting chemistry to mechanics, Boerhaave argued that the changes of bodies effected by motion 'is the subject of chemistry, and of chemistry alone:'

> All changes that befall bodies are effected by motion alone, when this is imparted to a mass and sets it going. We must therefore scrutinize the cause of this motion and learn to know the ways in which it may be called forth between bodies, be changed, or brought to a stand. Yet these forces wholly elude the perspicacity of the human mind – only through observation of their evident effects do they become manifest to the senses, and hence they eventually become known to the mind. This is why it will be worthwhile carefully to scrutinize such movements as come into being when bodies in the vicinity of others begin to stir. Bringing some bodies close to others, then, and again removing them from this neighbourhood, meanwhile rousing them with the powerful help of stimulating fire to their proper activity – is it not evident that all this is the subject of chemistry, and of chemistry alone? [137]

Boerhaave's emphasis on the individual characteristics and powers of bodies is directly visible in his *Elementa chemiae*, where he describes the processes of digestion and secretion. We have seen that for Boerhaave the particles of the body are perfectly round and neutral. What gives individuality to every animal is the *effluvia*, 'the most subtile part of the juices of animals [present in the nervous fluids], which is continually exhaling, wherein the proper character of each animal seems to reside, and whereby it is distinguished from all others.' [138] These *effluvia* are comparable to the *spiritus rector*, the presiding spirit in all matter, giving each body its own individuality, and seems 'of an oily origin, or to reside in a subtile vehicle of an oily kind.' [139] Also, *in vitro* chemical experiments had shown Boerhaave that the animal salts and oils appear to act differently in every body and in every situation. Thus, Boerhaave argued that

> it is in vain to expect that by carefully separating these [the elements of the animal body], and artfully mixing them again, we should reproduce the natural humours from whence they were obtained. On the contrary, by such mixture we should produce compounds very different from the primitive ones; for in each part of an animal we find humours of a peculiar kind, which always appear specifically different from one another.

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[137] *CSEE*: 199-200.
[138] Boerhaave. (1741). *A New Method*: 1, 151. See also Boerhaave in Schulte. (1959). *Hermanni Boerhaave Praelectiones de Morbis Nervorum 1730-1735. Een Medisch-Historische Studie van Boerhaave's Manuscript over Zenuwziekten*. Leiden: prae. 4, 1 April 1732, 154-155.
[139] Boerhaave. (1741). *A New Method*: 1, 151.

In contrast, Keill also believed that the individual particles of bodies are the same, but he ascribed the difference between the humours to a difference in cohesion between the corpuscles of salt and minerals swimming in an aqueous fluid. [140] Boerhaave, on the contrary hardly ever spoke about the forces of attraction, but ascribed individual characteristics to non-mechanical entities like *effluvia* and *spiritus rector*. Also Keill believed that chemical experiments could reveal the effects of the forces of attraction and cohesion and so be a great help in the building of a trustworthy physiology. [141] Boerhaave on the other hand expressed his doubts about the possibility of ever knowing to the fullest the processes of the body, for the effects visible in *in vitro* experiments are not necessarily the same as the effects of the body. This means that for Boerhaave chemistry is essential in medicine, not for its usefulness in formulating general laws, but for its ability to reveal the powers peculiar to a particular part of the natural body in a particular situation.

Boerhaave's emphasis on the smallest particles of matter and the powers peculiar to every part of the body, means that he moved away from the traditional attention to the nature of the blood. Instead of discussing the relatively big globules of the blood he is far more interested in the smallest vessels and fluids of the nervous system. In his *Institutiones medicinae* he had already pointed to the importance of the nerves in the explanation of motion and also in the process of nutrition. The last process can only take place in the smallest vessels of which the larger vessels are built. This means that the particles of the chyle are too big and unable to nourish and repair the solid parts of the body. For this reason, Boerhaave argued that nutrition chiefly happens in the nerves, with the nervous juice, which is the most subtle humour prepared from the serum of the blood, feeding the solid parts. [142] Boerhaave called this process 'one of the ultimate and most perfect actions of nature.' [143]

For Boerhaave the nervous system was not only important in the process of nutrition and growth, but was also of crucial significance for the life and movement of the body. Boerhaave was so concerned with the working of the nervous system that he decided to extensively lecture on the brain and nerves in the last years of his academic life. [144] The lectures give a good impression of Boerhaave's ideas on the working of the nerves as well as on issues

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[140] Keill. (1717). *Essays*: 97-98.

[141] *Ibid.,* 102-103.

[142] *Boerhaave in Haller. (1742). Academical Lectures*: iii, 363.

[143] *Ibid.,* iii, 366.

[144] Boerhaave's lectures on nervous diseases are in the Kirov collection as well as microfilmed and brought to Leiden. Leningrad XIII, 10, 11 and IX, 40/Leiden F699 and Q259, *Chemica opera, De morbis nervorum, 1730-1735*. The historian Schulte translated and annotated the lectures available on microfilm in Leiden in Schulte (1959). *De morbis nervorum*.

of intellect and will. I have already spoken of the latter, so I shall restrict myself to a discussion of the medical side of Boerhaave's lectures. Still, the argument remains the same. Just as Boerhaave believed that God imprints true knowledge upon the mind, he believed that the brain and nerves and thus the movements and powers of the body are similarly directed by God.

Boerhaave's teaching on the nervous system moved away from the ideas taught by Thomas Willis (1621-1675) who at the time was the most well known physician investigating the anatomy and action of brain and nerves. [145] Willis adopted many iatrochemical ideas into his physiology and he ascribed the working of the nerves and muscles to fermentations in the blood of the *spiritus animales* with the sulphurous and nitrous particles of the vital soul. Boerhaave, on the other hand, ascribed the working of the nerves to spirits in the nervous fluids and their peculiar power to generate motion. Boerhaave defined the spirits as exceedingly small particles, different in every organ of the body, endowed with a power of causing motion and sensation. [146] Thus the motion of the heart is caused by nerves that enter the heart between the aorta and pulmonary artery where they cause muscular contractions and relaxations. [147] The spirits, of which the above mentioned *effluvium* is an example have an oil at their basis. Moreover, Boerhaave points to the chemists who best explained the nature of the spirits. [148]

Unfortunately the spirits do not only account for their own power, but have the ability to take on new powers. Hence, many diseases are caused by a poison working its ill power via the nervous fluids upon the organs of the body. [149] Boerhaave referred in particular to contagious diseases like the plague, the pox and venereal diseases, illnesses resulting from the bite or sting of an animal, and the disorders after drinking too much alcohol or smelling the poisonous spirits of plants and minerals. At a later stage I shall discuss how Boerhaave tried to cure the disorders by looking at his prescription of mercury in the case of venereal disease.

In conclusion we can say that Boerhaave, far from subjecting chemistry to physics, proposed a chemistry of living things as the best way to discover the latent powers of bodies, and therefore as the best instrument to investigate the

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[145] See: Willis, T. (1664). *Cerebri anatome cui accessit nervorum descriptio et ususi*. London; Willis, T. (1683). *Two Discourses concerning the Soul of Brutes, which is that of the vital and sensitive of Man*. London.

[146] Boerhaave in Schulte (1959). *De morbis nervorum*: prae. 3 and 4, 21 March and 1 April 1732, 152-155.

[147] *HMS*: 255.

[148] Boerhaave in Schulte (1959). *De morbis nervorum*: prae. 20, 23 September 1732, 178-179.

[149] *Ibid.,* prae. 5, 3 April 1732, 156-157. Boerhaave also believed that many nervous diseases are caused by defects in the vessels of the brain causing illnesses in the *dura mater*. However, these illnesses are not directly relevant for the argument.

working of the body. For this reason we should be careful with the interpretations of Peter Shaw, for although he was sometimes right in commenting upon Boerhaave's chemistry in a Newtonian manner, he was also a bit too enthusiastic in doing so. Boerhaave did adopt Newtonian ideas in his medicine, but at the same time he developed his very own medical programme in which chemistry, and not 'sublimer mechanics,' was most important in revealing the rich variety of powers installed by God in the solids and fluids of the body. I shall now turn to Boerhaave's Calvinist approach in studying the body as a machine.

The making of a Calvinist physician

Although Boerhaave's medicine changed considerably over the years, one thing remained the same: Boerhaave tried to be a Hippocratic physician all his life. In his first medical oration in 1701 as well as thirty years later in his last oration, Boerhaave recommended the study of Hippocrates to his listeners. An ever returning point in the two orations is that Hippocrates followed nature as his sole guide.[150] Unlike others, Hippocrates did not spoil his perception of the world with preconceived ideas, but he based his knowledge on experience and observation. The result of his approach was the presentation of a medicine which excelled in simplicity and truth. Hippocrates' method was extremely useful in Boerhaave's Calvinist teaching of medicine, for Hippocrates kept within the bounds of human knowledge while investigating nature. Rather than discussing general laws, Hippocrates kept to the observation of particulars.

The nature of Boerhaave's Calvinist medicine is more clear, thirty years later in his 1731 oration. Once again, Boerhaave, like Hippocrates had done before him, stressed that a physician should follow nature in curing the sick. In order to make his point Boerhaave set out to define the meaning of the term 'nature' and its importance for the medicine of his day. Boerhaave's approach was not new. In fact 'nature' had been a recurring theme in Western natural philosophy since Antiquity.[151] Boerhaave, however, gave the term a distinctly Calvinist meaning, for nature in his eyes, is not a category existing outside the realm of God, but is included in it. Nature shows man God's power and care for every single creature, for 'everything obeys His commands.'[152]

An important part of nature, being God's Divine craftmanship, is the hu-

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[150] *CSH*: 69; *HMS*: 261

[151] *Orations*: 237-238.

[152] *HMS*: 248.

man body, and 'human nature, signifies the sum-total of everything required for the body to fulfil all its functions, promptly, without pain and with adequate regularity.' [153] It works according to God's divine rule which means that anything that harms the healthy functioning of the body is working against God's divine intentions. [154] It follows that the physician has to carefully study the divine design in the nature of the body in order to understand its working in health and to find cures for the diseased body.

All the parts of the body are related to one another, which means that the physician has to study the body as a circle without a beginning nor end. All its parts were created at the same time and they cannot function properly without one another. Boerhaave argued against the traditional opinion that the heart is the most important part of the body 'as if the heart's power did not depend upon the nerves, upon the great arteries, and on the veins entering it.' [155] The heart is created at the same time as all other organs and consequently while causing all solids and fluids to move is itself moved by the solids and the fluids. [156] It is likely that Boerhaave adopted the analogy of the circle from chemistry. In his time the symbol of the circle was an important icon in chemistry and symbolised perfection. Hence, the symbol of mercury has a circle in the middle and gold, the most perfect of all metals, is represented as a circle with a dot in the middle. The symbol for gold also had a divine meaning. On a macrocosmic level, it symbolised the Creator. [157] For Boerhaave, the symbol of the circle with the dot in the middle was so important he adopted it as his seal, thereby indicating his devotion to God the Creator. Nature, and most of all the human body, gave him a glimpse of God's perfection.

With much admiration Boerhaave spoke about the complicated structure of the individual parts of the body, working together as a whole. He points out that no-one, even if he were to study all his life, would be able to recreate the tiniest part of the body. Boerhaave points to the processes of digestion and secretion and he argued that God provided the body with many artful mechanisms in order to transform crude matter into fluids and solids of its own nature; 'nothing is left to chance; nothing is redundant or accidental.' For this reason Boerhaave told his students that they 'should worship God, who has ordered these solids and fluid substances in one structure in such a

[153] *Ibid.*, 250.
[154] *Ibid.*, 250.
[155] *Ibid.*, 251.
[156] *Ibid.*, 255.
[157] Abraham. (1998). *Alchemical Dictionary*: 41.

manner that through its unique powers He can eventually replace lost parts by wholly similar ones.' [158]

At this point is must be noted that Boerhaave, although he emphasised the involvement of God in moving the body, also seems to present an almost Deistic medicine. He argued that once the body has started to move through an external stimulus, nature regenerates these motions, giving life and motion to the body. Boerhaave even named the body 'the true image of the *perpetuum mobile* so long sought after' and he emphasised on many occasions that the body works like a machine, according to fixed laws of nature. [159] Boerhaave scholars have stated that Boerhaave's comparison of the body to a machine shows that Boerhaave, through advocating a mechanical method of study, 'points to the right way in which the physician may achieve a truly scientific attitude towards his art.' [160] An important aspect of this 'truly scientific attitude' is that it is not religious. However, I shall argue that Boerhaave's mechanical approach did not exclude his religion, but on the contrary was a direct result of his Calvinist beliefs.

Boerhaave's great emphasis on the creation of the whole structure of the body at the same time was directed at those who 'hoped to trace down the cause of the vital interaction of the fluids exclusively in the structure of the body (...) or in the fluids alone!' [161] Although Boerhaave does not mention any names, we can perhaps say that here the later Boerhaave speaks his mind. He does not seek the cause of life in the hydraulics of the fluids like Pitcairne had done, nor in the nature of the particles of the fluids themselves, like Keill had argued. Instead, Boerhaave proposed to 'keep to the notion that nature has made the body in its entirety previously, and that, once it is so adjusted, one single impulse is given to it which suddenly imparts motion to the whole and causes this to continue.' [162] However, Boerhaave did not leave God out of his medicine, for he held that God ultimately is the 'Father and Keeper of the human race.' [163]

Why then, did Boerhaave advise his students to study the body as a machine? I would suggest that Boerhaave's Calvinist opinion that man cannot and should not even try to know the first cause of things, led to the idea that

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[158] *HMS*: 253.
[159] *Ibid.*, 254.
[160] Luyendijk-Elshout, A.M. (1982). 'Mechanicisme contra Vitalisme. De School van Herman Boerhaave en de Beginselen van het Leven.' *Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek,* 5 (1), 16-26; Lindeboom, G.A. (1970). 'Boerhaave's Concept of the Basic Structure of the Body.' *Clio Medica,* 5, 203-208.
[161] *HMS*: 255.
[162] *Ibid.*, 255.
[163] *Ibid.*, 255.

the study and observation of the structure of the body and its powers is the only thing open to the mind. In other words, looking at the body as a machine is a safe way to obtain true knowledge, for it prevents the physician from trying to ascend to the heights of the divine. God installs and maintains His creation and the only thing man can perceive are the laws of nature through which God moves the world. [164]

> wise men observe the works of nature as they offer themselves, and then by experiments endeavour to learn the law; which the Creator has impressed upon his work, and in which manner each thing, according to its peculiar nature, arises, is produced, or perfected. [165]

Man, who is himself subject to change cannot change anything about the immovable laws installed by the unchangeable God. He can only study and observe the structure of nature, the effects of an incomprehensible cause.

A particularly good example of how the working of the body is related to God's divine will is Boerhaave's discussion of the Aristotelian concept of *sensorium commune* in explaining the connection between the body and the mind as well as the connection of man to God. It is the place in the brain where all sense perception and impressions of the nerves come together and cause ideas, emotions, passions and voluntary motions. [166] Boerhaave localised the *sensorium commune* in the place where all sensations originate, i.e. in all the points where the cerebral cortex and spinal marrow transfer into nerves. [167] Boerhaave is very particular in stating that once the *sensorium commune* has set the body into motion it functions automatically, which means that for instance when someone decides to walk from Leiden to Amsterdam and back, the body will automatically do so. [168]

However, this does not mean that the body functions independently from the divine cause. Boerhaave spent a whole lecture explaining that God causes the motions of the *sensorium commune* and that it is therefore entirely dependent upon God's divine will. Boerhaave proved this by stating that:

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[164] For God's working in the world through laws of nature see also: Vermij, R. (1999). 'Een Nieuw Concept: De Wetten der Natuur.' In F. Egmond, E. Jorink, R. Vermij, *Kometen, Monsters en Muilezels. Het Veranderende Natuurbeeld en de Natuurwetenschap in de Zeventiende Eeuw* (pp. 105-119). Haarlem.

[165] Boerhaave. (1741). *A New Method*: 1, 201.

[166] Boerhaave in Schulte (1959). *De morbis nervorum*: prae. 75, 5 November 1733, 256-257. Aristotle mentioned the koinon aesterion (*sensorium commune*) in his *De vita et morte* and in *De longitudine et brevitate vitae*, and he localised it in the heart. Schulte, B.P.M. (1959). *Hermanni Boerhaave Praelectiones de Morbis Nervorum 1730-1735. Een Medisch-Historische Studie van Boerhaave's Manuscript over Zenuwziekten*. Leiden: 387.

[167] Boerhaave in Schulte (1959). *De morbis nervorum*: prae. 76, 9 November, 1733, 256-257.

[168] *Ibid.,* prae. 86, 10 December 1733, 268-269.

In Him [God] we live and move, and whose people we are (...) In death the principle of perception and driving force [*sensorium commune*] flees outside the reach of experience, and in that sense disappears, when the perception, emotion, passion and the source of motion are destroyed, and the pure thinking principle, with the understanding and will, returned to the original cause, God, without any interaction with the working and suffering body. [169]

Boerhaave believed that man is no more than a soap bubble dependent on the will of the Creator. He can contemplate how God gives the motion of the *sensorium commune* to man, and how it always functions according to the same law, but he can never grasp the nature of God Himself. [170]

In practice this means that the Calvinist physician, in order to find out more about the causes of health and disease, has to observe and so acquire an accurate knowledge of the particular properties and powers of the human body. His observations should be written down as simple and accurately as possible:

It [observations] (...) should be written down with the same simplicity with which it was revealed by Nature to the sense-perception; every modification of the facts derogates from this and the addition or omission of even the slightest detail is prejudical to it. Everything which meets these requirements is clear, true, and eternally valid. [171]

Boerhaave argued that 'the facts should determine the argument and not the other way round.' [172] Conclusions should be based on a well-defined description of a phenomenon. However, if every physician has to start his observations anew, he would never get anywhere. There are so many diseases and so much to be observed that the study of medicine would never be based on a solid foundation if every student would have to do what others had already done before his time. For this reason Boerhaave recommends a selection of works that leads the student of medicine to a certain level before he even starts his medical practice. In particular Boerhaave suggested the works of Hippocrates and Sydenham who based their medicine upon the true principles of nature rather than on the corrupt faculties of the human intellect. [173]

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[169] *Ibid.,* prae. 87, 11 December 1733: 270-271.
[170] *Ibid.,* prae. 87, 11 December 1733, 268-269.
[171] *CSH*: 69.
[172] *Ibid.,* 80.
[173] *Ibid.,* 70. It is not my intention to say much about the influence of Sydenham upon Boerhaave's thought, in particular since Sydenham did not have much to say about chemistry. Presumably Sydenham's method of experiment and observation, rather than the content of his medicine attracted Boerhaave to Sydenham. Perhaps we should not overestimate the importance of Sydenham. Recently A. Cunningham has argued that Sydenham was not very popular among contem-

Surprisingly enough, Boerhaave in his last academic oration in 1731 also strongly recommended the works of Van Helmont, for Van Helmont, more than any other physician 'acknowledged nature as being the generative force that sets everything into motion.' [174] This must be an effect of Boerhaave's later ideas on emphasising the peculiar properties of bodies.

Boerhaave argued that the glory of the physician 'consists solely in the fact that the physician is a humble servant of nature.' [175] He stated:

> You, man, may realise from this that you cannot understand anything at all about even the minutest particles of the ingenious structure of the body, apart from the knowledge for which you are indebted to Nature alone, in as far as she has granted to you to become acquainted with her by means of sense-perception. [176]

Luyendijk-Elshout and Kegel-Brinkgreve have added in a footnote that Boerhaave suggests that man's knowledge is limited and incomplete. They have compared Boerhaave's views to Sydenham who stated that 'Man, indeed may so have his intellectual faculties shaped by nature as to be enabled to perceive not what is absolutely true, but only that which is necessary for him to know and fitted to his nature.' However, they have attributed this view to the influence of scepticism, rather than Calvinism. Yet Boerhaave taught a particular Calvinist medicine when he told his listeners to:

> Observe the act of creation through which God constructs the human body from insignificant dust (...) Listen to the men who relate their experience (...) they have devoted their lives to this and have learned from their teacher Nature, what may serve to protect health, to cure diseases and to prolong life. [177]

I shall now turn to a discussion of Boerhaave's chemistry for medicine in practice. In doing so I shall mainly concentrate on Boerhaave's views in the latter part of his life, as chemistry became more and more important in his

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poraries, but that Boerhaave's mentioning of Sydenham among the masters of the history of medicine (Hippocrates, Bacon, Sydenham and Newton) transformed Sydenham into a 'medical hero' in the eyes of his English speaking students and many historians of medicine afterwards. See: A. Cunningham (1989). 'Thomas Sydenham: Epidemics, Experiment and the "Good Old Cause".' In R. French & A. Wear (Eds.), *The Medical Revolution of the Seventeenth Century* (pp. 164-190). Cambridge.

[174] *HMS*: 261-262. Compare Boerhaave's 1701 oration where he mentioned 'Hippocrates, Sydenham and some few other true physicians besides.' Boerhaave only mentioned Van Helmont in a list of chemical authors which should be consulted. The recommendation in 1701 is not as strong as in 1731 though. See: *CSH*: 112-113.

[175] *HMS*: 247. The quotation brings to mind the biblical quotation that 'he that is the least among you all, the same shall be great.' Luke 9:48.

[176] *Ibid.,* 252.

[177] *Ibid.,* 263.

later career. This means that I shall use Boerhaave's *Elementa chemiae* (1732), rather than the *Institutiones medicinae* (1708) in discussing Boerhaave's views.

Throughout his *Elementa chemiae* Boerhaave discussed the relationship of chemistry to medicine. Unlike the works of contemporaries, Boerhaave's book not only described the working and preparations of cures, but also explained bodily processes in terms of chemistry. Once again we see that Boerhaave's work was directed towards understanding, more than towards prescribing. Where Lémery and Geoffroy described the medicinal value of animal matters like vipers, hartshorn, honey, bones, etc., Boerhaave discussed the chemical make-up of milk, urine and blood and the way these substances work their powers in the (human) body. Of course Boerhaave also gave prescriptions, but never without explaining the pathological condition of the body and how a particular remedy could relieve the illness. This means that, since the powers of bodies work differently in every situation, Boerhaave promoted a chemical understanding of bodily processes before explaining the working of a particular cure.

The structure of Boerhaave's chemical textbook shows a determined direction towards physic.[178] Unlike his contemporaries Boerhaave started the description of the operations of chemistry with the vegetable, rather than the mineral kingdom. The reason for doing so was that Boerhaave believed that, since animal bodies are made up of vegetable matter, it is logical to speak about the vegetable kingdom, before discussing animal bodies. Moreover, minerals are essentially different from vegetable and animal bodies, which means that presumably they are of least use in medicine. Since the human body is made up of vegetable matter, Boerhaave argued that it is most important to understand the nature of vegetables before understanding and chemically treating animal bodies.[179] Only then 'the nature of the animal will by degrees be better learnt, especially that of the human body, for the sake of which all the labour is undertaken.'[180]

An important aspect of Boerhaave's medicine is the continual disposal of particles and the ability of the body to replenish the lost substance. Boerhaave had observed that the body continually looses its solids and fluids in sweat, saliva, urine, milk, and other matters as hair, nails and skin. He argued that the daily supply of food and drink, made up of vegetable matter (for even animal matter like milk, cheese, butter and meat is made up of vegetables, like grass and hay, and water) supplements the lost substances. Even fractured

[178] Boerhaave. (1741). *A New Method*: ii, 2.
[179] *Ibid.,* ii, 2-3, 185.
[180] *Ibid.,* ii, 185.

bones join together in a few weeks time, which according to Boerhaave clearly shows the continual motion of the solids by means of the vital power.

Not only does vegetable matter feed the body, but also the structure of animal bodies is similar to vegetables. Both are made up of earth giving solidity to the body, water, gluing the solid parts of the body together, salt and oil or sulphur. Just as vegetables extract and imbibe their nutriments from the soil, animals too have internal roots, the lacteals and mesenteries, through which they absorb food and drink. In vegetables as well as in animals the food transforms into the properties of the host the longer it circulates in and mixes with the juices of the body through the vital force. The chief difference between plants and animals consists in the variety of the structure and the quicker passage of the aliment through the vessels of the animal. [181]

In Boerhaave's chemistry for medicine, just as in his chemistry in general, the simple particles constituting the healthy human body are neither acid, nor alkaline, but neutral. Chemical experiments on urine had shown Boerhaave that the body particles have a spherical figure so as not to damage any tissue. [182] Even the urine of a man who drank a large quantity of rhenish wine, sour beer, vinegar and fruits did not show any sign of acidity, which means that the 'natural powers' of the body neutralise all acid and alkaline tendencies. [183] Once again, Boerhaave in describing the experiments of Glauber and Boyle ascribed the tendency of the acids and alkalis to neutralise each other to a generative power in nature:

> alkali appears a kind of impregnated or female body, to be impregnated by an acid, which acts as the male with respect thereto, and generates its own kind, or preserves its species: and therefore the indifferent nature of the alkali is determined by the acid. [184]

Boerhaave's experiments on urine and his conclusion that the bodily salts are of a neutral nature run contrary to the opinion of iatrochemists like Sylvius, Lémery and many others, who developed the acid-alkaline hypothesis, explaining all bodily processes in terms of fermentation caused by the joining of sharp acid and spongy alkaline particles in the blood. [185] However, Boer-

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[181] *Ibid.,* I, 148-153.

[182] *Ibid.,* I, 152. The reason Boerhaave looked at urine is because urine, made twelve hours after eating and drinking, contains all the bodily particles for it has circulated through all the parts of the body

[183] *Ivid.*, ii, 189.

[184] *Ibid.*, ii, 250.

[185] For a discussion on acids and alkalis in chemistry see: Boas, M. (1956). 'Acid and Alkali in Seventeenth Century Chemistry.' *Archives Internationales d'Histoire des Sciences, 9*, 13-28.

haave denied that the blood is either acid or alkaline and that even if it be mixed with any of the two, it would lead to a fermentation. [186] He also denied the presence of an inflammable spirit in the body, for the most volatile part of the healthy juices is nearly elementary water, and contains nothing vinous or inflammable. So, Boerhaave argued, 'the modern physic must be greatly corrected in these particulars.' [187]

Instead of using iatrochemical ideas Boerhaave based his medicine upon the God-given motion or vital powers of the human body. He especially referred to the motions of the smallest parts, tubes and vessels, for the operative force of the larger vessels depends upon the communication of the least vessel. Boerhaave's thought on the matter is particularly visible in the *Aphorisms*. Boerhaave starts explaining the illnesses of the smallest channels before he continues with the *vasa minora* and *vasa majora,* for in most instances illnesses of the latter are caused by malfunctions of the former. Thus changes most often occur in the minutest channels, and medicines should be made to work upon those vessels. Both Von Haller and Van Swieten have argued that Boerhaave held that 'a simple elementary particle consider'd in itself suffers no disease (...) nor do two or more elementary particles admit of any other disease than what regards their connection.' [188] So a disease is in the powers peculiar to the fluids and solids and not in the elementary particles themselves as they are unchangeable. [189] For instance this means that when the blood is too thin, it is caused by the particles being too small, and not having the right *conatus* and tendency to cohere to one another. [190] It follows that a major object of Boerhaave's chemistry for medicine was the discovery of the latent peculiar powers of bodies in order to regulate them with a salutary effect. Boerhaave argued:

> chemistry is the joining together, or separating certain bodies by violent motions, directed at first by fire, which element gives us thereby an opportunity of thoroughly considering and observing what are joined and what separated from each other, and confining those that are changed to vessels: Now as physicks totally consists in a plain and simple observation of experiments, no one can doubt but that it

[186] Boerhaave. (1741). *A New Method*: ii, 341.
[187] *Ibid.,* ii, 45, 50. See also Boerhaave's 'History of Fermentation' where he argued that fermentation is a process that only appears in chemical experimentation upon vegetables, but that he never saw fermentation in the animal body. Ibid., ii, 105-106, 193.
[188] Haller. (1742). *Academical Lectures*: v, 281.
[189] Swieten, G. v. (1773). *Commentaries upon the Aphorisms of Dr. Herman Boerhaave*: 1, commentary upon Aph. 22 and 23.
[190] Boerhaave, H. (1720). *De viribus medicamentorum: Or a Treatise of the Virtue and Energy of Medicines.* (unknown, Trans.). London: 31.

is absolutely necessary for a physician perfectly to know what bodies are, and their singular effects, and of what they are compounded. [191]

As a result Boerhaave made extensive use of the chemical theory of menstrua in his medicine. Nothing, he argued, is more remarkable in this doctrine of menstrua, than the production of new powers by their action; which powers before existed neither in the solvent, nor solvend, but depend entirely upon the union of both.' [192] This means that menstrua, because of their ability to reveal many different powers, are not only most suitable in discovering the latent powers of bodies but they are also extremely useful in the prescription of drugs. Boerhaave even thought that the theory of menstrua would contain the secret of dissolving cancers and stones. [193] Boerhaave's emphasis on the individual working of every menstruum also caused that he did not believe in the Alcahest, or universal menstruum. He argued that

> Chemical solutions (...) are the effect of a latent attraction, and repulsion betwixt the parts of the solvent and the solvend; and consequently (...) the whole action depends upon a certain relation betwixt these two. And hence it follows (...) that there is no one body, either natural or artificial, which can universally dissolve all the rest. [194]

Although Boerhaave praised the use of menstrua in medicine, he also admitted that in chemical preparations the '*specific essence*' of a substance is altered by the fire. For this reason he recommended the use of simple medicines and he repeated after Van Helmont that he is '*happy, who could with safety and expedition cure diseases by means of crude simples*; this being the ancient method of cure and recommended in Scripture.' 'This admonition,' he argued, 'should be carefully remembered.' [195]

Boerhaave considered the drinking of water and milk as innocent and most effective medicines. The particles of water are so minute that they insinuate themselves between the minutest solids and dissolve any hard impacted manner. [196] This is not only the case in bathing, which Boerhaave often prescribed for relaxation of the body, but, when brought to the same temperature as the healthy body water is also a very comforting medicine for all parts of the body. Water also dilutes whatever is sharp, hence in the case of a woman who suffered from a self-inflicted disorder in which 'the humours have be-

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[191] Boerhaave, H. (1719). *A Method of Studying Physick* (Mr. Samber, Trans.). London: 99-100.
[192] Boerhaave. (1741). *A New Method*: I, 167
[193] *Ibid.,* I, 167.
[194] *Ibid.,* I, 169.
[195] *Ibid.,* ii, 7. In his *Orations*, Boerhaave also frequently recommended the use of simple cures. See for instance: RMS: 140, HMS: 260-261.
[196] Boerhaave. (1720). *De viribus medicamentorum*: 71.

come sharp and the nerves have dried out more than they should, as a consequence of an injudicious way of life,' Boerhaave prescribed, among other things, that 'beverages should consist of four parts of water to one part of the best Moselle, to which may be added a little orange juice and a little sugar or Syrup of Violet.' [197] Boerhaave also advised his friend Bassand to 'suppress the unfavourable tendency of the humours to degenerate into phlogiston' by drinking three ounces of cold water every morning on an empty stomach. [198]

The nature of milk is similarly inoffensive, for it consists of bodily particles. It is prepared from the chyle and has flowed through the veins, the heart, the lungs and the arteries and therefore has mixed with all the humours of the body. This process takes time and Boerhaave advised that a wet-nurse after eating 'should wait three or four hours before giving the breast, so that all rawnes is well absorbed.' [199] It follows that milk contains all the nutritious parts vital for the development of the solid and fluid parts of the body. Yet, Boerhaave's argument is circular for he states that man can live on milk alone, hence the serum, the blood, the lymph, the spirits, cartilages, membranes and vessels proceed from milk. In any case, Boerhaave often advised his patients to walk the *via lactea*. He similarly recommended a milk diet to Bassand to cure his gout, for apparently the drinking of water first thing in the morning had not helped his friend. In 1728, Boerhaave recommended combining the drinking of milk with water, for he remembered that Bassand had been 'a little stout' and he suspected that his weight would increase too much, while drinking milk only. [200] However, in 1731, the illness was not any better and Boerhaave advised him to return to drinking water again in order to temper the 'strange vital force that creates of light food stoppages which only too readily give rise to inflammation.' [201]

Most of the time Boerhaave prescribed medicines having a vegetable basis. We have seen before that Boerhaave believed that animal and vegetable

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[197] Boerhaave to Bassand, 17 September 1728, *Correspondence 2*: 276-279. Boerhaave defined the injudicious life as 'nocturnal fatigues, wakefulness, heat, cold, overeating, the consumption of generous wines and brandy, and lastly immoderate doses of spirits of salt (*sal volatile*).' The waters for the medicine have to be the best waters from the Pouhont spring at Spa or from Schwalbach.

[198] Boerhaave to Bassand, 5 April, 1726, *Ibid.,* 232-233. Boerhaave also prescribed bodily exercise so the waters would not stagnate and drown the joints. Boerhaave to Bassand, 15 December 1735, *Ibid.,* 344-345.

[199] Boerhaave to Bassand, 12 July 1714, Ibid 110-111.

[200] Boerhaave to Bassand, 12 July 1714, 19 July 1728, *Correspondence 2,* 234-235, 272-275. For a history of gout see: Porter, R., & Rousseau, G. (1998). *Gout: The Patrician Malady.* London.

[201] Boerhaave to Bassand, 25 December 1731, *Ibid.,* 296-297. This time Boerhaave also advised Bassand to regularly take a little Saltpetre and to massage his joints.

bodies are built of the same elementary earth, which means that their solid parts have the same mechanical solidity or gravity. [202] This means that vegetable matter is very suitable in medication for the animal body can easily absorb vegetable matter. On the other hand Boerhaave considered metals as potentially harmful to the body for they have quicksilver as their basis. However, in some cases Boerhaave did prescribe medicines containing metal particles. He argued that the closer the calx of a metal approaches the nature of elementary earth, the easier it assimilates in animal and vegetable bodies. For example gold causes a violent reaction in the human body, since its basis is quicksilver, but the calx of iron, which approaches nearest to the nature of vegetable and animal earth is most easily received and digested. For this reason, iron makes an 'admirable and almost innocent medicine.' [203]

Even though Boerhaave was cautious in prescribing metals, in the case of Bassand's gout, he got so desperate that he started investigating the properties of metals in order to find another medicine apart from water and milk. He wrote to Bassand:

> I spend days and nights, working with unusual intensity, trying to find out according to the indications of the Alchemists whether there is perhaps some remedy that would safely and effectively undermine the tenacity of this terrible disease, which affixed itself to the innermost recesses of the nerves. [204]

Medicines of an acid nature loosen the tight cohesion between particles, so Boerhaave already prescribed the acid spirit of sulphur for inflammations and hot diseases, and he quoted Van Helmont, who had said that the medicine is conductive to the prolongation of life. [205] Boerhaave had also scored some success with the *sulphur of chalcanth* in cases of melancholia as it had cured the dementia of a lady of rank. Boerhaave ascribed the medicinal value of the medicine to the iron it contains, since he believed that iron is a very good medicine in distempers caused by acids such as in 'leucophlegmatic, scorbutic, icteric, hypochondriacal and hysterick cases, or when the body is relaxed, weak thro' the sluggishness of the parts, rickety, or abounding with worms.' [206] Moreover Boerhaave argued that

> The old Chemists maintain almost unanimously that in ore which has not been changed by fire, there lies concealed a healing property which has the power to

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[202] Boerhaave. (1720). *De viribus medicamentorum*: 29-30.
[203] Boerhaave. (1741). *A New Method*: I, 486.
[204] Boerhaave to Bassand, 31 December 1732, *Correspondence 2*: 310-313.
[205] Boerhaave. (1720). *De viribus medicamentorum*: 68; Boerhaave. (1741). *A New Method*: ii, 268.
[206] Boerhaave. (1741). *A New Method*: II, 279.

extirpate the sharpness of the humours, and thus also constitute a cure for gout (...) It is present in Chalcanth. [207]

Boerhaave experimented with the chalcanth in order to find the exact nature of the medicinal property. Following the old alchemists he mixed the ore with mercury, so that the mercury could attract the medicinal virtue to itself. Boerhaave then poured water on the mixture and observed that the metals gave off an ash-coloured powder, which proved to be very helpful in the case of a woman suffering from collected fluids in the abdomen.

This powder (...) I caused to be digested by the warmth of a person in health. I gave it to a dropsical woman from whom fluid had already been removed three times by paracentesis of the abdomen, and to whom it immediately returned every time, so that she was in a state of complete despair: it was also completely impossible to purge her. An amazing result! Half a grain will open the bowels several times. It expels the fluids. They do not return. This I have seen. Whether it will always have a similar effect? I shall put it to the test. [208]

Boerhaave pursued his experiments untiringly and he wrote to Bassand that he aimed at either demonstrating the hidden medicinal force of the metal or making clear why it is sought in vain. [209]

Boerhaave was very cautious in prescribing mercury. Yet he did investigate its medicinal properties. [210] In chapter three we have already seen how Boerhaave, inspired by the success of the iatrochemists in curing the venereal disease, tried to purify mercury so that it would be suitable in medication. [211] However, it seems as if Boerhaave was only enthusiastic about the prescription of mercury in severe cases of venereal diseases, when 'the patient's case [is] to be given up as desperate.' [212] Nevertheless, Boerhaave considered the working of mercury in bodies affected with the venereal diseases of considerable importance, since he wrote a treatise on the subject. His *Treatise on the Venereal Disease and Its Cure in all Its Stages and Circumstances* (1729) gives insight in

[207] Boerhaave to Bassand, 20 July, 1735, *Correspondence 2*: 336-337.
[208] Boerhaave to Bassand, 20 July, 1735, Ibid., 338-339.
[209] Boerhaave to Bassand, 9 September 1735, *Ibid.,* 342-343.
[210] Boerhaave. (1741). *A New Method*: 304-318; Boerhaave. (1720). *De viribus medicamentorum*: 133-135; Boerhaave, H. (1729). *A Treatise on the Venereal Disease and its Cure in all its Stages and Circumstances* (J.B.B., Christ Church College, Oxford, Trans.). London
[211] K. Dewhurst gives an interesting account of the life and medicine of Thomas Dover, who prescribed quicksilver on so many occasions that he got the name 'quicksilver doctor.' His enthusiasm for quicksilver as a medicine brought him into conflict with the more reserved medical doctors of the Royal College of Physicians. Dewhurst, K. (1957). *The Quicksilver Doctor. The Life and Times of Thomas Dover, Physician and Adventurer.* Bristol.
[212] Boerhaave. (1729). *Treatise on Venereal Disease*: 76.

the way Boerhaave thought about the working of the particular powers of a cure upon the diseased body.

Boerhaave classified venereal diseases among illnesses caused by an invading subtle particle, corroding and changing the humours, starting with the nerves. [213] The subtle particles are extremely contagious, and spread via bodily contact. A patient having venereal disease is like someone who suffers from an itch and who communicates the disease to someone else by shaking hands. Boerhaave warned to be aware that 'contagion is capable of being communicated by gloves, clothes, beds, and as my own experience has assured me even by warm money.' [214] Boerhaave believed that God has installed an internal mechanism in the body that reacts upon the invasion of foreign matter. For example, when a smut enters one's eye, the eye starts running in order to get rid of the grit. Boerhaave similarly argued that the appetites of the body are directed towards health, and a doctor should never refuse to let a patient eat what he wants. This automatic motion or want cannot be understood by man, for it happens through 'the will of the great Author of all Things.' [215] However, many occasions, and in this instance in the case of venereal disease, the physician has to help the body in order to restore health.

Unlike Lémery, who had argued that because of its alkaline nature, mercury dissolves the acid humours in venereal tumours, Boerhaave ascribed the medicinal quality of mercury to its power to divide itself and attract and unite with harmful substances. [216] Since the particles of mercury are even smaller than the particles of blood or water, it can reach the smallest vessels of the nerves and attract the poisonous particles to itself. Boerhaave did not value mercury because of its alkaline nature, but because of 'a certain quantity of acid adhering to its metallic part' that makes mercury the most corrosive or acrid body in nature. [217] This results from his belief that the more acids the metals contain, the more suitable they are in curing diseases, for Boerhaave argued that

metals alone have little effect upon the body, except by their bulk, figure and

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[213] Nervous diseases also are important part of the illnesses caused by invading small particles for they are often caused by the particles of mineral or other spirits entering the nervous system. See: Boerhaave in Schulte (1959). *De morbis nervorum*: prae. 5, 3 April 1732 ff.

[214] Boerhaave. (1729). *Treatise on Venereal Disease*: 15.

[215] Boerhaave in Haller. (1742). *Academical Lectures*: 1, 7.

[216] We find the same opinion in the work of Geoffroy. See: Geoffroy, E.F. (1736). *A Treatise of the Fossil, Vegetable, and Animal Substances, that are made use of in Physick*. London: 218-238. For Lémery see: Lémery, N. (1686). *A Course of Chymistry. Containing an easy Method of Preparing those Chymical Medicines which are Used in Physick with Curious Remarks and Useful Discourses upon each Preparation, for the Benefit of such who Desire to be Instructed in the Knowledge of this Art.* (Harris, W., Trans.). London: 191-195.

[217] Boerhaave. (1729). *Treatise on Venereal Disease*: 72.

weight; but by addition of salts, especially the acid kind, they acquire new properties (...) according as the acids are more fixed therein, or adhere more externally.' [218]

The acid causes the metal to be caustic, which means that it 'purges, vomits gently, kills worms, opens and cleanses the vessels concerned in preparing the chyle, resolves phlegm, and thus cures many distempers.' [219] In particular in severe cases of the venereal disease, mercury has the ability to break the texture of tumours and resolve the diseased humours into the subtlety of water that can be carried out through the smallest vessels via the sweat, saliva, stool or urine, carrying not only the mercury itself, but also the 'materials of the disease.' [220] However, Boerhaave warns that mercury should be taken cautiously and in small quantities as it acts very violently when given in large quantities.

Boerhaave's prescription of mercury in venereal diseases depends upon the principle that remedies have to work in accordance with the motions of the body. For example infusions and decoctions only work when the vital motion of the living body mixes them with the bodily humours and transports them to the parts of the body where they are supposed to 'act their own peculiar force.' [221] Mercury, likewise, only works on account of the vital force moving the solid and fluid parts. [222] This means that it cannot do any good when the disorder is seated in a part where the force of the heart and arteries cannot be felt. So, for example mercury is of no use when the marrow of bones is affected or when a gonorrhoea is situated in the cavities of the penis, where the humours have a very weak impetus. On the other hand:

> venereal disorders which lie in places through which the red, yellow, serous, pellucid, and other arterial fluids pass with a requisite velocity, and are capable of admitting mercury, and of giving it due degree of motion, there mercury will perfectly cure them. [223]

In other words, Boerhaave warned against the danger of using mercury as a universal remedy. Every disease asks for its own remedy and as there are innumerable diseases it is an impossible task to present the physician with a textbook full of solutions. Again, we meet with Boerhaave's aim to make his pupils understand the causes of diseases and their cures, rather than delivering a recipe book.

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[218] Boerhaave. (1741). *A New Method*: ii, 312.
[219] *Ibid.,* ii, 307.
[220] Boerhaave. (1729). *Treatise on Venereal Disease*: 73.
[221] Boerhaave. (1741). *A New Method*: ii, 15.
[222] Boerhaave. (1729). *Treatise on Venereal Disease*: 75.
[223] *Ibid.,* 75.

Boerhaave's chemistry for medicine contains cures for many more diseases, but it would be too laborious a task, and also besides the point, to describe every illness with its proper cure. Also we could devote another chapter to a more detailed account of Boerhaave's pathology with respect to the larger vessels, i.e. the *vasa minora* and *vasa majora*. However, this would not substantially enrich the thesis of the book. It is most important to realise that Boerhaave looked for the origins of diseases in the powers in between the smallest particles of the human body. He did not build his chemistry for medicine upon iatrochemical theories of fermentation, effervescence and putrefaction. His individual bodily particles are perfectly simple and do not have any chemical properties themselves. It is only when they combine with another particle in a particular place that a latent power becomes visible. These powers are different for every body in every situation, so it is impossible to formulate a general theory for the working of all bodily processes. Often illness is the result of an invading particle changing the working of the powers, and a cure is directed towards removing the cause of disease via its power to dissolve the invading particle and so restoring the normal function again. The task of chemistry for medicine is the discovery of the latent powers of the parts of the body. The physician can even consider the body as a machine. However, he should not forget that he is dependent upon God for the success of his endeavours. He should be aware that 'a physician cannot always relieve the sick because sometimes an affliction won't give in to art or learning.' [224] So Boerhaave accompanied every prescription with a prayer for the divine blessing of his endeavour. [225]

In this chapter I have opposed the argument of Lindeboom and Luyendijk-Elshout that Boerhaave only used mechanistic ideas in medicine, and that only later did some of these get a vitalistic meaning. [226] From 1715 Boerhaave presented a chemistry for medicine which was mainly directed at the discovery of latent powers in nature. Boerhaave did not explain these powers in a mechanical way. In chapter three we have already seen how Boerhaave explained the working of fire in very religous terms. In medicine the working of seminal principles, or 'threads of the warp' is also a good example of how Boerhaave presented a picture of the world filled with vitalistic principles. His

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[224] Boerhaave, H. Leningrad MS XIII 38 (68)/Leiden MF Q255, *Formulae Remediorum*. The original Dutch reads: 'Een arts kan juist altijd den kranken niet verlichten, Want somtijds wil de quaal voor kunst noch kunden zwichten.'

[225] *Gentleman's Magazine* (1738), viii, 491.

[226] Lindeboom. (1968). *Herman Boerhaave*: 272-274; Luyendijk-Elshout, A.M. (1982). 'Mechanicisme contra Vitalisme. De School van Herman Boerhaave en de Beginselen van het Leven.' *Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek, 5* (1), 16-26.

chemistry of living things involved a theory of generation that not only reached to his medicine but, as we have seen in chapter three, even reached to the 'inanimate' kingdom of the metals. [227] Thus Boerhaave's chemistry of living things is as important for his medicine as it is for his alchemy. Both disciplines have the same goal, i.e. showing the wisdom of God in the powers peculiar to living matter.

The question remains whether instead of looking at the influence of British natural philosophers, like Newton and Boyle, we should also look at the effects of German scholarship upon Boerhaave's work. Chemists like Georg Ernst Stahl and Friedrich Hoffmann were not satisfied with mechanical explanations. Stahl held that there is a principle of life or directing force which is immaterial and and cannot be explained by the laws of motion. The principle is visible in the phenomena of growth and development and as such directs movement towards a certain goal. [228] Hoffmann opposed Stahl and he argued that the development of a living body did not need an *anima*, or living principle, but an indwelling *virtus organizans plastica*, present in the seeds of things. [229] This force (*virtutus*) is not an intelligent force, but implanted by God in matter to obey the laws of creation.

In his *Elementa chemiae* Boerhaave referred to Hoffmann regularly. However, it is not clear how much of Boerhaave's views we can really ascribe to a direct influence. When speaking about seminal principles in his orations, Boerhaave did not mention Hoffmann. Moreover, Boerhaave's great emphasis on particular properties and powers not only make his medicine partly independent from general natural laws, but also make it more religious. Unlike Stahl's *anima* and Hoffmann's *virtutus*, which are not meant to be religious entities, Boerhaave's latent peculiar powers directly show God's hand in nature. Also neither Stahl nor Hoffmann believed that chemistry could explain bodily phenomena, whereas, as we saw, Boerhaave argued that chemistry is of crucial importance in understanding the life and motion of the body. Maybe it is the case that Boerhaave held the middle position between British mechanism and German animism? However, it would be the topic of another book to carefully compare the views of Boerhaave and German animists. For now it is sufficient to realise that Boerhaave was not as mechanistic as historians of

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[227] B.J.T. Teeter Dobbs has similarly argued that Newton was interested in the similarities and dissimilaries of the three kingdoms and that he thought that 'in the vegetation in metals lay the most accessible key to the problem of nonmechanical action.' Dobbs, B.J.T. (1991). *The Janus Faces of Genius. The Role of Alchemy in Newton's Thought.* Cambridge: 38.

[228] King, L. (1964). 'Stahl and Hoffmann: A Study in Eighteenth Century Animism.' *Journal of the History of Medicine and Allied Sciences, 19*, 118-130: 122-123.

[229] *Ibid.,* 125.

medicine have made us believe. His chemistry of living things shows that Boerhaave did not make a clear distiction between animate and inanimate matter, for it was based on the assumption that God steers the movements of the animal body as well as those of vegetables and minerals.

Conclusion

At the end of the story, after having examined the influence of Boerhaave's Calvinist beliefs upon his chemistry and chemistry for medicine, we can now understand slightly better what Boerhaave meant with his lifelong motto: *Simplex veri sigillum*, simplicity is the sign of truth, accompanied with the chemical sign for gold. Luyendijk-Elshout and Kegel-Brinkgreve, in their translation of Boerhaave's orations, have tried to trace Boerhaave's motto to Classical sources. Although they managed to come up with some similar sayings, they have not found an exact quotation. Boerhaave, as I suggested in chapter four, might also have been attracted by Newton's call for simplicity in natural philosophy. However, rather than looking for the source of the motto it is more important to realise that it reflects the Calvinist aim of Boerhaave's intellectual pursuits.

Boerhaave's search for simplicity and truth, in theological doctrine as well as in chemical experiment, was his lifelong project. In Calvinist theology the absolute perfection of simplicity and truth is God, for God is a Being absolutely simple and free of any composition. Thus God is not the sum of divine attributes, but the attributes are 'identical with and inseparable from the essence of God.' [1] This means that God must be the absolute standard of truth. For Boerhaave simplicity is an important attribute reflecting the wisdom of God. The elements fire, air, water and earth, as well as mercury and the *spiritus rector*, although they cannot be found perfectly simple, show Boerhaave a glimpse of the perfection of the Creator. Moreover, the working of the simple powers peculiar to every body, showed him God's active working in nature.

In the classic definition of medieval scholastic and Protestant theology, truth is 'the correspondence or conformity of a thing with the intellect.' It is important to note that in the definition neither the thing itself nor the intellect are valued true of false, but the human understanding and judgement are

[1] Muller, R.A. (1985). *Dictionary of Latin and Greek Theological Terms. Drawn principally from Protestant Scholastic Theology*. Carlisle: *simplicitas*, 283.

either true or false.[2] More than any other Christian doctrine Calvinism emphasised the fallen state of the human intellect and the inability of man to come to true knowledge of his own accord. Rather than saying that 'true knowledge' is in nature, waiting to be discovered by man, Calvinists argued that the mind itself is darkened by sin and cannot recognise 'the truth' in nature. Man depends upon God's grace to lift up the cloud and imprint true knowledge upon his mind. For Boerhaave this meant that true knowledge was not to be found in human reasoning, but in experiment and observation. Keeping to this method will also prevent man from trespassing onto God's domain. Unlike general doctrine which explains the whole world according to fallible human rules, experiment and observation reveal the incomprehensibility of God's wisdom and power in His creation. In other words, it shows the greatness of God, the littleness of man and the dependence of the latter upon the former.

Not only does Boerhaave's chemistry show Boerhaave's search for simplicity. Just as Boerhaave rejected the claims of the so-called false chemists and alchemists, he also dismissed the corruptions in theology brought about by fierce debates on the correct doctrinal interpretation. In the same way as simple bodies and individual powers most clearly reveal God's hand in nature, Boerhaave believed that the teaching of Christ as handed down in the New Testament by the early church fathers is the simplest of doctrines. Thus Boerhaave's chemistry of living things, his alchemy, his untiring investigations into the nature of mercury, as well as his (Spinozean) plea for freedom of the mind, his dislike for the Royal court and his daily reading of the Bible, all point towards his Calvinism. Of course, we find similar ideas in the work of other (non Calvinist) natural philosophers, but I hope to have showed that all aspects together make Boerhaave a Calvinist, and his natural philosophy a Calvinist one.

Boerhaave's most important purpose in life was to align himself to the will of God. When he saw obstacles in obtaining a position in the church he turned to the study of nature, for he believed that in addition to the Scriptures 'all creatures, big and small, are like letters, which show us the invisible things of God, namely *his eternal power and Godhead*.'[3] Chemistry, alchemy, and chemistry for medicine showed him the particles with which God built His creation and the powers lodged by God in His creatures. Mercury he considered the most wonderful thing created and it showed him the wisdom and perfection of God. Boerhaave did not want to go to the Court of William III, for he

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[2] *Ibid*: veritas, 325.

[3] Article II of the *Dutch Creed*. 'his eternal power and Godhead' is derived from Romans 1:20.

wanted to continue his studies. Besides, Boerhaave appreciated his freedom of mind and he hated bickering about the right interpretation of the simplest of doctrines.

Boerhaave's obituary published in the *Gentleman's Magazine* states that Boerhaave admired and exalted God in all His works, and that Boerhaave's written advices were always accompanied with a prayer for the divine blessing on his endeavour. [4] In all he did Boerhaave sought to do the will of his Maker. Every morning he got up at five o'clock in order to read his Bible and to meditate. Boerhaave was a serious believer, not someone who would speak about God because the convention of the time prescribed that he should. This means that we have to take Boerhaave's Calvinism seriously, for it was not something on the sideline, something for the church on Sunday, but it was an intellectual framework that not only determined Boerhaave's life, but also his studies in chemistry and medicine. We can even say that Boerhaave's eclecticism best shows his Calvinism, for Boerhaave, in order to choose a particular theory needed a specific, in this case Calvinist, frame of mind on which he based his decision. Most clearly, Boerhaave's definition of fire, being an all-pervading matter and cause of all motion, appears to be based on Calvin's opinion that God sustains the world through diffusing a divine energy in all its parts. Moreover, Boerhaave's method of acquiring true knowledge and the emphasis he placed on the limitations of the human intellect, reflect the beliefs of a true Calvinist. When Boerhaave gave up a career in the church, he did not give up studying theology after all, for the purpose of the study of the Scriptures as well as the study of the Bible of nature was aimed at gaining knowledge of God and His creation. So when Boerhaave put on a doctor's gown he only changed his clothes, but the man underneath remained the same, a Calvinist theologian searching for God's will in the operations of His creation.

[4] See the obituary in the *Gentleman's Magazine*, quoted in Lindeboom, G.A. (1968). *Herman Boerhaave. The Man and his Work*. Leiden: 261.

Appendix. Boerhaave manuscripts on chemistry in St. Petersburg

List of Boerhaave Manuscripts relevant for his chemistry and his chemistry for medicine in the Library of the Military Medicine Academy (S.M. Kirov Academy) in St. Petersburg. Unfortunately I was only able to see the manuscripts briefly, as I was refused permission to do extensive research on them. B.P.M. Schulte published a full list of the Boerhaave Manuscripts in St. Petersburg in the back of his *Hermanni Boerhaave Praelectiones de Morbis Nervorum 1730-1735*, published in 1959 as part of the Analecta Boerhaaviana edited by G.A. Lindeboom. In this appendix I heavily rely on Schulte's inventory. Part of the Boerhaave collection is microfilmed and brought to Leiden, but much of the alchemy is still only available (in principle) in St. Petersburg. I shall list the manuscripts according to their numbers in the Kirov (Leningrad) Collection and when available on microfilm in Leiden, I shall also mention the number of the Leiden collection between brackets directly following the Leningrad number. The translations of the contents of the manuscripts are largely repeated after Schulte.

XIII, 1. *Medicamenta Boyleana*, 1692-1702.

XIII, 2. *Notae chemicae variae*, 1693-1723. Contains: *Medicum parae ef* [sic.] *Helmont 1696-1736;* notes on metals; *Medicamenta Helmontiana*; *Experimenta chemia Helmontii*; various notes on alchemy, Paracelsus, the alcahest, menstrua, elixers; notes on chemical experiments.

XIII, 3. *Collegium chemicum*, 1702-1729. Lecturenotes in Boerhaave's hand. It also contains notes on chemical experiments on the reverse of the papers.

XIII, 4 (F693). *Index eorum quae chemiam spect. alphabeticus*, 1705.

XIII, 5 (F702, although missing in the University Library of Leiden). Chemical experiments from 27 December 1718 until 24 March 1735.

IX, 6 (Q249). *Notae chemicae*, 1694-1702. The map also contains notes of later years up until 1755, which cannot all be ascribed to Boerhaave.

IX, 7 (Q250). *Praelectiones chemicae* (1718-1728). This is an exact handwritten version of Boerhaave's later textbook the *Elementa chemiae*, published in 1732.

IX, 8 (F698). *Notata chymica*, 1728.

IX, 9 (Q259). *Experimenta chemica* (1720-1732). According to Schulte the experiments are partly published in the *Elementa Chemiae*.

XIII, 10 (F699). *Chemica opera*. The map contains many notes on various subjects. Directly relevant with reference to Boerhaave's chemistry and chemical medicine are only a sheet of paper with instruments from the chemical laboratory and two pages of Boerhaave's lecture on 'de argento vivo.' The map also contains part of the lectures on nervous diseases helt between 21 November 1730 until 28 June 1735.

XIII, 11 (F699). *Chemical Opera*, N. 124, 1735. The map also contains *Praelectiones publice habitae de morbis nervorum inchoatae 21.IX.1730*.

XIII, 15 (Q240). *Institutiones chemicarum tomus alter, complectens partem, tertiam, quae ipsas artis operationes exhibit*, 1724. Manuscript of 'De Operationes,' the last part of the *Elementa chemiae*.

XIII, 18. Contains notes on magic and medicine in Antiquity, on seminal principles and theories of generation, on anatomy, recipes.

XIII, 19. Contains notes on chemistry (pp. 19-23).

XIII, 22. *De viribus medicamentorum praelectiones,* 1705-1712.

IX, 37 (F601). Correspondence between Fahrenheit and Boerhaave, containing 13 letters in Dutch about topics in physics and chemistry.

XIII, 38 (Q 255). *Formulae remediorum adversus hypohondriacam (a)egritudinem.*

IX 40 (Q259). Among various papers are lecture notes of Van Swieten on Boerhaave's lectures on nervous diseases.

IX, 41 (Q264). *Opera alchemia*, N. 97. The Leiden microfilm also contains a manuscript called: *'Clavis.' Decimus Liber Antidotorum in M.S. codice Germanico vetustissimo.*

IX, 43 (F606). *De Viribus Medicamentorum.*

IX, 44. *Tinctura metallica Boerhaaveiana*; *Spiritus antiscorbuticus sive essentia Boerhaavianus.*

IX, 56. *Materia Medica. Chemia*. Contains 90 chemical experiments after 1710 (disappeared from the collection).

IX, 73. *Notationes Morborum*. Contains a work called 'De gaudiis alchemistorum' with notes in the hand of Boerhaave (1735-1738?).

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