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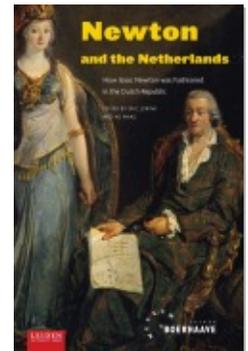
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Newtonianism at the Dutch Universities during the Enlightenment

The teaching of 'philosophy' from 's Gravesande to Van Swinden

HENRI KROP

Introduction

In 1779 Jean Henri van Swinden (1747–1825), a leading late-eighteenth-century Dutch scientist and the rector of the Frisian University at Franeker, on laying down his office delivered an address on Newtonian philosophy.¹ The argument of this huge text, which runs to more than eighty pages, illustrates the fact that during the eighteenth century Newtonianism at the Dutch universities had developed into a full-fledged philosophical system, which at that time philosophers and scientists put on a par with the preceding Cartesianism and its contemporary rival system, Wolffianism. From the 1720s onwards 'Newtonianism' was generally taught at the universities of the Republic as an integrated and comprehensive philosophical system, which besides natural philosophy also included logic and metaphysics. Obviously, 'Newtonianism' is a problematic term and in this article no attempts will be made to identify a general meaning, but merely the 'Newtonianism' taught by Willem Jacob 's Gravesande (1666–1742) and his followers at the Dutch universities will be dealt with.²

In his *Philosophie der Aufklärung*, E. Cassirer was one of the first historians to give Newtonianism a significant place in the philosophy of the Enlightenment, and his example was adopted by the famous historian of Dutch philosophy, F. Sassen, albeit hesitantly.³ The development of such an academic Newtonianism in the United Provinces seems to be unique and is, for example, clearly opposed to the situation in Germany, where during the first half of the eighteenth century Newtonianism was taken to be a set of merely mathematical and

physical doctrines. For example, Zedler's *Universalexicon* in its entry 'Newtonische philosophie'⁴ listed contemporary debates on questions in these fields at random.⁵

In the Dutch Republic the philosophical Newtonianism supported by the universities has to be distinguished from a more popular Newtonianism of a markedly religious nature, which had the societies of enlightened burghers as its institutional background.⁶ Apparently this Newtonianism for some decades outlived the academic one and survived well into the nineteenth century. It is marked by its close alliance with physico-theology and its openness to other philosophical ideas. This popular Newtonianism even adopted Leibnizian themes.⁷ The apparent split between two diverse forms of Newtonianism, a popular and an academic one, confirms M. Jacob's recent observation: 'In the course of the eighteenth century, Newtonianism took a multitude of forms'.⁸ This plurality of Newtonianisms was already recognized by d'Alembert (1717–1783), who in his article 'Newtonianisme, ou philosophie Newtonienne' distinguished no less than five meanings of the term.⁹

The creator of academic Newtonianism in the Netherlands was the Leiden professor Willem Jacob 's Gravesande.¹⁰ In his many university addresses, the preface to his manual of physics, *Physices elementa mathematica, experimentis confirmata, sive introductio ad philosophiam Newtonianam* (1720–1721),¹¹ and his manual of philosophy, the *Introductio ad philosophiam* (1736), 's Gravesande developed an open Newtonianism which was spread by his pupils to most other universities of the Republic: Utrecht – Petrus van Musschenbroek (1692–1761),¹² appointed in 1723; Franeker – Johannes Oosterdijk Schacht (1704–1792), appointed in 1727; and Harderwijk – Johan Hendrik van Lom (1704–1763),¹³ appointed in 1734. Nearly everywhere it replaced Cartesianism as the framework for the teaching of philosophy. In the Netherlands the University of Groningen was an exception in that it resisted the general eighteenth-century Dutch tendency towards Newtonianism by adopting Wolffianism together with the university's German hinterland.¹⁴ The academic Newtonianism of the four other universities in the United Provinces was open as well, because 's Gravesande categorically rejected a slavish imitation of the British scientist.¹⁵

Moreover, the particular nature of Dutch academic Newtonianism appears from its attitude towards physico-theology. With good reason Jonathan Israel observed that contrary to the Newtonians outside the

universities, 's Gravesande ignored physico-theology, which attempted to prove God's existence and His attributes from the order of nature, observed by the senses.¹⁶ With the exception of Van Musschenbroek in his address *De sapientia divina* (1744), none of the major academic Newtonians ever dealt with this hybrid of experimental physics and theology.¹⁷ 's Gravesande and his school realized that the empirical knowledge of God and the divine attributes is pointless when trying to prove the reliability of the senses and the viability of the empirical sciences and of the laws of nature. The justification of Newtonian physics in such a manner is a vicious circle and would have been a fallacy without any philosophical significance. Hence, 's Gravesande and his Newtonian school attempted to supply such a justification of physics by means of the a priori science of metaphysics.

The argument of this article is that Newtonianism at the Dutch universities, or 'Newtonian philosophy', the term current in the eighteenth century, was primarily conceived as a philosophical system. It does not rely on the use of the word 'philosophy' in contemporary sources. In the juxtaposition of disciplines in the teaching assignment of Van Swinden, philosophy is apparently not to be taken in the traditional sense of a master discipline covering all things divine and human.¹⁸ The word is here obviously used in the more specific meaning of physics. At that time this specific meaning of philosophy was rather current and as late as the first half of the nineteenth century it remained usual in the Netherlands to use the word in the sense of physics. In an 1828 essay on the deplorable state of philosophy at the university, after the split of the faculty of philosophy into a faculty of physics and mathematics on the one hand and a faculty of humanities on the other, Jacob Nieuwenhuis (1777–1857), the Leiden professor of speculative philosophy, drew attention to the fact that it was not the new faculty of the humanities that inherited the name philosophy, but the new faculty of mathematics and physics which popularly continued to be called the faculty of philosophy.¹⁹ However, although the word philosophy in the eighteenth-century phrase *philosophia Newtoniana* may well mean physics, the fact remains that Van Swinden at Franeker and the other Newtonian professors had to teach the whole of philosophy and were forced to place their scientific activities within the context of a full-fledged philosophical system. Therefore, at the Dutch universities Newtonianism had been more than a method of physics.²⁰

In the outline of this academic Newtonianism, I will be mainly guid-

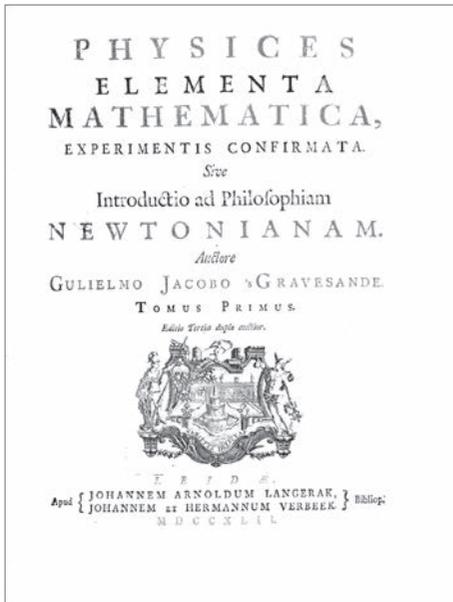


Fig. 1:
Title page of 's Gravesande's
manual

ed by the texts of Van Swinden's academic addresses and his manual of philosophy. Although in his philosophical writings he took no new course, he more than other Newtonians tended to call all parts of his philosophy 'Newtonian'. Hence, his writings may be safely used to deal with the particular nature of the Newtonian philosophical system taught at the Dutch universities, which like other eighteenth-century philosophical systems consisted of interrelated notions of method, epistemology and metaphysics. The first section will present an outline of Van Swinden's intellectual biography. Such an overview will facilitate our understanding of the social and institutional background of Dutch academic Newtonianism. Van Swinden's rectorial address, the *Oratio de philosophia Newtoniana*, typifies the notions of philosophical method (second section). The third second section will deal with the epistemology at the basis of it. The fourth section will discuss the Newtonian metaphysics that justifies this epistemology. The final section will contain some remarks on the intellectual and institutional context of this form of Newtonianism.

Life and works of Van Swinden (1746–1823)

Van Swinden was born in 1746 at The Hague.²¹ In 1763 he matriculated as a law student at Leiden University, but also attended the philosophy lectures of 's Gravesande's successor J.N.S. Allamand (1713–1787) and

the mathematical lessons of Johann Friedrich Hennert (1733–1813), a pupil of Euler at Berlin, who ran a mathematical school at Leiden and in 1764 was appointed professor of philosophy, mathematics and astronomy at Utrecht University. On 12 June 1766 Van Swinden took his philosophical degree by discussing the typical Newtonian topic of the force of attraction. The first three of the theses appended to his dissertation summarize the basic principles of 's Gravesande's philosophy: the metaphysical proof of God (thesis 1), the notion of moral necessity of the will (thesis 2), and the dualistic epistemology (thesis 3).²² A year later Van Swinden accepted a chair in Franeker, which covered philosophy, logic and metaphysics. The philosophical interests Van Swinden cultivated at Franeker, besides his many scientific pursuits, are apparent from his Franeker inaugural address of 1767, which dealt with the causes of error in philosophy.

For eighteen years, until 1785, Van Swinden remained a professor at Franeker. His years spent there were a period of much original work in the fields of electricity, magnetism, meteorology and the northern lights. His strength lay in his internationally acclaimed observational and experimental work. An impressive part of his activities is the series of meteorological observations made during the years 1771–1784, which in the first six years were done on an hourly basis. The results of these observations were published in the journals of several scientific academies, sometimes in Latin and Dutch, but mostly in French. In 1777 he together with Ch.A. Coulomb (1736–1806) received a gold medal awarded by the Paris Academy of the Sciences for his prize essay on magnetic needles. His teaching of physics resulted in a manual entitled *Positiones physicae* and several disputations, dealing for example with the elasticity of water and of air, the nature of fire, electricity and the Leyden jar.

Van Swinden, however, taught philosophy as well. From 1767 till 1775, the year a budget cut of the university precluded their continuation, eight disputations were published, which by their continuous pagination were meant to form a manual of philosophy with the title *Cogitationes de variis philosophiae capitibus* (Thoughts about Various Chapters of Philosophy).

In 1785 the Amsterdam magistrate offered Van Swinden a professorship at the Amsterdam Illustrious School. This chair not only covered mathematics, physics and astronomy, but also metaphysics. Although the Amsterdam Illustrious School (Athenaeum Illustre) was no univer-

sity, Van Swinden accepted, since he would earn a salary that was double his Franeker wages. His inaugural address, *De hypothesibus physicis quomodo sint e mente Newtoni intelligendae*, which referred to Newton in the title, had no less than 111 pages in its printed form, but it dealt with a special topic of Newtonian method already touched upon in the Franeker rectorial address: the concept of hypothesis. Here he advanced his conviction that Newton never denied the need for hypotheses in physics. During his Amsterdam years Van Swinden did not publish on philosophy again. Apparently at the Amsterdam Athenaeum, which, being no university, in principle did not produce theologians, physicians or lawyers, there was no longer a need to deal with the philosophical presuppositions of the sciences. In this respect he anticipated the emancipation of the sciences from philosophy at the Dutch universities. After the 1795 Batavian revolution Van Swinden briefly became a minister in the Batavian government. In 1808 he became president of the Mathematical and Physical Department of the first Dutch national Academy of Sciences, established by King Louis Napoleon. After the Napoleonic era he was appointed councillor of state by King William I. He died in 1823. The next year his library was sold. His collection gives evidence of the wide range of the philosophical interests he entertained besides his scientific endeavours. Van Swinden possessed books by Spinoza, Wolff, Kant – in Latin and the original German – and the Dutch Kantians, P. van Hemert (1757–1825) and J. Kinker (1764–1845).²³ Apparently Van Swinden did not buy philosophical books published after the first years of the nineteenth century.

The philosophical method

Basic to every philosophy are its notions on scientific method and epistemology (dealt with in the next section). Van Swinden dealt with his notions on method in his 1779 rectorial address on Newtonian philosophy in Franeker. He began by observing that after the renaissance of the sciences in the sixteenth century many philosophers and scholars flourished.²⁴ Although many deserve our praise and admiration on account of their teaching, ingenuity of mind and their art of discovering new things, no man has to be extolled more than Isaac Newton, Van Swinden concludes after two pages of academic rhetoric.²⁵ In order to confirm this view he quotes a verse taken from Edmund Halley's commendatory poem in the *Principia* ('no mortal may approach nearer to the gods') and Herman Boerhaave's lavish

laudation of Newton as ‘a man in whom Nature has revealed the acme of human perspicacity’.²⁶ The religious overtone in the Halley verse is no literary device, for as Van Swinden underlined it was the ‘Supreme Maker and Ruler’ who aimed at man’s blessedness by removing the darkness and obscurity brought forth by scholasticism, which veiled the face of nature, by sending Newton to restore natural philosophy.²⁷ God elected Newton to accomplish the task which his predecessors had begun. According to Van Swinden, Newton represented a crucial moment in the history of God’s relations with mankind: ‘in order to complete this work the divine providence generated Newton’.²⁸ In this view it was Newton who created the highway of philosophy by combining the two previous roads taken by mankind. Some scholars followed in the footsteps of Descartes and practised the mathematical sciences (page 11), other scholars, such as Galileo, Toricelli, Boyle and Mariotte, joined forces and created a complete ‘catalogue of the phenomena’ (page 12). Through this dichotomy Van Swinden transforms Newtonianism into a synthesis of all preceding thought by observing that Newton combined the mathematics of the Cartesian tradition with an empirical approach in natural philosophy. Hence, according to Van Swinden, Newton’s greatness is due to the powers granted him by God to transcend the limitations of rationalism and empiricism by establishing a new method in philosophy.²⁹ Newton’s successors all followed in his footsteps and combined mathematics and observation, reason and experience, in the practise of natural philosophy. In the second part of his address Van Swinden dealt with Newton’s scientific achievements. However, in his argument he wanted to ignore these accomplishments, together with Newton’s research in the fields of chronometry, metaphysics and theology, since Newtonianism in his view was primarily to be seen as a method, which complemented the Wolffian notions on method (pages 39–40). Van Swinden reminded his audience that exactly thirty years earlier his predecessor Samuel Koenig (1712–1752) had held his inaugural address by dealing with the harmony between the Newtonian and Wolffian methods of philosophizing. However, Van Swinden’s predecessor only dealt with the Wolffian method and a second oration dealing with Newtonianism remained an unfulfilled promise till Van Swinden undertook this task (page 41).

According to Van Swinden – and many others – Newton described his method in a nutshell in query 28, observing: ‘the main business

of natural philosophy is to argue from phenomena without feigning hypotheses and to deduce causes from effects till we come to the very first cause'.³⁰ This observation implied three principles:

1. In natural things only claims are to be admitted which are substantiated by empirical observation.
2. Most hypotheses are to be rejected; some, however, are to be examined and applied.
3. It is all-important, after investigating the degrees of certainty of all our knowledge, to keep certain and uncertain things apart.

The truth of the first methodological principle is obvious. If we ignore this principle, Van Swinden states, then just like Descartes we arrive at studying a factious universe instead of the universe created by God.³¹ However, we are unable to investigate many things by means of the senses and these have to be examined by reason alone. The implication of this conclusion is that Newton – and Newtonianism – did not attempt to reduce the whole of philosophy to mere experimental philosophy. Experimental and rational philosophy should be combined and a real marriage of experience and reason is to be aimed at.³² The same programme was formulated by Van Swinden's Wolffian predecessor thirty years earlier and exemplifies the tendency of Dutch philosophy during the eighteenth century to link the new experimental sciences to a more general philosophical context of non-empirical sciences. The consequence of the need felt both in the Newtonian and Wolffian method to link empirical and intellectual knowledge is that according to Van Swinden, Newton did admit hypotheses. The famous '*hypotheses non fingo*' of the *General scholium*, therefore, only refers to false or metaphysical hypotheses (page 48). Van Swinden's *bête noir* is in this respect Descartes who in the *Principles of Philosophy* I, 24, advocated an utterly false method – *verae scientiae adversa* – by observing that, as God is the cause of all things, it would be wise in philosophy to attempt to explain natural phenomena by means of our knowledge of God. The nefarious effect of this intermingling of metaphysics and the empirical sciences had been that the French philosopher, by severing the necessary link with experience and observation, led the sciences into the field of fiction and error. In order to distinguish false 'Cartesian' from sensible 'Newtonian' hypotheses, Van Swinden once more

refers to the Queries (I quote from the English original, although as in the previous quotation the Latin not exactly renders Newton's words):

in natural philosophy the investigation of difficult things by the method of analysis ought ever to precede the method of composition. This method of analysis consists in making experiments and observations and in drawing general conclusions from them by induction and admitting of no objections against the conclusions but such are as taken from experiments or other certain truths.

Van Swinden's reading of Newton is one of the better examples of creative hermeneutics, since the next (not quoted) sentence in Newton's text runs: 'for hypotheses are not to be regarded in experimental philosophy'.³³

The last principle of the Newtonian method exhorts the philosopher to respect the order of the sciences, which precludes the deduction of physics from metaphysics. Leibniz readily but erroneously inferred from final causes and the general principles of metaphysics how things in sensory reality should be. God's wisdom, for example, led him to deny the existence of the void (page 56), while Wolff argued for the universality of mechanical explanations on account of God's power (page 60). Such arguments are pointless if they are not corroborated by the phenomena. We may sum up Van Swinden's argument as follows: Newtonianism is a method which first of all presupposes the epistemological need to link reason and observation, and which follows from the metaphysical dualism of bodies and minds (dealt with in the following sections).

Newtonian epistemology: *Oratio inauguralis de causis errorum*

The new Franeker professor began his discourse by laying down the two basic metaphysical principles of Dutch Newtonianism. Van Swinden established the first principle, namely of nature's order, by observing that all human knowledge is based on Cartesian introspection.³⁴ By contemplating our mind we become clearly and distinctly aware that we are endowed with the powers to know the ultimate Truth and the means to attain our happiness.³⁵ Moreover, we know that in us a 'natural instinct' exists aiming at our good and a reason enabling us to know that good, although vice disturbs this natural order and

installs itself by false education and the imitation of false examples. They cause immoderate appetites in our minds for honour and greed, through unnatural passions.³⁶ Hence, just as philosophers had done from Plato and Aristotle onwards, Van Swinden believes that the science of nature intrinsically possesses a moral significance. Moreover, we acknowledge the all-embracing order in the universe. This metaphysical notion of order constitutes the metaphysical base of the epistemology of Dutch Newtonianism and forms part of the natural law tradition.

The second metaphysical principle advanced by Van Swinden is a Cartesian dualism between mind and body. By contemplating ourselves we know that on the one hand there are spiritual substances existing eternally, unchangingly and acting freely, while on the hand there are bodies, which are changeable, existing in time and determined by necessary causes.³⁷

From this metaphysical dualism Van Swinden in a natural manner deduces two general epistemological notions. One is a basic epistemological dualism. The material universe we know by observation and the intelligible world by reason. The truth of our ideas of immaterial entities we assess in a Cartesian reflective manner by considering their intrinsic attributes of clearness and distinctness alone. Hence in the sciences dealing with immaterial substances, such as metaphysics and mathematics, we can rely on arguments which use the geometrical method.³⁸ These rational sciences, therefore, are in principle exempt from error and dispute. Contrary to the physicists, mathematicians readily accept each other's inferences, and between the mathematics of the ancients and the moderns there is a substantial agreement. On the other hand, the knowledge of the bodily world begins with the observation of phenomena. Only by using our senses do we ascertain the truth of our ideas about bodies and their properties. The sole application of the a priori method of geometry in the empirical science of physics resulted in 'the monstrous doctrines of Spinoza's *Ethics*'.³⁹ Other examples of philosophers who ignored this epistemological dualism are Leibniz with his doctrine of monads (page 18) and Descartes with his laws of motion (page 33), which are deduced in an a priori manner from God's attributes without consulting the senses and without seeking confirmation by observation.

The second epistemological inference from his metaphysical dualism is a limited 'scepticism', that is to say, the need to accept the limits

of human knowledge. Of certain phenomena we have mere empirical or factual knowledge, and we are unable to acquire full insight in their causes.⁴⁰ Our knowledge of the material world is basically of an a posteriori nature and does not transcend the limits of the senses. By contemplating ourselves we know that we consist of a mind and a body, two distinct beings. At the same time experience teaches us that although body and mind interact, how this interaction is produced we do not know.⁴¹ Since Van Swinden hardly comments on this scepticism, I turn to 's Gravesande's teachings. In the eighteenth century this metaphysical theory of mind-body relation went by the name of *influxus physicus* and it was generally opposed to the doctrines of Cartesian occasionalism and Leibnizian pre-established harmony. Although the theory of bodily interaction rests on experience, it is inconsistent with arguments that 's Gravesande tends to consider irrefutable. 'How can a thing which is by no means material resist the action of a body?'⁴²

More in general: we know bodies by the effects they produce on our senses, that is to say the phenomena, but of their substantial nature we have only a partial understanding.⁴³ This scepticism in Van Swinden's epistemology may be derived from Locke.⁴⁴ The British philosopher in his famous *Essay Concerning Human Understanding* denied our having any knowledge of the real essences of substances. Of substances we can have no certain but only probable knowledge, or in Locke's words, opinion or belief. In the case of substances, Locke prefers the 'historical, plain method' to the geometrical method (*Essay* 1,2), but 's Gravesande and Van Swinden did not share Locke's preference.

What is more, Van Swinden's scepticism resulted in the notion of a discontinuity between metaphysics and physics, which undermined the Cartesian belief that philosophy or the encyclopaedia of the sciences may be compared to a tree, the roots being metaphysics, the trunk physics and the other sciences its branches.⁴⁵ According to Van Swinden, metaphysical principles applied in physics are regulative ideas, if I may use this Kantian notion here anachronistically. The so-called law of continuity, which states that natural phenomena give evidence of a continuous sequence and which apparently directly follows from the metaphysical notion of the order of nature, for example, the metaphysical law of continuity seems to preclude the existence of perfectly solid bodies, which suddenly lose their velocity (page 33). Such an abrupt change would mean an infraction of this metaphysical principle. Hence, if we observe phenomena that apparently contradict

this law, we have to call into question the accuracy of the empirical data. However, the adoption of metaphysical principles in empirical science often leads to error. An example given by Van Swinden is the Jesuit mathematician and philosopher R.G. Boscovitsch (1711–1787), who used this principle to argue for the hypothesis that a body consists of a series of mathematical points kept together by the force of attraction (page 34). According to Van Swinden, such a theory is false and its falsity is caused by the reckless use of principles which in themselves are true. On the other hand, the metaphysical law of simplicity was used with good reason by Leibniz and Descartes to elucidate the laws of light's refraction by arguing that nature chooses the shortest way in the shortest time and by P.L. de Maupertuis (1698–1759) in his attempts to prove that the amount of action involved in all motion remains constant (page 35). Such hypotheses agree with all physical truths known to us. Van Swinden, therefore, accepts the heuristic value of metaphysical principles, but in general the physicist should refrain from using final causes to discover the laws of nature. According to the Calvinist Van Swinden, the metaphysical order remains to a large extent unknown to our limited intellect.⁴⁶ However, we do know what is useful and required to attain our end in this life.

Cogitationes de variis philosophiae capitibus

The eight dissertations from Van Swinden's Franeker period that made up the *Cogitationes de variis philosophiae capitibus* develop the principles that Van Swinden outlined in his inaugural address. It should be noted that of the seven students who presented these disputations compiled in a manual of the professor and published under his name, as was usual at the premodern Dutch universities, four studied theology, two were medical students and only one is recorded as a student of 'humanities and philosophy'.⁴⁷ This fact reminds us of the propedeutic character of the teaching of philosophy and physics at the universities during the Enlightenment. Nearly all students ended their educational career not as philosophers or scientists, but as lawyers, ministers or physicians. The basis of Van Swinden's manual is 's Gravesande's popular *Introductio ad philosophiam*, widely read in its eight contemporary editions and its French and Dutch versions, which, however, was modified at several points.⁴⁸ For example, although both philosophers began their manual with metaphysics, the Leiden philosopher started with ontology, observing that metaphysics is useful

because it acquaints us with abstract ideas and so enables the mind to be effective in the study of truth.⁴⁹ However, Van Swinden began with natural theology and the teleological order in the universe, a topic that 's Gravesande only touched upon in the second logical part where he dealt with the evidence of the senses.⁵⁰ In the first dissertation (submitted by G. Coopmans, who in 1770 presented a physical thesis on the winds, and afterwards became a professor of medicine), Van Swinden observed that from ideas immediately present in our mind we necessarily and a priori deduce the existence of an infinite and perfect Being.⁵¹ Hence, according to metaphysics, every being possesses its proper goal and as part of the whole of nature partakes in its common end. In order to reach this common end the relations between the parts have to be fixed: the same causes should always have the same effects, as Newton with good reason, Van Swinden observed, recorded in his second rule.⁵² From this metaphysical premise, Van Swinden infers the invariability of the laws of nature.⁵³ However, due to the limitations of our intellect, our knowledge of this metaphysical order is only fragmentary.⁵⁴ For example, we know that both in the material and in the intelligible world all things happen in accordance with the eternal decrees of God. Yet we are also certain that a will acting in accordance with its own laws is free. How both certainties are to be reconciled is a mystery.⁵⁵ The same applies to the material world. Bodies are apparently inert: without an external cause setting them in motion they do not move. However, as far as we know attraction is neither caused by an external cause, nor is an inner property of a body. The first disputation ends by observing that miracles as such (that is, with respect to God) are impossible. However, with respect to man, in possession of a limited intellect only, they obviously occur.⁵⁶ To quote Van Swinden's own example, the making of ice is a miracle to an African, unless the natural laws, which are used in the production of ice, are explained to him (page 18). Moreover, the common people often consider miraculous natural phenomena, which the scientist fully understands, thanks to his insight into the inflexible rules God uses to govern the world. The limits of our understanding force us to accept the fact that for us the universe will always be of miraculous nature. It is this scepticism, which prevents Van Swinden from adopting a full-fledged Spinozistic determinism. The universe is ruled by invariable laws of nature determined by God, who by His unchanging nature precluded the existence of miracles. However, our knowledge of God's

nature is limited. Hence, Van Swinden did not adopt Nieuwentijt's and 's Gravesande's voluntaristic view of natural laws.

The second disputation in Van Swinden's manual was presented by F.N. de Villepoix, a student of theology, and deals with logic. It focuses on the distinction between ideas 's Gravesande made in chapters 6 and 13 of the second book of his *Introductio*. On the one hand, we know ideas originating in the mind itself. Such ideas concern the determinations of our will, our memory, the operations of our intellect, and our passions. We may have an idea of a pain without knowing its cause in our body.⁵⁷ Our judgements consisting of such ideas are certain, because the mind immediately perceives the relation between the ideas involved. This direct evidence, according to Van Swinden and 's Gravesande, results in mathematical certainty. On the other hand there are ideas produced in the mind by means of the senses. Such ideas denote an object in the material world outside the mind. Judgements passed by means of such ideas possess moral certainty, which may equal the certainty of mathematically evident judgements but is indirect.⁵⁸ The mind perceives the link between the combined ideas by using the senses – in observation or experiment, in analogy or the testimony of others (page 28). 's Gravesande's distinction of these three means was adopted by Van Swinden, but he noted that in fact all three amounted to experience.⁵⁹ Hence he summarizes his logic by stating that reason and experience are the two sources of our knowledge. Their relation was a basic theme that had engaged the minds of Dutch philosophers since the final phase of Dutch Cartesianism.⁶⁰ Moreover, Dutch Newtonians underlined the fact that both forms of knowledge were of a scientific nature. Although empirical knowledge is often merely probable, something in between perfect science and ignorance, with the help of mathematics we can determine the precise degree of probability of a judgement. Instead of the two short chapters in 's Gravesande's *Introductio*, Van Swinden elaborates for some eighty pages on mathematical probability. He stresses that the *ars conjecturandi*, the art of guessing, is a science as well, based on two metaphysical principles: first, that the whole of the universe is governed by unchanging laws, and second, the Leibnizian principle of sufficient reason.⁶¹ From this point in the argument onwards, which continues by dealing with error, method and syllogism, Van Swinden does not follow the *Introductio* any longer.

He next discusses the order of the sciences and their epistemologi-

cal principles.'s Gravesande had dealt with this important topic not in his *Introductio* but in the address he had delivered in 1724 when resigning as rector of Leiden University. Applying the distinction between moral and mathematical evidence to the sciences, he sets those sciences that are based upon rational ideas and use the geometrical method apart from the empirical sciences. The first group consists of mathematics, both pure and applied, logic, ontology, natural theology and the universal principles of moral philosophy. The second group consists of physics, history, Christian theology and social morality. The ideas of these sciences denote objects in the material world existing outside the mind and are therefore of an empirical nature. Van Swinden replaces 's Gravesande's clear-cut dichotomy with an encyclopaedia of the sciences containing many gradations. On the one hand there is mathematics, the only rational and a priori science both with respect to method and ideas; on the other hand there are the historical sciences, which are empirical both with respect to method and ideas. In this scheme the other sciences are placed in between. Metaphysics, for example, is not a pure science, since its ideas of substance, mode, being and cause are learned by experience and only afterwards abstracted by the intellect.⁶² Moreover, if metaphysics is to be of any use it must be applied to and checked against the phenom-

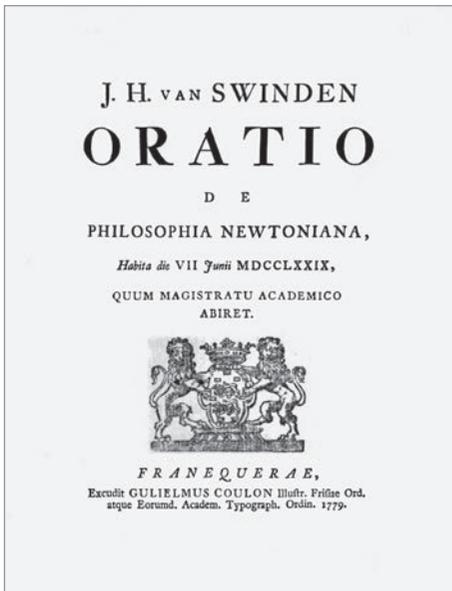


Fig. 2:
The title page of Van Swinden's
address.

ena observed by the senses. So this part of Van Swinden's argument restricts the significance of the rational sciences. On the other hand Van Swinden seems to underline the rational element in the empirical sciences by arguing for the use of mathematics in all natural sciences, even in chemistry and biology. In conclusion, it might be observed that the *Cogitationes philosophicae* does not contain substantially new notions, but only develops the philosophical principles of the academic addresses.

The university context

At the end of this article outlining Dutch academic Newtonianism as adopted by 's Gravesande and his successors, some remarks will be made in order to explain why Dutch Newtonians were not only scientists but also philosophers. In the first place, Dutch scientists were academics, working at a faculty of philosophy. The first scientific society, the *Hollandsche Maatschappij der Wetenschappen* (Dutch Society of Sciences) at Haarlem, was only established in 1752. The teaching in the faculty of philosophy was general and propedeutic, most students completing their education in the higher faculties, which gave access to certain learned professions.⁶³ Where in the modern universities the teaching aims at the training of experts in a particular branch of learning, pre-modern universities continued to provide a general education. This institutional context forced the professors of philosophy, who in general had a broad teaching assignment not restricted to physics, astronomy or mathematics, to include logic and metaphysics in their teaching.

My second remark concerns the reading public of Dutch Newtonian texts. The readers of scientific and philosophical texts produced at the universities were either students or members of the so-called 'learned class' who thanks to their education could read Latin. Latin remained the official language of instruction at the Dutch universities well into the nineteenth century.⁶⁴ However, at the end of the eighteenth century more and more scholarly literature was becoming available in Dutch translations. Manuals, academic addresses and even disputations were often translated into Dutch. However, the reading public basically remained the class of citizens with a broad cultural and social interest, instead of experts who more naturally found their way to the specialist dissertations and journals published by the learned societies. This appears, for example, from the translation of Van Swin-

den's manual of physics written during his Franeker period, the *Positiones physicae* and published in 1792. In the preface Van Swinden observed that the translation aimed at young people eager to acquire 'true learning'. Such learning had to be encyclopaedic, consisting of *belles-lettres*, history, logic and the philosophical and mathematical disciplines.⁶⁵ Philosophy included the knowledge of God, of ourselves and of nature.⁶⁶ Physics, however, he observed, was seldom studied by those who aimed at a specialised and intimate knowledge of some particular subjects, but Van Swinden wrote for those not professionally interested in physics.⁶⁷ Such writing called for an overview of the general principles of a particular science and an orderly treatment of the subject matter.⁶⁸ Hence even in his non-academic writing the scientist Van Swinden had to be a philosopher as well. Apparently this dual function of the professors of philosophy at the Dutch universities during the eighteenth century stimulated Dutch academic Newtonians to develop a Newtonianism, which was both a scientific theory and a philosophical system.

Notes

- 1 J.H. van Swinden, *Oratio de philosophia Newtoniana, habita die VII Junii MDCCLXXIX, quum magistratu academico abiret* (Franeker 1779) [22], 82, [13] pages.
- 2 Cf Vermij's contribution to this volume.
- 3 F. Sassen, *Geschiedenis van de wijsbegeerte in Nederland* (Amsterdam 1959), pp. 218–222. Sassen preferred the designation 'experimental philosophy' or 'empiricism', which, however, in his view on account of its eclecticism lacked all philosophical depth. Cf my 'Die niederländische Newtonianismus', in: H. Holzhey and V. Mudroch (eds), *Grundriss der Geschichte der Philosophie: die Philosophie des 18. Jahrhunderts*, Vol. 2, *Grossbritannien und Nordamerika, Niederlande* (Basel 2004), pp. 1094–1112.
- 4 J.H. Zedler, *Grosses vollständiges Universal Lexicon aller Wissenschaften und Künste, welche bisshero durch menschlichen Verstand und Witz erfunden und verbessert worden* (Halle and Leipzig 1731–1751), vol. 24, coll. 413–416, 414: 'so haben sich doch unter den Ausländer nicht wenige gefunden welche den herrn Newton zwar für einen unstreitig großen Mathematicum von ersten Rang, aber nur für einen mittelmäßigen Philosophen gehalten haben'.
- 5 Th. Ahnhert, 'Newtonianism in early Enlightenment Germany, c. 1720 to

- 1750: metaphysics and the critique of dogmatic philosophy', *Studies in history and philosophy of science* 35 (2004), special issue on Newton and Newtonianism (ed. S. Mandelbrote), pp. 471–491, on p. 482.
- 6 E. van der Wall, 'Newtonianism and religion in the Netherlands', *Studies in history and philosophy of science* 35 (2004), special issue on Newton and Newtonianism (ed. S. Mandelbrote) (note 5), pp. 493–514.
- 7 Ibidem, p. 494.
- 8 M. Jacob, 'Introduction', in: J.E. Force and S. Hutton (eds), *Newton and Newtonianism: new studies* (Dordrecht 2004), pp. ix–xvii, on p. xi.
- 9 D. Diderot and J. le Rond d'Alembert (eds), *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers* (Paris 1751–1780), vol. 11, p. 1222; see I. Bernard Cohen, *Franklin and Newton* (Philadelphia 1956), pp. 179–183, and the 'Introduction' in: I. Bernard Cohen and G.E. Smith (eds), *The Cambridge companion to Newton* (Cambridge 2002), pp. 29–31. See also R.E. Schofield, 'An evolutionary taxonomy of eighteenth-century Newtonianisms', *Studies in eighteenth-century culture* 7 (1978), pp. 175–194.
- 10 Still the most basic study of his thought is G. Gori, *La fondazione dell'esperienza in 's Gravesande*, pubblicazioni del Centro di studi del pensiero filosofico del cinquecento e del seicento in relazione ai problemi della scienza del Consiglio Nazionale delle ricerche Studi 2, Serie I (Florence 1972).
- 11 The title in the contemporary English translation by Desaguliers ran *Mathematical elements of natural philosophy, confirmed by experiments or an introduction to Sir Isaac Newton's philosophy* (London 1720–1721). See the contribution by Jorink and Zuidervaart in this volume.
- 12 C. de Pater, *Petrus van Musschenbroek (1692–1761), een newtoniaans natuuronderzoeker* (PhD-thesis, Utrecht 1979).
- 13 H.A. Krop. 'Tussen wetenschap en levensleer. de beoefening van de wijsbegeerte aan de universiteit te Harderwijk', in: J.A.H. Bots et al. (ed.), *Het Gelders Athene: bijdragen tot de geschiedenis van de Gelderse Universiteit in Harderwijk (1648–1811)* (Hilversum 2000), pp. 133–162, on 145–157.
- 14 M.J. Petry and M.R. Wielema, 'Antonius Brugmans (1732–1789), bruggenbouwer in de filosofie' and M.R. Wielema, 'Nicolaus Engelhard (1696–1765), de leibniz-wolffiaanse metafysica te Groningen', in: H.A. Krop, J.A. van Ruler and A.J. Vanderjagt (eds), *Zeer kundige professoren: beoefening van de filosofie in Groningen van 1614 tot 1996* (Hilversum 1997), pp. 135–147 and 149–161.
- 15 W.J. 's Gravesande, 'Monitum ad lectorem', *Physices elementa mathematica* 2 vols (Leiden 1725), vol. 1, p. v. English version 'To the reader', *Mathematical elements of natural philosophy*, 2 vols (London 1737), vol. 1, p. xi: 'He only who in Physics reasons from the phaenomena, rejecting all feign'd hypotheses, and pursues this method inviolably to the best of his

- power, endeavours to follow the steps of Sir Isaac Newton, and very justly declares that he is a Newtonian philosopher; and not he who implicitly follows the opinion of any particular person.’
- 16 J. Israel, *Enlightenment contested: philosophy, modernity and the emancipation of man (1670–1752)* (Oxford 2008), pp. 216–218.
 - 17 De Pater, *Musschenbroek* (note 12), pp. 318–324.
 - 18 Zedler, *Universal Lexicon* (note 4) vol 27, p. 2014, and Diderot and d’Alembert (eds), *Encyclopédie, ou dictionnaire raisonné* (note 9), vol. 12, p. 512 s.v. ‘philosophie’.
 - 19 J. Nieuwenhuis, *Gedachten over het akademisch onderwijs der bespiegelende wijsbegeerte in het Koninkrijk der Nederlanden* (Leiden 1828), p. 27: ‘bij de wis- en natuurkundige faculteit, die zij [philosophy] heeft moeten verlaten, heeft zij haren naam als erftitel achtergelaten’.
 - 20 E.G. Ruestow, *Physics at seventeenth- and eighteenth-century Leiden. philosophy and the new science in the university* (The Hague 1973), p. 121, who to that end quotes from ’s Gravesande’s *Philosophiae Newtonianae institutiones*: ‘we justifiably call Newtonian that philosophy in which hypotheses having been rejected, conclusions are deduced from phenomena. No one before Newton followed that method unremittingly.’ See also De Pater, *Petrus van Musschenbroek* (note 12), ch. 3.
 - 21 His biography in S.H.M. Galama, *Het wijsgerig onderwijs aan de Hogeschool te Franeker (1585–1811)* (Franeker 1954), pp. 177–181; M. van Hoorn, ‘Jan Hendrik van Swinden (1746–1823), een gemeenebestgezind geleerde’, in: J.H. van Swinden, *Beschrijving van het Eijsinga-planetarium te Franeker* (fotomechanische herdruk van het oorspronkelijke werk uit 1851; Franeker 1994), pp. ix–xxv; M. van Hoorn, ‘De gemeenebestgezindheid van Jan Hendrik van Swinden (1746–1823)’, in: E.O.G. Haitsma Mulier et al. (eds), *Athenaeum Illustre, elf studies over de Amsterdamse Doorluchtige School (1632–1877)* (Amsterdam 1999), pp. 227–231. About his views on educational politics: B. Theunissen ‘Nut en nog eens nut’, *wetenschapsbeelden van Nederlandse natuuronderzoekers (1800–1900)* (Hilversum 2000), pp. 13–36.
 - 22 J.H. van Swinden, *Dissertatio philosophica inauguralis, de attractione* (Leiden 1766), p. 76 (between brackets the source in the writings of ’s Gravesande). The theses are: ‘Causarum effectuumque series infinata dari non potest’ (cf. J.N.S. Allamand (ed.) *Oeuvres philosophiques et mathématiques de Mr. G.J. ’s Gravesande*, 2 vols (Amsterdam 1774), vol. 2, p. 1. ‘Essai de métaphysique’ 2, II, pp. 176–180) and ‘Actiones hominis liberae pendent ab voluntate, voluntas ab judicio, judicium ab ideis’ (cf. G.J. ’s Gravesande, *Introduction à la philosophie* (Leiden 1737), part 1, ch. 12) and ‘Ideas seu notiones omnes sensuum ac reflexionum acquirimus’ (*Introduction à la philosophie*, part 2, ch. 19).
 - 23 *Catalogue des livres de la bibliothèque de feu Mr. Jean Henri van Swinden*

- (Amsterdam 1823). It is interesting to note that in the title of this catalogue and in the *avertissement*, 'philosophy' is used unambiguously in the modern sense, opposing it to the '*sciences exactes*', '*théologie*', '*histoire naturelle*', '*chemie*', '*belles lettres*' and '*histoire naturelle*'.
- 24 Van Swinden, *Oratio de philosophia Newtoniana* (note 1), p. 3: '*a renatis scientiis haud pauci floruerint philosophi, viri doctrina et ingenio eminentes, et de republica litteraria optime meriti [...] novas veritatem inveniendi atque demonstrandi aperuerunt vias*'.
- 25 Ibidem, p. 4: '*nullus [...] honoribus dignior quam Isaacus Newton*'.
- 26 Ibidem, p. 8: '*natura ultimam posuisse videtur perspicientiae humanae metam*' (a note refers to the *Orat. de Chemia suos errores expurgente*, in fine, in: *Boerhaave's orations*, trans. with introd. and notes by E. Kegel-Brinkgreve and A.M. Luyendijk-Elshout (Leiden 1983), p. 212, and: '*Nec fas est proprius mortali adtingere divos*'.
- 27 Ibidem, *Oratio de philosophia Newtoniana*, p. 9: '*Artifex et Gubernator Deus*'.
- 28 Ibidem, p. 14: [Newton] '*ad hoc opus perficiendum Divina providentia suscitatum arbitror*'.
- 29 Ibidem, p. 14: '*nova et inaudita methodo*'.
- 30 Ibidem, p. 43: '*in rerum sc. proprietates diligenter inquirere, has experimentis stabilire e phaenomenis vero arguere et ab effectis ratiocinatione progredi ad causas donec ad causam omnium primam perveniamus*'. Van Swinden more or less conflates two sentences of Newton. One taken from query 28 and the other from a Latin version of *Philosophical Transactions*, nr. 85, p. 5014.
- 31 Ibidem, p. 45: '*fictitium condere mundum in animo [...] non veram quem Supremus rerum artifex creavit*'.
- 32 Ibidem, p. 47: '*multa denique quae scire interest ratione tantum intelligi possunt*'. Hence 'by no means should we either forgo the rational sciences, or pay them hardly any attention. We also do not take pride in the title of empiricists', but '*ubivis experimentalis et rationalis philosophiae connubium*'. For the theme of the '*connubium*', see my 'Het moeizame einde van een huwelijk (1687–1781), filosofen in de rol van een echtscheidingsadvocaat', *Gewina* 30 (1987), pp. 230–246, with an English summary.
- 33 Van Swinden, *Oratio de philosophia Newtoniana* (note 1), p. 54: '*methodum analyticam, tamquam primum omnium nostrarum investigationum partem commendat, jubet ut ex institutis experimentis observatis phaenomenis conclusiones inductione inferamus*'. He inaccurately quotes the last query from the Latin version (published at Lausanne and Genève 1740, p. 329).
- 34 J.H. van Swinden, *Oratio inauguralis De causis errorum in rebus philosophicis* (Franeker 1767), p. 3: '*si quis mentis humanae attente perpendat*'.
- 35 Ibidem, p. 4–5: '*homines ad imaginem Dei esse confectos [...] eximias mentis facultates iis ad veritatem et felicitatem consequendum datas [...] instinc-*

- tu naturali Creatore optimo hominis indito*’.
- 36 Ibidem, p. 6: ‘*ex mentis facultatibus percipiendi, cogitandi, volendi, agendi [...] patet, nil corporei ad mentis essentiam concurrere*’.
- 37 Ibidem, p. 3: ‘*homines partim suapte natura in pejus versa, partim prava educatione partim aliorum exempla inducti. Hinc innumeri in vita instituendi errores, hinc indominati animi affectus, hinc pleraque vitia, hinc omnes pravae hominum actiones*’.
- 38 Ibidem, p. 13: ‘*ideae perfectae [...] ab omni parte sunt clarae, distinctae, adequatae [...] Hinc nullae inter mathematicos disputationes nullae pugnae, sed maxima potius stupenda fere inter veterum et recentiorum mathematicorum placita concordia, egegrius inter ea consensus*’.
- 39 Ibidem, p. 12: ‘*Spinosae ethicam, quae licet mathematica methodo sic satis concinne digesta, ideo tamen quod falsis notionum substantiae et attributi definitionibus monstra dogmata produxit*’. See also Vermij’s contribution in this volume.
- 40 Ibidem, p. 13: ‘*limita est mentis vis [...] vix posse ut homines ab errore semper stent immunes*’.
- 41 ‘s Gravesande, *Introduction à la philosophie* (note 22), vol. 1, ch. 17, p. 36: ‘*l’expérience est l’unique fondement de cette opinion*’.
- 42 Ibidem, vol. 1, ch. 17, p. 37: ‘*Mais ce qui n’est point matériel, peut-il résister au Corps? Qui oserait avancer une pareille proposition?*’
- 43 Ibidem, vol. 1, ch. 2, p. 4: ‘*Les substances sont connues que par le moyen de leurs attributes*’ and more clearly in the preface of the *Mathematical elements* (note 15), p. xi: ‘*what substances are, is one of the things hidden from us. We know, for instance, some of the properties of matter, but we are absolutely ignorant, what subject they are inherent in*’.
- 44 P. Schuurman, *Ideas, mental faculties and method: the logic of ideas of Descartes and Locke and its reception in the Dutch Republic (1630–1750)* (Leiden 2004), pp. 137–148.
- 45 Van Swinden, *Oratio inauguralis* (note 34), p. 33: ‘*omnia quae ex applicatione metaphysicae ad physicam redundant errores*’.
- 46 Ibidem, p. 38: ‘*nimum arcti sunt mentis limites quam ut semper ad scopum Dei in hoc illo phaenomeno producendo assequari queamus*’.
- 47 J.H. van Swinden, *Cogitationes de variis philosophiae capitibus, quas [...] praeside Johann. Henr. van Swinden [...] publico examini submittit G. Coopmans* [et al.] (Franeker 1767–1775).
- 48 Gori, *La fondazione dell’esperienza* (note 10), pp. 134–154.
- 49 Allamand (ed.), *Oeuvres philosophiques* (note 22), vol. 2, p. 1.
- 50 Van Swinden, *Cogitationes* (note 47), p. 1: ‘*Deus [...] entia creavit varia determinatas partes agentia ad communem finem*’.
- 51 Ibidem, p. 5: ‘*Haec propositio ex ideis immediate menti praesentibus a priori deducta, necessario vera est*.’ The order of nature may be deduced a priori from God’s wisdom, Van Swinden continues, but it is difficult to

- reconcile the doctrine of nature's order a posteriori with 'both moral and physical evil'. This observation implies the pointlessness of physico-theology. Experience might establish the order of nature at most imperfectly.
- 52 Ibidem, p. 12: '*Quae itaque effectus edunt prorsus eosdem, easdem quoque habent causas, eandem habent naturam. [...] Haec regula eximia veroque philosopho digna a summo Newtono fuit prolata.*'
- 53 Ibidem, p. 16: '*natura secundum constantes et determinatas agit leges*'. Cf. Vermij's contribution to this volume.
- 54 Ibidem, p. 3: '*mentis vis limitibus angustissimis circumscribitur*'. Hence: '*omnia probe cognoscere et perfecta habere nullius est aut hominis aut aetatis*'.
- 55 Ibidem, p. 7: '*hujusmodi repugnantiae apparentes a sola mentis imbecillitate oriundae non solum in mundo intellectuali occurrunt, sed et in Physico*'.
- 56 Ibidem, p. 20: '*miracula nobis philosophis duplice sunt consideranda modo, vel in relatione ad totam rerum in hoc universo existentium seriem et creationis fines i.e. respectu Dei, vel in relatione ad illam seriei istius partem quam cogniscomus et ad nosmet ipsos*'.
- 57 Ibidem, p. 25: '*alquando similis dolor adest, licet nullus acus nos pugnat. Dolores sentimus, licet nullius causae externae actionem percipiamus*'.
- 58 Ibidem, p. 30: '*persuasionem aequae validam quam evidentia mathematica*'.
- 59 Ibidem, p. 30: '*reducantur ad unicum principium*'.
- 60 Ibidem, p. 32: '*rationem et experientiam esse sola omnium nostrarum cognitionum fundamenta*'.
- 61 Ibidem, p. 60: '*universum constantibus legibus regi – nil fieri absque ratione sufficiente*'. Cf. p. 184: '*haec conjectandi ars immensi est usus*'.
- 62 Ibidem, p. 189: '*ejus principia esse debent constituta ut absque errore singulis entibus applicari possint*'.
- 63 L. Roberts, 'Going Dutch, situating science in the Dutch Enlightenment', in W. Clark, J. Golinski and S. Schaffer (eds), *The sciences in Enlightened Europe* (Chicago 1999), pp. 363–367; G. Wiesenfeldt, *Leerer Raum in Minervas Haus: experimentelle Naturlehre an der Universität Leiden, (1675–1715)* (Amsterdam 2002), ch. 5. Of the students who held disputations under the Leiden professors B. de Volder (1643–1709) and W. Senguerd (1646–1724), as far as facts about their career could be established, the majority were theologians, who afterwards became ministers, while the rest consisted equally of future physicians on the one hand and lawyers and government officials on the other. He sums up (p. 253): '*Von allen Fächern, die an den Universitäten gelehrt wurden, war Philosophie dasjenige, welches am wenigsten in Hinsicht auf eine zukünftige Berufstätigkeit studiert werden konnte*'.
- 64 This fact made the Republic an exception, as Van Swinden realized, and restricted the usefulness of Dutch academic writing. J.H. van Swinden,

‘Voorrede van den schrijver’, *Natuurkundige stellingen* (Harderwijk 1792), p. xi: *‘het aanhoudend gebruik van de oude schryveren’* and p. ix: *‘En eindelijk dat op buitenlandsche Akademien, het gebruik om alle wetenschappen, zelfs de zodanige die rechtstreeks Latijnsche en Grieksche litteratuur betreffen in de landstael te behandelen zo sterk was toegenomen, dat [...] de taal alleen waer in dit werk geschreven is, het gebruik van het zelve zoude beletten’.*

- 65 Ibidem, p. vii: *‘fraeie letteren, de geschiedenissen, de oordeelkunde [...] wiskundige en wijsgeerige wetenschappen’.*
- 66 Ibidem, p. xii: *‘kennis van God en van ons zelve en van de natuur’.*
- 67 Ibidem, p. xv: *‘zelden natuurkunde beoefenen om beroepshalven natuurkundige te worden, maar alleen op een wijze, die alle geletterden past’.*
- 68 Ibidem, p. xiv: *‘om de beginselen der Physische wetenschappen en konsten te verstaen’.*