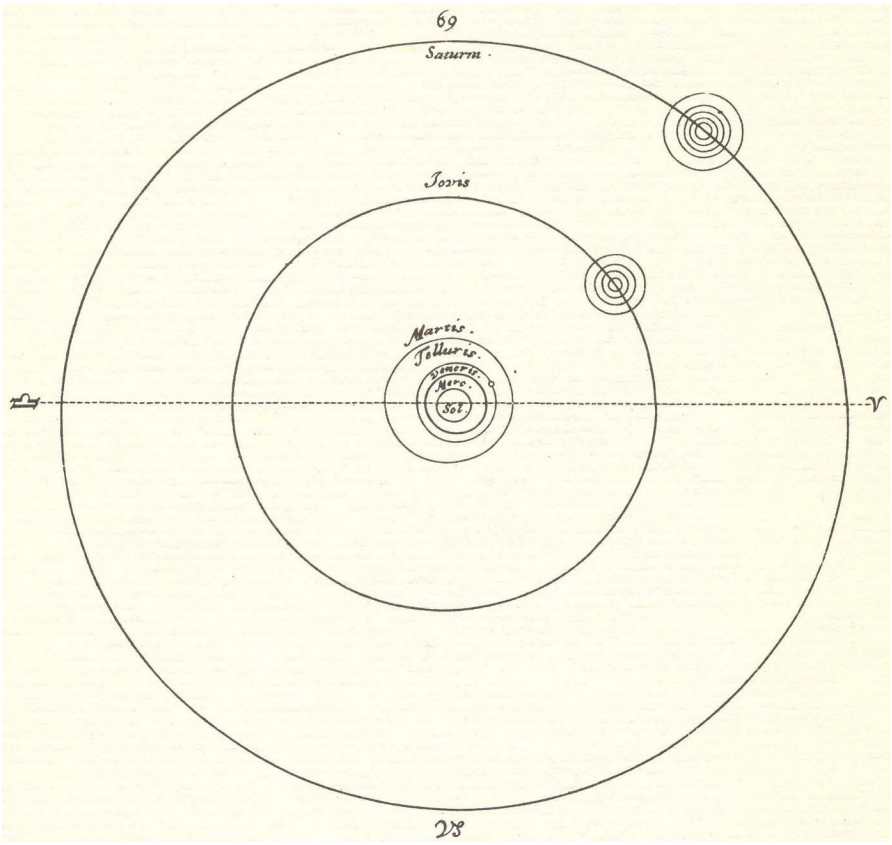
The Necessity of the Universe

Christiaan Huygens's *Cosmotheoros* (1698) and its philosophical and literary backgrounds: an intellectual testament



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Cover image:

Diagram of the solar system, including the moons of the planets. *Cosmotheoros* (1698).

Contents

Short titles and abbreviations

Christiaan Huygens's published and unpublished writings have been collected in the *Oeuvres Complètes de Christiaan Huygens,* published in 22 volumes between 1888 and 1950 in The Hague. This enormous work was commissioned by the Dutch Society for the Sciences, and edited by D. Bierens, J. Bosscha, D.J. Korteweg, and J.A. Vollgraff. The edition is in French, and the sources are presented in the original French, Latin and Dutch, sporadically accompanied by a French translation.

The first ten volumes contain Huygens's correspondence. Volume XI to XXI contain Huygens's other published and unpublished writings and are ordered thematically and chronologically. Volume XXII contains 'varia' and a concise biography that sums up the facts of Huygens's life. To the subject of this thesis, especially volume XXI (Cosmologie, ed. J.A. Vollgraff, The Hague 1944) is of interest. This is the volume that contains Huygens's cosmological works, including the *Cosmotheoros,* accompanied by a French translation of the Latin; and some of his unpublished writings from the period (1686-1690) touching upon cosmological themes.

As the source of my citations from the *Cosmotheoros* I have used an English translation published in 1698 in London by the printer Timothy Childe.

I have used the following abbreviations and short titles for citation from the *Oeuvres Completes*:

OC, X, n	*Oeuvres Complètes,* Volume, page.
Kosm.	*Kosmotheoros, sive De Terris Coelestibus, conjecturae, etc. OC,* XXI, 653-821.
QD	Que penser de Dieu? [1886 et 1687?]. *OC,* XXI, 339-343.
Pensees	Pensees Meslees. [1686]. OC, XXI, 345-371.
DRI	De rationi imperviis. De Morte. De Gloria. [1690]. *OC,* XXI, 509-528.
Réflexions	Rélexions sur la probabilité de nos conclusions et discussion de la question de l'existence d'êtres vivants sur les autres planètes. [1690]. *OC,* XXI, 529-568.

Other abbreviations and short titles used:

CW	*The Celestial Worlds Discover'd: Or, Conjectures Concerning the Inhabitants, Planets and Productions of the Worlds in the Planets. Written in Latin by Christianus Huygens, And inscrib'd to his Brother Constantine Huygens, Late Secretary to his Majesty K. William.* London, 1698. (Facsimile reprint, London 1968)

I also used short titles to cite other primary sources. Page numbers refer to the editions found in the bibliography. Finally, after the first citation of the works of Bernard le Bovier de Fontenelle and Baruch de Spinoza, only the short titles are noted.

1

Introduction

In the year 1698, a remarkable book by Christiaan Huygens (1629-1695) was posthumously published in The Hague by book dealer Adriaan Moentjes. The work was titled *Κοσμοθεωρος, sive De Terris Coelestibus, earumque ornatu, conjecturae. Ad Constantinum Hugenium, Fratrem.* It was unlike anything else that the Dutch Republic's greatest scientist had ever published. Composed in the form of two letters addressed to his brother Constantijn and written in Latin, the *Cosmotheoros* contained an introduction to the Copernican system, a critique of Cartesian cosmology, and the presentation of some new (and revolutionary) astronomical calculations. In addition to these conventional themes, the first book also contained an extensive discussion in support of the possible existence of intelligent life on other planets, followed by the description through a series of 'probable conjectures' of how these planetary inhabitants might look, how they might live, and what they might believe and know.

The work opens with a personal introduction that dedicates the work to Huygens's brother Constantijn. Here, Huygens reflects on the hours spent with his brother observing the night sky – and on their dreams of the planets, and their possible natural worlds and inhabitants. The brothers had always ended their speculation with the conclusion that it would be in vain to "enquire after what Nature had been pleased to do there".[1] Huygens then touches upon the historic question for plurality of worlds. He mentions the ancient atomist notion of the infinite universe and the speculations on planetary life of 'Cusanus', 'Brunus', and 'Keplerus', as well as the 'French author' of the 'ingenious dialogues on the Plurality of Worlds'.[2] Huygens qualifies these writings as entertaining speculations that express no ambition to seriously enquire the possibility of habitation of the planets. He also touches upon the 'fairy tales' of Lucian and Kepler. Subsequently, Huygens explains how he has come to the realization that there actually is some room for 'probable conjectures' on the subject.

In the second book, after a harsh critique of Athanasius Kircher's anti-Copernican story of a cosmic journey entitled *Iter Extaticum*, Huygens takes a more astronomical approach to his subject. He now compares the different celestial bodies of the solar system and discusses how the heavens would look from the moon and the different planets. The second book also contains a new and revolutionary method of calculating distances in the universe, that significantly enlarged the conception of the size of the universe, exemplified by a

1 *CW,* 2.
2 *Kosm.* 683; *CW,* 3.

calculation of the distance of Sirius.[3] The *Cosmotheoros* concludes with some more contemplative remarks about the infinity of space (Huygens is not sure about the infinity of the universe) and with some critical remarks on Cartesian cosmology.

Whereas all his other published material – he did not publish very much – dealt with specialised scientific or technical subjects, this posthumous work was accessible to a larger audience, unskilled in the natural sciences. After Huygens had first written the *Cosmotheoros* in French, as he mentions in a letter to his brother Constantijn Huygens, he eventually decided to publish it in Latin, not intending to produce a popular work.[4] It became his best-seller. Within a few years the book was translated into the English, Dutch, French and German, and in 1717 even a Russian translation was published, ordered personally by Tsar Peter I the Great. The work was repeatedly republished in its different editions and remained popular and was still widely read throughout the eighteenth century. This was not the case with most of his other works, which were often outdated by the rapid developments in the sciences, such as the widespread acceptance of Newtonian physics.[5] The popularity of the work is not surprising: not only did the *Cosmotheoros* provide an accessible introduction to Copernicanism by one of the most famous and authoritative scientists of the period, it was also a good read. The discussion of the lives and habits of the planetarians in particular offers its readers sheer fun, no less today than at its first publication.

Although the *Cosmotheoros* is by far Huygens's most successful work, it plays only a minor role in the biographical and historical scholarship on Huygens's life and work. The reason for this may be that the speculative work is seemingly at odds with the conventional image of Huygens as a stringent mathematician and a pragmatic scientist. The study of his life and work in historical research has mostly been confined to field of the history of the sciences in the narrow sense. Whereas recent research on contemporaries like Isaac Newton has given extensive attention to the social, philosophical and religious backgrounds and problems involved in the study of a seventeenth-century scientist, the life and work of Christian Huygens are predominantly studied in a rather isolated way, focusing exclusively on his contributions to the development of the natural sciences. The prevalent image of Christian Huygens that results from this approach is that of a pragmatic scientist who was hardly interested in religion and philosophy, and who almost exclusively focused his efforts on the study of separate natural phenomena, without ever providing a comprehensive framework to understand these phenomena and their scientific explanations. This sets him apart from many of his contemporaries, who were almost always interested in the construction of such a coherent world view – some examples of famous and influential philosophers who did develop such a system are Descartes, Spinoza, and Newton.

3 Andriesse, *Titan kan niet slapen* (2007) 174.

4 19 March 1694, Chr. Huygens to Constantijn Huygens, *OC*, X, 583.

5 *The Celestial Worlds Discover'd: or, Conjectures concerning Inhabitants, Planets, and Productions of the Worlds in the Planets*. London, 1698; *Nouveau traité de pluralité des mondes.* Paris, 1702; *Weltbetrachtende Muthmaaßungen von den himmlischen Erdkugel;* Leipzig, 1703; cf. Snelders, 'Kosmotheoros' (1989) 12-13.

From this perspective, the speculative first book of the *Cosmotheoros* has often been considered an anomaly in Huygens's oeuvre, at best a fanciful work of popularization, at worst the result of the deteriorating mind of an old man. The importance of Huygens's final work has therefore often been downplayed. Although this negligence cannot be justified, it is in a way quite understandable. For the playful tone and the philosophical and speculative nature of the work indeed seem difficult to reconcile with the austerity of almost anything Huygens had written before; ranging from his work on mathematics, astronomy, optics and pendula to the content of his notebooks and the large body of (scientific) correspondence that has been preserved. While Huygens himself clearly did not consider the work to be at odds with his previous work, he did consider it to be something special, referring to it in several letters as a 'work on philosophy'.[6]

Whereas in the traditional approaches to Huygens's life and work the unusual character of the *Cosmotheoros* has often resulted in neglect of the work, I prefer to regard Huygens's final work as an opportunity to explore a new perspective on his work and thought. Since the interpretations of the *Cosmotheoros* as a problematic anomaly often result from the narrow perspective of a classical concept of 'the history of the natural sciences', I will take a broader approach to the work, placing it in its wider historical context, and taking into account its possible philosophical, theological, literary, and cultural backgrounds.

This thesis therefore poses two central questions: how should the *Cosmotheoros* be interpreted in its wider historical and intellectual context? And what new insights can the *Cosmotheoros* offer to study of Huygens's life and work in general?

To develop and alternative and more positive interpretation of the *Cosmotheoros,* I will need to clarify its wider historical background, and discuss the philosophical, literary, and scientific traditions that shaped the intellectual backdrop against which Huygens wrote his 'philosophical work'. This broad approach to the work is also suggested by Huygens himself, who in the opening pages of the *Cosmotheoros* directly connects his work to a wide range of literary and philosophical traditions, that deal with the concept of extraterrestrial life and the plurality of worlds. The scope of the frame of reference provided by Huygens himself is enormous. It encompasses sources ranging from Greek philosophy and classical literature to medieval mysticism and Renaissance hermeticism. Furthermore, Huygens also refers to a large body of seventeenth-century cosmological texts, including literary space voyages, systematic expositions, and speculative dialogues.

It is not the purpose of this thesis to scrutinize every detailed reference and allusion that Huygens makes to this broad intellectual background. I aim to offer an interpretation of the *Cosmotheoros*, not a critical

6 24 December 1693, Chr. Huygens to the Marquis de l'Hospital, *OC,* X, 577-579; 19 January 1694, Chr. Huygens to David Gregory, in: Vermij and Van Maanen, 'An Unpublished Autograph by Christiaan Huygens' (1992).

commentary. However, a good understanding of its intellectual backgrounds is crucial to any meaningful interpretation of the work. The first part of this thesis will therefore consist of a comprehensive discussion and interpretation of the different traditions that offered the material used by Huygens to construct his own work of cosmological speculation.

The discussion of these traditions is both helpful and challenging. It is helpful because it uncovers the themes, concepts, ideas and sensitivities, that helped shape the *Cosmotheoros.* A proper understanding of these traditions is crucial in avoiding a biased interpretation of the *Cosmotheoros.* On the other hand, the sheer size of the frame of reference – ranging from antiquity to the late seventeenth century – is problematic in the context of a master thesis. I will therefore not discuss every available text, but only a selection that is representative for the broader corpus of relevant texts.

Overall, in the intellectual background of the *Cosmotheoros* three traditions, or influences can be discerned. First, there are the classical and mythological sources of cosmic literature; second, there is a corpus of philosophical texts ranging from antiquity to the sixteenth century that all somehow deal with the idea of the existence of a 'plurality of worlds'; and third, there is a diverse collection of seventeenth century texts, some fictional, some more systematic, that accept the premise of the Copernican heliocentric system, and that all have somehow integrated the older literary and philosophical traditions with the emerging new sciences, and blended these three elements into something new. While these three categories are still quite arbitrary at points, sometimes overlapping each other, and sometimes internally incoherent, this scheme helps to clarify what different perspectives on the *Cosmotheoros* are offered by these sources.

The first two chapters (ch. 2 and 3) of this thesis will discuss the respective traditions of 'classical literature' and 'the concept of plurality of worlds' from antiquity to the Renaisance. As I will argue, these broad traditions first shaped the fundamental concepts and ideas that form the basis of the *Cosmotheoros*. These two chapters together comprise the first part of this thesis. This parts thus discusses the 'sources' of Huygens's cosmological speculations.

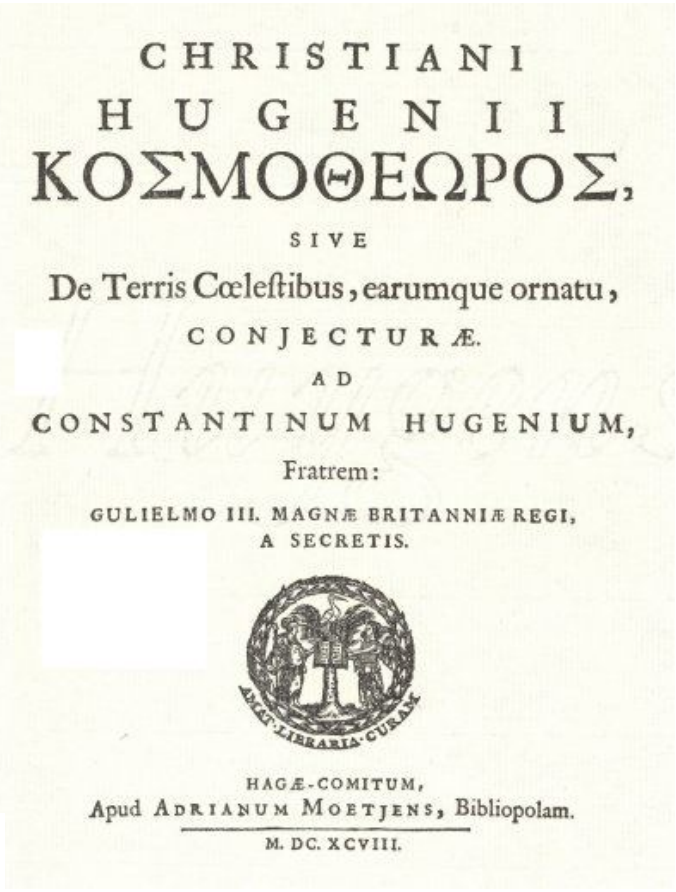
In the second part, I will first discuss how the previously discussed classical literary and philosophical traditions were transformed in the face of the historical developments of the 'Scientific Revolution'. I will discuss a corpus of seventeenth-century texts that illustrates how literature and philosophy were connected not only to one another, but also to the new scientific ideas that were fiercely debated in the seventeenth century. Here, I will also address some of the contemporary scientific, philosophical and religious backgrounds of Huygens's life and work.

The fifth and last chapter of this thesis comprises of an analysis of the contents and argumentation of the *Cosmotheoros.* Here, I will try to offer a comprehensive interpretation of Huygens's final work, taking into account its literary, philosophical, historical and biographical backgrounds. Apart from the work itself, I will also discuss some unpublished writings by Huygens, that touch upon the subject of the published work. This

final chapter explores the fundamental ideas that made Huygens describe the *Cosmotheoros* as a 'work of philosophy'. I will also try to connect the work to Huygens's own life, and argue that it can be read as his 'intellectual testament'.

In conclusion, two notes of a historiographical nature. First, considering the limited space of this thesis, I will not discuss Huygens biography. As noted above, Huygens's life and work have mostly been described from the perspective of his scientific pursuits, to variable result. Three notable positive exceptions to this rule can be found in the work of R.H. Vermij, in a study of Huygens's natural philosophy by F. Chareix, and in an excellent article on the problematic nature of Huygens's biography by F.J. Dijksterhuis.[7]

Second, in the reconstruction and interpretation of what I have called the 'frame of reference' and the 'intellectual background' of the *Cosmotheoros*, I have consulted a wide range of primary and secondary sources. Three publications in particular have been useful in identifying and interpreting the primary sources that make up the discussed and referenced corpus of primary texts. However, all three works have disadvantages as well: the classic work of M.H. Nicolson focuses exclusively on the literary and narrative aspects of flight; and the works of J.E. Dick and K.S. Guthke discuss the plurality of worlds tradition from a biased perspective, based on modern conceptions of extraterrestrial life and exobiology.[8] That this last perspective is problematic, will become clear in my own discussion of this tradition.


CHRISTIANI
HUGENII
KOΣMOΘEΩPOΣ,
SIVE
De Terris Cœleſtibus, earumque ornatu,
CONJECTURÆ.
AD
CONSTANTINUM HUGENIUM,
Fratrem:
GULIELMO III. MAGNÆ BRITANNIÆ REGI,
A SECRETIS.
HAGÆ-COMITUM,
Apud ADRIANUM MOETJENS, Bibliopolam.
M. DC. XCVIII.

1.1 Title page of the *Cosmotheoros. OC,* XXI.

7 Vermij, *Huygens* (2004) and *The Calvinist Copernicans* (2002) 148-153; Chareix, *La philosophie naturelle de Christiaan Huygens* (2006); Dijksterhuis, 'Huygens in werk en leven' (2000); Although these sources offer a more positive evaluation of the *Cosmotheoros,* they do not give the work much attention; For the 'classical' perspective, cf. Andriesse, *Titan kan niet slapen* (2007); Romein, *Erflaters van onze beschaving* (1977).

8 Nicolson, *Voyages to the Moon* (1948); *Dick, The Plurality of Worlds* (1982); Guthke, *The Last Frontier* (1990).

Part I

Cosmic fiction and the plurality of worlds from antiquity to the Renaissance

2

Literature: celestial voyages and cosmic visions

Discussing the literary tradition that provided seventeenth century cosmic fiction with much of its material presents two methodological difficulties. The first involves determining the range and boundaries of the literary corpus to take into account. Secondly, because literary elements used in both ancient and early modern texts often differ in form and structure it is not self-evident that a meaningful connection can be demonstrated. I will therefore have to argue that the influence of these literary sources on the authors of cosmic fiction is real. I believe these methodological problems can be overcome by taking a panoramic approach to the available material. The relevance of these sources lies not primarily in the specific connections that may exist with early modern authors and texts, but in the general ideas that are expressed in them. For it are these wider perspectives that make up the intellectual backdrop against which later literary styled discussions of cosmology can be understood. I will therefore try to sketch on the basis of a few key sources the broad spectrum of cosmic and lunar themes in classical literature, and the meanings attributed to them. These sources are selected on the criteria of their general significance, their representative nature, and their availability to the early modern reader.

2.1 Celestial voyages and cosmic visions as moral and metaphysical metaphors

At least two stories of flight from antiquity were known to probably every literate person in the seventeenth century, since they are found in the principal source of Western literature: the Bible. In the second book of Kings, a story is told about how the prophet Elijah is taken up into the heavens by God. As the prophet and his successor Elisha wander about, a chariot of fire pulled by horses of fire appears and separates the two men. Elijah is carried away in a storm, riding the chariot. A very similar story can be found in the New Testament in the book of Acts, which opens with the account of Jesus's ascension to Heaven. Although not directly involved with the moon or the cosmos, these narratives contain the two archetypical elements of all classical forms of cosmic fiction. First, these stories express the idea that God's dwelling is to be located in or above the skies, and that it is thus separated from the realm of Man.[9] Also, they suggest that with the appropriate Divine intervention, this place can be reached by way of flight.

These biblical ascension-narratives are especially interesting because they provided Christian authors with canonical variations on a theme also known from Greek tradition. In classical mythology, stories of flight can

9 Other biblical references to the heavens as God's dwelling are for example found in the book of Psalms.

have several different meanings. In addition to the plain narrative function of flight as a means of transportation, celestial voyages usually have metaphorical connotations, that can be either positive or negative. A recurring negative theme in these myths is the notion of arrogance and pride, or *hubris*. An interesting example can be found in one of the Greek myths about the flying horse Pegasus. In this myth, the warrior Bellerophon catches Pegasus and rides the horse through the sky. Because Bellerophon has become reckless after having slain the monster Chimera, he believes that he deserves to fly to the mountain of the Gods, Mount Olympos. Zeus is angered by Bellerophon's arrogance, and sends a gad-fly to sting Pegasus, causing the horse to jolt and throw off his rider. The high-minded hero falls deep, and spends the rest of his life on the plain of Aleion ('wandering'), crippled by his fall, and consumed by grief.[10] With this tragic conclusion, the myth gives a strong warning against the vanity of unbridled human self-esteem.

Flight as an expression of *hubris* is a recurring motive in classical mythology and is also found in the famous myths of Phaeton and Icarus. Probably the most famous versions of these myths can be found in Ovid's *Metamorphoses.*[11] Since Ovid (43 BCE-18 CE) remained a consistent source of inspiration to artists from antiquity through the Middle Ages to the Renaissance, these myths are of great importance to the metaphorical connotations of the heavens in Western literature. Ovid's work was a commonplace for Western artists, and especially in Renaissance art and literature his writings are referenced continuously.

The myth of Phaeton adds another element to the motive of pride and fall. When Phaeton persuades his father Helios/Sol to allow his son to ride the sun-chariot, it is not just his own life that he endangers. Losing control of the chariot, Phaeton sets the skies and the earth on fire. Only an intervention of Zeus, who strikes Phaeton with a thunderbolt, can prevent the complete destruction of the world. Human pride or *hubris* not only jeopardizes one's own life, it threatens the order and well-being of the whole cosmos.

Although they are not explicitly involved with cosmic travel to other planets, as imagined by our seventeenth century authors, these myths are of importance to the literary genre of cosmic fiction. Two important themes of later literary thought about the heavens are defined by these biblical and classical stories. First, there exists a strict spatial separation between the realm of Man and the domain of the Divine, and second, it is foolish and even dangerous when human pride pushes Man to venture beyond the limits of his earthly place.

Classical literature also offered positive tales of human celestial voyages. In the dialogues of Plato, who refers to the Phaeton myth in his *Timaeus,*[12] the celestial voyage functions as a metaphor for the transition from the physical to the metaphysical world. In the *Phaedrus* dialogue the soul is compared to a winged chariot riding through the heavens. The quality of the two horses indicates the purity of a soul: the divine chariot is pulled by two good horses, lifting it up into the heavens, but the human chariot is equipped with

10 Maas, 'Perseus and Bellerophon' (2010).
11 Ovid, *Metamorphoses*, I, 750-II, 408; VIII, 183-235.
12 Plato, *Timaeus*, 22c-d.

2.1 'The fall of Phaeton'. Drawing by Michelangelo Buonarroti, c.1533. Royal Library, Windsor.

one good and one bad horse, making the chariot hard to steer and pulling it down to earth. While it is impossible for the human soul to reach the realm of the gods, skilful steering (a virtuous life) is rewarded in the afterlife.[13]

A theme quite similar to that of the *Phaedrus* is discussed in the myth of the soldier Er, which is told in the tenth book of the *Republic*.[14] Killed in battle, Er revives on his funeral pyre and reveals how he has travelled trough the afterlife, and is now sent back to warn his fellow men. Together with the souls that are punished and rewarded for their deeds in life, Er has voyaged trough the cosmos, seeing the 'pillar' and the revolving concentric spheres of the universe from afar, and the order of the cosmos by Necessity and Fate. The myth concludes with the story of the reincarnation of the dead, and the cleansing of their memories in the river Lethe.

13 Plato, *Phaedrus*. 246a-249d.
14 Plato, *Republic*, X, 613e-621d.

What is interesting to us about this myth are not so much the ideas of eschatological Judgement and reincarnation, but the way in which metaphysics and cosmology are connected. Not only does the cosmic travel of Er function as a metaphor for the afterlife, but the travel through death, in antiquity usually connected to the underworld, gives room for speculation about the cosmos. Plato is in this way the first to take an imaginative extraterrestrial position to 'observe' and speculate about the cosmos.[15]

A text somewhat similar in its narrative form to the myth of Er can be found in Cicero's *De re publica*.[16] In the sixth book of this work, the protagonist Scipio Aemilianus has a cosmic dream-vision, which offers a grand view of the cosmos, the Milky Way and the earth 'below'. Scipio realizes the insignificance of the earth, which is dwarfed by the stars of the Milky Way, and feels sorry for Rome, whose glory covers not even the whole earth. The human individual is even more humble. Cicero's myth thus gives different associations to the celestial voyage than the myths of Phaeton and Bellerophon. The stoic perspective on the scale of the universe and the place of the earth and man in it teaches humility, the opposite of *hubris.* In his reverence for the measure of the universe, Cicero does not stand alone. It is this thematic connection of *hubris* and humility that would be an important aspect of many cosmological texts to follow, ranging from poetry to philosophy and from satire to cosmic fiction.

2.2 Lucian: lunar literature and satire

Although the classical sources discussed thus far helped shape the thematic backdrop of the literary tradition of cosmic fiction, the most influential classical author of celestial voyages and lunar fiction is the Greek-Syrian rhetorician and satirist Lucian of Samosata (c. 120 – after 180 CE). Recurring themes in his satire are philosophers, religious leaders, and human vanity. Although his works were banned by both the Byzantine and the Roman Catholic church, Lucian's influence on Western literature is profound, and especially the genre of utopian literature is indebted to him.[17] Lucian was also acknowledged as a source of inspiration by some important seventeenth-century authors of cosmic fiction. Lucian's works had long been available in Greek and Latin, and an English translation of some of his work was published in 1634, making the second-century texts available to a wider range of English readers.[18] Two of Lucian's writings deal with cosmic elements, namely the *True Story* and the *Icaro-Mennipus.* These texts provide the first classical descriptions of an imaginary voyage to an earth-like moon (that are still available to us).[19]

In the very amusing fictional narrative titled *A True Story,* Lucian mocks the epic tradition and especially Homer's *Odyssey*, describing the imaginary voyage of a group of adventurers travelling beyond the Pillars of Hercules. Moreover, the work also satirizes the existing literature on utopian societies, such as Plato's

15 Cf. Nicholson (1948) 16.
16 Cicero, *De re publica,* 'Somnium Scipionis', VI, 9-29.
17 Whitmarsh, 'Lucian of Samosata' (2010).
18 Cressy, 'Early Modern Space Travel' (2006) 966; Nicolson, *Voyages to the Moon* (1948) 14, 21.
19 Dick, *The Plurality of Worlds* (1982) 20.

discussions of the mythical island of Atlantis in the dialogues *Critias* and *Timaeus* and his description of the ideal society in the *Republic*. Lucian makes his satirical intentions clear from the start, stating that he has no intention to tell the truth, since "this was already a common practice even among men who profess philosophy." Not as bad as the philosophers, Lucian is at least honest about his fraud: "though I tell the truth in nothing else, I shall at least be truthful in saying that I am a liar."[20]

The story that follows meets the promise: the adventures of the first-person hero and his companions take us from amazement to amazement. After they sail their ship past the pillars of Hercules, the travellers first experience some terrestrial adventures, before a sudden whirlwind lifts them into the air. Miraculously, the ship can sail through the air, and the journey continues upwards. After a week, the travellers reach the moon, from where they can see the stars and planets and 'another country below', which they identify as Earth.[21] The company then has an 'encounter' with the creatures that inhabit the moon, and Lucian gives descriptions of the moon, including 'ethnographic' details that imitate the work of Herodotus.[22] The story then reaches another level, as Lucian and his companions get involved in an interstellar and imperialistic war... Lucian ridicules Homer by describing how the clouds overflow with blood, causing a rain of blood to pour down on Earth – an event featured in the *Iliad*.[23] Subsequently, the company visits some other 'islands' in the skies, before returning to earth.

In his dialogue *Icaro-Mennipus,* Lucian makes fun of the pretentious and conflicting opinions of philosophers and astronomers. In this dialogue, the protagonist Mennipus tells a friend of his adventurous travels to the moon and sun. He explains how his desire to fly to the heavens was born out of dissatisfaction with the poor explanations of the nature, dimensions and origins of the universe provided by the philosophers. To find out for himself, Mennipus decided to recreate Daedalus's flying machine; and he succeeds. After some practice, Mennipus soars up into the heavens and makes a rest-stop at the moon, from where he has a panoramic view of the earth, but is also able to see cities and villages, which he compares to an ant colony. As Mennipus moves on, soaring ever upwards towards the dwelling of the Gods, the lunar goddess Selene asks him to bring a message to Zeus:

> I am tired at last, Mennipus, of hearing quantities of dreadful abuse from the philosophers, who have nothing else to do but to bother about me, what I am, how big I am, and why I become semi-circular, or crescent-shaped. Some of them say I am inhabited, others that I hang over the sea like a mirror, and others ascribe to me – oh, anything that each man's fancy prompts. Lately they even say that my very light is stolen and illegitimate, coming from the sun up above, and they never weary of wanting to

20 Lucian, *True Story,* 251-253.
21 Lucian, *True Story*, 259.
22 Graham Anderson, *Lucian's comic fiction* (1976) 4.
23 Homer, *Iliad,* XVI, 459.

entangle and embroil me with him, although he is my brother; for they were not satisfied with saying that Helius himself was a stone, and a glowing mass of molten metal.[24]

Another three days of flight bring Mennipus to Heaven. He considers slipping in for a moment, using his wings as a disguise, but decides to just knock on the door. His call is answered by Hermes, who rushes off to inform Zeus. To his own surprise, he is allowed into Heaven. After Mennipus has informed Zeus on the latest news from earth, he watches Zeus hear and answer prayers, and dines with the Gods.

The next morning (poor Mennipus is puzzled that it can be night and day in a place were the sun-god is present...), Zeus calls an assembly of the Gods, discussing the complaints of Selene. The gods are infuriated: it is decided that in the spring of next year, all philosophers shall be annihilated by Zeus's thunderbolt. To prevent Mennipus from entering Heaven again, his wings are taken away from him, and he is returned safely to earth by Hermes. When his story is finished, Mennipus says goodbye to his friend, and leaves to bring the philosophers the bad news of their impending doom.

In the *True Story* and the *Icaro-Mennipus,* Lucian first established the cosmic voyage as a genre of fiction literature, drawing from existing sources, and enabling later authors to use his material and improvise on its themes and motifs. Lucian's own source material for his stories is often easily recognized. The *True Story,* which is full of references, intends primarily to ridicule epic traveller´s tales, especially Homer´s *Odyssey.* The classic storm at sea, sweeping the hero to amazing unknown islands, offered Lucian the basic structure of a great whirlwind. And if one can ride the heavens in a chariot, why not sail it in a ship? In a similar way, the flight of Mennipus combines the wings of Icarus with Bellerophon's attempt to reach Heaven. An important difference between the two accounts also draws attention: while the voyage to the moon in the *True Story* happens by chance, Mennipus' flight is intentional in nature.

Significant as Lucian's stories may be as narrative examples to later authors of cosmic fiction, his influence on a thematic level is even more important. When Lucian constructed satire out of imitation and inversion, he transformed the genres he ridiculed. The view of Earth from the moon in the *True Story* and the parallel episode on the moon in the *Icaro-Mennipus* form a good example: while describing another world, Lucian satirically reflects life on earth. This thematic analogy, reflection and inversion in his extraterrestrial descriptions echoes in many later works of both utopian and cosmic fiction, giving the latter often a strong utopian character. By turning the utopian fantasy into a means of intellectual criticism of religion and philosophy, Lucian also transformed the function of the utopian genre itself. It is this function of satirical and critical reflection that is also to be connected to the cosmic fiction of the seventeenth century. Lucian was admired by such renaissance authors as Erasmus, More and Rabelais, and without the *True Story,* the later

24 Lucian, *Icaro-Mennipus,* 303.

utopian tradition would not have looked the same.[25]

2.3 Plutarch: myth and philosophy in the world in the moon

It may very well be that the Greek-Roman historian and essayist Plutarch (c. 45 - after 120 CE) was one of the 'philosophers' satirized in the *Icaro-Mennipus.* Whereas all classical sources discussed so far are literary or mythological in nature, the work of Plutarch offers us a text that connects this early literary tradition to the (pseudo-)scientific and philosophical tradition concerned with the nature of the cosmos and the concept of a 'plurality of worlds'. This text, titled *De facie in orbe lunae* (*Of the face in the orb of the moon*) is part of Plutarch's famous *Moralia.*

Plutarch's text is no scientific treatise, but should be understood as a literary text that touches on a scientific subject.[26] The text is composed as a dialogue and its subject is the nature and the possible habitation of the moon. The first and largest part of the dialogue consists of a philosophical discussion on the nature of the moon and the possibility of lunar habitation, while the final part of the dialogue also contains imaginative descriptions of a mythical oceanic island called Ogygia, and a myth of the soul's travels after death, somewhat resembling the tales of Er and Scipio in form and theme.

From a literary perspective, especially the second part of the myth is interesting.[27] Here a Carthaginian participant of the dialogue relates a metaphysical allegory about the nature, phases, punishment, purification, liberation, and reincarnation of the soul. Although the somewhat vaguely told myth is confusing at points and seems to contain some inconsistencies, the general metaphor is that earth, moon and sun represent the three human parts of body, soul and mind.[28]

While it is clear that the myth is solely allegorical in nature, and expresses a metaphysical idea about the soul, the first half of Plutarch's dialogue contains a more practical philosophical discussion on lunar habitation. After a discussion of the differing philosophical beliefs (e.g. Aristotelian, Epicurean, Stoic) that exist about the nature of the moon (it is agreed on that the moon resembles the earth) and its phases and eclipses, the participant Theon introduces the theme of lunar habitation. He wants to hear “about that beings that are said to dwell on the moon — not whether any really do inhabit it but whether habitation there is possible.”[29] This specific formulation of the subject as the possibility of habitation is both important and inventive, as it limits the measure of speculation that would occur in a discussion on actual lunar habitation, and at the same time widens its philosophical scope and plausibility. Theon, who had raised the issue, opens the discussion by asserting that habitation of the moon is impossible. Due to the hot and ethereal atmosphere, no winds, clouds and rains occur, without which vegetation cannot arise or exist. But even if the moon were

25 Whitmarsh, 'Lucian of Samosata' (2010).
26 Cf. Dick, *The Plurality of Worlds* (1982) 20.
27 Plutarch, *Moralia,* section 27 ff., 193-223.
28 Cf. the confused older interpretation by Nicolson, *Voyages to the Moon* (1948), p.17; Cressy is aware of Plutarch's vagueness, 'Early Modern Space Travel' (2006).
29 Plutarch, *Moralia,* 157.

habitable, its inhabitants could not stay there for long, as they would be thrown off by the moons rapid motion. Further, Theon introduces the metaphysical argument of the final cause: “If [habitation] is not possible, the assertion that the moon is an earth is itself absurd, for she would then appear to have come into existence vainly and to no purpose, neither bringing forth fruit nor providing for men of some kind an origin, an abode, and a means of life, the purposes for which this earth of ours came into being”.[30] In opposition to this negative conclusion, Lamprias, the primary participant in and narrator of the dialogue, tries to prove the possibility of lunar habitation. First he counters the metaphysical argument that an uninhabited moon would be in vain and could not be called earth-like, as the earth itself also contains places without life, such as deserts and oceans. Just as these parts of the earth have a purpose other than to sustain life, so has the moon a purpose, even if it is merely to reflect the light of the sun. Therefore, the moon can be asserted to be earth-like, even if it were not inhabitable.

Then Lamprias tackles the argument of motion: the moon's motion is so gentle, he asserts, that it would pose no problem to the lunar inhabitants. Lamprias also counters Theon's argument that no life could survive in the harsh atmosphere and climate of the moon. It is well possible, he argues, that although rain is absent, light moist and dew rising from the moon's soil suffice for vegetation to grow on the moon. As for the heat, the moon also has its colder seasons; and do not plants survive in the harshest conditions on our own Earth? Lamprias concludes that “those who demand that living beings there be equipped just as those here are for generation, nourishment, and livelihood seem blind to the diversities of nature, among which one can discover more and greater differences and dissimilarities between living beings than between them and inanimate objects.”[31]

Plutarch's discussion on the habitability of the moon is very important in the tradition of plurality for several reasons. In the first place, it is significant that the possibility of an inhabitable celestial body is discussed in a literary text. Further, the way in which Plutarch combines natural philosophical and mythical elements in the literary motif of a dialogue would profoundly influence early modern cosmic fiction.[32] For example Johannes Kepler's work *Somnium,* a key text in seventeenth-century cosmic fiction, connects literary, philosophical and scientific elements in a very similar way. Also specific arguments about the world in the moon would recur time and again in later sources; for example the teleological question whether a planet void of life can have any purpose; or the analogical argument of the diversity in the terrestrial natural world.

Finally, Plutarch's dialogue stands also in a close relation to its predecessors. It contains mythical elements reminiscent of Plato and it addresses the theme of *hubris* in questioning the thought that the moon could not

30 Plutarch, *Moralia,* 158-163; cf. Dick, *The Plurality of Worlds* (1982) 20-21.
31 Plutarch, *Moralia,* 163-177.
32 Because I discuss the classical philosophical discussions about the plurality of worlds in the next chapter, I will briefly comment on the philosophical backgrounds of Plutarch's dialogue there. Cf. §3.2.

exist for any other purpose than sustaining life. The dialogue also discusses the cosmological beliefs of the philosophical schools, a subject which I will discuss in the next chapter, since this takes us from the sphere of cosmic literature to that of philosophical speculation. It is important however, to note that both atomistic and Aristotelian philosophy pre-date Plutarch, and provided the theoretical background for his own lunar speculation.

2.4 Conclusion: classical literature connected to seventeenth-century cosmic fiction

So far we have discussed several classical texts and passages which are all somehow connected to the themes of flight, celestial voyage, space travel, or lunar habitation. This limited but important corpus of texts is diverse in meaning and nature, ranging from classic myth to metaphysical allegory and philosophical discussion. At this point, some general observations can be made.

In the first place, we should be aware of the different meanings and functions these texts and passages have. A flight or speculation can convey moral, religious, cosmological, metaphysical, scientific, philosophical or satirical ideas – and usually, these different meanings overlap. The classical myths of flight and fall give a moral warning against hubris, but also assert a cosmological claim by indicating the boundaries of the separated realms of the human and the divine. Plutarch does not mind connecting a philosophical discussion about the nature of the moon with a metaphysical allegory. Lucian's *True Story* is a funny ridicule of Homeric epic poetry, but it also contains some serious criticism of the religious and philosophical schools of his day. The diversity in form and meaning of classical cosmic literature offered authors a wide spectrum of narrative structures and meaningful associations to use.

The discussed corpus of texts constitutes no classical tradition of 'cosmic fiction' as there existed for epic or satirical literature. However, despite all their differences, these texts together helped shape several general notions that would persist in Western thought. The strong moral connotations of (celestial) flight and the allegorical significance of the cosmos and the celestial bodies and spheres as established by Biblical, Greco-Roman, and Platonic mythology, became deeply entrenched in philosophy, theology, literature and art. Also in the seventeenth century, the literature of the Bible, Plutarch, and Lucian, and the poetry of Ovid, were known to everyone with some classical education. This strongly classical mindset of the 'wider' Renaissance is reflected in seventeenth-century cosmic fiction, as well as in the more systematic discussions of the plurality of worlds. The basic themes of hubris-humility, human-divine, are all there. Moreover, like in classical literature, seventeenth-century cosmology always implied reflection on Earth, whether its purposes were religious, philosophical, political, or scientific.

Before turning to the classical philosophical tradition in the next chapter, we should also take a short look at the historical connection of classical literary sources to the seventeenth century.

In medieval literature, there is surprisingly little resonance of classical cosmic literature. Marjorie Nicolson,

who is particularly interested in narratives of actual moon travel, has observed that only slight variations on these themes occurred in medieval texts. The celestial voyage was familiar to medieval literature, but it was used almost exclusively in a religious sense. In dreams or in ecstasy, the souls of the holy transcended time and space, and the spirits of the dead flew to the regions of the blessed, located in stars or planets.[33] The celestial voyage was primarily allegorical and metaphysical in nature. The most famous of these medieval examples is found in Dante's mystical journey to Paradise in the *Divine Comedy*. The nine spheres of Heaven that Dante describes reflect medieval cosmology: the seven spheres of the classical celestial bodies (including moon and sun); the sphere of the fixed stars; and the outer sphere of the Primum Mobile. Beyond these spheres Dante eventually reaches the Empyrean, the dwelling of God. In the first four Canto's of *Paradiso,* Dante visits the first sphere of heaven, which contains the moon. Leaving Mount Purgatory, the poet and Beatrice are lifted up into the heavens and are brought to the moon by the natural longing of the soul for God:

> In that order, all natures have their bent
> according to their different destinies,
> whether nearer to their source or farther from it.[34]

The second Canto also contains a passage in which Beatrice gives Dante a metaphysical explanation of the dark spots in the moon, including the distribution of divine light, after she has first rejected some other (naturalistic) possibilities.

Although Dante's *Divine Comedy* was known to many sixteenth- and seventeenth-century readers, medieval influence on later celestial voyages appears to be minimal.[35] The influence of classical literature on seventeenth-century cosmic fiction was not transmitted through medieval literature, but through the renewed interest in classical literature. Since most classical literature discussed is written in Greek, except Ovid, many of these works were simply not available to medieval readers. It was the renewed interest of Renaissance and Humanist scholars in the Greek language and its literature that recovered the works of Plato, Plutarch and Lucian, and made them available to a wider educated public. However, the rediscovery of Plutarch and Lucian, did not directly prompt Renaissance authors to write new works of cosmic fiction – expect maybe an episode in Ludovico Ariosto's *Orlando Furioso* (1532), where a trip to the moon takes place in 'Elijah's chariot'.[36] Nevertheless, the influence of Plutarch and Lucian is strongly present everywhere in Renaissance literature (e.g. in the utopian work of More; the satirical travels described by Ariosto and Rabelais; and the philosophical *Essays* by Montaigne).

33 Nicolson, *Voyages to the Moon* (1948) 17-18.
34 Dante, *Paradiso,* I, 109-111. Note that the explanation of the natural longing of the soul strongly resonates the Aristotelian theory of 'natural places', cf. § 3.2 below.
35 Nicolson, *Voyages to the Moon* (1948) 18.
36 Ariosto, *Orlando Furioso,* canto xxxiv; this passage is retold by Fontenelle in his *Entretiens* (1686), cf. §4.6 below.

It was only after the literary tradition of celestial voyages and cosmic visions was combined with other traditions, that cosmic fiction became popular the seventeenth-century. The new genre that would emerge was not an exclusively literary enterprise, but took a more realistic turn, and drew heavily from classical philosophy, as well as recent philosophical and cosmological innovations. Therefore we must now turn to philosophy.

2.2 Dante and Beatrice on the moon, with in the background a diagram of the medieval cosmos. Drawing by Sandro Boticelli in a manuscript of the Divine Comedy. c.1480-c.1495. *Zeichnungen von Sandro Botticelli zu Dantes Göttlicher Komödie* (Berlin 1921).

3

Philosophy: the (dis)order of the cosmos and the plurality of worlds

> At the very birth of Astronomy, when the Earth was first asserted to be Spherical, and to be surrounded with Air, even then there were some men so bold to affirm, there were an innumerable company of Worlds in the Stars. But later Authors, such as Cardinal *Cusanus, Brunus, Kepler,* (and if we may believe him, *Tycho* was of that opinion too) have furnish'd the Planets with inhabitants.[37]

In this passage from the opening section of the *Cosmotheoros*, Christiaan Huygens makes clear that he was not the first to speculate about the possible existence of extraterrestrial life. Referring to more recent works of cosmological speculation, including some seventeenth-century works of cosmic fiction, he also alludes to a much older tradition of speculation on 'an innumerable company of Stars in the World'. In this chapter I will discuss this older tradition, beginning with the Greek philosophical controversy on the asserted unity or plurality of the universe. Following that discussion, I will address the medieval considerations on the theme. This chapter concludes with a discussion of two influential Renaissance authors on the theme, Nicholas of Cusa and Giordano Bruno. In this chapter, I will explain how the concept of plurality was often used as a vehicle to address fundamental issues of metaphysics, physics, and theology. Moreover, I will argue that many of the ideas and concepts that are found in seventeenth-century cosmic fiction were first formulated within the context of these older philosophical or theological controversies in Greek philosophy, scholastic theology and Renaissance Neo-Platonism.

3.1 Atomism and the infinite universe

The idea of a plurality of worlds was first conceived in ancient Greece and was expressed most clearly by the atomistic philosopher Epicurus (341-270 BCE).[38] However, the Greek conception of a plurality of worlds differs significantly from the concept as it was developed in the sixteenth and seventeenth centuries. While early modern authors conceived other worlds as other earth-like celestial bodies within the universe, the

37 *CW*, 3.

38 I will only discuss the 'infinite universe' as it occurred in ancient atomism, and the Aristotelian cosmology that dominates the Western tradition up to the Copernican Revolution. For other Greek pre-socratic ideas about cosmology and the plurality of worlds see: Furley, 'The Greek Theory of the Infinite Universe' (1981); Hetherington, 'The Presocratics' (1993); Kragh, *Conceptions of Cosmos* (2007) 13-16; On Greek astronomy in general see also: North, *Cosmos* (2008) 67-133; Wilson, *Astronomy through the Ages* (1997) 23-39; Danielson (ed.), *The Book of the Cosmos* (2000) 12-65.

definition of a world as used by Epicurus refers to something quite different:

> A world [*κόσμος*] is a circumscribed portion of the sky [*οὐρανός*], containing heavenly bodies and an earth and all the heavenly phenomena, whose dissolution will cause all within to fall into confusion: it is a piece cut of from the infinite [*ἄπειρον*] and ends in a boundary either rare or dense, either revolving or stationary: its outline may be spherical, or three-cornered, or any kind of shape.[39]

It is clear that in this description, 'world' does not constitute another 'earth-like celestial body', but encompasses a concept we would describe as 'cosmos', or even 'universe'. By defining a world in such comprehensive terms, the atomist philosopher questions how our visible world is related to the core concepts of Greek ontological thought. Does a world constitute the 'all', or the universe, or do several of worlds (*kosmoi*) coexist?[40] Raising these questions about the relation between our cosmos and that what might exist beyond its boundaries – and answering them! – seems at first rather pretentious, given how little of the Earth and the heavens was understood by Greek philosophy and science. However, these questions and the answers provided did not originate in scientific arrogance, but inevitably followed from the ontological principles that constituted the doctrine of atomistic philosophy.[41]

The primary doctrine of atomism was that the universe is ultimately composed of the smallest physical entities called 'atoms', literally meaning 'uncuttables'. Everything that exists is formed by chance out of the clustering of atoms moving randomly through an infinite void. The atomists used this firmly materialistic concept to explain a wide range of natural phenomena and also to formulate views on ethics, theology, politics and epistemology, all within one comprehensive physical system. According to Aristotle, the idea of indivisible atoms was first posed as an alternative to the monistic philosophy of Parmenides of Elea (first part 5th c. BCE).[42] Claiming that any change in Being implies that something non-existent comes into existence, Parmenides had denied the possibility of change altogether.[43] By dividing the Eleatic ultimate Being into unchangeable and indivisible atoms, both the reality of change and the unchangeable nature of Being were accounted for. While atomism offered explanations for everyday phenomena such as movement and change, but also perception and sense, the system also had some cosmological and cosmogonic implications.

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39 Epicurus, 'Letter to Pythocles', §88, 59; Cf. Dick, *Plurality of Worlds* (1982) 6.

40 Dick, *Plurality of Worlds* (1982) 6-7; Dick connects 'all' to *πᾶν* and universe to *ὁλον*, but I find such tight definitions implausible. *πᾶν*, *ὁλον*, and *κενός* indicate more or less similar ideas like 'all', 'that what is empty', 'space' 'universe', 'whole', etc., The specific meaning of these words depends on its use in a sentence, and on its use by different authors in different periods.

41 The classical school of atomism is represented primarily by Leucippus, Democritus, Epicurus and Lucretius. While not much is known about Leucippus, his student Democritus is known from many secondary reports. He is thought to have systematized his teacher's theory.

42 Berryman, 'Ancient Atomism' *SEP* (2008).

43 As Pamenides is not our main subject here, I allow myself this somewhat blunt statement, for the sake of the argument.

The supposed founders of the atomistic school, Leucippus (5th c. BCE) and his student Democritus (460-370 BCE), first claimed that there was an infinite number of atoms moving through an infinite void, randomly forming into *kosmoi.* As whirling motions of atoms in the void collide, they establish clusters of atoms large enough to form a cosmic system. When a cosmos is established, it forms an outer membrane of atoms and as these outer atoms catch fire a sun and stars occur. This cosmogony is purely contingent. No purpose or design should be contributed to the existence of a cosmos, and over time it will again disintegrate. While these speculations by Leucippus and Democritus were primarily cosmogonic in nature, Epicurus also seriously considered the cosmological views they implied. It is therefore first in the works of Epicurus and his Roman follower Lucretius (c. 99-55 BCE) that connections between atomism and the plurality of worlds are made explicit:

> [...] there are infinite worlds both like and unlike this world of ours. For the atoms being infinite in number, as was already proved, are borne on far out into space. For those atoms which are of such nature that a world could be created by them, have not been used up either on one world or a limited number of worlds, nor on all the worlds which are alike, or on those which are different from these. So that there nowhere exists an obstacle to the infinite number of worlds.[44]

This statement in Epicurus's *Letter to Herodotus* not only shows Epicurus's belief in a plurality of worlds, but it also reveals the nature of this belief. The infinite number of worlds that Epicurus asserts is the direct consequence of some of the most important principles of his atomism: the infinite number of atoms and the infinitude of the universe. As there is an infinite amount of atoms, the possible number of worlds can only be limited by a lack of space. However, as the same *Letter to Herodotus* had earlier asserted the infinitude of the universe, no obstacle limiting the number of possible *kosmoi* exists:

> Moreover, the universe is boundless.[45] […] Furthermore, the infinite is boundless both in the number of the bodies and in the extent of the void. For if on the one hand the void were boundless, and the bodies limited in number, the bodies could not stay anywhere, but would be carried about and scattered through the infinite void, not having other bodies to support them and keep them in place by means of collisions. But, if on the other hand the void were limited, the infinite bodies would not have room wherein to take their place.[46]

At the end of the *Letter to Herodotus*, Epicurus also explains how worlds are created, and how they end:

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44 Epicurus, 'Letter to Herodotos', §45, 25; Cf. Dick, *Plurality of Worlds* (1982) 6.
45 *τὸ πᾶν ἄπειρόν ἐστι* ; one of several other possible translation is: 'the all is infinite.'
46 Epicurus, 'Letter to Herodotos', §41-42, 23.

> [...] we must believe that worlds, and indeed every limited compound body which continuously exhibits a similar appearance to the things we see, were created from the infinite, and that all such things, greater and less alike, were separated off from individual agglomerations of matter; and that all are again dissolved, some more quickly, some more slowly, some suffering from one set of causes, others from another.[47]

The underlying argument in Epicurus assertion of the infinitude of worlds exemplifies a typical trait of Epicurean reasoning: when there is nothing contradicting a hypothesis, it can be asserted as true until it is disproved. While Epicurean belief in the infinitude of worlds is not empirically motivated, it is not empirically countered either. As we will later see, this rather controversial (and from an Aristotelian perspective unacceptable) manner of reasoning is used in seventeenth-century cosmic fiction as well.

While Epicurus was satisfied with asserting the possibility of the infinitude of worlds by taking away possible objections, his Roman student Lucretius pushed the argument a little further. In his great poem *De rerum natura* – which is the main source of atomism to later European authors and philosophers – Lucretius claims that the existence of other worlds is implied by the nature of the universe. Not only are there infinite possibilities of other worlds, but the actuality of these other *kosmoi* is implied by the uniformity of the natural process that has created the Earth. If our cosmos has been brought into order out of chaos, other *kosmoi* should have been ordered as well. According to Lucretius, the uniformity of nature demands that the formation of our cosmos is not the result of a unique accident, but that similar processes occur. This natural philosophical argument is reinforced by a metaphysical assertion that would be reproduced time and again in the tradition of plurality. While Epicurus had simply derived the possible existence of infinite worlds from the absence of obstacles, Lucretius supported plurality with the metaphysical argument of the necessary actualization of possibilities: “when abundant matter is ready, when space is to hand, and no cause hinders, things must assuredly be done and completed.”[48] The general thought behind this argument for necessary plurality was not unfamiliar to Greco-Roman thought and can be compared to what Arthur Lovejoy in his classic study *The Great Chain of Being* (1936) has called the 'principle of plenitude'. It is defined as follows:

> the thesis that the universe is a *plenum formarum* in which the range of conceivable diversity of *kinds* of living things is exhaustively exemplified, but also any other deductions from the assumption that no genuine potentiality of being can remain unfulfilled, that the extent and abundance of the creation must be as great as the possibility of existence and commensurate with the productive capacity of a 'perfect' and inexhaustible Source, and that the world is the better, the more things it

47 Epicurus, 'Letter to Herodotos', §73 47.
48 Lucretius, *De rerum natura;* cf. Dick, *Plurality of Worlds* (1982) 11. For more background on Lucretius and *De rerum natura,* cf. Sedley, 'Lucretius' *SEP* (2008).

contains.[49]

Lovejoy connects the principle of plenitude primarily to the dualistic philosophy of Plato, but Lucretius's puts forth a similar idea in his demand for actuality in the case of infinite worlds. Whether the Source in Lovejoy's definition is identified as Nature or the Platonic Ideas or the Christian God, the idea is expressed in many works on the plurality of worlds from *De rerum natura* onward – seventeenth-century cosmic fiction forming no exception.

Despite this general agreement, the Platonic principle of plenitude does not correspond with the atomist concept of the uniformity of natural process. Plenitude in atomism results from the combination of an infinity of possibilities with the availability of infinite matter, whereas the Platonic concept is derived from the perfection of the Ideas. In atomism, the three arguments based on plenitude, the uniformity of natural processes, and atomist physics support and reinforce one another in what we might call the final atomist statement on the plurality of worlds.[50] Lucretius was the 'final' atomist in a chronological sense, and he was also the atomist who most directly and most strongly influenced European thought after his *De rerum natura* was rediscovered in the Italian Renaissance.

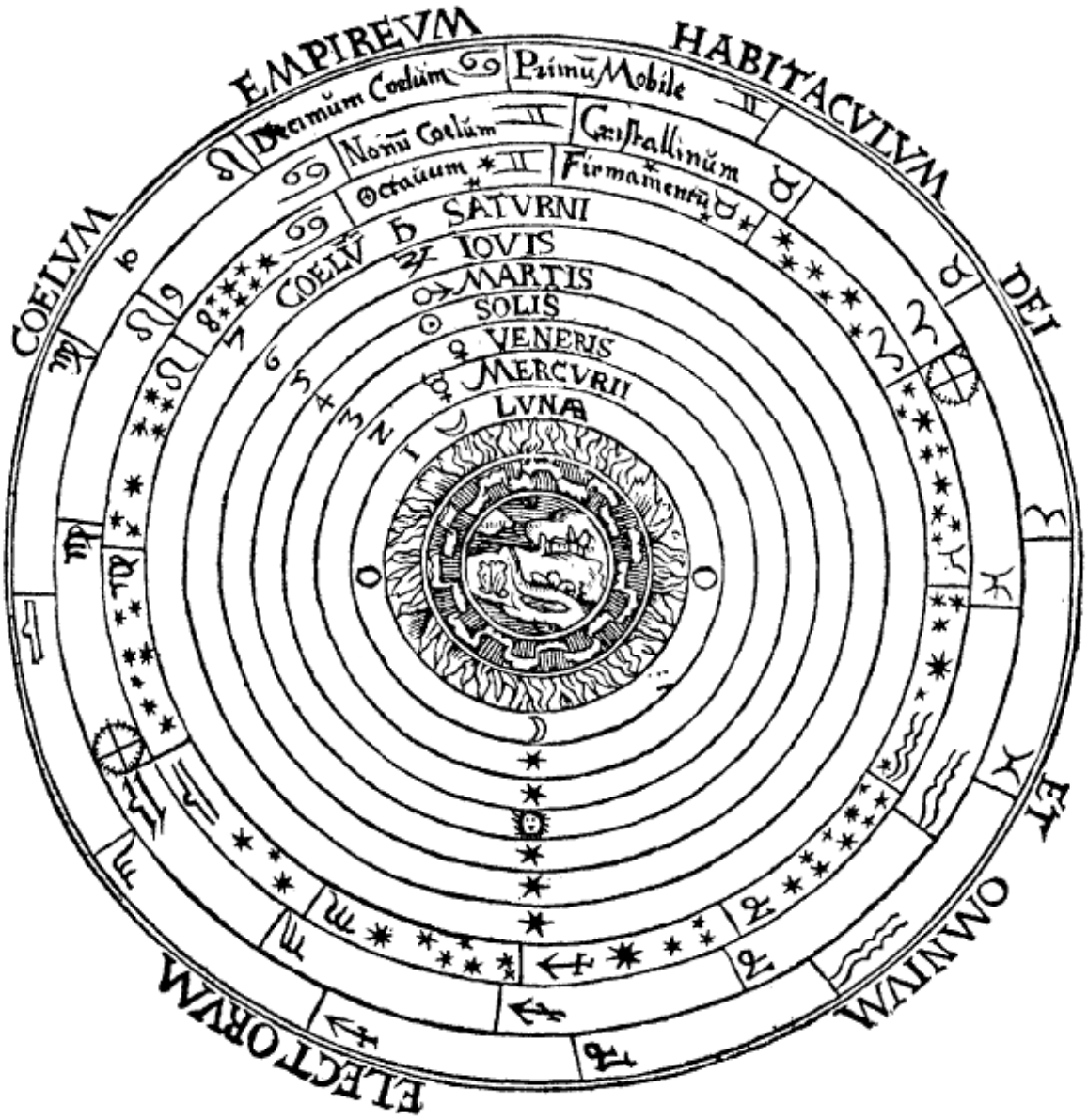
3.2 Aristotelian cosmology and the rejection of the plurality of worlds

Atomism was not the only school of Greek natural philosophy, and the important Athenian schools offered profoundly different views on nature. Although Plato presents in his *Timaeus* a physical theory based on indivisible entities somewhat resembling atoms, his strongly metaphysical philosophy had nothing to do with the strict materialism of atomism and rejected the atomist concepts of infinity and the plurality of worlds: to be perfect, to be the expression of the world of ideas, the world had to be unique. In the Athenian school, the essential properties of nature are therefore unity and singularity. Whereas the physical ideas of Platonism were not entirely incompatible with atomism, it was the comprehensive and more coherent physical and cosmological system developed by Plato's student Aristotle (384-322 BCE) that would completely overshadow the influence of the atomist system in the classical and medieval world.

In his *De caelo* (*On the heavens*), Aristotle explicitly discussed the question of the plurality of worlds – and rejected the possibility. Aristotle's cosmos was unique, and the universe beyond the Earth was finite and unchanging. In fact, for Aristotle, our world, our cosmos, coincides with the universe. Not only did Aristotle deny the infinity of the universe and the infinitude of matter, thus rendering Epicurus's argument invalid, but he also refuted the possibility of even a single cosmos other than the one known to man. However, like Epicurus, Aristotle held the view that the world consisted of a cosmic order: the celestial bodies and the

49 The principle is also strongly connected with Neo-Platonism, and plays an important role in the Platonic tradition in the Renaissance; Lovejoy, *The Great Chain of Being* (1960) 52; cf. Dick, *Plurality of Worlds* (1982) 12.

50 Dick, *Plurality of Worlds* (1982) 12.



3.1 A scholastic representation of Aristotelian cosmology, showing the earth, spheres, and Empyreum, the 'dwelling of God'. Peter Apian, *Cosmographia,* Antwerp, 1523.

spheres rotate around the Earth, which is in the centre of the cosmos. The outer boundary of the cosmos consists of the sphere of the fixed stars.

One of Aristotelian cosmology's greatest strengths was that it formed a comprehensive and coherent system, in which every part followed logically from the rest. In this way, Aristotle's cosmology relies strongly on his physics.[51] A basic concept of his *Physics* that also supported his cosmology in *De caelo* in general and especially his rejection of the plurality of worlds, was his explanation of the causes of the

51 Hetherington, 'Aristotle's Cosmology' (1993) 98.

motions of the four elements composing the universe – earth, fire, air, water. This explanation, known as the doctrine of motion and place, held that each of the four elements has a natural place. Each element continually strives to move to this designated spatial position. The natural place of the element earth is the centre of the universe, coinciding with the centre of the Earth. The element of fire, which is light by nature, tends to move upwards, away from the centre and towards the surrounding sphere of the fixed stars. Water and air assume intermediate positions. In this coherent system, every element and every body had its specific designated place with respect to the centre and the circumference of the cosmos. Aristotle believed that a void could not contain a natural place for the bodies to return to and he therefore rejected altogether the possibility of such a void – one of the core ideas of atomism.[52] As noted above, Aristotle's physical theory of the elements and his cosmology are closely connected. Just as Aristotle's teleological philosophy is always permeated with ideas of causality and with classifications, so too is his cosmology. Connected to the identification of the different elements with their natural places, every motion could be classified as violent or natural: for example earth moving upwards / away from the centre is violent; earth moving downwards / towards the centre is natural.[53]

Whereas the atomists had concluded the plurality of worlds from their physics, Aristotle derived from his own physics that only one world could exist. Aristotle's foremost argument against a possible plurality of worlds follows from the teleological doctrine of natural place: because every element has its natural place with respect to the centre of the universe, the existence of more than one cosmos, and thus more than one centre, is impossible.[54] For if it were the case that two worlds exist, an element of earth moving from one centre to the other, would move naturally in respect to the one element and violently in respect to the other. Another world could only exist if the similar elements of the two worlds would move to different centres, implying that similar elements could have different natural places. This, according to Aristotle, is simply impossible. The possible suggestion, which was actually made in medieval commentaries on Aristotle, that another world could exist if its centre were removed far enough from the centre of the Earth is forestalled by Aristotle through a definition:

> The same rule must apply to all, since all alike exhibit formal identity with each other but numerical individuality. My meaning is this, that if the relation of particles in this world to each other an their relation to those in another world are the same, then any given particle from this world will not behave otherwise towards the particles in another world, than towards its own, but similarly; for in form they do not differ from one another at all.[55]

52 Hetherington, 'Aristotle's Cosmology' (1993) 99.
53 Dick, *Plurality of Worlds* (1982) 14-15.
54 The idea of natural place is teleological because it understands nature from the perspective of its intended state, not from its original or actual state.
55 Aristotle, *On the Heavens,* 277a; cited in Dick, *Plurality of Worlds* (1982) 17.

This absolute and dogmatic statement affirmed the contradiction between the doctrine of natural places and a plurality of worlds. Therefore, every particle of earth must strive towards the centre of the Earth, which is the centre of the only existing cosmos.[56]

Whereas the philosophical system of atomism had led to the assertion of a plurality of worlds, Aristotle's theory of the elements and his doctrine of natural motion and natural place led him to take an opposite position. The two dominant traditions of Greek natural philosophy of the fourth century BCE thus took diametrically opposed positions on the possibility of the existence of a plurality of *kosmoi*. In the end, this disagreement over the plurality of worlds embodied the expression of a disagreement over ontology and the fundamental understanding of Nature and the nature of our own world.

Although the possibility (and actuality) of life in other worlds was considered reasonable by the atomists, it was no primary concern of the debate (and of course, from an atomist perspective, it did not matter very much to the understanding of life on Earth). However, as I have shown above when I discussed the literary sources of Lucian and Plutarch, later Greco-Roman thought playfully speculated on human-like life on the moon. Although I have already discussed Plutarch's dialogue *De facie in orbe lunae* in the previous chapter I can shortly point out here how its philosophical background is formed by the discussion between the atomist and Aristotelian cosmologies as explained above.[57] I already mentioned that Plutarch's discussion on the habitability of the moon was permeated by the problem of teleological justification of an earth-like moon, but now we can also see how its arguments are shaped by classical philosophical ideas, such as the Aristotelian concept of circular lunar motion and the atomist notion of the uniformity of nature.

At the beginning of the discussion of the atomist concept of the infinite universe, I raised the question how these Greek philosophers understood the concept of a world: does a world constitute the 'all', or the universe, or do several of worlds (*kosmoi*) coexist? Having examined the conflicting ancient Greek cosmologies of atomism and Aristotelianism, we need to realize that these traditions answered this question in a more or less similar way – one that is very different from our basic cosmological concepts, which were first shaped in the early modern scientific revolutions. As I have discussed above, the world was conceived by both atomists and Aristotelians as a closed system with an Earth, celestial bodies, and an outer sphere of stars. The atomist concept of the infinite universe and the plurality of worlds as a plurality of *kosmoi* are therefore only partially comparable to the concepts that arose in early modern Europe. In the words of David Furley: "Greek theories of the infinite universe [...] present a significantly different picture. What they saw in the night sky was not the beginning of the infinite universe: it was rather the boundary beyond which the infinite universe began."[58]

56 Dick, *Plurality of Worlds* (1982) 17; Although more Aristotelian arguments against a plurality of worlds exist, I will not discuss them here. They are less relevant to our subject.
57 Cf. above: § 2.3.
58 Furley, 'Greek Infinite Universe' (1981) 572.

3.3 Medieval discussions on the plurality of world

Departing from the (meta)physical and ontological discussions of Greek philosophy, the plurality of worlds tradition developed in new directions during the middle ages. From late antiquity to the reintroduction of Aristotle in the twelfth century, the only cosmological texts from antiquity available in Western Europe were a partial Latin translation of Plato's *Timaeus* and some loose fragments associated with classical authors including Seneca (4 BCE-65 CE) and Pliny the Elder (c. 23-79 CE). Since the few sections on cosmology in the works of Latin Church Fathers such as Augustine (354-430) offered no comprehensive view either, no strong cosmological tradition developed in the early Middle Ages.[59] It first were the rediscovery of Aristotle and the development of the scholastic system that led to the beginning of cosmological debate in the West. Given the almost complete disappearance of cosmological (and atomist) thought in late antiquity and the early Middle Ages and the dominance of Aristotle in later medieval scholasticism and cosmological thought, one might expect that the concept of a plurality of worlds was first reintroduced through the rediscovery of classical atomism in the Renaissance. Surprisingly however, it was Aristotelian scholasticism itself that would inspire medieval debate on the possibility of other worlds.

Although the classical sources that championed the plurality of worlds were unknown to medieval scholars, Aristotle's rebuttals of the idea from his *De caelo* were available. In the late twelfth and early thirteenth century, Greek cosmology had entered Western Europe by way of Latin translations from Greek, and much more important, Arabic manuscripts. These translations that opened up classical philosophy and astronomy to the West included translations of the works of Aristotle – primarily his *De caelo, Physica,* and *Metaphysica* – and some astronomical and astrological works of Ptolemy (c. 100-c. 170).[60]

As medieval natural philosophers elaborated upon the foundations laid by Aristotelian cosmology, a large body of cosmological writings was created. Using this newly found tradition as the basis of their work, scholastic authors produced commentaries and (mainly from the 14th century) *questiones,* in which they discussed the authoritative texts of Aristotle and some others and the principles explained in these works. In the course of this process, the principles in Aristotle's cosmology were scrutinized, and eventually also challenged. While Aristotelian cosmology remained practically undisputed within the first century after the introduction of *De caelo,* thirteenth-century scholasticism ushered some subtle but far-reaching departures from Aristotelian cosmology.[61]

What is particularly interesting about medieval debate is its strong theological focus that surpassed the natural philosophical aspects of the plurality of worlds. This sets them apart from the discussions of both Antiquity and the Renaissance. As I have argued above, classical atomist speculation on the plurality of worlds arose out of atomistic physical theories. Likewise, the Aristotelian rejection of the plurality of worlds was a direct consequence of Aristotelian physics. Although theological considerations also played a role in

59 Edward Grant, 'Medieval Cosmology' (1993) 181-182.
60 Grant, 'Medieval Cosmology' (1993) 181-182.
61 Dick, *Plurality of Worlds* (1982) 24-25.

these periods, only the medieval discussion was primarily concentrated on these theological aspects – to the degree that theological arguments were used to counter physical positions.

Christian theological considerations in medieval cosmology were mostly involved with the relation between God and creation.[62] It was this theological reflection on creation, and the biblical account of creation, that spurred some of the sharpest criticism on Aristotelian cosmology. The first and probably the most obvious departure from Aristotelian principles was a direct consequence of the theological doctrine of '*creatio ex nihilo*'. Whereas Aristotle had maintained that the world was eternal, having neither a beginning nor an ending, Christian medieval theology declared that God had created the world out of nothing (*ex nihilo*). Therefore, the world had a beginning and could not be eternal in nature. During the thirteenth century, the problem of the eternity of the world that stemmed from the conflicting Aristotelian and Christian doctrines was widely debated. While some authors – including St. Bonaventure (1221-1274) – tried to demonstrate the absurdity of an eternal world, others – including Thomas Aquinas (c. 1225-1274) – believed the eternity of the world was philosophically reconcilable with divine creation. At least one fourteenth century scholastic, Marsilius of Inghen (died 1396) went so far to assert that the theory of a eternal and beginningless world was preferable.[63]

Thirteenth century discussions on cosmology even invoked official clerical condemnation. On March 7 1277 Stephen Temier, Bishop of Paris, published a list of 219 condemned philosophical and theological theses. Presumably instigated by papal concern about rumours of heresy, this well-known Condemnation of 1277, also included several cosmological theses, focussing particularly on the eternity on the world.[64] What the debate on the eternity of the world and this clerical intervention demonstrate, is that medieval scholasticism employed theological arguments in cosmological debates and that these theological considerations were authoritative and often conclusive in their rejection or affirmation of propositions based on physical (ontological) arguments. The debate on the plurality of worlds formed no exception to this pattern.

In defence of the doctrine of one world, Thomas Aquinas stated that a limited number of worlds and beings does not compromise God's omnipotence. According to Aquinas, omnipotence is closely connected to perfection and God's omnipotence is expressed not so much in plurality as it is in unity. In unity lies perfection, Aquinas had learned from Plato's *Timaeus*. Whereas every world that is just one among many is imperfect because it cannot contain everything that exists, one world that contains all existence is perfect. God's omnipotence and plenitude are therefore not found in a plurality of worlds, but in the uniqueness of this one.[65]

To Thomas, the unity of the world did not only constitute its perfection; it also implied its order. This order

62 Grant, 'Medieval Cosmology' (1993) 184.
63 Grant, 'Medieval Cosmology' (1993) 186.
64 Cf. Thijssen, 'Condemnation of 1277' *SEP* (2008).
65 Dick, *Plurality of Worlds* (1982) 27.

further supported the unity of the world. All things come from God and are related both to God and to one another in a divine hierarchical order. According to Thomas, a plurality of worlds can only be asserted by those who deny the existence of the supreme wisdom altogether and who "rather believe in chance, as Democritus, who said that this world, beside an infinite number of other worlds, was made from a casual concourse of atoms."[66]

Just like the Aristotelian assertion of the eternity of the world was rejected on theological grounds, the Aristotelian rejection of a plurality of worlds was questioned (or affirmed, as by Aquinas) on the basis of theological principles. Aquinas' argument of perfection through unity was not unanimously agreed upon. In fact, in the Condemnation of 1277, one of the theses denounced was the claim that God could not create other worlds. Although the scholastics agreed with Aristotle and Aquinas that God had not actually created any other worlds (the biblical account suggested the creation of just one world), many of them were convinced that He could do so if He would want to.[67] While the Ancient atomists had concluded that the possibility of an infinite amount of worlds also demanded its actuality,[68] the medieval argument implied that God's omnipotence not only made possible the existence of a plurality of worlds, but also required that God could choose to create nothing.[69] The rejection of the Aristotelian doctrine that only one world could exist was thus first and foremost theological in nature. The medieval belief in the possibility of a plurality of worlds was ultimately based on the metaphysical possibility of plurality, not on the physical possibility, let alone its actuality. In the scholastic controversy God's infinite *potentia* was at stake.[70]

However, as a consequence of their claim that the possibility of a plurality of worlds was theologically plausible, scholastic natural philosophers felt compelled to substantiate this claim with physical arguments as well. God's unlimited metaphysical *potentia* suggested that a plurality of worlds should be physically possible as well – even though this plurality was not believed to actually exist. The basic idea of most of these arguments was that although Aristotle's physics were essentially correct, his claims that only one centre could exist in the universe and that the doctrine of natural places was absolute, were considered problematic, too exclusive. It was argued that if enough distance between centres existed, more than one could exist in the universe. Consequently, the elements could be distributed over different worlds, as they would all move to the centre closest to their actual place. Whereas Aristotle rejected the possibility of a void, some scholastics contradicted this assertion as well. They argued that a void could exist and identified it on theological grounds as the expression of Gods infinite omnipresence. Matter was finite and limited, while God was infinite and unlimited.[71] Additional arguments were formulated against the Aristotelian physics that

66 Thomas Aquinas, *Summa Theologica,* pt. I, question 47, art. 3; cited in Dick *Plurality of Worlds* (1982) 27.
67 Grant, 'Medieval Cosmology' (1993) 189.
68 Cf. above § 3.1, the notions of the 'uniformity of nature' and the 'principle of plenitude'.
69 The idea that God's omnipotence surpasses the order of the principle of plenitude is supported by a passage in Augustine's *De Civitate Dei,* XI, 5, in the context of a defence of the *creatio ex nihilo* in XI, 4-6.
70 Guthke, *The Last Frontier* (1990) 38.
71 Grant, 'Medieval Cosmology' (1993) 189.

3.2 A cosmographical diagram that includes the medieval conception of hell in the centre of the universe, inside the Earth. Gossuin de Metz, *Image du Monde*, 13th C. Bibliothèque nationale de France.

contradicted the possibility of worlds. To discuss all these contributions here in detail is unnecessary however, as their influence on later debate is minimal. Two general conclusions can be drawn about the medieval discussions on the plurality of worlds. First, the debate was primarily understood as a matter of theology. Second, the physical discussions on the possibility of worlds compromised the hegemony of Aristotelian physical doctrine, preparing the way for the new cosmological and astronomical ideas that would arise in the Renaissance and the radical innovations of the so-called Copernican Revolution that would forever change the human conception of the universe.

Before I discuss these new ideas, I want to emphasize the theological and metaphorical importance of medieval cosmology. It was a cosmology in the literal sense: it expressed divine order and hierarchy. Just like in classical literature, medieval cosmology was fraught with allegorical meaning. Here is one example:

While some of the seventeenth-century authors of cosmic fiction considered it human pride to believe that the earth was the centre of the universe, in the medieval mind the opposite was true. “The centre of the world

was not a place of honor."[72] Earth was the place were all the filth of the universe sank to and where it was piled up.[73] In Dante's *Inferno,* the centre of the universe is the place were Satan is kept, the place removed farthest from the divine sphere of the Empyrean. Here, removed from the natural place of fire, the worst sinners suffer, traitors of friends and patrons are frozen in a lake of ice.[74] As Dante's travels take him through purgatory to the heavens, eventually facing the eternal light of God, he moves away from the centre of the world to its circumference and eventually beyond, to the Empyrean.

Every place in the medieval universe had its meaning and its order: the Earth, celestial bodies and spheres, and the Empyrean all expressed the Divine providence, wisdom and omnipotence. The thought was: the universe is the way it is because it is ordained to be so by God. We need to keep these sensitivities in mind when discussing the centuries that follow. The eventual disqualification of the geocentric and hierarchically ordered conception of the cosmos not only changed astronomy and cosmology, it also demanded the re-evaluation of the cosmos and its meaning. The implications of the Copernican Revolution therefore stretch beyond astronomy. As we will see, seventeenth-century cosmic fiction is not just about empirical findings and physical ideas; it is about their meaning and their value; about what it means to live on earth – and to be human.

3.4 The reinvention of the infinite: Nicholas of Cusa and Giordano Bruno

Although the elements of Aristotelian philosophy were subject of critical discussion throughout the Middle Ages, the Aristotelian world view as such was never contested: medieval scholasticism still conceived the world as a closed system, as a *kosmos* in the most literal sense. Two developments in Renaissance thought first challenged this Aristotelian hegemony, and reintroduced the notion of cosmological infinity.

The first challenge to Aristotelian cosmology came from Neo-Platonism, revived in the early Renaissance by such philosophers as Marsilio Ficino (1433-1499) and Giovani Pico della Mirandola (1463-1494).[75] One of the first thinkers to introduce a Neo-Platonic concept of infinity, was the learned cardinal Nicholas of Cusa (1401-1464). One of the leading German thinkers of the fifteenth century, he was not only a cardinal, but also ecclesiastical reformer, mathematician, and papal legate. More recently, Cusa has become famous as one of the first thinkers to reject the closed Aristotelian cosmological system. In his famous book *From the Closed Cosmos to the Infinite Universe*, first published in 1957, Alexadre Koyré credits him as the man "to whom, as often as not, is ascribed the merit, or the crime, of having asserted the infinity of the universe."[76] Likewise he was also interpreted by sixteenth- and seventeenth-century authors like Bruno, Kepler and

72 Lovejoy, *The Great Chain of Being* (1960) 101.
73 Lovejoy, *The Great Chain of Being* (1960) 101-102.; cf. Guthke, *The Last Frontier* (1990) 39.
74 Cf. Dante Alighieri, *La Divina Commedia, Inferno,* XXXIV.
75 For a recent publication on the role of Platonism in early modern Philosophy, cf. D. Hedley and S. Hutton (ed.), *Platonism at the Origins of Modernity. Studies on Platonism in Early Modern Philosophy* (Dordrecht 2008).
76 A. Koyré, *Closed Cosmos* (1957) 6.

Descartes. In a well-known letter to Père Chanut of 6 June 1647, René Descartes writes about Cusa: "In the first place I recollect that the Cardinal of Cusa and many other doctors have supposed the world to be infinite without ever being censured by the Church: on the contrary, to represent God's work as very great is thought to be a way of doing him honour."[77]

Altough Cusa takes a traditional perspective in most of his astronomical works, asserting the centrality of the Earth in an ordered cosmos, in his most influential writing, *De docta ignorantia*, he departs from these assumptions, and argues for the infinity of the universe.[78] In this work, Cusa does not reason on the basis of physical arguments, but instead derives his ideas from metaphysical principles. To understand the natural universe, Cusa uses a metaphysical metaphor that has been used by medieval theologians to describe the 'immensity' of God.[79] C.L. Miller explains that "Nicholas begins with a single trope or symbol to lay out the parallels between his teachings in the three books [on God; the created universe; and Jesus Christ, the God-Man], that of the 'maximum.' God is the absolute Maximum; the universe is a created image of God, the 'contracted' or restricted maximum. Christ unites the first two as the Maximum at once absolute-and-contracted."[80] It is in God, that everything is One. "It is not that creatures coincide with God or God with creatures, but that in God all else coincides as nothing else than God."[81]

The maximum and minimum of the natural universe coincide in the infinite, which is God. Therefore, the world has no distinguishable boundary, and its centre coincides with the circumference. It is God who is both centre and circumference. Rather than asserting that the universe is infinite, Cusa asserts that the universe is indefinite: its circumference and centre are uncertain: "And although the world is not infinite, it cannot be conceived as finite, because it lacks boundaries within which it is enclosed."[82]

The seemingly revolutionary cosmology of *De docta ignorantia* is surprisingly conventional, when we realize that Cusa's assertion of infinity is theological in nature and that Cusa holds on to Aristotelianism in his astronomical works. Although the cosmological speculation is concerned primarily with mystical theology, Cusa is nevertheless one of the first thinkers to fundamentally challenge the hierarchical cosmology of 'the Philosopher'. He not only contemplates the idea of an 'open' universe, but he also rejects the medieval idea that the earth was the most lowly and despicable place in the universe.[83]

77 This translation of the letter is cited in Moran, 'Nicholas of Cusa' (2008) 11, from R. Stoothoff et al., *The Philosophical Writings of Descartes,* vol. 3 (Cambridge 1991) 319-320.

78 North, *Cosmos* (2008) 269. Cf. Lovejoy, *Great Chain of Being* (1960) 114. The conservatism of Cusa's more specifically cosmological writings is overlooked by Dick and Guthke, who tend to stress Cusa's belief in the plurality of worlds and its supposed physical implications. Cf. Dick, *Plurality of Worlds* (1982) 40-41; Guthke, *The Last Frontier* (1990) 39-42. For a general introduction to Cusa's philosophy and especially to *De docta ignorantia,* cf. the already mentioned article by Miller, 'Cusanus', *SEP* (2009). Cf. also Koyré, *Closed Cosmos* (1957) Ch.1, 5-27.

79 Lovejoy, *The Great Chain of Being* (1960) 112.

80 Miller, 'Cusanus', 2.1 *SEP* (2009). In Cusa's thought, this discourse is connected with negative theology (hence the title of the book). On the relation between Cusa and Meister Eckhart, cf. Brient, 'Transitions to a Modern Cosmology' (1999) 575-600.

81 Miller, 'Cusanus', 2.1 *SEP* (2009).

82 Nicholas of Cusa, *De docta ignorantia,*II, 11.

83 Cf. Nicholas of Cusa, *De docta ignorantia,* II, 12; Guthke, *Last Frontier* (1990) 39; Koyré, *Closed Cosmos* (1957)

Using an argument of the sort of the 'principle of plenitude', Cusa also asserts that it is improbable that the celestial regions are void of life:

> For although God is the center and circumference of all stellar regions and although natures of different nobility proceed from Him and inhabit each region (lest so many places in the heavens and on the stars be empty and lest only the earth – presumably among the lesser things – be inhabited), nevertheless with regard to the intellectual natures a nobler and more perfect nature cannot, it seems, be given (even if there are inhabitants of another kind on other stars) than the intellectual nature which dwells both here on earth and in its own region. For man does not desire a different nature but only to be perfected in his own nature.[84]

Although Cusa thus suggests that some form of extraterrestrial life exists, he stresses that these life-forms can hardly surpass the intelligent beings on Earth; but he does not want to speculate any further, "since that entire region is unknown to us, those inhabitants remain altogether unknown." What little room for imagination there is left, he than fills with some discussion on the diversity of beings in different conditions. It is interesting to see that the discourse used to discuss these differences is rather Aristotelian: "Thus, [we surmise], these intellectual solar natures are mostly in a state of actuality and scarcely in a state of potentiality; but the terrestrial [natures] are mostly in potentiality and scarcely in actuality; lunar [natures] fluctuate between [solar and terrestrial natures]."[85]

In *De docta ignorantia*, the cardinal of Cusa was not discussing physical reality. His contemplation of life in the universe has much in common with the ecstatic dreams and visions of classical and medieval literature, and very little with the later seventeenth-century speculations about planetary life and the plurality of worlds. His 'inhabitants' are still the mythological demons, spirits and angels of mystical allegory, not the planet-dwellers that we will encounter in the works of for example Godwin and Fontenelle. *De docta ignorantia* should be read as a work of speculative philosophy and mystical theology, not as a work of serious speculation about the plurality of worlds. However, its influence on the plurality of worlds should not be underestimated either, since it is Cusa who first reintroduced a concept of infinity that can compete with the Aristotelian focus on unity. Furthermore, seventeenth-century authors considered Cusa to be their predecessor – and therefore the question whether he really was becomes less relevant.

In this respect, Descartes's comparison of his own ideas to those of Cusa is quite interesting: "And my opinion is not so difficult to accept [by the Church] as theirs, because I do not say that the world is infinite but only that it is indefinite. There is quite a notable difference between the two: for we cannot say that

19-21.

84 Nicholas of Cusa, *De docta ignorantia,*II, 12.

85 Nicholas of Cusa, *De docta ignorantia,* II, 12.

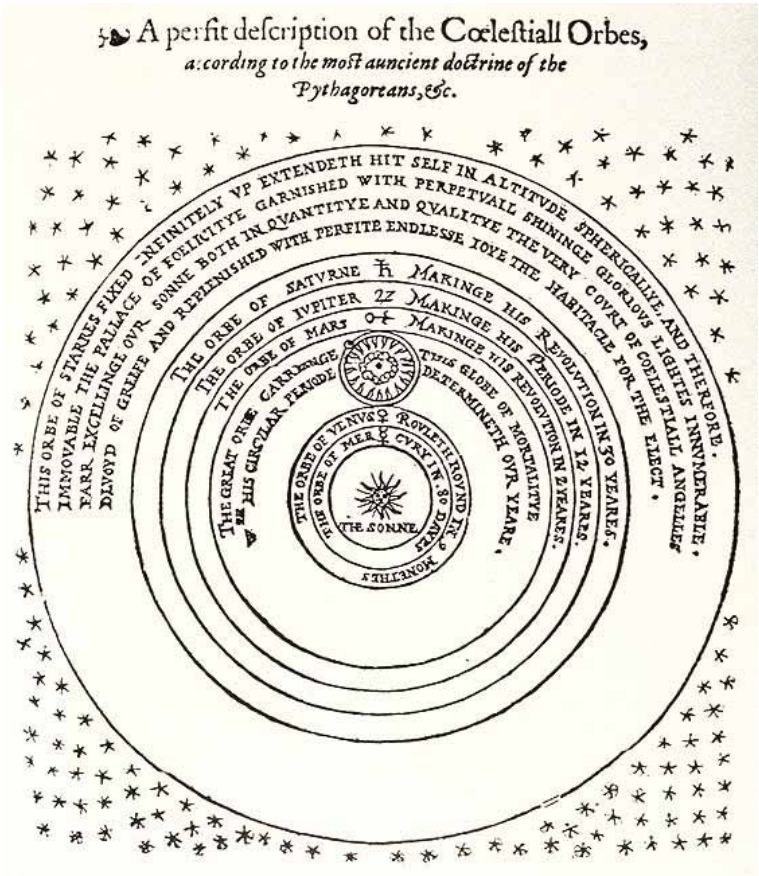
something is infinite without a reason to prove this such as we can give only in the case of God; but we can say that a thing is indefinite simply if we have no reason to prove that the thing has bounds."[86] Although Descartes seems fully aware of the theological sensitivities of the subject, he is mistaken to think that Cusa actually asserts the infinity of the universe. Like Descartes, he formulates his opinion carefully, and only denies the world's finitude. The qualification 'infinite' is reserved by Cusa exclusively for God.[87]

The notion of the infinite universe as a physical reality, which played a significant role in Greek atomist philosophy, was also reintroduced in the Renaissance – mainly through the rediscovery in 1417 of Lucretius' *De rerum natura*. Despite the enthusiastic reception of this didactic poem by humanist audiences, it did not directly influence cosmological thought in the fifteenth and early sixteenth century. Lucretius was read and praised for his literary style, but not for his 'blasphemous atheism and materialism'.[88] When the concept of the infinite plurality of worlds did re-emerge in the later sixteenth century, the original atomist doctrine was radically transformed.

It was the renegade Dominican and hermetic philosopher Giordano Bruno (1548-1600) who first took the cosmological content of *De rerum natura* seriously. Bruno is separated from his 'predecessor' Cusa by an important event in the history of science that would cause profound cosmological changes: the publication of Copernicus' revolutionary *De revolutionibus orbium coelestium* in 1543. I will not extensively discuss the so-called Copernican Revolution here, but I do want to point out two things. First, the Copernican system abolished the hierarchy in the Aristotelian and medieval cosmos; and second, it was still a closed and finite system: the sun had become the centre of the solar system, but also of the universe, surrounded by the planets and a sphere of fixed stars.[89]

Giordano Bruno was the first important author to break open the Copernican system, and expand it into infinity.[90] The starting point to understand Bruno's cosmology is therefore his understanding of Copernicanism. In the preface to Copernicus' *De revolutionibus,* the Lutheran theologian Andreas Osiander (1498-1552) had cautiously stated that the presented work merely offered a model for astronomical calculation, that did not necessarily hold claims about physical reality.[91] However, Bruno believed that the Copernican system was not a purely mathematical concept, or even an astronomical system, but that it

86 Cf. note 77.
87 Koyré, *Closed Cosmos* (1957) 8.
88 Sedley, 'Lucretius', *SEP* (2008); Dick, *Plurality of Worlds* (1982) 46.
89 I consider an extensive discussion of the Copernican revolution to be superfluous in the context of this thesis, as an extensive body of literature on the subject already exists; cf. Lerner and Verdet, 'Copernicus' (1993) 147-173; Kuhn, *Copernican Revolution* (1957); Vermij, *De wetenschappelijke revolutie* (1999); Rossi, *The Birth of Modern Science* (2001); Vermij, *Kleine geschiedenis van de wetenschap* (2006); Cohen, *De herschepping van de wereld* (2007); Rabin, 'Nicolaus Copernicus', *SEP* (2010).
90 Thomas Digges, a 'minor' figure in the history of cosmology, had already concluded that the Copernican universe was infinite in a 1576 paraphrase of *De revolutionibus*, cf. Kuhn, *Copernican Revolution* (1957) 233-234.
91 As the preface was an anonymous addition, most early readers probably believed that this reservation was made by Copernicus himself.



3.3 Thomas Digges's diagram of the infinite Copernican universe. The Earth orbits the sun, and the sphere of the stars is left open, no longer bordered by the Empyreum. *A Perfit Description of the Coelestiall Orbes* (1576).

expressed a radical new world-view: it was a truthful description of physical reality.

Bruno's infinite universe is worked out in three texts in particular: the Italian dialogues *Ash Wednesday Supper* (1584) and the *On the Infinite Universe and Worlds* (1584), and the Latin work *De immense* (1591). In the Italian dialogues, Bruno's infinite universe is presented primarily as founded upon the Copernican system. In the later Latin work, more attention is given to the pre-Copernican traditions.

Bruno's Copernicanism was the ultimate foundation of his belief in the infinite universe.[92] However, he did not consider the Copernican system to be flawless. Copernicus's universe was still a closed system. Also, it was primarily a mathematical description of physical reality. The system that Bruno developed constituted a comprehensive mystical world view. Although he acknowledged the achievement of Copernicus, it was Bruno himself who would reveal the truth about the universe, as he confidently explains at the beginning of the first dialogue of the *Ash Wednesday Supper*: "a man [Copernicus] who had to liberate himself from some false presuppositions of the common and commonly accepted philosophy, or perhaps I should say, blindness. But for all that he did not move too much beyond them." And further on about 'the Nolan', referring to Bruno himself: "Now here is he who has pierced the air, penetrated the sky, toured the realm of stars, traversed the boundaries of the world, dissipated the fictitious walls of the first, eight, ninth, tenth spheres, and whatever else might have been attached to these by the devices of vain mathematicians and by the blind

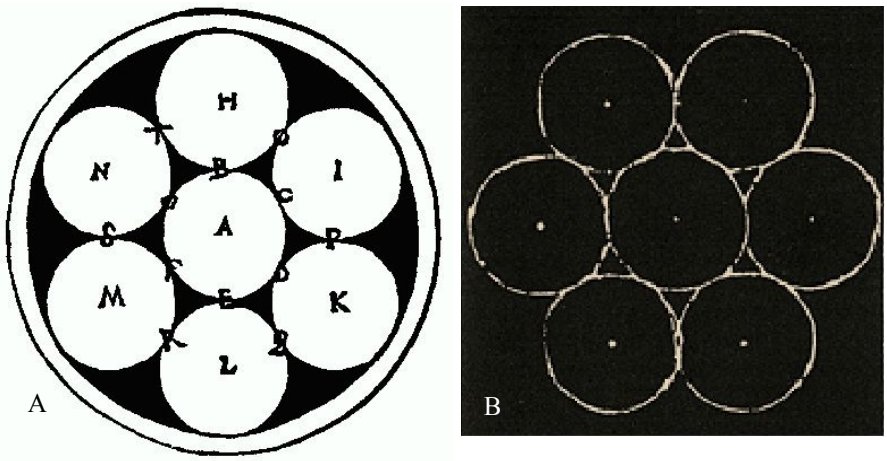
92 Gatti, *Giordano Bruno* (1999) 100-101.

vision of popular philosophers."[93] Bruno's criticism was that Copernicus had not pushed beyond mathematical studies, and had therefore failed to understand the ultimate truths that now were to be unveiled in Bruno's own natural philosophy. Whereas Copernicus had still understood the universe as a closed system, Bruno firmly asserted the infinity of the universe in his own rejection of the medieval cosmos:

> We recognize many stars, many astral bodies, many protective spirits, which are those hundreds and thousands who accompany us in our praise and contemplation of the first, universal, infinite, and eternal efficient cause. Our reason is no longer imprisoned by the bands of the imaginary eight, nine, and ten revolving orbs. We understand that there is one sky, an immense ethereal region, where these magnificent lights keep their proper distances in order to participate in eternal life. These flaming bodies are ambassadors who announce the excellence of the glory and majesty of God. In that way, we are led to discover the infinite effect of the infinite cause, the true and living image of infinite power.[94]

Despite its Copernican assumptions, Bruno's work is also very much indebted to the theological work on the subject of infinity by Nicholas of Cusa. While Cusa's mystical theology had little to do with natural philosophy, its Neo-Platonic understanding of infinity was in itself compatible with the new cosmology of Copernicanism. Most notably, the argument of divine plenitude as used by Cusa is applied by Bruno to support the infinity of worlds. The concept of plenitude as employed by Bruno is thus connected to the Copernican system, providing the existing Neo-Platonic idea with physical credibility. We can safely assume that Bruno's physical interpretation of the theological infinity of Cusa shaped later interpretations of the German humanist as well.[95]

While Cusa's Neo-Platonic influence on Bruno is clear, Bruno was a student of ancient atomism as well. However, his interpretation of the plurality of worlds clearly departs from the atomistic doctrine when it



3.4 Diagrams representing the coexistence of multiple worlds in [A] *De immenso* (1591) LVII, cxi; and [B] *De l'infinito* (1584) V.

93 Bruno, *Ash Wednesday Supper,* 57, 61.
94 Bruno, *Ash Wednesday Supper;* citation translated by Gatti, *Giordano Bruno* (1999) 101; Cf. the translation by Jaki (1975) 61-62. Cf. Bruno, *On the Infinite Universe and Worlds,* 246.

comes to the basic understanding of what constitutes a 'world', and his Copernicanism enabled him to transform the atomist concept and incorporate it in his own comprehensive cosmology. He interpreted the atomistic concept of the infinite world from a Copernican perspective, ignoring that the atomistic worlds each formed a closed spherical system, somewhat like Aristotle's cosmos:

> Concerning this question, you knew that his [Aristotle's] interpretation of the world is different from ours. For we join world to world and star to star in this vast ethereal bosom, as is seemly and hath been understood by all those wise men who have believed in innumerable and infinite worlds. But he applieth the name world to an aggregate of all those ranged elements and fantastic spheres reaching to the convex surface of that *primum mobile*, the perfect sphere which draweth the whole revolving with it at immense speeds around a centre near which we are placed.[96]

Bruno supposed that 'all those wise men' understood the concept as he had himself developed it. The Copernican system thus provided the basic astronomical discourse that enabled Bruno to integrate different existing traditions concerned with infinity, plenitude and plurality in one encompassing world view.[97] The plurality of worlds tradition had been transformed by Bruno from a transcendent (albeit physical) atomist doctrine into an immanent Copernican concept.[98]

Although his own system was strongly influenced by Hermetic and astrological ideas, Bruno can be credited (as he was in the seventeenth century) as the inventor of the first modern concept of an infinite universe. However, infinite space does not necessarily imply infinite solar systems, celestial bodies, and a plurality of 'worlds' – nor are these concepts implied by Copernicanism. The specific 'Brunonian' infinite universe, composed of a Neo-Platonic principle of plenitude combined with atomism and Copernicanism, does also imply an infinite plurality of celestial bodies and solar systems in the universe. Moreover, this infinite universe also harbours a great abundance of life.

Here, we touch upon another important aspect of Bruno's philosophy – his hermeticism. Although Bruno was influenced by the atomist doctrine of infinity and the Neo-Platonic idea of plenitude, the main influence in his philosophy is the Renaissance interest in Hermetic philosophy, occultism and astrology. Therefore, when discussing his view on the infinite universe and the plurality of worlds, it is important to realize that Bruno, like Cusa, was not primarily concerned with the astronomical aspects of cosmology. Significantly, when he was burnt at the stake in Rome as a heretic in 1600, this had nothing to do with his Copernicanism

95 Cf. the letter by Descartes cited above.
96 Bruno, *On the Infinite Universe,* 329.
97 On the relation between Bruno's cosmology and his Hermetic ideas, cf. Gatti, *Giordano Bruno* (1999) 99-114.
98 'transcendent' in the sense that the atomistic infinite universe lay beyond the boundaries of the sphere of stars; cf. the end of § 3.2.

or his beliefs in an infinite plurality of worlds, but everything with his religious ideas.[99]

We should therefore be careful to not too easily attribute to Bruno a belief in extraterrestrial life in the sense of planet-dwellers. His ideas draw heavily on Lucretius, but they are not 'Lucretian'. Especially in his concept of the abundance of life in the universe, Bruno departs further from the atomistic understanding of the plurality of worlds. The vitality that he believes to exist in the universe is not a materialistic concept of life on the surfaces of a plurality of Earth-like worlds; but it is a hermetic understanding of the universe as being itself animate, vibrant and alive. It can therefore be concluded that Bruno's ideas about actual planetary life, like those of Cusa, remained vague and subordinate to the higher truths of his system. It is most likely that Bruno still could not imagine 'humanoids' to inhabit the planets – his planets were still the celestial animate beings of Greek mythology; and he still conceived extraterrestrial life in the medieval and classical language of demons and spirits.

Giordano Bruno's work is not just the final expression of an old speculative tradition of plurality. Bruno is a transitional figure, who integrated the philosophical concept in the heliocentric system, and so gave it an unprecedented measure of actual possibility. He also relates to the past and the future on a textual level. Lucretius and Nicholas of Cusa are cited and mentioned frequently, and his work contains numerous references to others as well, including Democritus, Epicurus and Lucian.[100] Bruno's comprehensive employment of the existing different literary, philosophical and astronomical traditions, can be seen as a turning point in the history of cosmological plurality.

Despite his revolutionary ideas, Bruno never consistently draws the materialistic conclusion implied by the connection of Copernicanism and infinity. Plurality to him remains a philosophical concept, subservient to his comprehensive Hermetical system of the world. Further, his language has more in common with the mystical allegories of Cusa than with the increasingly anthropomorphic images that characterizes seventeenth descriptions of extra-terrestrial life. Giordano Bruno therefore remains a figure that is closer to the classical understanding of plurality, than to the realist approach of the seventeenth century.

3.5 Conclusion: the non-existence of the plurality of worlds tradition

Reconsidering the philosophical tradition of the plurality as I have presented and discussed it in this chapter, several concluding observations can be made. First of all, it can be concluded that the plurality of worlds is a flexible concept that was interpreted and used in many different ways. While it was promoted by the atomists as an expression of their most fundamental beliefs on ontology and the physical composition of reality, it was rejected by Aristotle on similar grounds. Upon its introduction in Greek philosophy

99 Cf. the large corpus of secondary literature on Bruno; for a recent biography: Rowland, *Giordano Bruno: Philosopher, Heretic* (2008); for an influential study on Bruno as a Hermetic: Yates, *Giordano Bruno and the Hermetic Tradition* (1964). On the conviction and the plurality of worlds, cf. Cohen, *De herschepping van de wereld* (2007) 159; Rabin, 'Copernicus' *SEP* (2010).

100 Ironically, in the third dialogue of the *Ash Wednesday Supper,* Bruno rebukes Lucian for poking fun at the 'philosophers who make up nonsensical theories about the universe' in his *True Story.*

cosmological plurality was therefore not thought of as an autonomous philosophical concept. It was used rather as a thought experiment expressing more fundamental discussions on physics and the nature of reality. This use of cosmological plurality as a metaphor or symbol remained essentially unaltered in the later discussions on the subject.

While the concept had been employed as a physical or ontological metaphor in Greek philosophy, its meaning changed in medieval and Renaissance thought. In these different contexts, the concept naturally evoked different associations, such as the qualities of God or the place of man in the world. While the antithesis of plurality and unity remained central in medieval and Renaissance thought, the implications were now not so much physical, but became more theological and mystical in nature. In scholastic discussions, it was not so much Aristotle's theory of matter and motion that was at stake, but God's omnipotence and the nature of Divine order and harmony in creation. As noted above, although the idea of plurality primarily supported Giordano Bruno's hermetic concept of an infinite and harmonious animate universe, it was he who first connected the plurality of worlds of to Copernicanism. He thereby created the possibility of an understanding of cosmological plurality as an immanent and physical possibility.

Ironically – and in disagreement with those scholars who have exclusively approached the tradition of the plurality from the perspective of a modern notion of biological extraterrestrial life[101] – I must conclude that the plurality of worlds constitutes no uniform and clearly defined tradition, and that a plurality of worlds tradition does not exist as such. This does not mean that the notion of the existence of such a continuous tradition is worthless. On the contrary, the seventeenth-century authors who employed the discourse of plurality were very well aware of the ambiguity of the plurality of worlds. They knew that the plurality of worlds could be used to evoke all kinds of different spheres and connotations; and they knew that it had been connected to different ideas in the past, and that it could be easily connected to new ideas ass well. As I will argue, it is precisely this flexibility and ambiguity of the plurality of worlds, that made it a beloved subject of seventeenth-century literary and popular-scientific texts.

101Cf. the Introduction above.

Part II

New Worlds:
plurality in seventeenth-century literature, philosophy, and science

4

The plurality of planets and the new sciences

4.1 Johannes Kepler and the heliocentric universe

The man often credited as the 'inventor' of science fiction – a very dubious but interesting claim – and the first writer of a work of 'lunar literature' significantly influenced by Copernicanism was Johannes Kepler (1571-1630), astronomer and court mathematician of the Holy Roman Emperor in Prague.

Kepler's work of lunar fiction titled *Somnium* or *Dream,* published posthumously in 1634 in Frankfurt, is an interesting work with a complex history. The work has two parts: a lunar story of some 25 pages that discusses a dream-voyage to the moon and the astronomical phenomena as witnessed from there; and 223 explanatory notes by Kepler containing scientific explanations of the elements of the story. This commentary is almost three times as long as the narrative itself.

The leading (but implicit) question of the work is: how would the phenomena of the heavens appear to an observer stationed on the moon? Through a discussion of this question, Kepler makes an argument for the movement of the earth, and the Copernican system in general: just as the lunar observer cannot feel the motion of the moon, so too the earth appears motionless to man – whereas in reality, neither are stationary.

This idea is already found in a dissertation, written by Kepler in 1593, that was withheld from disputation by an anti-Copernican professor.[102] The basic idea of the *Somnium* can therefore be dated before 1600, well before Galileo made his ground-breaking observations of the lunar surface with the newly invented telescope.[103] The headline above Kepler's commentary states that the notes were written between 1620 and 1630. The *Somnium* has thus evolved in different phases spanning a period of over thirty-five years.

The narrative framework is classical, blending the medieval theme of dream-visions with the occult methods of travel described by Plutarch and Lucian.[104] The story relates how in a dream an Icelandic astronomer and traveller named Duracotus tells Kepler of an extraordinary lunar voyage. With the help of his mother, a 'wise woman', this astronomer is transported to the moon by means of occult and natural forces. Subsequently, the story takes a more serious turn. Kepler first describes the geography of the moon in a manner similar to the speculations of Plutarch's *De Facie*. He explains that there are mountains on the moon, and how the lunar climate is influenced by its astronomical position. While the Lunar parts known as Subvolva enjoy the light of the Lunar moon Volva (Earth), the parts called Privolva only enjoy the light of the sun. Kepler then explains how life on the moon would be determined by its geographical and

102 Rosen, *Kepler's Somnium* (1967) xvii.
103 The narrative can be dated 1609; cf. Rosen, *Kepler's Somnium* (1967) xviii.
104 Cf. Campbell, 'Alternative Planet' (2002) 234, 246, n. 8.

astronomical conditions, and before the story is quite abruptly ended (the narrator is awakened by the noise of wind and rain) he gives descriptions of the astronomical phenomena as seen from the moon: now it is not the moon that moves, but the Earth.

The notes on the *Somnium* are extensive and diverse. They clarify scientific details, add data provided by telescopic observations, and comment on the literary backgrounds and allegorical mechanisms of the narrative, such as names and references. These notes thus give the work a more scholarly character. Kepler explains in a letter from 4 December 1623 to a friend why he has started to work on his commentary to the story: "The people wish that this kind of fun, as they say, would throw itself around their neck, with cosy arms; in playing they do not wish to wrinkle their foreheads. Therefore, I decided to solve the problem myself, in notes ordered and numbered."[105]

The *Somnium* is not an easy work to interpret and it has been subject to several different readings. Whereas some commentators have seen the narrative work as a 'sugar-coating' for a pill of controversial ideas, such as Copernicanism or extraterrestrial life, others have focused on its literary significance and on its importance to the history of science fiction.[106] Although I agree that the literary form of the work is more than a cloak to avoid controversy, I do believe that the narrative is subservient to the 'message'. The main argument for this position is provided by Kepler himself. He makes some very clear statements about this in the commentary. In note 4, he clarifies the central theme, and connects it to a more general understanding of the nature of science. Commenting on Duracotus's remark that the recent death of his mother, a woman of ancient lore, 'freed me to write, as I had long wished to do', Kepler explains that 'untutored experience' is the mother of 'Science', but that 'Ignorance' and the false pretension of manifest experience must die before science can bloom. He then explains the theme of the *Somnium,* and connects it to the mathematical anti-Aristotelianism advocated by scholars like Galileo and Kepler himself: "The purpose of my *Dream* is to use the example of the moon to build up an argument in favour of the motion of the earth, or rather to overcome objections taken from the universal opposition of mankind. This ancient Ignorance was then, I thought, already dead enough and erased from the memory of intelligent men. Yet the creature still struggles on in a tangle of so many knots tied tightly together through so many centuries. The aged mother continues to exist in the universities, but such is her existence that seemingly she ought to look upon death as more desirable than life."[107] He makes similar remark about Aristotelian natural philosophy in note 96: "Here is the thesis of the whole *Dream;* that is, an argument in favour of the motion of the earth or rather a refutation of the argument,

105 Cited from Baumgardt, *Kepler: Life and Letters* (New York 1951) in Christianson, 'Kepler's Somnium' (1976) 88.

106 For example Christianson, 'Kepler's Somnium' (1976) interprets the fiction in this way. This interpretation is opposed by Campbell, 'Alternative Planet' (2002) who stresses the literary value of the work, and connects it to early modern travel literature and imaginations of the New World. Dick, *Plurality of Worlds* (1982); Guthke, *The Last Frontier* (1990) and Ferraro, 'Giordano Bruno's *Infinitely Numerous Worlds*' (2006) 727-736, interpret the *Somnium* as a work in the tradition of the plurality of worlds, focusing on the descriptions of the Lunar inhabitants. Hutton discusses the *Somnium* in the literary context of early seventeenth century lunar voyages, '*The Man in the Moone* and the New Astronomy' (2005) 3-13. Bozzetto calls the work 'science fiction's missing link' between Lucian fantasy and the modern 'hard' science fiction, 'Kepler's "Somnium"'(1990) 370-382. Langler gives a balanced interpretation that connects the work with Kepler's cosmology, 'Das Kugelspiel' (2011).

107 Kepler, *Somnium* (1967) 11, 36.

based on the sense of perception, against the motion of the earth."[108] Again, the propagation of Copernicanism is connected to the false premises of Aristotelian physics.[109] While Kepler's propagation of Copernican heliocentrism versus Aristotelian and Ptolemean geocentrism is closely connected to his more general criticism of Aristotelian physics, the apology of Copernicanism is the main purpose of the *Somnium*. Through the description of lunar astronomy and geography and its obvious similarity to the qualities of the earth, Kepler constructs a twofold argument for the Copernican view. Not only does he disprove the appeal to everyday perception as an argument for the stationary earth, but through his description of the moon as an earth he also supports the Copernican view of the earth as a planet.

That Kepler rejected Aristotelian physics, does not imply that he also shared the atomistic view of Giordano Bruno and the Greek atomists. On the contrary, as he embraced the Copernican astronomy, he gave it his very own interpretation. The cosmology that he developed, remains a classical cosmology: it was a closed system, with a centre and a circumference; and it was a harmonious cosmos, created by God in geometric order. This cosmology is based on Kepler's comprehensive philosophy, that was firmly based in Platonic and Neo-Platonic ideas. Especially in his larger cosmological works, such as the *Harmonice Mundi* (1619), Kepler tries to explain the universe according to Platonic principles of geometry and harmony.[110]

Kepler thus rejected Bruno's notions of a centerless and infinite universe, and upheld the unique and exceptional place of the sun and the solar system in the universe.[111] He also remained confident of his belief in the central position in the cosmos of the earth and of man who inhabits it: earth remained "the seat of that rational being for whom the universe was created, and the place dedicated to the most important and noble corporeal beings."[112] In other words, Kepler not only believed in a heliocentric planetary system (the solar system), but also in a heliocentric universe. In this rejection of Brunonian infinity and plurality, Kepler did not stand alone. As many sources of the period show, Bruno's enthusiasm about the infinite cosmos was not shared by many. The shifting views on cosmology and science were received more often with anxiety.[113] This discomfort was expressed in many contemporary literary sources, as in John Donne's famous lines from his *Anatomy of the World* (1611):

> And new Philosophy calls all in doubt,
> The Element of fire is quite put out;
> The Sunne is lost, and th'earth, and no man's wit

108 Kepler, *Somnium* (1967) 82.
109 On the seventeenth century critique of Aristotelian 'manifest experience' and its replacement with a mathematical understanding of nature, cf. Tamny, 'Atomism and the Mechanical Philosophy' (1990) 597-609; and Cohen, *De herschepping van de wereld* (2007) 110 ff.
110 On Kepler's cosmology and Platonism, cf. Donahue, 'Kepler' (1993); Di Liscia, 'Johannes Kepler', *SEP* (2011) §2, 7; Langner, 'Das Kugelspiel' (2011).
111 Rossi, *The Birth of Modern Science* (2001) 111; Gatti, *Giordano Bruno* (1999) 123.
112 Kepler, cited in: Rossi, *The Birth of Modern Science* (2001) 112.
113 For an extensive account of this early seventeenth-century confusion, cf. Guthke, *The Last Frontier* (1990) 112-136.

Can well direct him, where to look for it.
And freely men confesse that this world's spent,
When in the Planets and the Firmament
They seek so many new; they see that this
Is crumbled out againe to his Atomies.
'Tis all in pieces, all coherence gone;
All just supply, and all Relation;[114]

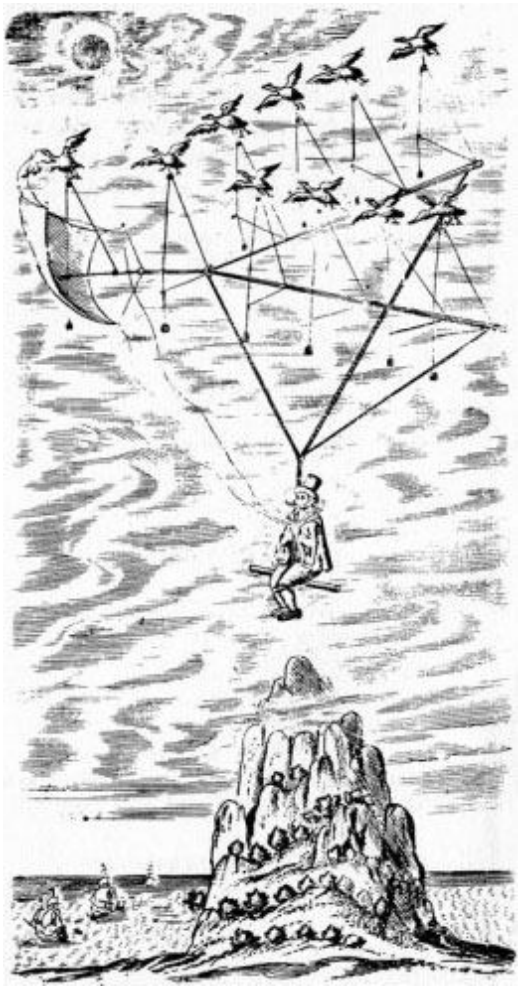
4.2 Bishops on the moon: Francis Godwin and John Wilkins

As I have argued, the main purpose of Kepler's speculations about the lunar world was to express and support his apology for Copernicanism. Interpretations suggesting that Kepler believed in a plurality of worlds, can only be upheld at the cost of ignoring his conservative (Platonic) ideas about the place of the Earth in the universe and its theological significance. Kepler employed a fictional lunar narrative to promote Copernicanism, and it was the heliocentric astronomy that inspired his use of a Lucian story. In doing this, he created a new genre, one blending traditional literary genres (Lucian travel, medieval dream-vision) with a serious astronomical discourse and using literature to promote and popularize a scientific position.[115]

Precisely because of this subtle combination of serious astronomy and cosmic fiction, modern readers and scholars should be cautious when interpreting seventeenth-century sources that include discussions of or references to the plurality of worlds. Though it is tempting to try to discern between jest and sincerity, it is more important to realize that in the intellectual turmoil of the early seventeenth century, probably not so many scientists and writers were fully certain of what they believed to be true, what they believed to be possible, and what they believed to be impossible. Of great importance in this respect is the relative absence of clerical and ecclesiastic interference and guidance in the scientific developments. The image of a church 'condemning scientific 'curiosity' and prosecuting or harassing its proponents – whether based upon the Roman Catholic condemnation of Galileo of the 1630's or the Reformed cleansing of Dutch universities in the 1650's – is biased at least when applied to the second half of the century. It is untenable and implausible when projected on the first half of the century.[116] Speculation on the plurality of worlds was not controversial in itself,[117] but when such thought experiments (like Copernicus 'mathematical' astronomical theory) became discussions about physical reality questioning the Aristotelian foundation of knowledge, they plunged the early-modern European mind into crisis.

Of course, not everyone shared John Donne's pessimistic view of the new astronomy. Several authors wrote systematic apologies for the rationality of the belief in the possibility of planetary worlds. Others quickly

114 John Donne, *An anatomy of the World,* lines 205-214.
115 This does not mean that other authors hadn't blended such genres before, but whereas many authors used scientific facts to 'spice up' their stories, or give them more allure, Kepler turns the tables and uses literature to the message.
116 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 74-76.
117 Neither had it been in scholastic philosophy, cf. above § 3.3.



4.1 Frontispiece of *The Man in the Moon,* 1638. The image shows several scenes from the book, including the flying-machine.

4.2 Frontispiece of an extended edition of *A Discovery of a New World in the Moone*, 1683. The Cosmological theme of the work is represented by Copernicus, Galileo, and Kepler, as well as the Copernican system.

recognized the comical and fantastical potential of planetary worlds. Although much more could be said about these entertaining and diverse satirical contributions, I will now only discuss a few of the most interesting texts, which can be seen as representative for the genre.[118]

In 1638, only four years after the extended *Somnium* was finally (and posthumously) published, two works of two English Bishops were published in London. The first, John Wilkins's *The Discovery of a World in the Moone*, was a popular scientific work 'tending to prove, that 'tis probable there may be another habitable World in that Planet.' This work contains a typically humanistic exploration of mainly theological and philosophical aspects and consequences of the possibility of a plurality of worlds. The second work, published only five months later, was entitled *The Man in the Moone: or, A Discourse of a Voyage thither.* This adventurous novel was posthumously published and was written by another Anglican prelate, Francis Godwin (1562-1633), who had died a year before the publication of Kepler's *Somnium*. This entertaining

118 For a comprehensive overview, cf. especially Nicolson, *Voyages to the Moon* (1948) and Guthke, *The Last Frontier* (1990).

work tells the fantastic travel story of a Spanish nobleman, who not only travels to the moon with a flying mechanism using large geese, but who also ends up on St. Helen and even in China.[119]

The *Man in the Moon* enjoyed great success, went through many reprints and editions in the seventeenth and eighteenth century, and was translated in French, German and Dutch. Not only was it popular, but its influence on seventeenth century (English) literature was profound. The combination of different genres in the work showed a new direction for fictional literature that would be widely followed. It is also a distinctly literary text. Whereas Kepler's story of a lunar voyage served as a framework to communicate his astronomical message, *The Man in the Moon* is not so much concerned with astronomical theory, but rather with social and cultural themes, blending travel adventure, space voyage, utopian fantasy and political satire into something new.

Reflecting the different sources and genres that Godwin used and combined in the writing of the *Man in the Moon,* the adventure of the work's protagonist and narrator Domingo Gonsales contains several different narrative stages. The story sets out as a conventional seventeenth-century adventure novel with Gonsales informing us of his adventures in the Spanish-Dutch war, the ill luck that struck him upon his return to Spain, and the following flight to the East Indies. The actual story relates Gonsales's return to Europe, which takes him through three adventures. The longest and central second adventure concerns Gonsales miraculous voyage to the moon, while the prior and following adventures cannot be ignored, as they demonstrate the utopian and satirical significance of the novel as a whole.[120] The first episode describes how at sea Gonsales is struck by illness and is left behind with only one 'negro' servant to recover his health on the “blessed Isle of St. Helen, the only paradise, I think, that the earth yieldeth.”[121] On this island, Gonsales is able to train a pack of 'gansas', and build a bird-powered flying-machine. After an unpleasant stop on another island, this machine takes him straight up to the moon.

The narration of the journey is detailed, and Gonsales relates how he encounters terrifying demons in the sky. He is even more astonished by the astronomical insight that his flight offers him: the earth appears from the skies like the moon appears from Earth! Not only does this passage reminiscence the classical descriptions of Earth-views found in Cicero and Lucian, it also resembles Kepler's lunar voyage in its critical discussion of Aristotelian cosmology. Here we also find some popular scientific discussions. Godwin/Gonsales only partially accepts Copernicanism.[122] But while these popular scientific considerations are definitely interesting, they are not the central theme of the *Man in the Moon*. Instead, the utopian society that Gonsales encounters on the moon forms the main focus of Godwin's work.

Gonsales's descriptions of the Moon reveal a fantastical world full of wonder, and a utopian society far superior to ours. Moreover, the lunar inhabitants are a utopian reflection of man. They have an inclination to

119 The work was probably written sometime between 1620 and 1630; Butler, 'Introduction', Godwin, *The Man in the Moon* (1995) 14.
120 Cf. Hutton, '*The Man in the Moone* and the New Astronomy' (2005) 4-5.
121 Godwin, *The Man in the Moon,* 76. The theme of the 'negro' companion in solitude is of course known from Robinson's friend Friday in Dafoe's *Robinson Crusoe* (1719).
122 Godwin, *The Man in the Moon,* 88-90; Hutton, '*The Man in the Moone* and the New Astronomy' (2005) 7-8.

Christianity (of the true, Protestant sort), and they are superior to earth in all aspects of life: they live longer, are more peaceful, more religious, less inclined to war or sin, and even their beautiful musical language is superior.[123] However, not all is perfect. Although a justice system is not really necessary in Lunar society, one punishment exists: the least worthy Lunars are banished as infants to earth, particularly to America, but sometimes also to Europe.[124] Since Gonsales longs for his own family, after a while he leaves the moon and returns to Earth. Landing in China, Gonsales finds himself in yet another unknown world. After a short episode here, he finally returns home with a group of Jesuits.

Although the *The Man in the Moon* has often been interpreted as a utopian work, it lacks the explicit moral or idealistic allegories and claims custom to the genre. On the other hand, the work does have some satirical and utopian aspects, such as the ridicule of Spain and Catholicism and the description of the lunar society as a classical hereditary monarchy.[125] As *The man in the Moon* is neither a vehicle of a scientific message like the *Somnium,* nor a utopian work in the strict sense, I am apt to believe Godwin's own qualification of the work as primary literary in nature.[126]

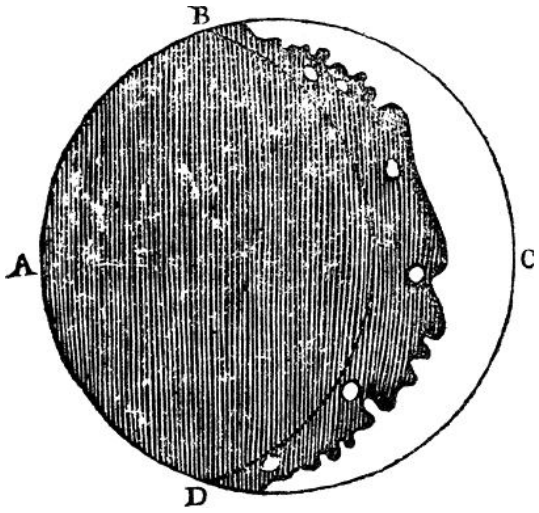
While the work fully utilizes its 'post-Copernican' and 'post-Galilean' context, it does not depend on it. Godwin takes an eclectic approach towards his scientific and literary sources: describing his lunar world in utopian terms, the moral and idealistic lessons of utopian literature remain absent; and while the structure of the work strongly resembles that of Lucian's *True Story* (sea voyage – island – unintended celestial voyage – visit to the moon – return – exotic destination), it lacks the biting sarcasm of the classical satire.[127] *The Man in the Moon* can therefore be regarded as primarily an early modern adventure novel. Perhaps it was especially the light-heartedness of this popular-scientific novel that made it so popular and influential?

Godwin's frivolous work reveals an important aspect of seventeenth-century cosmological literature. The mildly satirical *Man in the Moon* gives witness of a very relaxed approach to the theme of planetary life, that reflects on more serious contemporary writings as well. This interferes with the often much too serious interpretations of these texts by many modern scholars – the plurality of worlds was not the touchstone of orthodoxy versus materialism and atheism that they believe it to be.

The first work mentioning Godwin's *The man in the Moone* is the revised and expanded third edition of John Wilkins's *Discovery of a World in the Moone* of 1640: “I chanced upon a late Fancy to this purpose under the fained name of *Domingo Gonsales*, written by a late Reverend and Learned Bishop: In which […] there is delivered a pleasant and well-contrived Fancy concerning a Voyage to this other World.”[128]

123 Godwin, *The Man in the Moon ,* 98-99.
124 Godwin, *The Man in the Moon,* 105-106.
125 Cf. Butler, 'Introduction' (1995) 41-47; Gutkhe, *The Last Frontier* (1990) 156-158; Ferraro, 'Giordano Bruno's *Infinitely Numerous Worlds*' (2006); Hutton '*The Man in the Moone* and the New Astronomy' (2005). I strongly disagree with Guthke, who claims that the work “focuses on the possibility of a “different” kind of humanity in the context of the universe revealed by the new science.” *The Last Frontier* (1990) 158.
126 Cf. also Godwin, *The man in the Moon,* 71.
127 Cf. §2.2.
128 Cited in Butler, 'Introduction' (1995) 58.

Wilkins's work is a typical piece of Renaissance learning. It discusses and references many classical sources, and it draws on recent scientific developments and findings as well. Its main topic is the defence of the possible existence of a Lunar world. In his foreword, Wilkins writes that the work is the fruit of 'lighter studies', and although it presents serious arguments, readers should bear in mind that the argumentation is neither conclusive, nor pretends to be so.[129] This disclaimer is very similar to those made by Fontenelle and Huygens in their works defending the plurality of worlds.[130] The work was reprinted and translated many times. An English copy of the 1640 edition and a French translation of the work are mentioned in the auction catalogue of Christiaan Huygens's library.[131]



4.3 The shadows on the moon.Wilkins uses this image, based on a figure in Galileo's *Siderius Nuncius* (1610), to demonstrate that the Moon has mountains. *The Discovery of a World in the Moone,* 126.

Divided in thirteen propositions, the text not only examines recent discoveries about the nature and surface of the moon and the possibility of a world in the moon, but also gives attention to some theological considerations. Wilkins's scientific argumentation in favour of the lunar world is quite simple. First he argues against the theory of natural places, and then he appeals to both Copernican astronomy and telescopic observations to demonstrate that the moon is not intrinsically different from Earth. He also discusses some theological sensitivities, but nevertheless concludes that the similarity between the moon and the earth suggest that a world could exist in it. Dealing with possible religious opposition to his proposition, Wilkins points out the theological significance of a plurality of worlds. Mainly, he argues that no theological objections can be raised against the existence of a world in the moon: though Scripture nowhere indicates the existence of more than one world, it does not deny the possibility either. The implication for Wilkins's view on the relation between Scripture and the new science is therefore significant: Scriptural negative authority is

129 Wilkins, *The Discovery of a World in the Moone,* A3.
130 Cf. Cressy, 'Early Modern Space Travel' (2006) 979.
131 Only the titles of the works are mentioned. The entry 'Le Monde dans la Lune' almost certainly refers to *Le monde dans la lune, divisé en deux livres: le premier, prouvant que la lune peut estre un monde; le second, que la terre peut estre une planette*. *De la traduction du sr de la Montagne.* Rouen, 1656. Surprisingly, this translation does not mention John Wilkins, but only the name of the translator. Cf. the section 'Libri Mathematici in Octavo', Nos. 49, 57, 58, 63 in the *Catalogus Variorum & insignium in omni Facultate & Lingua Librorum, Praecipuè Mathematicorum, Politicorum, & Miscellaneorum Amplissimi ac Nobilissimi Viri Christiani Hugenii Zuylichemii.* The Hague, 1695; *OC,* XXII.

invalid outside of the realm of religion.

Wilkins argumentation was repeated by later seventeenth-century authors. Although Christiaan Huygens in the *Cosmotheoros* rejects the plausibility of lunar life, his argumentation for planetary life in some ways resembles that of Wilkins. It is important to note that Wilkins argues in the *Discovery of a World in the Moone* from a general level to the particular. First, he clarifies that the strangeness of his proposition of a world in the moon is no valid argument for its rejection. Then he rejects the general physics of Aristotelianism and establishes the general theological admissibility of his thesis. Subsequently, he gives his astronomical and telescopic arguments for the earth-like nature of the moon. And only in his last proposition does he conclude that the existence of a lunar world is quite possible, even probable. This type of reasoning is used also by – among others – Fontenelle and Huygens.

Interestingly, after asserting the probability of lunar inhabitants, Wilkins does not give any clues about the possible nature and appearance of these 'Selenites':

> ’tis requisite that in the next place I should come unto the third thing which I promised, and to say somewhat of the inhabitants, concerning whom there might be many difficult questions raised, as whether that place be more inconvenient for habitation then our World (as *Keplar* thinkes) whether they are the seed of *Adam*, whether they are there in a blessed estate, or else what meanes there may be for their salvation, with many other such uncertaine enquiries, which I shall willingly omit, leaving it to their examination, who have more leisure and learning for the search of such particulars.[132]

It might be suggested that in refraining from specific statements about the lunar inhabitants and their religious state, Wilkins avoids possible controversy. However, it may just as well show that he respected the reasonable boundaries of what can and what cannot be known – leaving these speculations to the kind of literary fancies as written by Lucian, Kepler and Godwin. David Cressy therefore rightly points out that the main content of the *Discovery of a World in the Moone* consists of a learned defence of Copernicanism, that takes into account not only astronomical arguments, but also tradition and theology.[133]

Just like Kepler's *Somnium,* Wilkins's book was a work of scientific popularization. Apart from defending Copernicanism, Wilkins also offers an early comprehensive and positive response to the findings of the New Philosophy. *The World in the Moone* may not be as exciting and revolutionary as some other cosmological works, but it gives yet another interesting insight in the seventeenth-century approach towards the plurality of worlds and planetary life. Whereas Godwin's work shows that these concepts can be the subject of an entertaining adventure novel, Wilkins's book further demonstrates that the belief in a lunar world does not have to be problematic to the seventeenth-century mind. It is only when the plurality of worlds is connected

132 Wilkins, *The Discovery of a World in the Moone,* 187-188 (prop. 13).
133 Cressy, 'Early Modern Space Travel' (2006) 979.

4.4 Frontispiece of a later edition of Kircher's *Iter exstaticum.* The cosmological/astronomical system depicted is that of Tycho Brahe: the planets orbit the sun, the sun orbits the Earth; and outside of the sphere of the fixed Stars is the dwelling of God (JHWH). Deutsche Fotothek.

to a materialistic world view, that the concept becomes controversial – or rather, the vehicle of a controversial idea. But this 'controversial turn' only takes place in the second half of the seventeenth-century, when the old Aristotelian world view was gradually replaced by a new corpuscular and mechanistic natural philosophy.

Godwin and Wilkins can be seen as representative figures for the understanding of discussions about the plurality of worlds in the middle of the seventeenth century. The subject was discussed by many authors in different ways, and touched upon in a wide variety of literary contexts, ranging from satirical novels to mystical poetry, theological disputations and tracts on natural philosophy. Just as Godwin and Wilkins, these authors were indebted to both the classical sources of cosmic fiction, as well as Kepler's innovative *Somnium.* The themes do not substantially diverge from examples provided by the early works by Godwin and Wilkins themselves.[134] Of course, there were also authors who strongly opposed the idea of planetary life. The most interesting of these texts is a theological polemic by the Jesuit scholar Athanasius Kircher (1602-1680), published in 1656, and titled *Itinerarium exstaticum* (from the second edition onward: *Iter exstaticum coeleste*). Although the argumentation of the work is not very interesting, two things make it worth mentioning here: first, it is discussed and ridiculed by Christiaan Huygens in the second book of his *Cosmotheoros*;[135] second, it is a work that not just rejects the plurality of worlds, but that uses the literary form of a cosmic voyage to do so. The work relates the story of a soul who takes an 'ecstatic voyage' through the universe. Attending the moon, planets, sun, and fixed stars, he nowhere finds life. In his inscrutable wisdom, God has decreed that only Earth is to be the abode of man, and life in general, and that the other celestial bodies are there for the sake and enjoyment of Man. Kircher also rejected the Copernican concept of the motion of the Earth, and defended the system of Tycho Brahe (1546-1601), that holds that the planets orbit the sun, while the sun orbits the Earth.[136]

4.3 The Scientific Revolution and mechanistic natural philosophy[137]

Although Aristotelian physics had lost much of its esteem and credibility in the later sixteenth century, no satisfactory alternative had yet been developed in the early seventeenth century. Although natural philosophers became aware of the limits and problems of Aristotelianism, they did in no way expect or

134 For an overview of these other (minor) contributions on the subject, cf. on the formal aspects of the plurality of worlds cf. Dick, *Plurality of Worlds* (1982); and Guthke, *The Last Frontier* (1990); for the literary aspects cf. Nicolson, *Voyages to the Moon* (1948). Several texts that I have not discussed, but which are worth mentioning are systematic expositions on the plurality of worlds by Pierre Gassendi and Pierre Borel (1620-1671); Satan's cosmic voyage in John Milton's (1608-1674) *Paradise Lost,* II; a biting satire by Cyrano de Bergerac; a utopian cosmic voyage by Margaret Cavendish. These last two texts do turn back to atomist materialism and plurality in infinity. Cyrano also uses his satire to establish a blunt relativistic anthropology.

135 *CW,* 102-105. It is noteworthy that despite his contempt for the *Iter Exstaticum*, Huygens respects Kircher for the famous *homo universalis* that he was.

136 Guthke, *The Last Frontier* (1990) 123-124.

137 In this concise overview I generally follow Vermij, *Kleine geschiedenis van de wetenschap* (2006). On the problematic nature of the term 'Scientific Revolution', that I will use for the sake of convenience, cf. Jorink, *Het Boeck der Natuere (*2006) 22-23; and Vermij, *Kleine geschiedenis van de wetenschap* (2006) 6-8.

prepare the scientific revolution of the seventeenth century.[138] Natural philosophy remained a predominantly abstract and scholastic activity and humanist scholars primarily tried to replace the depleted methods of scholastic Aristotelianism with an appeal to the classics, especially Neo-Platonism and hermeticism. Giordano Bruno's hermetic system is an example of the surprising consequence of the humanist principle that older wisdom is greater wisdom. While the Neo-Platonic impulse in philosophy was predominantly concerned with the human soul and with metaphysics rather than with a better understanding of natural reality, some practical enrichment of the study of nature also occurred in the period. Apart from a growing interest in 'natural history', the collection of knowledge about natural phenomena, an early impulse to the study of nature was provided through the cautious revitalization of the Greek mathematical approach to nature and astronomy, of which Copernicus *De revolutionibus* of 1543 is of course a crucial early example. The new impulse of humanism (the cosmological writings of Aristotle and Ptolemy were now directly studied with a new thoroughness) and mathematics led to various revolutionary ideas and observations. Not only this critical study of the classics, but also precise observations were important: while the immutability of the heavens had been one of the pillars of Aristotelian cosmology and the qualification of the celestial sphere as divine, this dogma was destroyed by Tycho Brahe's observation of a new star in 1572, that remained visible for several months (it was a supernova).[139] Working at the turn of the century, men like Galileo (1564-1642) and Kepler further developed the new astronomy. Kepler's introduction of elliptic planetary orbits – not acknowledged by most of his contemporaries – was revolutionary. More important however, was his attempt to understand not only the mathematics of astronomy, but also the physics of the heavens: why do the planets move? Posing this kind of questions, the new astronomy not only tried to correct the mathematics of Aristotelian physics, but aspired to actually overthrow Aristotelian physics and come to a new and improved understanding of nature.[140] The nature of the heavens and the Aristotelian dichotomy between heaven and earth became the central question in natural philosophy. The challenge of Aristotelian cosmological ideas by the practical and mathematical approach applied by Galileo in this period was crucial.

Educated in the mathematical tradition of Italian engineering, Galileo Galilei felt a strong dislike for Aristotelian natural philosophy and approached the natural world not in the abstract and speculative manner of Aristotelianism, but regarded the world as a mechanical construction. Using mechanics and building his own instruments for some of the first 'modern' scientific experiments, he tried to unravel the mysteries of natural phenomena, so expanding the knowledge of nature by mathematically understanding it. It was in the Italian circle around Galileo that the artificial effects generated in experiments were first understood as a means to understand nature, instead of just a source of wonder and entertainment.[141] Several of the results of Galileo's technical understanding of nature would be ground-breaking. His astronomical observations using a

138 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 31.
139 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 59.
140 Cf. Cohen, *De herschepping van de wereld* (2007) 87 ff., 110-130; Tamny, 'Atomism and the Mechanical Philosophy' (1990) 598-693; Vermij, *De wetenschappelijke revolutie* (1999), 73 ff.;
141 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 68.

telescope revealed that the planets were not the perfect heavenly spheres of Aristotle, but had craters, texture and even satellites, and were therefore of the same matter and nature as the earth!

Although their quantitative mathematical approach to physics was revolutionary and would eventually overthrow the qualitative system of Aristotelian scholasticism, the work of both Kepler and Galileo had its limitations. In his attempt to not only understand the 'how' of astronomy, but also its 'why', Kepler subjected his physics to a classical notion of 'world-harmony', thus preventing him from developing a new world-view that would be radically mechanical and that could definitively support the mathematical understanding of nature. On the other hand, Galileo's work remained mostly limited to the explanation of separate phenomena, failing to produce a comprehensive framework for his physics. That Galileo presented himself exclusively as a mathematician and that he forsakes to develop the new philosophical system that was required to complete the overthrow of Aristotelianism held both advantages and disadvantages. As long as the new mathematical approach to nature was not founded in a wider philosophical and religious world view, it could remain rather uncontroversial, but on the other hand, it also remained an anomaly to many contemporaries: holding on to the orthodox philosophical and religious world view, they could not make much of Galileo's revolution.[142] However, despite these restrictions and the lack of a comprehensive new world-view able to replace Aristotelianism, scientists like Galileo sent natural inquiry into a new direction.

Due to these reasons, the new science that emerged remained rather diffuse and incoherent during the first decades of the seventeenth century. However, all over Europe natural philosophers began to search for a new world-view to accommodate the new science. In the late 1630's, it was the Frenchman René Descartes (1596-1650) who shocked the learned world with the publication of a new and comprehensive philosophical system, explicitly intended to destroy Aristotelianism and provide human knowledge with a completely new foundation. Methodologically revolutionary was Descartes's rejection of tradition as the principal source of true knowledge: this not only opposed scholasticism, but also the methods of the humanist scholars. Not tradition formed the foundation of knowledge, but human reason, experience, and common sense.[143]

Replacing Aristotelian metaphysics, physics, cosmology and epistemology, Descartes changed everything. Also in the fields of natural philosophy and cosmology, the new system was both influential and controversial. The *Principia philosophiae* from 1644 was his most important publication on natural philosophy. In this work, Descartes simply rejected the hierarchical order that was so fundamental to Aristotelian cosmology and physics. He claimed the cosmos had no centre, but was boundless, and he rejected the qualitative theory of matter and natural places, replacing it with a corpuscular (quantitative) theory of matter not much unlike atomism – which was at the time revived, most notably by another Frenchman, Pierre Gassendi (1592-1655).[144] According to Descartes, the cosmos is not comprised of one single sphere that contains all elements of creation and keeps them in order, but of a multitude of solar

142 Vermij, *Wetenschappelijke revolutie* (1999) 80.
143 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 79.
144 Cf. Fisher, 'Pierre Gassendi' *SEP* (2009). On the differences between atomism and other corpuscular theories used in mechanical natural philosophy, such as Descartes's, cf. Chalmers, 'Atomism from the 17th to the 20th Century' *SEP* (2010).

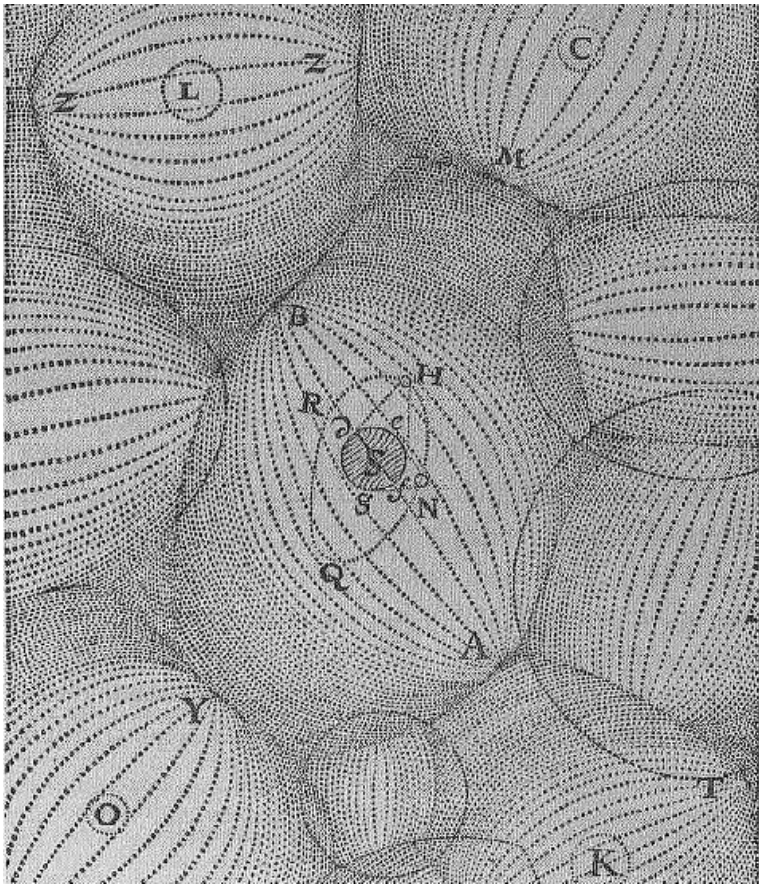
systems, each contained in a so-called 'vortex', which is basically a huge circulation of matter in space.

According to Descartes, all matter is essentially similar, whether located on earth, in the heavens, or on the planets. Consequently, all matter behaves similar. In the end, Descartes's physics comes down to his theories of matter and collision. The causality that is implied by this physical theory expresses a fundamental unity and uniformity in nature. Descartes was the first to express this uniformity of nature as 'laws of nature'. While Aristotle's world was determined by (Divine) order, the Cartesian world was ruled by laws. When God had created the world, he had set these fundamental laws, to which all matter was subjected.[145] These rules were like mathematical axioms: under all possible circumstances and on all kinds of bodies, they always work the same. Laws of nature are immutable and absolute. Consequently, every being or body and every phenomenon in the natural world can be understood in a similar way. If one would fully understand the laws of collision, one could eventually understand all natural phenomena (Descartes laws of nature were essentially laws of motion). This uniform understanding of nature could hardly be more different than Aristotelian natural philosophy, with its, categories, essences, and qualifications. Another fundamental innovation of Cartesianism was that natural phenomena were now regarded as the result of causal processes, forming chains of action and reaction that could be understood mathematically and physically. Again, the arbitrary explanations of Aristotelian teleology, which found cause in essence or result, were replaced by a uniform theory.[146] But at the same time, the laws of nature made sure that Descartes's corpuscular theory described a world of order, unlike the random and chaotic universe of ancient atomism.

Descartes's system had in general much to offer to the emerging new science. The greatest merit of his new philosophy was that it offered a new comprehensive theory in which many recent scientific developments and discoveries became understandable, made sense. While for example the heliocentric system was an absurdity in the Aristotelian system, it was perfectly logical in Descartes's mechanical world view. Not only offered the Cartesian system a synthesis of the wide spectrum of the recent scientific developments and discoveries, it was also a system that stimulated further research. The mechanical chain of causes and consequences that constitutes nature invites study and curiosity. Concluding, Cartesianism not just offered a new synthesis of knowledge and a new mechanical world view, it provided the inquiry of nature with a new method, and with a new scientific program. This program of Cartesian philosophy would set the agenda for scientists in the second half of the seventeenth century. Institutes like the English and French royal scientific academies and men like Christiaan Huygens, Robert Boyle and Isaac Newton would further develop Descartes's natural philosophy, and in the process correct most of his own explanations of specific natural phenomena. Philosophers like Spinoza and Leibniz would also think through its philosophical and religious consequences; supporting orthodoxy or stirring controversy and crossing the boundaries of heresy, they laid

145 Descartes claimed that only three laws of nature existed, regulating the movement of matter (matter is inert and can only be moved by outward movement, matter moves in a straight line when unhindered, movement is preserved). Cf. Slowik, 'Descartes' Physics' *SEP* (2009); Vermij. 'De wetten der natuur' (1999) 109.

146 Vermij, *Kleine geschiedenis van de wetenschap* (2006) 77-78.



4.5 Cartesian vortex cosmology. One of several similar images from the *Princia Philosophia* (1644).

the foundations for the early Enlightenment.[147] While much progress was made in the understanding of nature and the elaboration of the mechanical world view, not in the last place by Christiaan Huygens, these developments met with intense opposition as well.

4.4 Cartesian controversies in the Dutch Republic 1640-1700[148]

Especially in the Dutch Republic, where Descartes had worked and published, his new philosophy was initially greeted with great enthusiasm by academics and dilettantes alike. But while the mechanical natural philosophy developed by Descartes offered the new synthesis that many natural philosophers had been searching for, it also raised many theological and philosophical objections. Not surprisingly therefore, in the Dutch Republic the new philosophy was met not only with enthusiasm, but with philosophical and theological opposition as well.

That the new Cartesian physics raised controversy despite its great practical benefits is not that surprising, for in the early modern world-view natural philosophy was directly connected to philosophy and theology in general, like it had been in scholasticism. Therefore every attempt to formulate a new natural philosophy inevitably had theological consequences as well. Especially when this new philosophy dealt with the governing principles in nature, such as Descartes's laws of nature, the religious implications were significant.

147 Cf. Israel, *Radical Enlightenment* (2001).
148 Although I focus on the Dutch situation, these discussions and debates transcended the Dutch context.

As in Christian (scholastic) doctrine every natural or supernatural phenomenon is ultimately ruled by God, it is important to be able to determine (to some degree) which event is governed through the created natural order, and which event is the result of a free act of Divine will, outside of the natural order. More practical: how to discern between a natural phenomenon and a miracle or sign from God? While this problem had been subject of theological debate since medieval scholasticism, the Cartesian concept of a nature ruled by law made it even more difficult to make such a distinction between the natural and the supernatural. The basic problem raised by Descartes's physics is as follows: because the laws of natures are universal and absolute, the possibilities to explain exceptional events as the result of some supernatural action or effect become very limited. The unusual no longer implied a suspension of the natural order of nature, but unusual events simply implied that their causes were still unknown. So for example, while many seventeenth century Calvinists understood the occurrence of a comet as an omen sent by God, a Cartesian philosopher would try to find a mechanical description of this phenomenon formerly not understood, thereby explaining comets not as signs from God, but as an astronomical event caused by natural causes.[149] The religious implication is clear: while God had been always recognizably present in the material world, he became much further removed from everyday events in the mechanical universe. No longer could God's finger be found in miracles and comets, but only distantly, in the natural laws that governed these events. While the denial of the hand of God in the appearance of a comet was one thing, the way in which some Cartesians dealt with the Bible gave rise to even more disapproval. Criticizing the possibility of supernatural events in general, because they were in conflict with the laws of nature, some went so far to deny even the biblical accounts of miracles. When controversy over Descartes's philosophy fired up in the Dutch Republic, it is therefore not surprising that orthodox Calvinists soon identified Cartesianism with atheism.

The resistance against the new philosophy was led by the renowned theological professor and minister Gisbertus Voetius (1589-1676) and his influential faction. Voetians believed that Cartesianism was based on doubt and that the abandonment of Aristotelian philosophical principles was not much more than concealed atheism. The central issue in the conflict over Cartesianism was therefore Voetius's belief that Descartes's alleged scepticism ultimately undermined all knowledge of religion, philosophy and even science.[150] Especially in the 1640's, the 'Voetian' faction tried to remove and keep out Cartesianism from the Dutch universities.[151]

While Cartesianism was thus confronted with some fierce resistance within the Dutch universities, it was also embraced by many Dutch thinkers and scientists. From the 1650's onward, it turned out that the Voetian purge of the universities had failed and that an ever increasing number of students and scientists, some of them devout followers of the Reformed Church, were brought over to the Cartesian camp.[152] Moreover, not only Dutch natural philosophers were enthusiastic about the new approach, but quite many Calvinist

149 On the seventeenth century debate on comets, cf. Jorink, *Het Boeck der Natuere* (2006); Jorink, 'Van omineuze tot glorieuze hemeltekens' (1999) 89-104.
150 Israel, *The Dutch Republic* (1998) 890-892.
151 Cf. Van Bunge, *From Stevin to Spinoza* (2001) 34-44; Vermij, *The Calvinist Copernicans* (2002).
152 Israel, *The Dutch Republic* (1998) 891.

theologians as well. Instead of rejecting Descartes's philosophy as a threat to their Aristotelian-Christian world view, they embraced Cartesian natural philosophy while maintaining their Calvinist orthodoxy and its theological interpretations of the bible. Most famous in this respect is the Cocceio-Cartesian alliance, named after the German theologian Johannes Cocceius (1603-1669), who arrived in the Republic in 1650. Cocceianism acknowledged the division between physics and theology that Descartes had made and it believed that the Bible was not concerned with natural truths, but with theological truth, namely salvation. They therefore not only accepted Cartesian natural philosophy, but also rejected the biblical literalism defended by the Voetians.[153] However, the ungodly consequences that Cartesianism could imply remained a threat. While the Voetians feared Cartesianism in general, the moderates feared the identification of Cartesianism with the ideas of a few radicals.

Even though Descartes's philosophy became more widely accepted in the second half of the seventeenth century, both its adversaries and proponents were appalled by some of the philosophical and theological ideas that would be formulated by such Cartesian radicals as Adriaen Koerbagh (1623-1669), and most importantly by the philosopher Baruch (Benedict) de Spinoza (1632-1677). While Descartes had proclaimed the independence of philosophy and science from theological domination, Spinoza went much further, as he denied the distinction between physics and theology, claiming the predominance of philosophy. According to Spinoza, it was theology that had to answer to philosophy, not the other way around. In Spinoza, the orthodox opponents of Cartesianism found their fears realized: inevitably, Cartesianism would lead to materialism and atheism. While Descartes had remained cautious not to offend religion, Spinoza rejected miracles, creation, biblical infallibility and authority with an explicit appeal to the laws of nature.[154] These claims were considered blasphemous and the book in which Spinoza published these ideas, the *Tractatus Theologico-Politicus* (1670) was received with outrage. But Spinoza's 'heresy' did not end with criticism of Biblical authority, as the image of God he formulated was very distant from Jewish or Christian orthodoxy. Spinoza's God is no longer the Judeo-Christian creator, but an infinite being, 'in' which everything exists as finite modes. No substance exists except God.[155] In fact, Spinoza identified God with Nature, or more specific with 'natura naturans', the creative power in Nature and the laws that rule it. This God, although he is the only free cause, could through his absolute nature not have produced Nature in any other way than it has been produced. From these propositions follows a deterministic understanding of reality: fundamentally, everything is determined by necessity and causality.[156] Clearly, Spinoza's God is no longer the personal God of Judaism and Christianity. Academic debate still goes on today about the exact interpretation of Spinoza's (meta)physics and theology. Although his contemporaries discussed the exact meaning of his work as well,

153 Cf. Van Bunge, *From Stevin to Spinoza* (2001), 44 ff; Vermij, *Calvinist Copernicans* (2002) Ch. 12-14; Israel, *Radical Enlightenment* (2001) 23-29.
154 Vermij, 'De wetten der natuur' (1999) 116-117; Jorink, *Het Boeck der Natuere* (2006) 26-27.
155 Donagan, 'Spinoza's theology' (1996) 154.
156 Israel, *Radical Enlightenment* (2001), 231-232; Bennett, 'Spinoza's metaphysics' (1996) 74-76; Nadler, 'Baruch Spinoza' *SEP* (2011) §2.1.

there was a wide agreement about the controversial nature of Spinoza's philosophy: Spinoza was soon considered to be the ultimate heretic, and he was branded an atheist by public and intellectual opinion. In the period 1650-1750, “no other philosopher even remotely rivalled Spinoza's notoriety” as the chief challenger of the fundamentals of revealed religion, received ideas, tradition and morality.[157]

4.5 The Book of Nature

Despite the fact that Spinozism itself was widely condemned in the seventeenth century, some of its basic notions correspond to more moderate new ideas. Although most intellectuals and natural philosophers did not follow Spinoza in his identification of God with nature and his subjugation of the Bible and theology to the judgements of reason, his radical philosophy was representative for and had a great influence on the rationalism that gained ground in the last decades of the century. While most supporters of the new philosophy upheld Gods power to (temporarily) alter or lift the laws of nature, Spinoza's claim that God could not do so was not very distant from the increasingly popular idea that God did not want to do so. But Spinoza also became an argument in the hands of the anti-Cartesians, who frequently tried to associate more moderate Cartesian thinkers with the 'ungodly' philosopher. An example is found in the fierce attacks on the minister Balthasar Bekker (1634-1698), who in his 1696 book *De betooverde wereld* argued against all kinds of popular 'superstition', also denying the influence of the Devil on the material world. Although Bekker was a faithful reformed minister, his opponents tried to associate his Cartesian hermeneutics with Spinoza's 'atheist' understanding of the Bible.[158]

However, despite their efforts to impeach Cartesian moderates, the anti-Cartesian camp did not succeed in eradicating the new philosophy, and eventually a new spirituality developed that made explicit use of Cartesian concepts. Surprisingly, even the Spinozist understanding of God and Nature shows some striking similarities with the praises of God's Design in nature expressed by many scientists. For example Johannes Swammerdam (1637-1680), famous for his microscopic work and his study of the surprisingly complex anatomy of 'lower creatures' such as insects, recognized in the astonishing results of his natural enquiry the fingerprints of God.[159] Not much unlike Huygens's planetary explorations, Swammerdam's observations uncovered a new world that had been previously inconceivable. While this microscopic 'plurality' was just as baffling to the early modern mind as the possibility of planetary worlds with their own inhabitants, Swammerdam was now able to interpret this mystery not as a challenge to his faith, but as another expression of the Creator's greatness.

Notwithstanding that contemporaries derived Spinoza's atheism especially from his identification of God's will and intellect (free but necessary) and of the power of God and the power of Nature, it was in God's

157 Israel, *Radical Enlightenment* (2001) 160. Althoug it would be interesting, I will not extensively discuss Spinoza's thought and reception, but suffice with some references. Cf. Stewart, *The Courtier and the Heretic* (2005); Van Bunge, *From Stevin to Spinoza* (2001); Van Bunge and Klever, *Disguised and Overt Spinozism* (1996); Israel, *Radical Enlightenment* (2001); Nadler, *Spinoza* (1999); Garrett, *The Cambridge Companion to Spinoza* (1996).
158 Van Bunge, *From Stevin to Spinoza* (2001) 153.
159 Jorink, 'Outside God, there is nothing' (2003) 85-87.

works in Nature that the more devout rationalists found the proof of Gods existence.[160] While the identification of God with Nature by Spinoza made him an atheist in contemporary eyes,[161] this devout expression of Swammerdam is not that different: “en waar in dog is HY anders, als alleen in syne eygen werken kennelyk?”[162] Despite the similar resemblance of these ideas, the natural theology expressed here by Swammerdam was employed by many authors at the end of the seventeenth century, especially against the dangers of Spinozism and atheism. At the turn of the eighteenth century, some thinkers therefore reversed the argument: the laws of nature did not expel God from nature, on the contrary, they pointed to their Creator. In order to avoid any identification with the 'ungodly' Spinozists, moderate Cartesians therefore developed new ways to employ the new philosophy in favour of religion. While Descartes had cut the ties between philosophy and theology, these Cartesian apologists tried to connect theology and philosophy once more.[163]

The religious acceptance of Cartesianism in the work of intellectuals like Swammerdam and Huygens is illustrated as well by the language that seventeenth century scientists, theologians and poets used in relation to nature. Characteristic of many early-modern writings discussing is the metaphorical description of nature as the 'Book of Nature'. The idea of nature as a 'book' not simply comprised the idea that God could be known from nature, like a second book of revelation besides the Bible, but its use and meaning was remarkably diverse.[164] For the understanding of Huygens's *Cosmotheoros*, the use of the metaphor in the Dutch Republic as studied by Eric Jorink is of particular interest.[165] As Jorink argues, the notion that God made himself known to man not only by the Bible, but also by the Book of Nature, “lay deeply rooted in Dutch intellectual culture.”[166] The concept was well known and it was not only understood as a 'road to God', but also as a conclusive argument against atheists and other heretics challenging divine providence. Although the notion of the Book of Nature was therefore of great importance to the Dutch Calvinist understanding of nature, it always remained subordinate to the other book of revelation: it was the literal reading of the Bible that contained the only correct interpretation of the Book of Nature. As one Dutch professor of theology put it, 'the Book of Nature demonstrates Gods existence, the Book of Scripture reveals who he is.' So to say, it was only through piety and the understanding of Scripture that the natural world could become the Book of Nature.[167]

160 Van Bunge, *From Stevin to Spinoza* (2001) 114.
161 More precisely, it was the fatalism implied by Spinoza's identification of God with Nature that made Spinoza an atheist. Cf. the letter on Spinoza by Lambert de Velthuysen to Jacob Ostens, Letter 42 in: Spinoza, *Complete Works*, 869-878.
162 'For where else but only in his own works is He known?', Swammerdam, *Bybel der Natuure,* I, 394.
163 On the emergence of this so-called 'physico-theology' in the Dutch Republic, cf. Vermij, *Secularisering en natuurwetenschap* (1991); Vermij, *Calvinist Copernicans* (2002) 352-355; and in the wider European contex, cf. Israel, *Radical Enlightenment* (2001) 456-464.
164 For a more extensive and general discussion of the 'Book of Nature', cf. Van Berkel and Vanderjagt, *The Book of Nature* (2006).
165 The following passage on the 'Book of Nature' relies heavily on especially Jorink, 'Reading the Book of Nature' (2006) 45-69; Cf. also Jorink, *Het Boeck der Natuere.* (2006); Jorink, *'Geef zicht aan de blinden'* (2008).
166 Jorink, 'Reading the Book of Nature' (2006) 47.
167 Jorink, 'Reading the Book of Nature' (2006) 48-49.

This notion of the Book of Nature was of great importance to the understanding of nature in the Dutch Republic and was not just a theoretical idea. Not only scientists and theologians praised the manifestations of God's glory in Creation (ranging from the changing of the seasons to natural 'rarities' to astronomical phenomena), but also literary works expressed this piety, such as Constantijn Huygens's poem about the seemingly more everyday beauty of his domain *Hofwijck,* published in 1653. Justified through such biblical texts as Psalms 19 and 104 and Romans 1:20, the biblical language and mindset expressed through the Book of Nature remained an important theme in seventeenth-century Dutch learned culture. The variety of uses of the metaphor could also be founded on biblical verses, ranging from the piety of the Psalms: "The heavens declare the glory of God; the skies proclaim the work of his hands;" to the polemical argument of Paul: "For since the creation of the world God's invisible qualities – his eternal power and divine nature – have been clearly seen, being understood from what has been made, so that people are without excuse."[168]

It was the rise of Cartesianism in the 1640's that first seriously challenged the Calvinist biblical discourse that shaped the Dutch approach to natural philosophy. The reserve in the Dutch Republic in accepting the new heliocentric theory of Copernicanism in the first half of the century is partially a consequence of the Biblical presumption of a geocentric universe. When Descartes introduced his radical new (natural) philosophy, he therefore also stirred theological controversy.[169]

The rise of Cartesianism did not simply effect the demise of the metaphor, but instead contributed to the emancipation of the Book of Nature to a Book in its own right, that could also be understood without the biblical and theological presuppositions held by the Calvinist theologians. The development that the Book of Nature was more and more understood as a revelation alongside of, instead of subordinate to Scripture was also furthered by the progress in philological research in the seventeenth century and by the emergence of critical examinations of the Biblical text after 1650. At the end of the century, many authors believed that the Biblical references to the natural world could be critically assessed on the basis of the Book of Nature, in effect on the findings of the natural sciences. The understanding of nature therefore no longer had to be reconciled with the letter of Scripture. Along with the emancipation of the Book of Nature, its meaning also shifted from the second half of the seventeenth century onward, and the idea no longer indicated a pious searching in the natural world for wonders and biblical references such as natural rarities and monstrosities or comets and miracles, but a praise of the Design in nature, and of its Architect. Following this development, the term Book of Nature eventually became obsolete in the eighteenth century, as praises of the design of nature no longer referenced to the revelation of God, but to the Architect or Author himself.[170]

4.6 Fontentelle's Entretiens sur la pluralité des mondes

At the beginning of this chapter I have discussed some important contributions to the plurality of worlds

168 Psalm 19:1, Romans 1:20, *New International Version*, 2010.
169 Cf. Israel, *Radical Enlightenment* (2001); Jorink, 'Reading the Book of Nature' (2006) 54 ff.; specifically on the controversies surrounding Copernicanism cf. Vermij, *Calvinist Copernicans* (2002).
170 Jorink, 'Reading the Book of Nature' (2006) 54-68.

tradition in the seventeenth century. Now that I have clarified the developments in natural philosophy that shaped the intellectual context in which Christiaan Huygens lived and worked, I will discuss one final text that preceded the writing and publication of the *Cosmotheoros* and that also strongly influenced Huygens's final work. This popular work from 1686 was written by Bernard le Bovier de Fontenelle (1657-1757), who was one of the leading intellectuals of French society in the late seventeenth and early eighteenth century. It is titled *Entretiens sur la pluralité des mondes* and was 'the astronomical best seller of the Age of Enlightenment', going through thirty-three French editions before its author's death, as well as numerous editions in German and English.[171] With an anachronism it can be called an early work of 'popular science', owing its popularity not only to the speculative philosophical discussions and the introduction to Cartesian astronomy that it contained, but also to its literary attractiveness.

This entertaining work contains a literary account of six discussions on six evenings between 'a philosopher' and a dilettante marchioness about the infinite nature of the universe, cosmology and the plurality of worlds in particular. Based firmly in Cartesianism and specifically Descartes's vortex cosmology, the first discussion of the *Entretiens* makes the case for the Copernican system, while the second and third discussion deal with life on the moon.[172] Rejecting the belief in Lunar seas, Fontenelle argues for the possible existence of life-sustaining vapours.[173] The fourth and fifth conversation deal with the planets and the fixed stars, drawing most clearly from the Cartesian concept of vortices. In the fifth discussion, Fontenelle formulates the plurality of worlds in clearly Cartesian terms: “Les Etoiles Fixes sont autant de Soleils, notre Soleil est le centre d'un Tourbillon qui tourne autour de lui, pourquoi chaque Etoile Fixe ne sera-t-elle pas aussi le centre d'un Tourbillon qui aura un mouvement autour d'elle? Notre Soleil a des Planets qu'il éclaire, pourqoui chaque Etoile Fixe n'en aura-t-elle pas aussi qu'elle éclairera?”[174]

While Fontenelle tries to mask the controversial character of this idea with an appeal to the amusing intents of the work, he also claims that his argument is based on 'vrais raisonnemens de Physique.' He ironically warns his readers 'educated in physics' that his writings hold nothing new for them, “mais seulement les divertir en leur présentant d'une maniere un peu plus agréable et plus égayée, ce qu'ils sçavent déja plus solidement.”[175] Fontenelle thus simultaneously de-emphasizes and confirms the more serious aspirations of the work. Moreover, he also explicitly forestalls the theological objections his ideas could raise by claiming that a plurality of worlds only confirms God's omnipotence, and by pointing out that the planetary inhabitants he speaks of should not be necessarily understood as humans. Through these precursory arguments, Fontenelle disconnects his *Entretiens* from theology (and theological authority) and indicates that the plurality of worlds is a purely philosophical matter. The controversial nature of the subject is also played down by the work's entertaining literary form.

171 Guthke, *The Last Frontier* (1990) 227-228.
172 The sixth evening was added in the second edition of 1687, on which the critical edition of A. Calame (1966) is based. On Cartesian cosmology and the theory of Vortices cf. f.e. Slowik, 'Descartes' Physics', *SEP* (2009) §7.
173 Cf. the theories about the lunar world of Kepler and Wilkins.
174 Fontenelle, *Entretiens sur la pluralité des mondes* (1687), 134.
175 *Entretiens,* 5.

As demonstrated above, early seventeenth-century authors had already made ample use of the new Copernican theory to support their theories of planetary life and the plurality of worlds. Fontenelle turns to Copernicanism for his main argument as well. Based on the de-centralization of the Earth in the heliocentric system, and the de-centralization of the solar system in the Cartesian theory of vortices, Fontenelle uses the familiar argument of analogy to ascribe the planets their inhabitants, and the stars their planets:

> Vous convenés que quand deux choses sont semblables en tout ce qui me paroît, je les puis croire aussi semblables en ce qui ne me paroît point, s'il n'y a rien d'ailleurs qui m'en empêche. De-là j'ai tiré que la Lune étoit habitée, parce qu'elle ressemble à la Terre, les autres Planetes parce qu'elles ressemblent à la Lune. Je trouve que les Etoiles Fixes ressemblent à notre Soleil, je leur attribuë tout ce qu'il a.[176]

Fontenelle's use of the astronomical similarity of the planets as an analogical argument makes a typical Epicurean form of argumentation.[177] Fontenelle does not claim that the existence of planetary life can be proven, he simply assumes it to exist: "Mais, interrompit la Marquise, en disant toujours, *pourquoi non?* vous m'allés mettre des Habitans dans toutes les Planetes? N'en doutés pas, repliquai-je, ce *pourquoi non?* a un vertu qui peuplera tout."[178] Formulated rather light-footed, this 'why not?' expresses a fundamental shift in the understanding of the plurality of worlds. Whereas medieval and early modern authors mostly assumed that the plurality of worlds was in accordance with the order of nature, Fontenelle, like Giordano Bruno before him, returns to the Lucretian understanding of plurality as an implication of the belief in an infinite universe determined by chance. In the new Cartesian context of the *Entretiens*, this Lucretian universe is ruled by the laws of nature.

In an entertaining passage where Fontenelle ridicules Aristotelian physics, he explains that Descartes has discovered that the world is governed through the laws of nature, and compares Nature to a watch: "On veut que l'Univers ne soit en grand, que ce qu'une Montre est en petit, et que tout s'y conduise par des mouvemens réglés qui dépendent de l'arrangement des parties."[179] Consequently, the order of nature is no longer manifested in the hierarchical order in the manifestations of nature, wherein every being has its decreed place, but in the immutable laws of nature. The outcome of this order is not Aristotelian hierarchy, but atomistic infinite diversity.[180] This implies a principle of 'plenitude in variety', and the basic idea of the *Entretiens* is therefore, in Fontenelle's own words, "la diversité infinie que la Nature doit avoir mise dans ses Ouvrages."[181] It is this principle of infinite diversity that is expressed in the infinite plurality of planets, stars,

176 *Entretiens,* 138.
177 Cf. § 3.1.
178 *Entretiens,* 91.
179 *Entretiens,* 20.
180 In 1727, Fontenelle published a work dealing with the mathematical aspects of infinity; Blay, *Les raisons de l'infini* (1993) 175 ff.
181 *Entretiens,* 9.

and vortices. This variety in the universe correlates to the infinite variety in nature that can be witnessed on earth.[182] It is interesting in this respect, that Fontenelle also points to the new world that was discovered through the recent microscopic innovations for his analogical argument: "Alors je lui appris l'Histoire Naturelle des Abeilles […] Après quoi, vous voyés bien, poursuivis-je, qu'en transportant seulement sur d'autres Planetes des choses qui se passent sur la nôtre, nous imaginerions des bisarreries, qui paroîtroient extravagantes, et seroient cependant fort réelles, et nous en imaginerions sans fin, car afin que vous le sçachiés, Madame, l'Histoire des Insectes en est toute pleine."[183] Not surprisingly, Fontenelle also frequently applies the analogy of the discovery of the New World: his claims about planetary life are supported by the reports "qui nous sont rapportées par ces Sçavans qui y voyagent tous les jours avec des Lunettes d'approche. Ils vous diront qu'ils y ont découvert des Terres, des Mers, des Lacs, de très-hautes Monagnes, des Abîmes très-profonds."[184] Like the microscope-analogy, the discovery of new lands is used to stress the strangeness of the people that mankind would encounter on the moon: "Je ne croi point du tout qu'il y ait des Hommes dans la Lune. Voyés combien la face de la Nature est changée d'ici à la Chine; d'autres Visages, d'autres Figures, d'autres Moeurs, et presque d'autres principes de raisonnement."[185]

The infinite diversity in nature is emphasized in Fontenelle's descriptions of the planetary worlds. Although the claim that the other planets contain worlds and inhabitants is based on analogy and mechanistic causality, Fontenelle describes these other worlds in an entertaining literary style. His descriptions of the planetary worlds draw heavily on themes from classical and Renaissance literature, and the references to literature and mythology are abundant throughout the *Entretiens.* In an entertaining passage, Fontenelle describes the lunar voyage found in Ariosto's *Orlando Furioso* (1532), which relates how the knight Astolfo is helped by the Apostle John to travel to the moon in Elijah's chariot to find the lost wit of the protagonist Orlando. The knight is surprised to find that the moon is much larger than it looks from Earth, and that it contains – apart from the 'lost wits' of mankind – valleys, lakes, mountains and forests, and that it is inhabited by mythical creatures.[186]

Apart from this literary excursion, many of Fontenelle's descriptions of the planets are derived from their mythological associations. For example the inhabitants of Venus are passionate and hot-headed, and the 'Mercurians' are 'quick as quicksilver'. However, the use of these metaphors is also connected to the mechanistic interpretation of the plurality of worlds, and they are explained in relation to the positions of the planets in the solar system. The quickness of the Mercurians, alluding to the Roman God of trade and travel, is caused by their closeness to the the sun – since heat is associated with versatility (both in Aristotelian and in mechanistic physics). The mechanistic explanation of the passionate character of the inhabitants of Venus underlines the mythological metaphor with an analogical argument: "Ils resemblent aux Mores Grenadins, un petit Peuple noir, brûlé du Soleil, plein d'esprit et de feu, toujours amoureux, faisant des Vers, des Danses et

182 *Entretiens,* 38-39.
183 *Entretiens,* 101.
184 *Entretiens,* 59-60.
185 *Entretiens,* 66.
186 The whole episode can be found in canto xxxiv, 68-92 of Ariosto´s epic poem.

des Tournois." Likewise, Mercurians must be 'mad of vivacity': "Je croi qu'ils n'ont point de mémoire, non plus que la plûpart des Negres, qu'ils ne font jamais de réflexion sur rien, qu'ils n'agissent qu'à l'aventure, et par des mouvements subits, et qu'enfin c'est dans Mercure que sont les Petits-Maisons [madhouses] de l'Univers."[187] On the other hand, the Saturnians are slow and suffer from the cold, due to their great distance from the sun. The ethnic stereotypes that are enlarged here to imagine the planetary inhabitants reinforce the claim that Earth itself also gives witness of an 'infinite diversity'. However, these descriptions also point toward another significant aspect of the *Entretiens,* for it is through these literary and popular analogies that an anthropological theme is introduced.

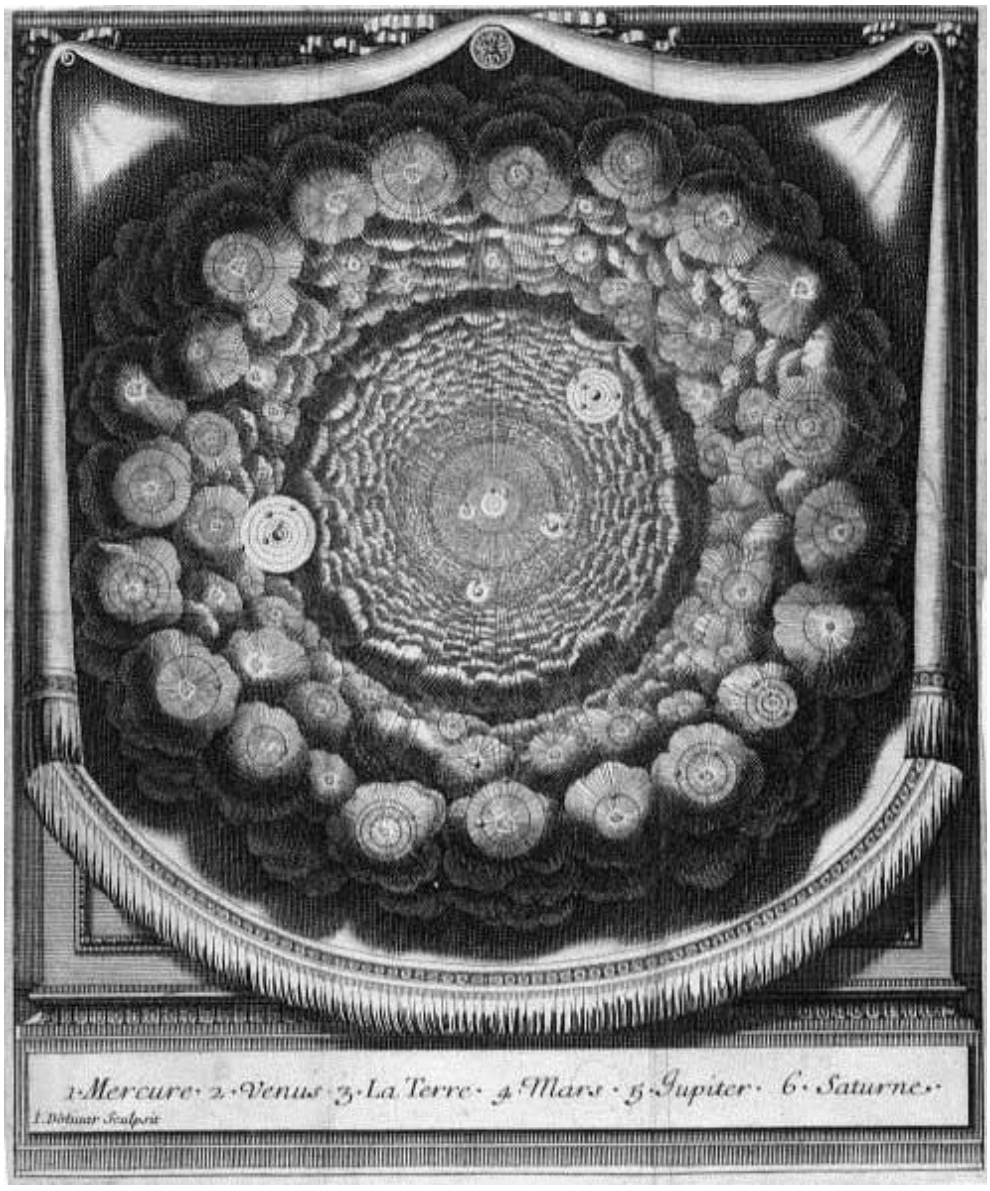
The encounter of other intelligent life – whether they are American Indians or Selenites – always provokes reflection on one's own identity. If the moon and the planets are believed to have their own worlds and inhabitants, based on their likeness to the Earth, what is the place of humanity and its planet in the universe? Despite Fontenelle's initial disclaimer that his ideas do not contradict the teachings of the theologians, he uses the plurality of worlds to open a fierce attack on geocentricism and anthropocentricism. Dismissing theological tradition, Fontenelle claims that these 'old-fashioned ideas' are the product of human vanity. Using another terrestrial analogy, he argues that the planetary inhabitants may differ from us like the peoples of the New World differ from those of the old. When the marchioness questions the philosopher's ambition to discuss the inhabitants of the moon, he replies: "Remettés-vous dans l'esprit l'état où étoit l'Amérique avant qu'elle eût été découverte par Christophle Colomb. Ses Habitans vivoient dans une ignorance extrême."[188] The Americans must have been astonished to find themselves visited by men clad in iron, riding great beasts, and navigating the impassible oceans. They probably wondered: "Sont-ce les Enfans du Soleil? Car assurément ce ne sont pas des Hommes."[189] When it comes to the peoples of the moon and the planets, it remains undetermined whether we are the Europeans or the Americans.

The *Entretiens* also addresses at a more existential level the insecurity and anxiety that may result from the confrontation with the innumerable vortices full of planets full of worlds full of people. The Marchioness is overwhelmed by the infinite universe and the endless plurality of the innumerable vortices it contains. "Voilà l'Univers si grand que je m'y perds, je ne sçai plus où je suis, je ne suis plus rien. […] Cela me confond, me trouble, m'épouvante."[190] However, Fontenelle is not impressed by the infinity universe. On the contrary, he argues, whereas the closed cosmos felt narrow and confined, restrictive, the infinite universe invokes a sense of freedom, and an admiration for the 'magnificence of Nature'.

The place of humanity in the cosmos has now been radically altered. Man is no longer at the centre of all things, but he has become an insignificant part of an infinite world. Fontenelle explains that the belief in the geocentric system suffered from vanity and megalomania. However, although he asserts the insignificance of humanity among the innumerable vortices of the universe, his descriptions of planetary life also imply some

187 *Entretiens,* 105.
188 *Entretiens,* 68.
189 *Entretiens,* 70.
190 *Entretiens,* 134-135. Similar astonishment about the infinity of the universe is expressed in a dialogue with the viceroy of Canada in Cyrano de Bergerac's *L'autre monde,* 13-27.

insights in the place of humanity that are not so humble. For whereas he claims that humankind occupies only an insignificance spot in the Universe, he also claims that it is an exceptionally good spot. Whereas the Selenites, Mercurians and Saturnians all suffer from the harsh conditions of their worlds, Earth's position in the solar system produces circumstances that constitute a good medium among the extremes of the other planets. In the words of the Marchioness: "Du moin, […] un commodité fort réelle qu'a notre Monde par sa situation, c'est qu'il n'est ni si chaud que celui de Mercure ou de Venus, ni si froid que selui de Jupiter ou de Saturne. […] laissés-moi avoir de la reconnaisance sur tout, jusque sur le Tourbillon oú je suis placée."[191] This goes not only for climate, but also for the characters of men: "Il n'y a poit pour les Hommes de Caractere fixe et déterminé; les uns sont faits comme les Habitants de Mercure, les autres comme ceux de



4.6 Frontispiece of the first edition (1686) of the *Entretiens sur la pluralité des mondes,* depicting the plurality of solar systems, each in their own vortex-cloud. Bibliothéque nationale de France.

191 *Entretiens,* 130-131.

Saturne, et nous sommes un mélange de toutes les especes qui se trouvent dans les autres Planetes."[192] In this sense, a secular form of anthropocentrism is maintained. The classic analogy between the New World and the planets is also repeated: humankind's favourable place in the solar system is comparable to Europe's comfortable place and temperate climate on Earth.

So despite his earlier theoretical claim that humanity is utterly insignificant in the infinite universe, Fontenelle grants mankind a comfortable spot in the solar system, and he even suggests that our vortex is better than others. This ambivalence of insignificance and comfort is also reflected in the relative absence of God in the *Entretiens.* Fontenelle is quite consequent in his references to Nature, and the lack of references to God. It has apparently become difficult to discuss God's omnipotence, omnipresence, and providence in relation to such a thoroughly materialistic interpretation of the universe. Whereas creation and nature become ever more magnificent to behold, God becomes ever more distant. No longer can the idea be upheld that God created everything for the use and enjoyment of Man. In the end, this idea has turned out to be the product human vanity: "Il est bien aise que tout soit fait pour lui; il suppose peut-être sans s'en appercevoir de principe qui le flatte, et son coeur ne laisse pas de s'interesser à une affaire de pure spéculation."[193]

4.7 Conclusion: the plurality of planets and solar systems

In the *Entretiens,* all the different aspects of the plurality of worlds tradition have come together: philosophical, theological, literary, fantastic, satirical and scientific elements are all discussed by Fontenelle. With him, the plurality of worlds has once again taken the materialistic and infinite form, that the concept had when it was first introduced by the atomists to support their physical theory.

Since the publication of Copernicus's *De Revolutionibus,* much had changed in cosmology, and much had stayed the same. Such texts as Kircher's *Iter exstaticum* demonstrate that in the second half of the seventeenth century, Copernicanism was not yet universally accepted. Philosophers, astronomers, poets, theologians, academics and dilletantes, they all took part in the exciting debate about Copernicanism, the foundation of knowledge, and the old and new sciences in general. Abandoning the scholastic *disputationes,* authors were exploring new literary forms to express and convey their opinions and ideas: some turned to poetry, like Donne and Milton; some returned to the 'socratic' dialogue, like Bruno, Galileo, and Fontenelle;[194] some turned to systematic expositions, like Descartes and Spinoza. It is in this light that also cosmic fiction and the concept of the plurality of worlds should be interpreted.

When Giordano Bruno connected the plurality of worlds to Copernican astronomy, he gave the concept an unprecedented sense of actuality, reality, and physical possibility. Copernicanism made it possible to conceive the plurality of worlds as a plurality of planets, a plurality of Earths, and to compare the physical essence of the moon to that of the Earth. This is what we see happen when Kepler, Wilkins and all those

192 *Entretiens,* 130.
193 *Entretiens,* 30, cf. 23-25, 30-31. For an extensive, but not always very plausible explanation of Fontenelle's anthropology as being paradoxical and problematic, cf. Guthke, *The Last Frontier* (1990) 226 ff.
194 Cf. his *Dialogue concerning the two chief world system,* published 1632.

others started reasoning from analogy on the basis of the fundamental equality of the planets and the assumed and observed physical similarity between the Moon and the Earth.

The corpuscular theories and the materialism that were reintroduced around the middle of the seventeenth century, and the geometrical and mechanistic explanations of nature that were developed, showed new ways of understanding cosmological plurality. Demonstrated best in Fontenelle's extremely popular *Entreties sur la pluralité des mondes,* the plurality of worlds now became a plurality of solar systems (or vortices). Fontenelle's materialistic description of a contingent and infinite universe, produced by chance and ruled by the laws of nature, and harbouring infinite variety, is the Greek atomistic cosmos reborn in the post-Cartesian world. There are also important differences: whereas the Lucretian infinite universe was still beyond the borders of our own world, outside of our own cosmos, Fontenelle had turned this around: Earth had become a place – a comfortable but insignificant one that is – within the infinite universe. In Huygens's words: "In coelo sumus."[195] A second important difference, Fontenelle's Cartesian materialism is not necessarily the 'atheist' materialism of the atomists.[196] For Cartesian metaphysics had ensured that the contingency of the material world could be fully attributed to God's free will, and his inscrutable decrees.[197]

Although the understanding of the plurality of worlds had profoundly changed during the sixteenth and seventeenth century, the function of the concept did not fundamentally change. Like planetary life, lunar worlds, and celestial voyages were used in classical literature as metaphors of a moral, metaphysical, religious, or satirical message, so was seventeenth-century cosmic fiction used to convey a message, whether it is the defence of Copernicanism, or entertaining jest, or razor-sharp satire. And just as the atomists had invented it to explain their physical theory, and Aristotle had rejected it to support his own; as the medieval theologians used it to discuss the properties and virtues of God; as Cusa and Bruno had employed it to represent their mystical understanding of reality; so too was the concept of plurality used by in the seventeenth century to express fundamental ideas about the universe, about nature, about reality. When I will discuss the *Cosmotheoros* in the following chapter, the most interesting question to ask is therefore not 'what does Huygens say about the plurality of worlds?', but 'what does Huygens's explanation of the plurality of worlds mean?'

195 *Pensees,* §37; 'we are in (the) heaven(s)'.
196 For the orthodox rejection of atomism, cf. for example the *Belgic Confession* (1561), art. XIII.
197 Cf. §4.3 above, and §5.5.1 below.

5

Cosmotheoros : analysis

5.1 Approaches to the Cosmotheoros

When I explained the subject and the questions of this thesis in the general introduction, I also discussed the existence of several existing interpretations of Christiaan Huygens's *Cosmotheoros*. As I have argued, many of its interpreters have understood the work rather superficially as simply defending the existence of extraterrestrial life. Consequently, the book has been appreciated in many different ways: it has been praised a visionary defence of a 'modern' understanding of extraterrestrial life, but it has also been set aside as the fabrication of a tired mind.

The alternative approach to the *Cosmotheoros* that I proposed was based on the exploration and interpretation of the two important traditions that together constitute the historical and intellectual background to Huygens final work: philosophy and literature.

The aim of this thesis that I formulated in the general introduction was twofold: not only do I want to offer an alternative and more in-depth interpretation of the *Cosmotheoros,* but I also want to disclose some of Huygens's opinions on matters of religion and philosophy that he did not speak openly about, but that form the theoretical foundation to the astronomical and cosmological ideas laid out in the published *Cosmotheoros.* A consequence of this approach is that the distinction between the discussion of the *Cosmotheoros* and the fragments found in the *Oeuvres Complètes* is not very sharp. The philosophical ideas that are explicitly and implicitly discussed in the *Cosmotheoros* form the primary subject of this chapter. Whereas I will relate the discussed ideas to contemporary philosophy, science and theology, I will not discuss the contemporary understanding and reception of the *Cosmotheoros*. Interesting as this historical reception may be, it is simply not the focus of this thesis, and it is not necessary for the understanding of Huygens's philosophical ideas.

Where it is relevant, I will briefly touch upon the issue of the differences between published and unpublished writings. Although I will not explicitly distinguish between the discussion of the different sources used, the structure of this chapter will follow a more or less logical order that follows from the structure of the *Cosmotheoros*.

5.2 The plea for planetary life: similarity and probability

Already in the opening lines of the *Cosmotheoros*, where Christiaan dedicates the work to his brother Constantijn, the reader is casually introduced to Huygens's general argument for the existence of planetary

life:

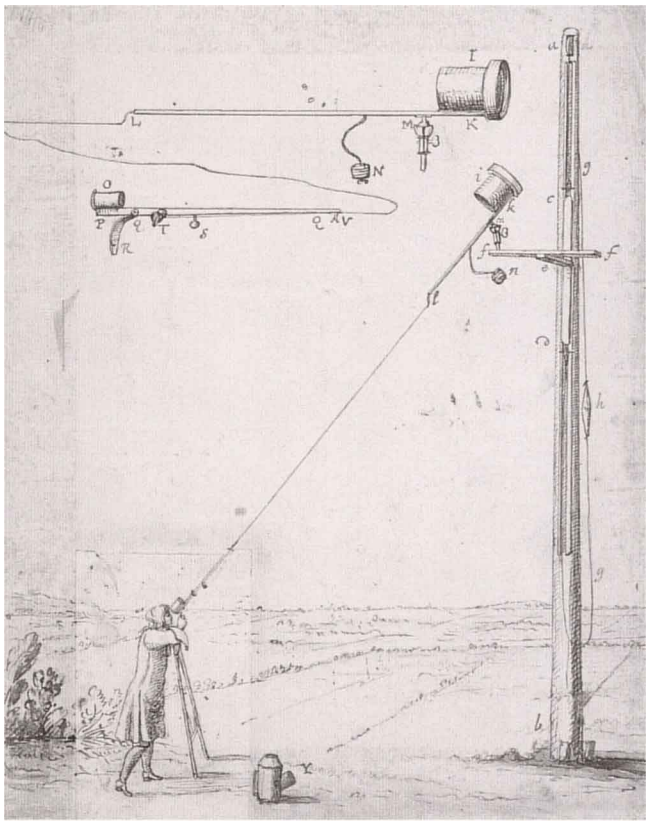
> "A Man that is of *Copernicus'* Opinion, that this Earth of ours is a Planet, carry'd round and enlighten'd by the Sun, like the rest of them, cannot but sometimes have a fancy that it's not improbable that the rest of the Planets have their Dress and Furniture, nay and their Inhabitants too as well as this Earth of ours: Especially if he considers the later Discoveries made since *Copernicus's* time of the Attendants of *Jupiter* and *Saturn*, and the Champain and hilly Countrys in the Moon, which are an Argument of a relation and kin between our Earth and them, as well as a proof of the Truth of that System."[198]

The Copernican premise of the *Cosmotheoros* and the general argument for the existence of planetary life are directly made clear in this opening statement. It is Huygens's Copernican understanding of the Earth as one of the planets that first raises the question how the other planets might look up close. The apparent similarity between the planets and the earth makes Huygens wonder whether these 'heavenly earths' (*terris coelestibus*) also have their 'decoration' (*cultu ornatuque*) and whether these worlds might even be inhabited. Although the Copernican system was not yet unanimously accepted, Huygens regards its truth as a clearly demonstrated fact.[199] The astronomical similarity between Earth and the other planets was firmly established by the Copernican system and had been reinforced by the telescopic observations of the early seventeenth century, such as the discovery of planetary moons. Observations of the surface of the moon also pointed towards a physical resemblance of the celestial bodies.

This confident appeal to Copernicanism and telescopic observation support Huygens's basic argument for the existence of planetary worlds: a) Copernican astronomy and telescopic observation respectively demonstrate the astronomical and the physical similarity between the Earth and the planets; b) this astronomical similarity suggests that more similarities between the planets might exist.

This is the general argument of the *Cosmotheoros,* and with this astronomical approach to the subject, Huygens follows the line of thought of many previous authors on the plurality of worlds. Plutarch, Kepler, Wilkins, Fontenelle and many others had already used similar arguments. Huygens explicates his awareness of and dependence on this legacy when he shortly touches upon the subject of the plurality of worlds tradition.[200] Christiaan explains how he and his brother Constantijn discussed the subject of planetary worlds during their nightly observations, but that they always considered it an impossible question to answer. This conclusion was shared by the philosophers, ancient or modern, who attempted to discuss the shape of planetary life. Of course, Huygens states, since the birth of astronomy, some have boldly claimed the universe to be infinite and containing an innumerable number of stars and worlds. It were Cusa, Bruno and

198 *CW,* 1-2.
199 Cf. Vermij, *Calvinist Copernicans* (2002) 149.
200 *CW,* 2-3; full citation at the beginning of chapter 3 above.



5.1 Huygens's design for a tubeless telescope. *Astroscopia compendiaria* (1684)

Kepler who first ascribed the planets with inhabitants. However, neither they, nor Huygens's contemporary Fontenelle have dared to seriously discuss the question for planetary worlds. While some have simply asserted the probability of planetary habitation and others have told entertaining fables, no one has tried to discuss the matter seriously.

With this firm statement, Huygens makes clear that his 'probable conjectures' on the matter are a novelty. While this is obviously not quite true, the claim does demonstrate that Huygens considered his contribution on the subject to be different from existing opinions. This difference, according to Huygens, consists of an unprecedented level of certainty on the matter. Thanks to Copernican astronomy and Cartesian natural philosophy, it has become possible to surpass mere speculation. Interpreted through mechanistic philosophy, there is ample material to base these conjectures on: "sed verisimilibus conjecturis abunde materiam praeberi."[201]

Now that he has established the empirical basis for his 'probable conjectures', Huygens feels the need to discuss the methodological foundation of these conjectures. First of all, he expresses some reserve about the intended readership of his work, making clear that it is not to be expected that just anybody can understand his arguments. He chooses his readers with care: "but that I might chuse my Readers, Men like you, not ignorant in Astronomy and true Philosophy."[202] Huygens wants to prevent himself from being attacked by the vulgar (here implied are the anti-Cartesian Calvinists), who in their stupidity even consider the movement of the Earth a ridiculous conjecture: "What should we answer to these Men, but that their Ignorance is the cause

201 *Kosm.,* 683; 'but enough matter is available for probable conjectures'.
202 *CW,* 4-5.

of their dislike, and that if they had more Sense, they would have fewer Scruples?"[203] Some understanding of learning and science is thus necessary to understand Huygens's work. As he puts it in the *Réflexions:* "Praeparatos esse eos quibus haec scribuntur oportet lectione librorum quibus tum veritas Terrae motae probatur, et neque hanc, neque plurium terrarum existentiam Scripturae sacrae adversam esse; ut sunt Galilei dialogi, Wilkeni mundus lunae, Keplerus &c. Nolo enim transcribere quae apud tam multos legi possunt."[204]

The goal of the remark is clear: the *Cosmotheoros* is not just a playful jest, that aims to entertain its readers with a story about such imaginary creatures as were made up by Lucian or Fontenelle. But despite his serious claims, Huygens acknowledges that his conjectures cannot provide absolutely decisive answers either:

> "I must acknowledge still that what I here intend to treat of is not of that nature as to admit of a certain knowledge; I can't pretend to assert any thing positively true (for that would be madnes) but only to advance a probable gues, the truth of which every one is at on liberty to examine. If any one therefore shall gravely tell me, that I have spent my time idly in a vain and fruitles enquiry after what by my own acknowledgement I can never come to be sure of; the answer is, that at this rate he would put down all Natural Philosophy[205] as far as it concerns it self in searching into the Nature of things: *in such noble and sublime Studies as these, 'tis a Glory to arrive at Probability, and the search itself rewards the pain. But there are many degrees of Probable, some nearer Truth than others, in the determining of which lies the chief exercise of our Judgment."*[206]

Huygens's justification of the methodological validity of his 'probable conjectures' is interesting, as the argument also sheds some light on his understanding of the natural sciences and natural philosophy in general: the natural sciences are ultimately concerned with degrees of probability. This (of course) does not render scientific efforts 'fruitless' or 'vain'. According to Huygens 'different degrees of probability' should be discerned, some closer to the truth than others.[207] In determining this measure of probability, a crucial role is reserved for human reason. And because man is capable to judge whether something is probable, it is also possible to discuss matters which cannot be understood with absolute certainty.

Having made clear this epistemological basis of his conjectures, Huygens returns to his main subject.[208] In the following of the first book of the *Cosmotheoros,* the concepts of similarity and probability are combined

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203 *CW,* 5-6.

204 *Réflexions,* II, §1, 542; 'Those for who this is written must have prepared by reading books, in which the truth of the moving earth is proven, and that neither this, nor the existence of a plurality of worlds, is opposed to Holy Scripture; such as the dialogues of Galileo, Wilkins's 'world of the moon', Kepler's etc. For I do not want to replicate what can be read in [the work of] so many others.'

205 'Physices studium', *Kosm.*, 689.

206 *CW,* 9-10, the italic emphasis is found in the Latin edition of the *Oeuvres Complètes,* but is left out in the 1698 English translation; Cf. *Kosm.,* 689.

207 *Kosm.,* 689; 'Sed verisimilium multi sunt gradus'. The term is first used by Huygens in a letter from 1673 to M. Perrault; *OC,* VII, 298; cf. on the limits of geometrical evidence also the summary of a letter by Chr. Huygens to B. de Volder, *OC,* X, 739: "Parce que dans la geometrie mesme on s'imagine souvent de comprendre tres clairement des choses qui sont fausses."

208 I will more extensively discuss this epistemology based on probability in the next paragraph.

with an implicit understanding of the uniformity of Nature to support the plea for the existence of planetary worlds. As said above, in this argument for the probability of planetary life, Huygens takes his starting point in Copernican astronomy, which forms the empirical basis of the *Cosmotheoros*: "the chief Argument for the proof of what we intend will be taken from the disposition of the Planets, among which without doubt the Earth must be counted in the Copernican System."[209] After a short explanation of the Copernican system, the astronomical similarity between the planets and the Earth is firmly established. Not only does the heliocentric astronomy suggest their similarity, but this is also affirmed by the observation of the moons of Jupiter and Saturn. Earth is one planet among others. The principal separation between Earth and Heaven that was fundamental to classical, medieval and biblical cosmology is abolished and the principal distinction between the Earth and the planets has been eliminated; the differences that remain are merely matters of size and measure, not of principle.[210]

After explaining the empirical basis of his argument, the similarity of the planets, Huygens connects this assertion to a general concept of the uniformity of Nature: "Now since in so many things they thus agree, what can be more probable than that in others they agree too; and that the other Planets are as beautiful and as well stock'd with Inhabitants as the Earth? or what shadow of Reason can there be why they should not?"[211] This analogy is supported by further examples from the natural world: if someone knows the organs of a dog, would he doubt that the intestines of an ox or a hog, or any other animal, would look more or less the same? Therefore, on the basis of the similarity of the planets and the uniformity of Nature, it is through analogy that Huygens will speculate about the face of the planets and the nature of their inhabitants: "'Tis therefore an Argument of no small weight that is fetch'd from Relation and Likeness; and to reason from what we see and are sure of, to what we cannot, is no false Logick. This must be our Method in this Treatise, wherein from Nature and Circumstances of that Planet which we see before our eyes, we may gues as those that are farther distant from us."[212]

With the formulation of this analogical method, Huygens has laid out the program for the remainder of the first book. The argument is repeated time and again as Huygens discusses many different aspects of planetary life: when our planet is found to be solid, we can assume that the planets are solid; as our planet has an atmosphere, we can assume that the planets have so as well; as life exists on earth, we can assume that life exists on the other planets as well; as our planet hosts intelligent life, we can assume that other planets do so as well; as terrestrial intelligent life builds houses, we can assume that planetary intelligent inhabitants build houses also; And because we know geometry, we can assume that the planetary inhabitants do so too; etcetera, etcetera.

209 *CW,* 11.
210 Vermij, *Calvinist Copernicans* (2002) 152.
211 *CW,* 17-18.
212 *CW,* 18-19.

5.3 The foundations of scientific knowledge

5.3.1 Huygens's concept of probability

As I have shown in the previous paragraph, the basic analogical argument of Huygens's theory of planetary worlds is founded on two 'argumentative' principles, *similarity* and *probability.* If we want to gain understanding of Huygens's basic philosophical ideas, a short enquiry into these principle's is necessary. In the following two paragraphs, I will therefore try to clarify Huygens's use of the principles of similarity and probability from the perspectives of respectively his epistemology and his metaphysical ideas.

While Huygens does not further explicate the epistemological ideas on probability that he applies in the *Cosmotheoros*, these ideas are discussed also in Huygens's other published work and in the private writings of the years 1686-1690. In the preface to his *Traité de la lumière* (1690) Huygens explicitly addresses the limits of the certainty of scientific knowledge:[213]

> On y verra de ces sortes de demonstrations, qui ne produisent pas une certitude aussi grande que celles de Geometrie, & qui mesme en different beaucoup, puisque au lieu que les Geometres prouvent leurs Propositions par des Principes certains & incontestables, icy les Principes se verisient par les conclusions qu'on en tire; la nature de ces choses ne souffrant pas que cela se fasse autrement. Il est possible toutefois d'y arriver à un degré de vraisemblance, qui bien fouvent ne cede guere à une evidence entiere.[214]

Huygens makes a similar distinction between the proof out of probability and the absolute certainty of geometrical and mathematical arguments in one of the paragraphs of the *Réflexions* (1690). This paragraph titled 'De probatione ex verisimili' deals with the nature of knowledge. The title itself comprises the main argument of the piece: proof (probatione) is derived from probability (verisimili). “Omnia fere huc reduci. forsan et mathematicorum demonstrationes. Certitudinem vero non bene poni in perceptione clara ac distincta. Patet enim ejus claritatis ac distinctionis varios quasi gradus esse. namque et in ijs quae plane nobis perspicue comprehensa putamus saepe fallimur;”[215] The scepticism expressed here does not imply that knowledge cannot be positively asserted at all. On the contrary, through the claim that in the end even mathematical evidence is derived from a judgement by reason, Huygens also vindicates knowledge on the

213 The *Traité de la lumière* is not Huygens's only work on optics, but emphasizes a physical approach to the subject, whereas the *Dioptrica* (1653, unpublished) discussed mathematical (geometrical) theories on the working of lenses; Vermij, *Huygens* (2004) 138.

214 *Traité de la lumière, OC,* XIX, 454.

215 *Réflexions,* I, 541; 'Almost everything can be reduced to this [proof from probability], perhaps also the demonstrations of the mathematicians. But certainty cannot be placed so well in clear and distinct perception. For it is clear that it is as if there are various degrees of clarity and distinction. For also in those things we think to fully understand, we are often mistaken.'

basis of arguments of probability.[216] In a letter from 1673 Huygens makes clear how close some degrees of probability can come to certainty:

> Que je ne crois pas que nous scachions rien très certainement mais tout vraisemblablement, et qu'il y a des degrez de vraisemblance qui sont fort differents, et quelques uns comme 100000 contre 1. comme dans les démonstrations géometriques, qu'elles peuvent être fausses mais qu'il y en a qui ont estè si souvent et si longtemps estè examinées qu'il n'y a presque point de raison d'en suspecter la veritè et de celles surtout qui sont courtes.[217]

Whereas the demand for absolute proof has often led people to reject reasonable ideas in favour of completely opposite and sometimes nonsensical beliefs, Huygens makes the case for a more moderate rationalism. He gives the bad example of the astronomical system of Tycho Brahe: even though it contradicts both reason and perception, it is nonetheless accepted by its supporters with an appeal to the lack of mathematical proof of the opposite.[218] Moreover, the same false argument is used to hold on to such superstitions as astrology. Their failure to judge the probability of claims leads people to believe all kinds of deception: "Nec perspicere valent haec ab impostoribus lucelli gratia fuisse excogitata; quoniam verisimilium gradus discernere nesciunt."[219] It is therefore not only possible to reason on the basis of probability, but also necessary. 'probatione ex verisimili' do not provide absolute certainty, but they are often the only arguments available and should therefore be tested and evaluated by both reason and perception. To be able to use these arguments, the different degrees of probability should be clearly discerned.

5.3.2 Epistemological backgrounds

The epistemological ideas explained here by Huygens should be understood in the light of the seventeenth-century debate on the foundations of knowledge. Not very long after the first enthusiastic responses to the new philosophy, the Cartesians soon stumbled upon some fundamental questions that were raised by the new philosophy. The main problem that occurred concerned Descartes's theory of knowledge, most famously discussed in his *Discourse on the Method* (1637) and *Meditations on first Philosophy* (1641). While he had rejected the Aristotelian scientific methods that were based on a rather simplistic understanding of and trust in the sensory perception, his own epistemological ideas would become problematic as well.

Taking a sceptical starting point, Descartes denied that the senses were able to reveal the true natures of the substances around us. However, this did not mean that the mind is unable to acquire any knowledge.

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216 This does not mean that the certainty of geometry is dubious, but its certainty is a degree of probability. Cf. the citation above from the *Traité de la lumière* and the *Réflexions*, II, §23 and III, §7, 554, 558.

217 ca. 1673, Chr. Huygens to Pierre Perrault, *OC,* VII, 298.

218 Ironically, Epicurus used a somewhat similar argument to establish the infinity of the universe and infinite worlds. Cf §3.1 above.

219 *Réflexions,* I, 541; 'They are unable to perceive that these have been devised by impostors for their own petty gain; for they do not know how to discern the degrees of probability.'

According to Descartes, the 'human intellect is able to perceive the nature of reality through a purely intellectual perception.' To obtain fundamental (metaphysical) knowledge, we must therefore turn away from our senses and aim our mind towards the ideas about the essences of all things, mind, matter and God.[220] In the *Meditations,* this process culminates in the discovery of one principal truth: 'cogito ergo sum'. This truth, claims Descartes, results from the 'clear and distinct' perception by the intellect. This intellectual perception that exists independently from the senses, forms the heart of Cartesian epistemology.[221]

I cannot discuss the Cartesian epistemology in full, but what matters here is that the 'rationalist' perspective that Descartes took on natural science, held some problematic implications.[222] Basically, the pre-eminence of the human intellect in matters of knowledge led to similar problems as those that were connected to the Aristotelian science. While the Aristotelians invented arbitrary physical theories due to a naive trust in the senses, the explantations of natural phenomena that were developed by Descartes were sometimes just as ridiculous due to a lack of empirical credibility. While scholastic scientists failed to distrust their senses, now the mind was unchecked by perception. The most important task of philosophy and science in the second half of the seventeenth century was therefore to learn somehow to balance these two poles in the theory of knowledge.

Generally, two opposite schools of philosophy on the matter that occurred after Descartes have been discerned. On the one hand, there were those philosophers who held on to the Cartesian predominance of the mind. This line of thought, referred to as 'rationalism', was most strongly represented on the European continent, and is represented among others by Descartes, Malebranche, Spinoza and Leibniz. On the other hand there are the 'empiricists', predominantly English scientists and philosophers such as Locke, Hume and Boyle, who were sceptical about the capabilities attributed to the human mind by Descartes, and who asserted that true knowledge can only be acquired through systematic scientific experimentation.

To clarify this debate, a comparison can be made between two of the most outspoken champions of either position. The most famous and uncompromising advocate of a strictly experimental study of nature is the English 'corpuscularian' scientist Robert Boyle (1627-1691).[223] A man not particularly fond of 'system-building', Boyle "considered the 'experimental way of philosophizing' the only secure basis for reliable knowledge, stressing the 'dimness and imperfections of our understanding'."[224] This scepticism towards the capabilities of the human mind, if unchecked by the results of experiments, is also expressed in Boyle's presentation of the results of his experiments: he strictly separated the report of an experiment and its result from his own personal interpretations and explanations of the witnessed experiment, so that every capable reader could judge for himself. Through this 'naked literary style', it would be as if every reader could

220 Hatfield, 'René Descartes' *SEP* (2011).
221 On the classical backgrounds of this 'new' theory of knowledge, cf. Ayers, 'Theories of knowledge and belief' (1998) 1003-1061.
222 For further backgrounds of Cartesian epistemology, cf. Cottingham (ed.), *The Cambridge Companion to Descartes* (1992); Broughton and Carriero (ed.), *A Companion to Descartes* (2007).
223 For a good discussion of Boyle's life and work with much attention for his intellectual and historical context, cf. Shapin, *Never Pure (*2010).
224 Israel, *Radical Enlightenment* (2001) 252.

personally witness the described experiment. This not only confirmed Boyle's 'theoretical innocence' (the lack of theoretical prejudice), but it also supported the credibility of his publications and their contribution to factual knowledge.[225] This scientific approach based on purely experimental work would not only help to construct (or rather: clarify, or uncover) a systematically mechanistic universe, it also strongly limited the room for speculative reasoning. Whereas 'reason unrestrained' had led philosophers to false and nonsensical conceptions, this system regulated the sphere of the unknowable, in effect the sphere of metaphysical and religious knowledge. Thus, Boyle's scientific system lacked an internal creative force like Spinoza's 'natura naturans'. The internal coherence of nature is no subject of science, but of religion, Boyle argued.[226] It is a matter of pious acceptance: "indeed, the difficulty we find to conceive how so great a fabric as the world can be preserved in order and kept from running again to a chaos seems to arise from hence: that men do not sufficiently consider the unsearchable wisdom of the divine architect."[227]

At he other end in the rationalism-empiricism debate we find another acquaintance of Christiaan Huygens. Spinoza, who lived close to Huygens in Voorburg for a while, strongly held on to the Cartesian faith in the power of human reasoning. Henry van Oldenburg (1618-1677), a German philosopher and diplomat living in London who was acquainted with both Boyle and Spinoza, tried to bring them in touch, hoping that the combination of their unique experimental and systematic talents could further their common cause of expanding knowledge.[228] "Our Boyle," he wrote to Spinoza once, "is one of those who are distrustful enough of their reasoning to wish that the phenomena should agree with it."[229] While Boyle tried to experimentally explore the natural phenomena themselves, and trough their explanation also confirm the new mechanical philosophy, Spinoza was not that convinced of these experiments. According to Spinoza, the truth that nature in general works according to the principles of the mechanistic philosophy cannot be demonstrated by experiments, but only through (mathematical) reasoning.[230] At best, experiments could verify the propositions derived from a philosophical system based on theoretical and mathematical reasoning. So to say, the controversy between Spinoza and Boyle was a matter of primacy: do experiments form the basis of philosophical knowledge, or can experiments only make sense within the context of a coherent philosophical system.

While the radical dichotomy between these different lines of thought as two opposing schools each sharing a well-defined scientific agenda as it has been described in the past is clearly wrong, the distinction clarifies an important issue in, and background to scientific and philosophical debates in the late seventeenth century.[231] An interesting example can be found in the debate about the possibility of a vacuum in the 1650's

225 Shapin, *Never Pure* (2010) 101-103. For further backgrounds on the problematic nature of what constitutes a 'fact', also in Boyle's opinion, cf. Daston and Park, *Wonders and the Order of Nature* (1998) Chapter VI, 'Strange Facts', 215-254.

226 Israel, *Radical Enlightenment* (2001) 253.

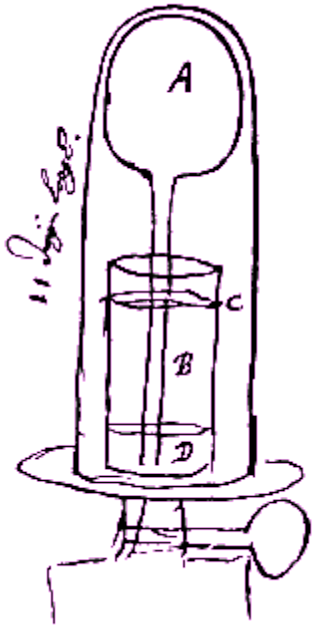
227 Robert Boyle, *A Free Enquiry into the vulgarly received Notion of Nature,* 60.

228 On this correspondence, cf. Israel, *Radical Enlightenment* (2001) 252-257; Nadler, *Spinoza* (1999) 191-193.

229 Cited in MacIntosh and Anstey, 'Robert Boyle', *SEP* (2010).

230 Nadler, *Spinoza* (1999) 192-193. This of course does not mean that Spinoza did not care for experiments at all, for he acknowledges their practical use. When it comes to metaphysics however, only reason can provide answers.

231 For further backgrounds on seventeenth-century thought on knowledge and the debate between rationalism and



5.2 A sketch by Huygens of an experiment with an air-pump filled with water. *OC,* XVII, 317.

and 1660's. Whereas Descartes had held that a vacuum was impossible on the rational basis of his identification of space and matter, Robert Boyle demonstrated the existence of such a space without matter through experimentation with an air-pump.[232] After Huygens had witnessed Boyle's experiment with the air-pump and a barometer at the Royal Society during a visit to London in 1660, he built a similar instrument upon his return to The Hague. When the results of these experiments contradicted Boyle's earlier experiments (the pressure indicated by the barometer placed in the void remained unaltered), the different reactions of both men is illustrative: Boyle claimed that this was a new phenomenon that had an explanation that was yet unknown – history proved him right – but Huygens suggested in a typical Cartesian manner that there was probably some kind of imperceptible matter left in the void.[233] The role Huygens's played in the discussion of this experiment offers a good demonstration of Huygens's attitude, ass well as that of many of his contemporaries: they took neither a dogmatic rationalist nor a radical empiricist position. While he remained true to the rationalist legacy of Descartes, Huygens also acknowledged the necessity of scientific experimentation to verify physical theories. In a similarly way, Huygens would be troubled by Newton's physics as presented in the *Philosopiae naturalis principia mathematica* (1687): he admired the mathematics and the ground-braking mechanical results of his theory, but he was horrified by the apparent occultism of the laws of gravitation and attraction.[234]

Concluding, it is in the light of the debate on the primacy of reason or perception/experiment that Huygens's ideas about probability and knowledge should be understood. His hybrid approach was not only

empiricism, as well as the scholarship on this debate, cf. Ayers, 'Theories of knowledge and belief' (1998); Serjeantson, 'Proof and Persuasion' (2006) 132-175; Israel, *Radical Enlightenment* (2001); Lennon and Dea, 'Continental Rationalism' *SEP* (2008); Markie, 'Rationalism vs. Empiricism' *SEP* (2008).

232 Vermij, *Huygens* (2004) 85-89. Cf. MacIntosh and Anstey, 'Robert Boyle' *SEP* (2010). For a more thorough discussion of the experiment and Boyle's interpretation and presentation of it, cf. Shapin, *Never Pure* (2010) 89-116.

233 Vermij, *Huygens* (2004) 87-89.

234 Vermij, *Huygens* (2004) 136-137.

refreshingly pragmatic in nature, but it was also able to harmonize experimental knowledge and rationalist metaphysics. In Huygens's life, we can see the results of this position. Not only did Huygens publish theoretical work on the principles of mechanics, but he was also one of the greatest astronomical observers of the century. He worked extensively with pendula and clocks, combining theory and practice. He criticized Descartes for the lack of experimental verification of his physical theories, but he remained loyal to many of the strictly mechanistic ideas of Cartesian philosophy.

With his work on mathematical probability, Huygens contributed to the construction of an instrument that could synthesise the rationalist demands for logical proof and the empiricist demand for experimental evidence. From the middle of the century onwards, mathematicians including Pascal, Huygens and Bernouilli had started to study and develop calculations of probability. While the concern with 'degrees of certainty' had already occupied many seventeenth-century intellectuals, this mathematical approach to the question of certainty opened new perspectives. The general idea was that in stead of trying to qualify certainty – as was also the point in the rationalist-empircist debate: what source provides greater certainty, reason or perception? – it could become possible to quantify certainty. This new concept of quantitative mathematical probability in turn supported "the growing seventeenth-century tendency to admit the less than certain into philosophy."[235] Of course, this is the case as well in the *Cosmotheoros* when Huygens claims that there is 'room left for probable conjectures.'[236] No definitive mathematical evidence is required.

However, that Huygens argues for the existence of planetary worlds with an appeal to probability does not mean that there might or might not be a plurality of worlds in a modern sense. It should be noted that the late seventeenth-century concept of probability was not concerned with chance – it did not measure the probability of a random event occurring, it measured human uncertainty. Probability was an epistemological category; its subject was what we can know, not what might happen or be. So to say, seventeenth-century probability is deterministic in nature, it tries to uncover events and things that are bound to happen or be, it does not predict what could happen. Consequently, the development of a deterministic concept of mathematical probability did not pose a self-sufficient alternative to the general desire for demonstrative proof (whether rational or empirical) and it remained strongly connected to the idea that universal mathematical laws formed the foundation of natural philosophy and of nature itself.[237]

5.4 The uniformity of Nature

5.4.1 Causality, plurality, uniformity

Taking into account these philosophical backgrounds, it is not surprising that apart from Huygens's argument of probability on the basis of the similarity between the planets, there is also a more fundamental

235 Serjeantson, 'Proof and Persuasion' (2006) 162-163.
236 *CW,* 4.
237 Serjeantson, 'Proof and Persuasion' (2006) 163-164. Note that my use of the term 'deterministic' sometimes takes a more radical meaning in the following paragraphs, especially in relation to Spinoza, indicating not just 'causally determined', but 'necessarily determined'.

and metaphysical layer of thought present in the *Cosmotheoros*. Although the argument of similarity and analogy forms the framework of the whole plea for the existence planetary worlds, it is not conclusive. Huygens would not be the lifelong critical student of Descartes if he would accept an argument that is in the end solely based on the observation of astronomical similarity.[238] While these arguments sufficiently prove that the Earth is one of the Planets, a more fundamental argument is required to support the claim that these Planets contain 'worlds'.

In order to clarify the problem, the Copernican theory that the Earth is one of the planets can be reversed. Now, based upon our knowledge of our the Earth, a planet can be defined as a solid celestial body orbiting the sun. The astronomical condition is satisfied through observation. The physical condition is satisfied to some extent: while telescopic observation demonstrates that the Moon is of similar physical nature, the Moon is not a planet and it therefore cannot be conclusively proven that the other planets are solid as well. Based solely on observation, the solid nature of the planets is only probable to a limited extent. In support of the claim that the planets are solid bodies, Huygens therefore also presents a composed astronomical argument: "First, 'tis more than probable that the Bodies of the Planets are solid like that of our Earth, and that they don't want what we call Gravity, that Virtue, which like a Loadstone attracts whatsoever is near the Body to its Center. And that they have such a quality, their very Figure is a proof; for their Roundness proceeds only from an equal pressure of all their Parts tending to the same Center."[239]

Concluding, the physical and astronomical similarity of the Earth and the planets can be demonstrated through observation and scientific reasoning. But does this also imply that the planets share the Earth's quality of 'containing a world'? Clearly, it does not. It cannot be simply assumed that two or more bodies sharing two of three attributes also share the third. To use Huygens's own example: a dog and an ox both have intestines and four legs, but this does not imply that the dog has horns. Likewise, Huygens cannot simply assume that the planets share Earth's 'third quality' of sustaining life and containing a natural world, but he will need to prove that the partial similarity between the planets and the Earth demands full similarity. Moreover, astronomical observation also reveals some differences between the planets, for example in size and in their position in the solar system.[240]

In order for the analogy to work, Huygens therefore needs to supplement the empirical evidence with rational and/or metaphysical arguments. Huygens will need to demonstrate that the observed similarity is not the result of mere chance, but that the similarity results from the causal regularity in nature, the 'uniformity of Nature.'[241] However, as for example Fontenelle's *Entretiens* demonstrates, this general Cartesian concept

238 On the influence Descartes philosophy had on the young Christiaan Huygens cf. the biographical literature, especially Vermij, *Huygens* (2004); Andriesse, *Titan kan niet slapen* (2007).

239 *CW,* 20.

240 Note the significance that other authors and especially Fontenelle had given to these facts. Cf. §4.6 above.

241 Although I have used this term several times before, a few clarifying notes are in place here, because neither seventeenth-century philosophy, nor present-day historiography use consistent terminology for what is the central principle of the 'new philosophy' – the idea that the (natural) world is causally directed by the unchanging laws of nature. Another term that can be used would for example be the 'universality of nature' as used in relation to the *Cosmotheoros* by Vermij, *Calvinist Copernicans* (2002) 152. In my further use of the term 'uniformity', note the important distinction between 'uniformity of Nature' (which describes the principle described above) and 'uniformity

does not necessarily imply the actual similarity of the planetary worlds. Whereas the astronomical and physical similarity between the planets and the earth could be conclusively demonstrated through observation and reasoning, the idea that the uniformity of Nature implies actual uniformity in nature is hard to prove.[242]

The concept of the uniformity of Nature as used by Huygens goes further than the essential mechanistic law that similar causes under similar circumstances demand similar results. Clearly, the similarity of the planetary worlds not necessarily follows from such an understanding of causality, which can just as well be used to argue for an infinite variety in planetary worlds – which includes the option that among an infinite variety of planets, Earth is the only planet sustaining life. The issue here is that the principle of the uniformity of Nature does not describe how its implied causality is 'directed'. In general, two sorts of causality can be discerned, which I will call 'random' causality and 'restrictive' causality. The type of causality that I call 'random' is causality based on chance and contingency, while the type of casualty I call 'restrictive' is deterministic in nature – determined by God or some other source of necessity).[243] These two opposite understandings of causality also imply opposite outcomes, and produce two respective types of reality that are infinite and infinitely plural on the one hand; and uniform and limited on the other.

In the tradition of the plurality of worlds, the former position is dominant.[244] The atomist 'atheists', medieval scholastics, and Renaissance Neo-Platonic mystics all shared this position. The concept of a plurality of worlds always expressed this fundamental notion of (possible) infinite variety. The atomists used it to express their belief in the essential contingency of nature – a reality that results from chance. The scholastics and mystics on the other hand, tried to express their belief in divine omnipotence in terms of infinity and plurality. Both 'Chance' and 'God's will' were presumed to express a principle of plenitude. Also after Giordano Bruno combined plurality with Copernicanism and developed the idea of an actual infinite universe (that coincides with one infinite cosmos), most authors still understood the concept of the plurality of worlds in terms of infinite variety. Kepler, Godwin and especially Fontenelle were all well aware of the variety in natural worlds that the different planetary conditions would generate. Although shaped more by classical mythology than astronomical data, the planetary worlds described by Fontenelle express the (infinite) variety that also exists between the planets. Only Aristotle, who rejects the idea of a plurality of worlds altogether, understands nature as essentially limited and singular.

Departing from this tradition, Huygens understands causality as a limiting principle. He prefers to think

in nature' (which describes the actual uniformity in nature as a result of the uniformity of Nature). This first idea is found in all Cartesian philosophy and physics, the latter is typical for Huygens.

242 I disagree with Vermij, who suggests that Huygens's idea of homogeneous planetary worlds is just the logical consequence of the mechanistic philosophy and the concept of the laws of nature in general. Cf. *Calvinist Copernicans* (2002)152.

243 It is important to note that 'chance' is a problematic concept within orthodox Christian theology: God's will governs the world, not chance. So to say, 'chance' eludes God's power. On the other hand, Spinoza's deterministic understanding of nature is problematic as well, as it limits Gods power. Cf. the *Belgic Confession* (1561), art. XIII: "And therefore we reject that damnable error of the Epicureans, who say that God mingles with nothing, but leaves all things to happen by chance."

244 Note that I refer to the two understandings of reality, not specifically causality. Atomist, Aristotelian and Neo-Platonic concepts of causality cannot differ from the seventeenth-century understanding of causality.

that the laws of nature produce essentially similar worlds on all planets, that only differ to a limited (and outward) extent. However, it is not easy to unravel the specific ideas on the fundamental uniformity of Nature and their role in the *Cosmotheoros,* and Huygens's is not very explicit on the matter. The controversial nature of the contemporary debate on causality and necessity (and in effect the possibility of miracles), and the dangerous 'Spinozist connection' of these ideas can probably explain Huygens's caution.

In this context, these different axiomatic presuppositions can have controversial theological and philosophical implications – for the philosophers were now discussing natural reality, not hypothetical possibilities. Not surprisingly, the 'atomist' understanding of the universe as directed by chance was widely considered to be atheistic. The theological problem is self-evident: even if a classical atomist would express faith in God, this God does not interfere with the world whatsoever, for every divine interaction would eliminate chance. However, the opposite position can be just as problematic, as the case of radical Cartesianism and especially its manifestation in Spinoza demonstrate:[245] a reality absolutely determined by causality is also incompatible with the orthodox image of an eternal God who is the free Creator of a temporal world and who can and does directly communicate, interact and interfere with the natural world and with humanity – culminating in the salvation of mankind through the incarnation and sacrifice of his divine son. Despite the problematic nature of both understandings of causality, orthodox scholasticism quite easily resolved the issue: the world is governed by the sovereign Creator, who himself is no part of creation. So to say, both chance and necessity are limited to the immanent world, and are subject to God's will. God permits that some things are governed by either chance or necessity (such as the laws of nature) in accordance with his omniscience, and the free actions of God directly or indirectly determine the outcome of some other things (miracles etc.). This orthodox 'intermediate' position could be specified as 'designed' causality, in stead of 'restrictive causality'.

These theological considerations clearly demonstrate the delicacy of the matter. What Huygens wants to say about planetary worlds now has become more than a playful jest or an entertaining conjecture. While the obvious soteriological problem implied by the existence of a plurality of worlds – are the planetarians also in a sinful state, and if so, can they be redeemed through Christ? – is never even mentioned by Huygens, his ideas about causality touch upon an even more important theological issue: for if someone were to defend a world view contradicting the existence of God, what does soteriology even matter?

5.4.2 Design and practical teleology

Before I will discuss the religious and philosophical backgrounds and implications of Huygens's ideas on chance/necessity, his position needs to be explained in relation to the particular subject of the plurality of worlds. As said, Huygens does not explicate his interpretation of the uniformity of Nature and the nature of causality anywhere in the *Cosmotheoros*. The central challenge to Huygens's analogical argument therefore

245 Note that the 'classical' Cartesian understanding of causality is closer to the atomist position than to Spinozism, in the sense that it does not share Spinoza's determinism. Cf. §5.5.1.

remains: why do the planets need to be all alike? Why do these planets – and their different astronomical circumstances – produce similar worlds and not an infinite variety of worlds?

Although Huygens does not explicate his philosophical assumptions, he appeals to theological arguments to support his claim. In a rather long passage, found just after the exposition of the astronomical and physical similarities of the planets, Huygens takes the first step:

> "But now to carry the search further, let us see by what steps we must rise to attaining some knowledge in the more private Secrets concerning the State and Furniture of these new Earths. And, first, how likely is it that they may be stock'd with Plants and Animals as well as we? I suppose nobody will deny but that there's somewhat more of Contrivance, somewhat more of Miracle in the production and growth of Plants and Animals, than in lifeles heaps of inanimate Bodies, be they never so much larger; as Mountains, Rocks or Seas are. For the Finger of God, and the Wisdom of divine Providence, is in them much more clearly manifested than in the other. One of *Democritus'*s or *Cartes'*s Scholars may venture perhaps to give some tolerable Explication of the appearances in Heaven and Earth, allow him but his Atoms and Motion; but when he comes to Plants and Animals, he'll find himself non-plus'd, and give you no likely account of their Production. For every thing in them is so exactly adapted to some design, every part of them so fitted to its proper life, that they manifest an Infinite Wisdom, and exquisite Knowlege in the Laws of Nature and Geometry, as, to omit those Wonders in Generation, we shall by and by show; and make it an absurdity even to think of their being thus haply jumbled together by a chance Motion of I don't know what little Particles. Now should we allow the Planets nothing but vast Deserts, lifeless and inanimate Stocks and Stones, and Deprive them of all those Creatures that more plainly Speak of their divine Architect, we should sink them below the Earth in Beauty and Dignity; a thing that no Reason will permit, as I said before."[246]

This rather dense passage advances two arguments that revolve around the notions of plenitude and design. The first argument has been repeated time and again in the tradition of the plurality of worlds: the glory of the Creator manifests itself in plenitude. Giving it an enlightened twist also used by Fontenelle, Huygens suggests that the belief that only the earth is inhabited, would be an inappropriate expression of human pride. Although this appeal to the Creator only makes an explicit argument for the existence of planetary worlds, Huygens's formulation also clarifies some of the backgrounds of his belief that these planetary worlds are in principle similar to ours. This argument is rather paradoxical and presumes that a hierarchy of value in the natural world can be discerned: why should the planets only contain rocks – or lesser creatures like Kepler's Selenites or Fontenelle's various planetarians, who suffer from unfavourable circumstances – and not the good world that we live in, and the intelligent rational species that humanity is? Huygens's positive anthropology, presupposed here and developed further in Huygens analogical discussion of the terrestrial

246 *CW,* 19-20.

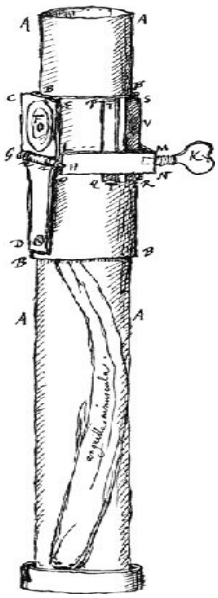
(i.e. human) world and the planetary worlds, can in this sense be qualified as orthodoxly anthropocentric.[247] It is not necessarily orthodox however, and remains far removed from the traditional Aristotelian (and i.e. Calvinist) qualitative classification of creation: Huygens's appeal to the Creator may imply a 'high' anthropology, it also implies the equality of the planets and the fundamental unity and uniformity of Nature. The use of the metaphor of design in the cited passage therefore also points towards a less orthodoxly inspired appreciation of the complexity of the natural world.

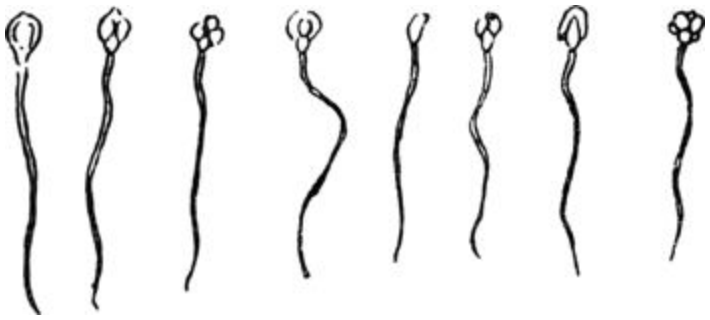
Huygens explicates his scepticism towards the supposedly contingent theories of atomists and radical Cartesians in seemingly conventional terms: animals and planets cannot be the result of chance, but they express the Wisdom of a divine Architect. This harsh criticism of atomist and radical Cartesian materialism (presumably) based on chance, is not only an expression of Christian indignation, but also of a more philosophical supposition. Huygens's objection to the atomistic concept of a natural world created and sustained by chance is that such a natural world could not reach the level of complexity and interdependency witnessed on earth. While the new materialist theories (in effect Cartesianism) can sufficiently explain how the celestial bodies came into being and are sustained, the explanation of natural life remains problematic.[248] The natural world as we know it could never have come into being as a result of the random collision of particles, and even if it did, it would immediately fall apart again – it is not sustainable.

This idea is also touched upon in Huygens's personal notes. Although he does not give a quotable philosophical statement, Huygens uses several smaller arguments against the chance origins of life. First, he argues that the atomist theories cannot explain the teleological characteristics of plants and animals, such as eyes to see and wings to fly: "Quis *enim* tam impudens ut aves volare dicat quia alatae sunt. non autem datas esse alas ut volent."[249] Subsequently, Huygens argues that even if chance could generate a body, it could not give it life, animate it: "nequaquam intelligi potest, ex semel ita concitatis materiae particulis ejusmodi quid quale est animal conflatum."[250] In fact, not only is it inconceivable that life could come into existence as a result from chance, the miracle of life itself is incomprehensible to reason: "Ratio invenire nequit quo modo homines caeteraque animalia extiterint."[251]

This argument is further supported by a rebuttal of the concept of spontaneous generation of mice from clay. Even the existence of mice and insects is beyond the grasp of reason. It is implausible that such an 'artificii automaton,' a well-crafted machine, can come forth from the dirt. With a further appeal to the recent study of insect life, Huygens further reinforces the idea that all life-forms are more or less uniform: not even insects can come into existence otherwise than through reproduction – as the recent microscopic discoveries of such scholars like Swammerdam, Hooke and Leeuwenhoek had shown.[252]

247 Cf. §5.6 below.
248 *CW,* 20; *Réflexions,* III, §3, 556.
249 *Réflexions,* III, §3, 556; 'For who is so imprudent to say that birds fly because they have wings. And not that wings are given to fly?'
250 *Réflexions,* III, §4, 557; 'In no way can it be understood, how once set in motion such particles of matter could merge into a living being.'
251 *DRI,* §7, 514; 'Reason cannot uncover in what way man and the other animals came into being.'
252 Cf. Jorink, *Het Boeck der Natuere* (2006); Ruestow, *The Microscope in the Dutch Republic* (1996); Daston and





5.3 Huygens also performed his own microscopic experiments. On July 15, 1678, he observed a sample of semen: “figures apparentes des animaux in semine, la veritable figure ne pouvant estre bien discernée a cause de leur transparence.” *OC,* XIII, 701-702.

5.4 Design for a microscope. *OC,* XIII, 720.

In the *Cosmotheoros*, Huygens applies this argument of the conservation of life repeatedly in relation to the possible terrestrial and planetary modes of nutrition, procreation, movement, perception, reason, etc. The principle is explicated several times as well, for example when discussing morality: “For the aim and design of the Creator is every where the preservation and safety of his Creatures.”[253] Huygens argues that in order to survive, any conceivable sort of rational being will need to be able to distinguish between Good and Evil. If an intelligent creature would exist that was only provided with a corrupt 'moral Reason', this morality would inevitably lead to the destruction of its society, and the extinction of the intelligent creature. The problem of the sustainability of nature in relation to the reality in nature of death and decay is explicated when Huygens's writes on procreation:

> Why may not the same rule be observ'd in the Planetary Worlds? *For't is certain that the Herbs and Animals that are there would be lost, their whole Species destroy'd without some daily new Productions*: except there be no such thing there as Misfortune or Accident: except the Plants are not like other humid Bodies, but can bear Heat, Frost and Age, without being dry'd up, kill'd, or decay'd: except the Animals have Bodies as hard and durable as Marble; which I think are gross Absurdities. If we should invent some new way for their coming into the World, and make them drop like Soland Geese from Trees, how ridiculous would this be to any one that considers the vast difference between Wood and Flesh? Or suppose we should have new ones made every day out of some such fruitful Mud as that of *Nile*, who does not see how contrary this is to all that's reasonable? And that 'tis much more agreeable to the Wisdom of God, once for all to create of all sorts of Animals, and distribute them all over the Earth in such a wonderful and inconceivable way as he has, than to be continually obliged to new Productions out of the Earth?[254]

Park, *Wonders and the Order of Nature* (1998) 303-328.

253 *CW,* 42.

254 *CW,* 29-31.

Huygens's appeal to design in the confrontation with atomism is quite subtle. He does not simply invoke the Book of Nature in an orthodox sense, appealing to God's continuous support of creation, but he points out that the complexity of life, and moreover its sustainability, cannot be the result of chance, but must be in accordance with some great design.[255] Even if the random collision of particles could generate life-forms, these animals created by chance would not be sustainable. Only life created according to the Architect's design – found in even the smallest living thing, as Huygens witnessed through his microscopes and during visits to Leeuwenhoek and Swammerdam – is properly equipped for survival and procreation.[256]

This practical teleological understanding of the concept of design is an important theme in Huygens's detailed analogical conjectures about the planetary worlds.[257] The question he therefore tries to answer time and again is not 'how things are', but 'how things can be and remain'. The complexity of these strings of causality and dependency that are omnipresent in the world is what ultimately makes Huygens believe that 'a world' can only exist in one way – Earth's way. Huygens points at the dependency of all life on water (or fluids in a more general sense), on the inevitability of decay and death and the consequential necessity of some form of procreation, on the need of possibilities of perception and movement for animals to survive, the need of a will to survive, of some measure of instinct or intelligence, the need of hands, shelter, eyes, etc. On the basis of these universal basic properties that all lifeforms require to survive, Huygens also argues for the existence of inevitable 'higher' capabilities. A creature will inevitably maximize these given 'survival' skills, resulting in the more noble arts, such as for example the study of nature and the invention of music.

However, the analogical conjectures on the basis of divine design and the preservation of life do not prove anything about the existence of planetary worlds. This argumentation only demonstrates that if extraterrestrial planetary natural worlds would exist, they would correspond to Earth. The argument for the existence of these worlds is found in Huygens's continuing appeal to divine plenitude and in his fundamental assumption of the uniformity of Nature. At a theological and philosophical level however, also Huygens's practical understanding of the necessary similarity of natural worlds on the basis of the preservation of life can be challenged. That Huygens can only imagine the sustainability of life through nutrition and procreation does not exclude the possibility that extraterrestrial life might be sustained in ways that go beyond our imagination.

255 Huygens does not appeal to God's *supernatural* support of the natural world, but to God's design *immanent* in Nature. Cf. for the classical position the *Belgic Confession*, art. XIII: 'We believe that the good God, after creating all things, did not abandon them to chance or fortune; but that He rules and governs them according to His holy will, so that nothing happens in this world without His decree.'

256 On Huygens's own microscopic observations, cf. *OC,* XIII, cxxxix-cxlii; For his own notes and drawings from 1678-1680 and 1692, cf. *OC,* XIII, 698-732. Huygens not only knew of the microscopic studies of Swammerdam and Leeuwenhoek, he also visited them at their workplaces. Ruestow, *The Microscope in the Dutch Republic* (1996) 140; Andriesse, *Titan kan niet slapen* (2007) 295.

257 Note that this principle of sustainability and preservation that I call 'practical teleology' has nothing to do with Aristotelian teleology.

5.4.3 The challenge of variety

After the presentation of his own arguments, in the *Cosmotheoros* Huygens also addresses the possible objection to his position that no reasonable ground exists to claim that planetary life must be similar to the terrestrial life: “They will not deny indeed but that there may be Plants and Animals on the Surface of the Planets, that deserve as well to be provided for by their Creator as ours do: but why must they be of the same nature with ours?”[258] This objection challenges Huygens's theory of the similarity and equality of the planets, and it contrasts the concept of limited plurality with a concept of plurality as infinite variety. This objection therefore not only revives the classical dichotomy between Platonic/Aristotelian concepts of unity and the atomistic concept of unlimited plurality and diversity generated by chance and infinity, it also directly concerns the different interpretations of the uniformity of Nature and causality discussed above.

In his response to this objection, Huygens therefore needs to explain his axiom of uniformity a little more clearly than he has done so far. However, he does not explicitly address the philosophical assumptions at the heart of the problem, but once again takes his starting point in the observation of nature. Huygens agrees that life on earth expresses great variety, but he also stresses that this does not necessarily imply infinite variety: “Nature seems most commonly, and in most of her Works, to affect Variety, 'tis true; But they should consider 'tis not the business of a man to pretend to settle how great this Difference and Variety must be. Nor does it follow, because it may be Infinite, and out of our comprehension and reach, that therefore things are in reality so.” Huygens thus clearly rejects the idea of an infinitely diverse plurality. Admitting that Nature does indeed produce variety in the natural world, Huygens claims that this variety is fairly limited:

> “For suppose God should have pleased to have made all things there just as he has here, the Inhabitants of those Places (if there are any such strange things) would admire his Wisdom and Contrivance no les than if they were widely different; seeing they can't come to know what's done in the other Planets. Who doubts but that God, if he had pleased, might have made the Animals in *America* and other distant Countries like ours? (and Nature you know effects Variety) yet we see he has not done it. They have indeed some difference in their shape, and 'tis fit they should, to distinguish the Plants and Animals of those Countries from ours, who live on this side the Earth; but even in this variety there is an Agreement, an exact Correspondence in figure and shape, the same ways of Growth, and new Productions, and of continuing their own kind. Their Animals have Feet and Wings like ours, and like ours have Heart, Lungs, Guts, and the Parts serving to Generation; whereas all these things, as well with them as us, might, if it had so pleased Infinite Wisdom, have been order'd a very different way. ”[259]

On the basis of this limited variety in the natural world on Earth, Huygens argues that the infinite

258 *CW,* 22.
259 *CW,* 22-23.

possibilities in nature do not necessarily need to be realized:

> 'Tis plain then that Nature has not exhibited that Variety in her Works that she could, and therefore we must not allow that weight to this Argument, as upon the account of it to make every thing in the Planets quite different from what is here. 'Tis more probable that all the difference is between us and them, springs from the greater or les distance and influence from that Fountain of Heat and Life the Sun; which will cause a difference not so much in their Form and Shape, as in their Matter and Contexture.[260]

In Huygens's opinion, the planetary worlds and their inhabitants differ from Earth and its inhabitants in their appearance and in their specific properties, but not in their essential attributes. Rejecting the Lucretian idea of am actual infinite variety in nature, Huygens applies the idea of uniformity in a restrictive way: as God chose to limit the variety in the natural world of the Earth, even among its different geographical parts, no reason exists to assume that the Architect would allow such a variety on other planets.[261]

The basic claim that Huygens again makes is that Nature is uniform and always works the same; therefore, similarity implies equality, and in similar circumstances, similar causes generate similar effects. Within the context of the *Cosmotheoros*, this world view basically implies that the diversity in nature is limited to the diversity in the natural world of the one planet we know. If another planet is similar to ours, it must be also similar in both its possibilities and in its limitations. Because every planet is subject to the laws of nature, it must bring forth a basically similar natural world. One obvious problem arises here: why does Huygens stress the similarities, but ignore the differences of the planets?

Even though Huygens could not see like we can that the other solar planets are indeed vast deserts, this notion had already been put forth by many contemporary authors through a circumstantial argument, most notably in Fontenelle's *Entretiens.* In this argument, the different astronomical circumstances of the planets result in natural worlds completely different from Earth.[262] The passage cited above clearly demonstrates that Huygens was well aware of the inevitable influence of the distance to the sun on planetary life. In fact, in the second book of the *Cosmotheoros*, Huygens does follow this line of thought when he questions the possibility of life on the moon. The apparent absence of water or even an atmosphere on the moon is the main argument here.[263] His claim that the different circumstances of the planets only effect the forms of life on the planets, and that they do not demand fundamentally different natural worlds, thus seems to be rather arbitrary. However, this deliberate and arbitrary choice by Huygens to limit the possible differences in planetary life, offers an important clue in understanding Huygens's more principal world-view: he does not accept the universe to be infinitely diverse, but understands it to be essentially uniform and the plurality of

260 *CW,* 23-24.
261 The arbitrariness of this claim is striking.
262 Cf. §4.6; Fontenelle actually defended the atomistic principle I just described as 'infinite diversity in plurality'.
263 *CW,* 128-132.

worlds to be limited to the model of the natural world found on Earth. If life exists on other planets, it can only result in a Earth-like natural world inhabited by an anthropomorphic intelligent life-form, even though its appearance might differ from ours, for planetary life would also be subject to the laws of Nature. Laws that ultimately express God's design of the world, and that must eventually result in Man, the purpose and crown of creation.

The idea of the uniformity of Nature expressed in the *Cosmotheoros* is therefore closely connected to the two other aspects of every 'classical' world-view, theology and consequently also anthropology. The question I must therefore now discuss is how Huygens understood the relation between Nature and God, who is called upon as the final authority supporting the argument of the *Cosmotheoros*. And of course what Huygens had to say about God.

5.5 God and/or Nature

5.5.1 The best of all possible worlds

In the previous paragraph, I argued that Huygens's belief in the strict uniformity of Nature is fundamental to his comprehensive world-view. Although it is against this backdrop that we should understand Huygens's theory of a homogeneous plurality of worlds, the axiomatic uniformity of Nature as such cannot conclusively explain this actual uniformity in nature. The infinite diversity proposed by Fontenelle derives from the same Cartesian understanding of the uniformity of Nature. In fact, it might be argued that Fontenelle applies the principle more consistently than Huygens, for how could planets at different distances from the sun habit similar worlds? A question that remains is therefore why Huygens decides to limit the variety produced by the uniform laws of Nature? Why does he understand the causality in Nature as 'limited' and not 'infinite'?

To understand the practical concept of the uniformity of nature as found in the *Cosmotheoros*, Huygens's underlying philosophical and theological ideas should be further explored in relationship to the contemporary mechanistic philosophy that Huygens subscribed to. Especially the ideas on the relation between nature and God as defined by Descartes and criticized and adapted by Spinoza are important here.

As I have explained above, in the *Cosmotheoros* and in his related unpublished writings, Huygens does not explicate his axiomatic position. Instead, he substantiates his theory of a homogeneous plurality of worlds with an appeal to the design supporting the preservation of life that is apparent everywhere in the natural world. It is this argument from design that most directly connects Huygens's to contemporary theology and metaphysics, especially to the emerging apologetic physico-theology of the early eighteenth century.[264] However, this 'argument from design'-connection is not as clear as it first appears. Although Huygens frequently appeals to either a design or its Architect, his writings lack both the devout wonder expressed by Swammerdam or Boyle and the apologetic intentions of for example Bernard Nieuwentijt (1654-1718).[265]

264 On the 'argument from design' as used by Swammerdam cf. Jorink, *Het Boeck der Natuere* (2006); on Boyle, cf. §5.3.2 above; on 'physico-theology', cf. §4.4 n. 162 and §4.5.
265 On Nieuwentijt, cf. the biographical study by Vermij, *Secularisering en Natuurwetenschap* (1991).

Huygens does not use the argument to praise or defend God, but his primary purpose is to stress the complexity as well as the vulnerability of the natural world. Huygens turns the argument from design around: nature is not invoked to support an opinion about God, but God is invoked to support an idea about Nature. Whereas the apologists use the natural world to defend God's Wisdom, Huygens uses divine providence to explain Nature. To explain Huygens's fundamental understanding of Nature, it is therefore necessary to discuss his ideas about God and divine providence.

In order to be able to clarify Huygens's ideas, I will first discuss some of the theological and philosophical ideas on the relation between God and Nature as understood by Descartes and Spinoza. It is against the backdrop of the thought of these two important philosophers that Huygens's use of the terminology of design and divine providence should be understood.

In Christian theology, the concepts of design and providence are closely related to a second theological theme: divine omnipotence, and the relation between God and creation. This concept also inspired the question why the omnipotent and free God has created the world in the way that it actually exists: is this world perfect – the best of all possible worlds? As I will argue, the theological and philosophical considerations involved in this question, which has been a constant theme in Christian theology since antiquity, are quite similar to Huygens appeal to the existence of a design in nature. The problem is clearly formulated by Steven Nadler in his book *The Best of All Possible Worlds*:

> Does God make or do something because it is good, or is something good because God does it? The Bible says that on each day of creation God surveyed what He had done and "saw that it was good." But did God choose to create what he did because He perceived it to be inherently good? Or was what God created good simply because God created it – with the implication that had God created something entirely different, then *that* would have been good instead?[266]

Formulated like this, the idea of 'the best of all possible worlds' is a theological and moral topic, dealing both with a qualification of creation and with the relation between God and reality. In this perspective, the possibility of a *different* world can be compared to the possibility of a *plurality* of worlds. As noted in the second chapter above, medieval scholastic discussions of the plurality of worlds were primarily characterized by theological considerations. When it came to the *possibility* of a plurality of worlds, the underlying subject was not physical but theological in nature: Gods *omnipotentia* and freedom were at stake.[267] Discussing the question whether the world is perfect or not, a similar theological value is at stake: is God omnipotent and free beyond the laws of nature? And is God bound by his own intrinsic morality and goodness, or are morality and goodness his to define? Although this theological theme is primarily

266 Nadler, *The Best of All Possible Worlds (*2008) 185.
267 Cf. §3.3 above.

concerned with God's nature and *potentia,* the problem also implied questions about natural reality. Where these issues overlap, a philosophical question arises: if another world could exist, could it exist in any other way than the way in which Earth exists?

This broader philosophical question implied by the theological debate also lies at the core of Huygens's philosophical ideas: could the world have been different from the world as it actually exists? And could a different world exist alongside the one we know?[268] The new Cartesian philosophy could not offer an unequivocal answer to this question. However, something like a 'traditional Cartesian' position can be discerned. Concerning the original theological question, the Cartesian position is quite clear: God did not create the Earth in its specific configuration for any independent reason or value; He is indifferent to his own creation. The technical background of this *voluntarist* position lies in the notion of God's unity, which Descartes derived from God's perfection. God's unity implies that no distinction can be made between His attributes, in particular between His will and His understanding. Therefore, God's will cannot be directed by His understanding of external objective values.[269] Consequently, the classical Cartesian position would be that the world is good 'simply because God created it', and that it could also have been different from its actual state. Therefore, the world is fundamentally contingent. In a theological sense, this means that divine providence is the expression of God's absolute freedom. According to Descartes, even necessary and unchanging truths are ultimately contingent upon a creative act of the divine will.[270] The uniformity of Nature is therefore contingent as well, and only exists because God wants it to. God is therefore also able to suspend the laws of nature, and whenever Cartesianism questions the reality of miracles – the archetypical form of Divine intervention and providence – it is on the basis of the idea that God does not *want* to govern nature otherwise than according to the laws of Nature.

The precedence of divine freedom was not the only possible 'Cartesian' solution to the problem. The most important advocate of an alternative Cartesian understanding of the relation between Nature and God was Spinoza.[271] While the Cartesian premise of God's unity was shared by Spinoza, he did not solve the paradox between divine knowledge/wisdom and freedom in favour of the latter. As discussed above, Spinoza argued that God only acts according to the laws of nature and that God can in fact be identified with the creative power in Nature. Consequently, God does not choose anything. Following from Spinoza's 'identification of God with the eternal, infinite, necessarily existing substance of Nature,' everything that exists within Nature is caused by 'God or Nature' with an absolute necessity.[272]

268 Note that 'world' is now used in the philosophical sense of 'reality', not in the cosmological sense of 'planetary world'. However, a philosophical position on this issue can sometimes also translate to an idea about the cosmological issue, as is the case in the Cartesian position discussed below.
269 On Descartes position on the theological issue, cf. Nadler, *The Best of All Possible Worlds (*2008) 190-196.
270 Nadler, *The Best of All Possible Worlds (*2008) 191.
271 Cf. §4.4 above on Spinoza's philosophy in general, and §5.3.2 on Spinoza's theory of knowledge.
272 Nadler, *The Best of All Possible Worlds* (2008) 227.

Spinoza explicitly refutes the concept of God's free will in the first part of his *Ethics.* First he asserts that God alone is the 'free cause' of all things, determined nor restrained by anything outside of his own nature – "God alone exists only from the necessity of his nature and acts from the necessity of his nature."[273] However, that God is a free cause does not imply that he has a will, or even freedom of will. Since free will would constitute an external cause on which God acts, free will is in contradiction with God's being. Will is therefore not a free cause (like God), but only a 'necessary or constrained cause'. "For the will, like all other things, requires a cause by which it is determined to exist and produce an effect in a certain way. And although from a given will *or* intellect infinitely many things may follow, God still cannot be said, on that account, to act from freedom of the will […] So will does not pertain to God's nature any more than do the other natural things, but is related to him in the same way [...]."[274] In other words, such affections as reason, will, desire, love, etc. can only be related to *Natura naturata,* not to *Natura naturans*.[275]

Following from the nature of God, in Spinoza's system no other world could possibly exist, and neither could the existing world exist in a different way. Moreover, this is a matter of causality, not of virtue: the world is neither good nor evil in an absolute sense. As everything in the world is produced by God's eternal essence, both evil and good are included in God. According to Spinoza, good and evil are only relative notions of the mind. Consequently, Spinoza's 'God or Nature' and the reality included by these terms is not good, but it is the only possible world; it is merely perfect, in the sense that it follows from God's own necessary nature.[276]

Spinoza's position can be clarified a little further by explaining his ideas on divine providence and the possibility of miracles and the supernatural. Whereas other radical thinkers before the eighteenth century only dared to cast doubt on the existence of miracles, Spinoza was the first thinker to open a frontal attack on the belief in miracles and the supernatural.[277] In the especially notorious sixth chapter of his infamous *Theological-Political Treatise* (1670), Spinoza altogether denied the possibility of miracles and the supernatural. The belief in miracles, he argues, derives from the popular misunderstanding that God and Nature are two contrasting powers. As long as Nature takes its normal cause, God remains inactive; and conversely, when God acts, Nature is suspended. According to Spinoza this is an absurdity, because: "If anything therefore were to happen in nature that contradicted its universal laws, it would necessarily contradict the decree and understanding and nature of God. Or if anyone were to assert that God does anything contrary to the laws of nature, he would at the same time be compelled to assert that God acts contrary to his own nature […]."[278]

In Spinoza's system a supernatural event cannot occur whatsoever, for everything is part of Nature. So-called 'supernatural' events that elude our understanding are in fact natural phenomena of which the causes

273 Spinoza, *Ethics,* Ip17c2.
274 *Ethics,* Ip32c2.
275 *Ethics,* Ip31.
276 Stewart, *The Courtier and the Heretic* (2005) 162.
277 Israel, *Radical Enlightenment* (2001) 218.
278 Spinoza, *Theological-Political Treatise, (TTP),* VI 3, 83.

remain unknown to us. Miracles are therefore purely mental constructions of ignorant men, who try to explain the unknown with an erroneous appeal to God. Whereas miracles are unintelligible to us, "it is only the phenomena of nature we understand clearly and distinctly that enhance our knowledge of God and reveal as clearly as possible the will and decrees of God."[279]

Therefore, if the reality of the supernatural were to be established, instead of proving God's existence, this could only result in atheism:

> For since a miracle does not occur outside of nature but within nature itself, even if it is said to be above nature, it must still necessarily interrupt the order of nature which otherwise we conceive to be fixed and unalterable by God's decrees. If therefore something happened in nature which did not follow from its laws, this would necessarily be conflict with the order that God established in nature for ever by the universal laws of nature; it would hence be contrary to nature and its laws and, consequently, it would make us doubt our faith in all things and lead us to atheism.[280]

Opposing the popular belief that the supernatural is the ultimate proof of God (a belief also held by the Church), Spinoza argues that it is only through the rational understanding of the order of Nature that God can be known. Consequently, the classical understanding of divine providence as a continuous active interference of God with creation cannot be upheld either. However, Spinoza does not simply reject the idea of divine

5.5 Baruch de Spinoza (163-1677). Anonymous portrait. Herzog August Bibliothek, Wolfenbüttel.

279 *TTP,* VI 7, 86.
280 *TTP,* VI 8, 87.

providence. Smartly retaining the phrase and even appealing to Scripture to support his views, he redefines the concept to suit his own non-providential understanding of God and Nature:

> I will show from Scripture that the edicts and commands of God, and hence of providence are nothing other than the order of nature. That is, when the Bible says that this or that was done by God or by the will of God, it simply means that it was done according to the laws and order of nature, and not, as most people think, that nature ceased to operate for a time or that its order was briefly interrupted.[281]

5.5.2 God and the design in nature

As noted above, Huygens addresses the relation between God and Nature primarily in the conventional language of design and providence. I will now try to clarify how he understood these concepts, and I will argue that his view does not conform to classical Cartesian voluntarism, but is more closely related to the deterministic necessity defended by Spinoza. As discussed in the previous paragraph, according to Huygens a world can only exist in one way. The world is configured as it is because that is the only way it can be preserved – and in effect exist at all. The world is intrinsically 'good', sustainable, perfectly designed.

The argument from design is in itself not unique. As noted above, this idea can in different forms also be found in the works of Swammerdam, Boyle, and Spinoza.[282] However, the meaning given to this metaphor varies greatly among its users. Huygens admiration for the great order in Nature runs deep: the configuration of the natural world on Earth is so delicately in balance, so well-designed in every detail, and its flora and fauna are so perfectly equipped for the purpose of the preservation and reproduction of life, that Huygens cannot imagine that the world could possibly exist in any other way.

But how should Huygens's appreciation of the apparent design in nature be understood? At times it seems that he fully endorsed the pious interpretation forwarded by Swammerdam: “And we shall worship and reverence that God the Maker of all these things; we shall admire and adore his Providence and wonderful Wisdom which is displayed and manifested all over the Universe, to the confusion of those who would have the Earth and all things formed by the shuffling Concourse of Atoms, or to be without beginning.”[283] Despite this pious language however, the general tendency in the *Cosmotheoros* is quite secular. As noted above, Huygens does not primarily use the argument from design for pious or apologetic purposes, but as a metaphor to explain nature. Primarily, Huygens appeals to design to support his argument of practical teleology: “The Stature and Shape of Men here does show forth the Divine Providence so much in its being so fitly adapted to its design'd Uses.”[284]

Because Huygens relies on an argument from Design, it is important to also clarify his understanding of

281 *TTP,* VI 12, 89.
282 Cf. above §4.4, 4.5, 5.3.2.
283 *CW,* 11.
284 *CW,* 73.

God, and his understanding of divine providence. In relation to the problem of the best of all possible worlds the new mechanistic philosophy offered two important interpretations of divine providence. Cartesian voluntarism states that the order of nature results from a decree of God's free will; nature is therefore fundamentally contingent. Opposing this view, Spinoza argues that the order of Nature is implied by God's own nature and that God and Nature therefore coincide. Consequently, providence is 'nothing other than the order of nature'.[285] Where does Huygens stand in this controversy? The strong emphasis that he puts on the necessary uniformity of nature, suggests that Huygens sympathised with Spinoza on the matter: God is not free to create any world he likes, because only one world can possibly exist. This position is at times also expressed in the *Cosmotheoros*: "And these things are not only contrived and framed with so great Wisdom and Skill, as not to admit of better, but to any one that considers them attentively, they seem to be of such a nature as not to allow any other Method."[286]

The more pious strands of thought that are also present in the *Cosmotheoros*, emphasizing the glory and wisdom of God, seem to contradict this suggested Spinozist affinity. The matter thus seems to have remained unresolved in Huygens's thought. However, whereas Huygens is quite cautious on matters of theology in the *Cosmotheoros*, in the unpublished writings of 1686-1690 he reveals a little more of his theological ideas. Although Huygens does not explicitly embrace Spinozism here either, several fragments suggest affinity to Spinoza's radical ideas.

The first of these clues can be found in Huygens's rejection of Descartes's understanding of God's will.[287] Most significantly, it becomes clear that the free and omnipotent God implied by Cartesian voluntarism is called into question. In several notes, he directly attacks anthropomorphic understandings of God. In §5 of the piece *De rationi imperviis*, Huygens writes:

> Error gentium plerumque fuit ut corpora humana dijs affingerent. Nihilo levius errant qui mentem Deo tribuunt nostrae similem, voluntatem, affectus, scientiam. Non enim intelligi potest quid sit voluntas in Deo, nec enim nunc hoc nunc aliud velle putandus uti nos. Non irasci, placari, ut nos. Non scire aut intelligere eodem modo. Non deliberare, non quaerere quomodo quid efficiat.[288]

Huygens rejects the attribution of a mind and a will to God. He suggests that if a will were to be found in God, he would be a changeable God. This seems unlikely to Huygens. In an earlier note from 1686, he formulated the same thought and added a psychological explanation to it:

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285 *TTP,* VI 12, 89.
286 *CW,* 46.
287 On Spinoza's rejection of God's will, cf. §5.5.1 above; *Ethics,* Ip31-33.
288 *DRI,* §5, 514; 'An error of the peoples [gentium] is that they attributed human bodies to the gods. It is nothing less than error to attribute to God a mind similar like ours, a will, affection [or: desire], knowledge. For it cannot be understood what a will in God is, and neither can it be conceived that he wills now this and than that; nor [for him] to be angry, or to be appeased, like us. Nor to know or understand in the same way. Nor to deliberate or to inquire how he will bring something about.'

> Les paiens et barbares attribuoient à Dieu un corps semblable au corps humain, les philosophes luy attribuent une ame semblable a l'ame humaine et des affections semblables aux nostres, seulement differentes en perfection. Ils luy donnent une maniere de penser, de vouloir, d'entendre, d'aimer. Que pouvaient-ils faire autre chose? Avouer qu'il surpasse de bien loin l'homme d'avoir une idée de Dieu.[289]

The comparison to the classical deities who were even given anthropomorphic bodies emphasizes the absurdity of divine 'will'. Huygens sceptically remarks that the attribution of emotions, thoughts, and desires to God cannot hide the human incapability to understand God. However, this denial of God's will – along with the other anthropomorphic properties that are ascribed to him – and the claim that God surpasses human understanding does not mean that Huygens is altogether sceptical about the possibility of knowledge of God.

The first thing that can be known about God is implied in Huygens's rejection of divine will and reason. His ridicule of the attribution of anthropomorphic properties ascribed to God implies an understanding of God as immutable, in contrast to the changeability of humankind. The argument of §5 of *De rationi imperviis* is drawn to its conclusion in the subsequent fragment: "Quod certa ratione se habet, cum aliter se habuisse per naturam potuisset, non esse ab aeterno. Habet enim causam cur potius tale sit, ergo aliquando non fuit. Hinc nihil tale Deo convenire potest."[290] Not only is God immutable, he is also not contingent, for he is necessarily who he is because of who he is. The reminiscence of Spinoza is evident here: "God alone exists only from the necessity of his nature and acts from the necessity of his nature."[291]

Apart from this metaphysical argument about the divine being, Huygens asserts a second source of knowledge about God, as he explains that God can be known from his works: "Cherchons a prouver qu'il y a un autheur summe intelligens, mais d'une intelligence tout a fait autre que la nostre, non pas par ces idees, mais par la consideration des choses creees, ou il parait tant de art et de prudence, sur tout en ce qui regarde les animaux."[292]

Here we touch again upon the argument from design. With this statement therefore, we seem to have arrived at a dead end in Huygens's thought. I turned to Huygens's understanding of God to explain his use of the concept of design, but Huygens uses the same concept to explain God. Both nature and God are thus explained by Huygens in terms of design and providence: nature is designed for its preservation, and God can be known through this design. God and Nature can therefore be properly understood only in their

289 *QD,*§1, 341. Cf. also the longer passage refuting the Cartesian ontological argument for God's existence in *Appendix to DRI,* §7-8, 525-527. In relation to divine will, Huygens's here states: "Voions aussi qu'est ce que nous pouvions entendre par summe potens. C'est de pouvoir faire et effectuer tout ce qu'on veut. Nous reconnoissions en nous un vouloir, et de la nous l'attribuons aussi a Dieu. Ainsi nous imaginons qu'il vient a Dieu la volontè de creer le monde, d'envoyer un deluge, de punir un mechant. ne considerant pas qu'il ne peut convenir a cet Estre eternel et tout parfait de commencer a former des resolutions, differees jusques la, sans cause, ou que des choses contingentes le poussent a vouloir. En fin l'on verra que cette idee de pouvoir ce qu'on veut aussi bien que de scavoir tout ne mettent rien en Dieu qu'a l'imitation de ce que nous sentons en nous."

290 *DRI,* §6, 514; 'Everything that is the case for certain reasons, while it could by nature have been otherwhise, exists not from eternity. For it has a cause why it is such [as it is]; therefore at some time it was not. Hence no such thing can belong to God.'

291 *Ethics,* Ip17c2.

292 *QD,*§2, 342.

correlation. The focal point of this connection can be identified with, and explained by yet another theological concept: divine providence. Further explanation of Huygens's idea of providence is therefore demanded. In this respect, some further interesting notes are found in his unpublished writings where, like in Spinoza's *Theological-Political Treatise*, the subject of providence is closely connected to the criticism of miracles.

Although Huygens's does not explicitly reject the possibility of miracles like Spinoza had done, his cynicism speaks for itself: "An naturae legibus corpora ferri et moveri sinat, quod in omnibus quae videmus ita esse constat: an nonnunquam manum admoveat, quod ex auxilio saepe praestito apparere dicent ex historijs. Sed quot sunt qui innocentes indigne perierunt!"[293] Opposing the classical understanding of miracles as divine interventions temporarily abolishing the laws of nature, Huygens claims that God always acts according to the laws of nature: "Que quoyque Dieu ait ainsi disposè ces choses, pourtant il est certain qu'il agit par les loix immuables de la nature, et qu'il est autant permis de rechercher dans ce bastiment du monde la suite et l'efficace des causes naturelles que dans la production du flus et reflus de la mer, du tonnerre, de l'arc en ciel et autres choses de cette sorte."[294]

This short passage explains the relation between God and the design in nature through an implied concept of providence: the design in nature can be known, because God created it according to the immutable laws of nature. In relation to the plurality of worlds, this idea is further explicated. In a note from the *Réflexions*, Huygens argues that the planetarians must know algebra like we do, because 'geometria tamen ubique eadem est necessario.'[295] This position is also found in the *Cosmotheoros*: "For that Science [Geometry] is of such singular worth and dignity, so peculiarly imploys the Understanding, and gives it such a full comprehension and infallible certainty of Truth, as no other Knowledge can pretend to: *it is moreover of such a nature, that its Principles and Foundations must be so immutably the same in all times and places*, that we cannot without Injustice pretend to monopolize it, and rob the rest of the Universe of such an incomparable Study."[296] The immutability of geometry is also connected to the practical teleology that I discussed above: "And then the artful Composition of the Eye, drawing an exact Picture of the Objects without it, upon the concave side of the Choroides, is even above all admiration, nor is there any thing in which God has more plainly manifested his excellent Geometry."[297]

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293 *DRI,* §13, 516; 'Does he [God] allow the bodies to be produced and moved by the laws of nature, which is established in everything we see? Or does he sometimes move his hand to help, which as they say happens often, according to the stories? But how many innocents there are who have undeservedly perished!' Cf. also §9: 'Probabile mundum omnem et genus humanum ita esse creata ut Dei opera particulari postmodum non indigeant. quemadmodum machina a perito artifice. Ita syderum motus, ita terrae. quidni et animalia et homines. Nemo putat opinor cum pluit cum tonat cum aedes corruunt, data opera ista a Deo fieri, quid enim templa et rupes fulmine ferit. An dicent credo, consilio atque opera peculiari Dei fieri si domus corruens aliquem opprimat, si neminem, tunc casu concidere? At quam saepe et innoxios sic perire videmus.'

294 *Pensees,* §40, 362.

295 *Réflexions,* II, §23, 554; 'Geometry, after all, is necessarily the same everywhere.'

296 *CW,* 84. The emphasis is mine.

297 *CW,* 20. This idea is expanded further in a complement to *Dioptrique,* De l'oeil et de la vision' (ca. 1670-1690). Here, 'prevoiance' is connected explicitly to the geometrical aptitude of the eye. I cite the passage in full as it clearly illustrates the connection between practical teleology and the more fundamental concept of providence through geometrical and natural universality. *OC,* XIII, 797: 'En faisant reflexion sur tout ce qui vient d'estre expliquè

The use of practical teleology in the *Cosmotheoros* – nature is equipped for its preservation – can be understood as perfectly orthodox, and perhaps even devout.[298] However, the arguments found in Huygens's unpublished writings cast doubt on this conventional interpretation. Huygens's combined claims that God has no free will, that God always acts according to the universal laws of nature and that the design in the natural world is in accordance with the immutable principles of geometry, suggest a rather unorthodox understanding of divine providence. The rejection of God's free will is crucial here, for the idea that God and in effect divine providence follow the laws of nature is in itself not necessarily unorthodox as long the doctrine of divine free will is upheld – which is the position of Cartesian voluntarism. When God lacks free will and his actions are all in accordance with the laws of nature, God himself is bound to the laws of nature. Even though Huygens does not explicate this position, I believe it to be the only possible coherent explanation of his understanding of God and Nature. Ironically, whereas Huygens's *Cosmotheoros* became a best-seller, thirty years earlier Spinoza was branded an atheist for defending a similar position.

The Spinozist affinity of Huygens's ideas is expressed perhaps most clearly in a passage from the piece *De rationi impervii* (1690). In this fragment, that contains several aphoristic notes and one longer and more coherent argument, Huygens discusses the problem of human free will, and explains it with an appeal to divine providence and necessity. It opens with a commentary on human free will:

> Hominum cogitationes actionesque omnes necessitate quadam alias alijs succedere ut in machinis, etsi quisque sibi plenam esse et cogitandi et agendi libertatem existimet. [...]
>
> Omnia itaque quae contigerunt, quaeque contingunt, non potuisse quin ita fierent.
>
> Hoc remedium optimum nequid rerum peractarum poeniteat, aut male habeat, aut imprudenter gestum dolorem ingerat. quo tamen a rebus agendis, cavendoque damno, nequaquam averti debemus nec abstinere a puniendis malis. nam ut illi necessario mali ita et necessaria mali poena et exstirpatio.[299]

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touchant la structure de l'oeil, il ne se peut qu'on n'y remarque non seulement l'effect d'une admirable prevoiance mais aussi d'une haute intelligence de geometrie et plus manifestement, a ce qui me semble, qu'en aucune autre chose qui soit dans la nature. l'on ne scauroit concevoir sans cela ni l'invention de la surface convexe pour assembler a un point des rayons paralleles, ni la sphericitè de la cornée et du cristallin si bien compassées avec la profondeur de l'oeil qu'elles fassent que le concours s'y rencontre precisement au fond. ni cette lentille de refraction differente d'avec les liqueurs qui la contiennent et sa mobilité, pour faire que l'image des objects proches fust aussi distincte dans l'oeil que celle des plus eloignez. L'on reconnoit encor particulierement la prevoiance en l'exacte polissure du convexe transparent par ou les rayons entrent, et cela entretenue par le moyen d'une liqueur qui s'attache si uniment, qu'on ne voit point que l'eau ou d'autre humeur fasse un pareil effect lors qu'on en mouille quelque superficie, elle paroit de mesme en la parfaite transparence de tout le dedans de l'oeil; et en ce qu'il est tout rempli de ces corps diaphanes, pour eviter les reflexions de plusieurs surfaces en cas qu'il y eust eu du creux derriere et devant le cristallin. On la voit enfin cette prevoiance en l'obscuritè de toute la surface interieure de l'oeil pour eviter la reflexion de la lumiere qui aurait troublè les images.'

298 In my discussion of this subject above, I therefore did not want to prematurely explain Huygens's use of this argument as a clue towards Spinozism; cf. §5.4.2.

299 *DRI,* §10, 515; 'All human thoughts and actions succeed each other by a certain necessity like in machines, even though [or: and yet] everyone believes that for themselves there is full freedom of thought and action. Everything therefore that has happened, and that happens, could not have come to be otherwise [but so]. This is the best remedy so that nothing that has happened will be punished or have us distressed, or that an imprudent action will bring sorrow. Which however, must not keep us from doing the things that must be done, and from precautions against

The psychological anthropology expressed here is identical to the anthropology of the second half of Spinoza's *Ethics.* To cite just one proposition: "In the Mind there is no absolute, or free, will, but the Mind is determined to will this or that by a cause which is also determined by another, and this again by another, and so to infinity."[300] After Huygens has established that human acts and thoughts are predetermined through an eternal causal chain, he casually takes the claim to a higher level as he states: "Everything therefore that has happened, and that happens, could not have come to be otherwise." Whereas the first sentence of the paragraph only concerns the human mind, this second proposition postulates the universal determinism that had been championed by Spinoza: "Things could have been produced by God in no other way, and in no other order than they have been produced."[301]

The acceptance of this necessity, Huygens continues, can be of great comfort when tormented by remorse or grief.[302] Huygens also explains that the realization of man's lack of free will does not remove his responsibility. Although human emotions, thoughts and actions may be determined by necessity, so everyday labour, precautions against harm, and punishment for the wicked are demanded by necessity.[303]

In the following section of the paragraph, the necessity and causal determination of all things, including human thoughts and emotions, is further explained in mechanistic terminology:

> Cum omnia sic a Deo sint ordinata et perfecta, ut solo motu et agitatione corporum in corpora inque animas hominum [...] ut constare et perennare mundus omnis et genus humanum possint. cumque ad conservandam societatem ac rem publicam, amorem boni ac recti, ac rursus odium mali ac sceleris ingeneraverit, nunquid non solum à cura rerum singularum immunem sese Deus praestitit, sed et a futuri notitia? Nam si ea sapientia ac providentia totius mundi res ordinavit ut postea occursu vario et motu corporum et atomorum omnia peragerentur, an dicemus etiam infinitos istos occursus et reflexiones corpusculorum in antecessum Deo exploratos fuisse singulos? An praenoscere casus et eventa homunculorum dignum Deo, in ista mundorum immensa multitudine? an hoc tantum curasse ac providisse ut summa rerum salva esset, bonaque malis semper praevalerent universè, non autem in casibus omnibus sigillatim. Certe enim ita cum rebus humanis agi videmus. saepe indigna pati optimos

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damage, nor from punishment of the wicked. For like some people necessarily do evil, so the punishment and eradication of evil are necessary.'
Cf. the *Appendix to DRI,* §12, 528: 'Nous n'avons pas la libertè de penser et de vouloir comme nous nous imaginons, mais toutes nos pensees sont enchainees et vont necessairement de l'une a l'autre quoy qu'il nous semble que nous en disposons absolument. Elles vont leur train sinon que des objects nouveaux les detournent et font prendre d'autres routes.'

300 *Ethics,* IIp48.

301 *Ethics,* Ip33.While this parallel between the *Ethics* and Huygens's unpublished writings has been noticed by Klever, his explanation of the connection between Huygens and Spinoza is minimal; Klever, 'Spinoza en Huygens' (1997) 26-28.

302 Ironically, this idea, also found in Spinoza's *Ethics,* strongly reminiscences a passage from the orthodox Calvinist *Belgic Confession*, art. XIII: 'This doctrine gives us unspeakable consolation since we are taught that nothing can happen to us by chance, but only by the decree of our kind heavenly Father. He watches over us with paternal care, keeping all creatures under his control, so that not a of the hairs on our heads (for they are all numbered) nor even a little bird can fall to the ground without the will of our Father.'

303 Cf. on the necessity of planetary societies *CW,* 41-43.

quosque; occidere immerentes, idque casu persaepe, nec ratione ulla quare id fiat apparente. Frequentius tamen plecti sceleratos, puniri improbos, vel legum vindicta vel conscientiae torminibus.[304]

This concluding section touches upon several different ideas and connects them – most of which we have encountered before. Not only does Huygens confirm that the world is designed perfectly by God according to the mechanical and geometrical laws of nature, but he also connects this providential necessity to the practical teleology in nature that sustains and effects its preservation. Moreover, whereas Huygens rejected the materialistic explanations of life generated by chance supposedly held by 'the atomists', he now explains the generation, preservation and proceedings of life in corpuscular terms as the result of collisions of bodies, governed by the laws of nature that express God's providence.[305]

Huygens wonders whether God concerns himself with every particular incident and action in nature, or that he has arranged Nature in such a fashion, that it needs no further divine interaction or support. Moreover, he also doubts that God would burden himself with foreknowledge of the future. After posing these questions, Huygens also suggests an answer. He speculates that God only provided nature to be and remain in a general state of order: good will always prevail over bad in the universe, but this is not so in all singular cases. And although good men may suffer undeservedly, and wicked men may escape their rightful punishment, in general some moral order is maintained in society.

5.5.3 Providence, or the necessary uniformity of Nature

I argued in the previous paragraphs that in the *Cosmotheoros,* Huygens defends an understanding of the uniformity of Nature as a restrictive principle that produces also uniformity *in* nature – and therefore essentially similar worlds in the different 'celestial Earths'. In the light of other interpretations that hold that the uniformity of Nature does not produce similarity, but infinite variety, I questioned the underlying concepts and ideas of Huygens's interpretation of the uniformity of Nature as a restrictive principle. In order to answer these questions, I turned to Huygens's understanding of God and God's relation to Nature and the natural world. First I discussed the philosophical backgrounds of his position. Subsequently I tried to clarify

304 *DRI,* §10, 515; 'Because everything is thus arranged and perfected by God, that solely through movement and the concussion of bodies against bodies and against the souls of humans […]; and that the whole earth and the human kind can persist and last (a long time/forever) [perrenare]; and that in order to maintain society and the state, he implanted the love for goodness and righteousness, and on the other hand a revulsion for evil and crime; has not God freed himself of the care for separate affairs [rerum], but also from knowledge of the future? For if he has arranged with such wisdom and providence all affairs of the whole world, that afterwards will be realized through the varying movement and collision of bodies and atoms; shall we than say that these infinite corpuscular encounters and impacts have been examined in advance by God, each separate one? Or that it agrees with God's dignity to foreknow the experiences and affairs of mere humans [homunculorum], in that immense multitude of worlds? Or do we say that only this has been taken care of and provided for: that the sum of things is in order, and that good always prevails over evil, in general, but not in all individual cases. For certain, we see this happen in human affairs. Often the best [men] suffer undeservedly; innocents are slain, and this is so very often, and it happens without any apparent reason. Frequently however, the guilty are scourged, and the wicked are punished, whether by demand of the law, or the torments of conscience.'

305 On Huygens's rejection of the 'atomist' position, cf. §5.4.2 above.

Huygens's ideas about God, design, and providence. Having clarified these aspects of Huygens's thought, I should therefore now try to explain how these philosophical-theological ideas support the claim of the *Cosmotheoros* that the planetary worlds must be essentially similar to Earth, diverging only in appearances.

I have also argued that Huygens's use of causality is 'restrictive' in nature, as opposed to the 'random' causality found in ancient atomism and Cartesianism.[306] Now that I have also explained the philosophical and theological backgrounds of his philosophy, I can explain how Huygens's restrictive interpretation of the uniformity of Nature derives from his understanding of God and providence.

Divine providence as described by Huygens is twofold. First, it obeys the uniform and geometrical laws of nature. Second, it is teleological in nature, as it ensures the conservation of nature and the preservation of life. A similar understanding of providence can be found in Spinoza's early *Short Treatise on God, Man, and his Well-Being,* where it is described as a specific (*proprium*) attribute of God and defined as follows:[307]

> Providence, […] according to us is nothing but that striving we find both in the whole of Nature and in particular things, tending to maintain and preserve their being. For it is evident that no thing, through its own nature, could strive for its own destruction, but that on the contrary, each thing in itself has a striving to preserve itself in its state, and bring itself to a better one.
>
> So according to this definition of ours, we posit a universal and a particular Providence. The universal is that through which each thing is produced and maintained insofar as it is a part of the whole of Nature. The particular Providence is that striving which each particular thing has for the conservation of its being insofar as it is considered not as part of Nature, but as a whole.[308]

It is clear that providence as defined in the *Short Treatise* has nothing to do with the supernatural free and personal God of Jewish and Christian orthodoxy. Does Huygens share this view? Although this cannot be concluded with absolute certainty, it is most likely. Although the evidence in his unpublished writings is much more explicit on matters of theology and faith than the *Cosmotheoros,* Huygens remains reserved about his understanding of and belief in God. Primarily, it is never explicated whether Huygens conceived God as a transcendent being, or as immanent, as proposed by Spinoza. It also remains unclear whether Huygens subscribed to Spinoza's identification of God and Nature.[309] However, it does become clear in the

306 Cf. §5.4.1.

307 Written ca. 1660-1661 and discovered and published in the nineteenth century, this work was meant for circulation among friends. Cf. Nadler, *Spinoza* (1999) 186; Klever, 'Spinoza's life and works' (1996) 13, 25.

308 *Short Treatise,* 1, V, 84. Note that this early citation is not representative for Spinoza's later thought. Whereas he still redefines providence in the *TTP* (cf. the citation at the end of §5.5.1 above), Spinoza does not discuss the subject in the *Ethics*. For Spinoza's ideas about providence, cf. Nadler, *Spinoza's theory of providence* (2005). However, Spinoza's concept of *conatus* does express a striving for self-preservation that is at some points comparable to what I have called 'practical teleology' in relation to the *Cosmotheoros*; cf. Smith, *Spinoza's book of life* (2003) ch. 4; Della Rocca, 'Spinoza's metaphysical psychology' (1996).

309 Although Huygens uses the terms God, Architect, Providence, Nature, etc. interchangeably in some instances in the *Cosmotheoros* and in the unpublished writings in several instances, this fact offers insufficient evidence to assume an actual identification of God and Nature. Cf. *DRI,* §1, 513.

unpublished writings how Huygens understood the correlation between God and Nature.

Three facts have been established about (the properties of) Huygens's God: first, he has no will or reason, and surpasses human understanding; second, he is immutable; third, he created and preserves his creation in accordance with the laws of nature and geometry. From the first two divine properties, another can be inferred: because God has no free will *and* because he is immutable, he is necessarily who he is. The necessity of God in turn implies the necessity of providence and the necessity of Nature.

In accordance with the properties of God, providence – which is the expression of God's actions or decrees – is thus also necessarily determined. Because providence obeys the laws of nature, and as it expresses the decrees of the necessary God, it expresses a principle of necessary and therefore restrictive causality in Nature. If God is not contingent, neither is providence. The necessity of providence in turn implies the necessary and therefore restrictive causality in Nature. The necessity of providence, and its properties – the teleology of conservation; and the accordance to the laws of Nature – imply two things: Nature's necessity, and Nature's conservation.

Huygens therefore interprets the uniformity of Nature as a principle of necessity, like Spinoza, but unlike Descartes, who believed the uniformity of Nature to be fundamentally contingent – for the laws of Nature are the product of God's free choice. Both the practical teleology of the *Cosmotheoros* and this necessary uniformity of Nature therefore express a single comprehensive understanding of reality as determined by necessity.

How does this necessitarianism relate to the discussion of the plurality of worlds in the *Cosmotheoros?* How does it support Huygens's conception of the plurality of planetary worlds? Why cannot Huygens assert an infinite variety in Nature of planetary worlds that each in their own way are determined by necessity and are suitably equipped fro preservation? Based upon the found axiomatic convictions, these questions can finally be answered. The key concepts here are necessity and contingency.

If the premise of an infinite variety of planetary worlds is true, every one of these worlds could have been every other world. This would render them contingent. These worlds are all governed by providence, which equips each planet *fit for its conservation* and *following the laws of nature.* These two conditions must therefore coincide in each world, for no world could exist that is either unfit for conservation or in discord with the laws of nature. As providence derives from the necessity of God, it cannot but exist necessarily. Therefore, there is only one planetary configuration that is in concord with the laws of nature, and there is only one planetary configuration that is fit for its conservation. Consequently, *if* a plurality of worlds would exist, these worlds would necessarily have to be similar in essence – although not in appearance, for a variety in appearances does not compromise the set conditions. If two *essentially different* worlds would exist, one of them would either be unfit for its conservation, and hence it could not exist; or it would be in discord with the laws of nature, which is an absurdity.

In his discussion of the *Cosmotheoros*, Karl Guthke not surprisingly wonders 'what might be the point of an

infinite multiplication of essentially identical worlds?'[310] The answer to this question now has become clear: the infinite multiplication of essentially identical worlds reflects Huygens's fundamental belief that Nature and nature are produced by necessity. Because there in fact is reason to believe that a plurality of worlds exists (Copernicanism and plenitude), it cannot be concluded otherwise than that this must be a plurality of similar worlds.

5.6 Of Man

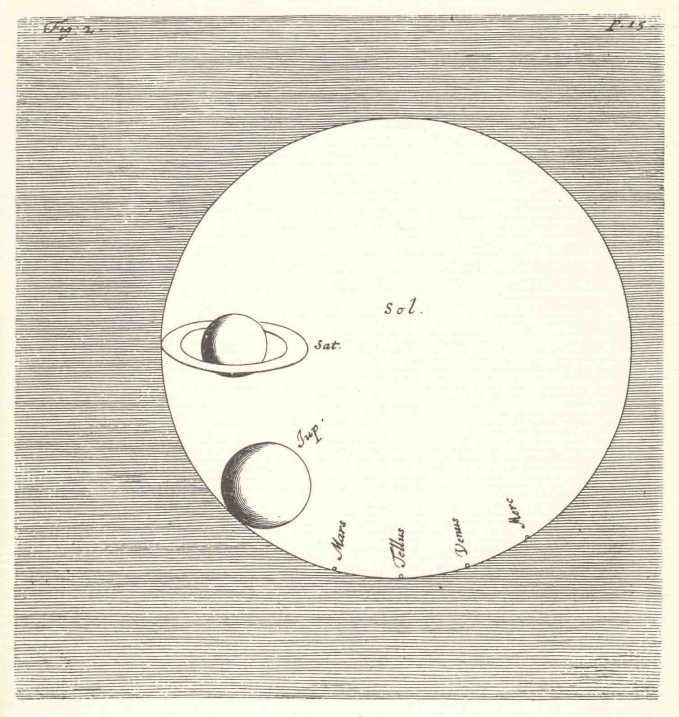
5.6.1 Mankind in the universe

In the previous paragraphs dealing with Huygens's ideas about Nature and God, my argumentation was strongly focused on his understanding of the uniformity of Nature. This approach primarily concentrated on the problem of variety and singularity/unity/similarity in relation to the plurality of worlds. As I have argued, Huygens's belief that all planetary worlds and stellar systems are essentially similar, expresses his axiomatic understanding of Nature as necessarily determined by the laws of nature and a principle of conservation.

Apart from the problem of plurality itself, another theme that is frequently discussed in the plurality of worlds tradition is the antithesis finitude-infinitude. Whereas almost every author in the tradition of plurality has explicated ideas about plurality-unity, many have been less outspoken on the problem of (in)finity. Although for example ancient atomism, Bruno, and Fontenelle, were all outspoken in favour of the proposition of the infinite universe, Descartes had not explicated his position, but spoke only of the 'indefinite' universe, whereas Kepler and Galileo rejected the notion.[311] Huygens's ideas on the infinity of the universe also remain inconclusive. In the second part of the *Cosmotheoros*, Huygens discusses some revolutionary astronomical ideas about the solar system and the universe, including his calculations of the sizes of the planets, and his argument that the distances in the solar system must be much larger than previously assumed. It is here that he also touches upon the subject of infinity. “For if with our bare Eye we can observe above a thousand [Stars], and with a Telescope can discover ten or twenty times as many; what bounds of number must we set to those which are out of the reach even of these Assistances! especially if we consider the infinite Power of God.”[312] Although the stars are innumerable, this does not imply that the universe is infinite:

> Some of the Antients, and *Jordanus Brunus* carry'd it further, in declaring the Number infinite: he would perswade us that he has prov'd it by many Arguments, tho in my opinion they are none of them conclusive. Not that I think the contrary can ever be made out. Indeed it seems to me certain, that the Universe is infinitely extended; but what God has bin pleas'd to place beyond the Region of the Stars, is as much above our Knowlege, as it is our Habitation.

310 Guthke, *The Last Frontier* (1990) 243.
311 Rossi, *The Birth of Modern Science* (2001) 110, 113-114.
312 *CW,* 155.



5.6 A diagram from the *Cosmotheoros* comparing the sizes of the planets and the sun. *OC,* XXI, 694.

> Or what if beyond such a determinate space he has left an infinite Vacuum; to show, how inconsiderable all that he has made is, to what his Power could, had he so pleas'd, have produc'd? But I am falling, before I am aware, into that intricate Dispute of Infinity: Therefore I shall wave this, and not, as soon as I am free of one, take upon me another difficult Task.[313]

Only affirming the existence of the astronomical infinity of space, Huygens is reluctant to confirm the physical infinity of the universe and the stellar systems, and suspends his verdict.

The problems of infinity and plurality have always raised questions about the place of humanity in the universe. Therefore, in the plurality of worlds tradition, and especially in its more literary expressions, anthropology is an important theme. The discourse of plurality has been used to reflect on many different themes, ranging from satirical commentaries of contemporary society and politics (as did for example Lucian, Godwin and Cyrano) to mystical or secular reflections on man's futility and vanity (as found in the ancient myths, and the works of Cicero, Bruno, and Fontenelle) to allegories of the afterlife (Plato, Dante). In the seventeenth century, the general tendency is to reject geocentricism as an expression of human vanity. Consequently, humankind is cast down from its elevated position in the centre of the cosmos/universe.[314] Man is no longer the graced purpose of Creation, and the focus of divine attention. This does not necessarily imply a pitiful anthropology, as is shown for example by Fontenelle's emphasis mankind's favourable location in the solar system. How does Huygens esteem humanity's position in the universe? First of all, the *Cosmotheoros* subscribes to the general opinion that the belief in the plurality of worlds is a humbling insight:

313 *CW,* 156.
314 This seventeenth-century idea does little justice to medieval cosmology; cf. §3.3.

> The other sort, when they hear us talk of new Lands, and Animals endued with as much Reason as themselves will be ready to fly out into religious Exclamations, that we set up Conjectures against the Word of God, and broach Opinions directly opposite to Holy Writ. For we do not there read one word of the Production of such Creatures, no not so much as of their Existence; nay rather we read the quite contrary. For, That only mentions this Earth with its Animals and Plants, and Man the Lord of them; but as for Worlds in the Sky, 'tis wholly silent. Either these Men resolve not to understand, or they are very ignorant; […] And these Men themselves can't but know in what sense it is that all things are said to be made for the use of Man, not certainly for us to stare or peep through a Telescope at; for that's little better than nonsense. Since then the greatest part of God's Creation, that innumerable multitude of Stars, is plac'd out of the reach of any man's Eye; and many of them, it's likely, of the best Glasses, so that they don't seem to belong to us; is it such an unreasonable Opinion, that there are some reasonable Creatures who see and admire those glorious Bodies at a nearer distance?[315]

However, whereas this rebuke of human vanity in for example the *Entretiens* is accompanied by a proclamation of man's insignificance in the face of the innumerable number of worlds in the infinite the universe, Huygens is not quite so pessimistic about the position of mankind. His opinion comes forth from the specific understanding of the plurality of worlds as plurality of essentially similar worlds. While this implies that mankind cannot be superior to other creatures in the universe, it cannot be inferior either. Consequently, to compare man to other living creatures, we can only turn to the other creatures found on Earth.

In the *Cosmotheoros* this is what happens when Huygens makes his conjectures about the planetary worlds in the continuous comparison to life on Earth. As he discusses how the other planets must also have animals, reasonable inhabitants, geometry, fire, houses, society, etc., Huygens therefore simultaneously explains life on Earth. Apart from the equality of the planets, another specific element of his philosophy is reflected in Huygens's anthropological insights. As the whole of Nature unfolds according to the principles of necessity and preservation, this also applies to humanity. Man is still a purpose of Nature – although not the exclusive purpose of nature, and not in the orthodox theological sense. As I have discussed above, to Huygens this a comforting thought.[316] Interestingly, this vindication of man as a valuable creature is not anthropocentric in nature, at leas not in the cosmic sense.

5.6.2 The glory of Man

On a more practical level, Huygens is not so modest about the position of mankind in the world. The demand for the equality of the planets in itself demonstrates that the different beings and bodies in Nature are

315 *CW,* 7-8. Cf. *Pensees,* §8, 351; 'N'ayons pas l'orgueil de nous croire seigneurs de toute la nature.'
316 Cf. the 'consolation of causality' in *DRI,* §10; cf. §5.5.2 above.

not valued equally. For why would it be 'against reason' that some planets have natural worlds and inhabitants and some have only rocks, when nothing has intrinsic value? Therefore, as I argued above, the secular argument of plenitude as applied by Huygens presupposes a hierarchy of value in the natural world.[317] This hierarchical approach to the planetary worlds, and in effect to the terrestrial world, is omnipresent in the *Cosmotheoros*. This is also clearly expressed in the approach towards the matter of planetary life: "But now to carry the search farther, let us see by what steps we must rise to the attaining [of] some knowlege in the more private Secrets concerning the State and Furniture of these new Earths."[318] Huygens begins his exploration of the planetary worlds with a discussion of the 'lower' creatures, and gradually climbs up to the 'higher' beings, and the 'higher' properties and capabilities attributed to them. In order, Huygens examines herbs, animals, 'rational beings', their senses, their reason, their technical skills, their society, their discoveries, their music, and ultimately, their knowledge and science. This reasoning is given a strongly anthropocentric emphasis, when Huygens argues for the existence of rational creatures in the planets:

> But still the main and most diverting Point of the Enquiry is behind, which is the placing some Spectators in these new Discoveries, to enjoy these Creatures we have planted them with, and to admire their Beauty and Variety. [...] That which makes me of this opinion, that those Worlds are not without such a Creature endued with Reason, is, that otherwise our Earth would have too much the advantage of them, in being the only part of the Universe that could boast of such a Creature so far above, not only Plants and Trees, but all Animals whatsoever: a Creature that has a Divine somewhat within him, that knows, and understands, and remembers such an innumerable number of things; that deliberates, weighs and judges of the Truth: a Creature upon whose account, and for whose use, whatsoever the Earth brings forth seems to be provided.[319]

Although Huygens previously rejected the notion that the whole cosmos is created by God for the purpose and enjoyment of man, he now strongly emphasizes the anthropocentric hierarchy that exists within each planetary world. This position, ironically based upon his egalitarian approach to the planets, is explicated in relation to mankind in the *Réflexions*: "Jam vero homo ipse, animal illud rationis particeps, nonne longe praecipua pars censenda est eorum quae in Terra existunt?"[320]

Huygens also discusses all the good use Man makes of his reason: he shapes the natural world that surrounds him and builds houses and cities; he tillages the soil to produce food; he invents machines to ease his labour; he navigates the seas; he observes the orbits of the planets and explains them; he makes music for his enjoyment; etc. But why does human reason set mankind apart from the other animals? Do their 'lower'

317 Cf. §5.4.2 above; *CW,* 19-20.
318 *CW,* 19.
319 *CW,* 36-38. The part left out of the cited passage rejects the idea that the whole cosmos was made for Man.
320 *Réflexions,* II, §4, 544; 'But now man himself, that animal in possession of reason, is he not by far the principal part of the things that exist in the Earth?'

instincts not serve them just as well, providing for their needs and their preservation? Huygens addresses this question in the *Cosmotheoros*:

> What is it then after all that sets human Reason above all other, and makes us preferable to the rest of the Animal World? Nothing in my mind so much as the contemplation of the Works of God, and the study of Nature, and the improving those Sciences which may bring us to some knowlege in their Beauty and Variety. For without Knowlege what would be Contemplation?[321]

It is thus the understanding of Nature, and therefore providence, that truly sets humanity apart. It is here also that Huygens addresses the topic that is so strikingly absent in Huygens's discussion of the planetary worlds: religion. While Huygens attributes to the planetarians all kinds of human capabilities and efforts, he does not speak of the planetary inhabitants as religious beings. Does the *Cosmotheoros* here show some sceptical utopianism? In his unpublished writings, as we have seen, Huygens strongly rejects the anthropomorphic ideas people attribute to God. He also questions the popular belief in miracles, and scorns the superstitious masses who believe in the fairy tales of greedy impostors.[322]

However, in relation to his praise of human reason Huygens also explains a positive idea about religion: it is in the contemplation of Nature that Man can contemplate God, and worship him for his Wisdom.[323] It is this religious aspect of the investigation of nature and the universe that Huygens advances at the beginning of the *Cosmotheoros,* in answer to possible accusations of irreligious *curiositas*:

> But besides the Nobleness and Pleasure of the Studies, may not we be so bold as to say, they are no small help to the advancement of Wisdom and Morality? so far are they from being of no use at all. For here we may mount from this dull Earth, and viewing it from on high, consider whether Nature has laid out all her cost and finery upon this small speck of Dirt. So, like Travellers into other distant Countrys, we shall be better able to judg of what's done at home, know how to make a true estimate of, and set its own value upon every thing. We shall be less apt to admire what this World calls great, shall nobly despise those Trifles the generality of Men set their Affections on, when we know that there are a multitude of such Earths inhabited and adorned as well as our own. And we shall worship and reverence that God the Maker of all these things; we shall admire and adore his Providence and wonderful Wisdom which is displayed and manifested all over the Universe, to the confusion of those who would have the Earth and all things formed by the shuffling Concourse of Atoms, or to be without beginning.[324]

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321 *CW,* 60.
322 *Réflexions,* I, 541; *DRI,* §5, 514; *QD*, §1-3, 341-342; cf. above §5.3.1, §5.5.2.
323 Cf. also *QD,*§2, 342; and §5.5.2 above.
324 *CW,* 10-11.

This concept of religious contemplation of Nature has two aspects: not only does it advance reverence for the Deity, it also teaches Man the virtues of wisdom and morality. This notion is quite similar to Spinoza's concept of 'true' or 'universal religion' as defined in the preface of the *Theological-Political Treatise*: "I began to consider first whether universal religion, or the divine law revealed to the whole human race through the prophets and Apostles, was really anything other than the law which the natural light of reason also teaches."[325]

With the formulation of this religious concept of knowledge, wisdom and virtue, we encounter yet another hierarchy of value in the *Cosmotheoros,* namely the distinction between better men and lesser men. For if the study of Nature and the reverence for God does not set Man apart from the animals, Huygens concludes;

> [than] what difference is there between a Man, who with a careless supine negligence views the Beauty and Use of the Sun, and the fine golden Furniture of the Heaven, and one who with a learned Niceness searches into their Courses; who understands wherein the Fixt Stars, as they are call'd, differ from the Planets, and what is the reason of the regular Vicissitude of the Seasons; who by sound reasoning can measure the magnitude and distance of the Sun and Planets? Or between such a one as admires perhaps the nimble Activity and strange Motions of some Animals, and one that knows their whole Structure, understands the whole Fabrick and Architecture of their Composition?[326]

5.6.3 Huygens's intellectual testament

According to Huygens, there can also be made distinctions among men, between the virtuous and the immoral, and between the wise and the ignorant. It is therefore in the discussion of the world and the pursuits of Man, that the *Cosmotheoros* takes an important personal and reflective turn. Not only does the work explore Huygens's ideas about the fundamental composition of Nature, it also uses the 'conjectures about the celestial worlds' as a framework to once more sum up the highlights of his own scientific career. It its therefore important to realize that the *Cosmotheoros* is Huygens's final work. It is not the debut of a young man, or just some entertaining work 'on the side' of an acclaimed scientist, but it is the comprehensive work that reflects a life of scientific effort. As he writes in his last known letter, to his brother Constantijn, Huygens mentions that he is still correcting the manuscript of the *Cosmotheoros*.[327]

Christiaan Huygens did not live to see his final work published. His health declined in the course of 1694, and after a painful sickbed in the first half of the following year, he died on July 8, 1695. Three sober notes about Christiaan's last days and passing away in the journal of his brother Constantijn give some more insight in Huygens's religious beliefs:

On May 25: "[Hij] seyde, dat de menschen, hoorende van sijne opinien en sentimenten omtrent de religie,

325 *TTP*, 9; cf. *TTP,* Ch. 4, 'On the divine law'.
326 *CW,* 60-61.
327 4 March 1695, Chr. Huygens to Const. Huygens; *OC,* X, 708-710.

hem souden verscheuren."

On June 20: "als sij hem wilde persuaderen om een Predicant bij hem te laten komen, hij begon te vloecken en te raesen."

On July 11: "Mijn vrouw schrijft […] dat het noch al eveneens was met broer Christiaen, maer dat er verleden donderdach een schielijcke verandering gekomen was, soo men t'samen goedt gevonden had een Predict. (Monsr. Olivier) bij hem te halen, wesende een kennis van broer. Dat dese hem langh aensprack en een gebedt of twee voor hem dede, doch dat hij hem antwoorde op deselve manier als ick hem laetst had hooren spreken, en dat, wat men hem seyde of niet en seyde, hij van die opinie niet af te krijgen was, dat haer alle seer bedroefde. Dat voorts het die nacht soo slecht wierd, dat men mijn vr. smergens ten half vieren quam haelen, en dat, als sij daer quam, sij hem buyten kennis vond, en dat dat soo duerde tot vrijdachs smergens, wanneer hij seer sacht ontsliep."[328]

That Huygens did not seek the consolation of the Church in the face of death may not come as a very big surprise, considering his religious ideas discussed so far. In the unpublished writings, we can still find a little more information on Huygens's approach of religion and the church:

> "Le doute fait peine a l'esprit. C'est pourquoy tout le monde se range volontiers a l'opinion de ceux qui pretendent avoir trouvè la certitude. jusques la qu'ils aiment mieux les suivre en se laissant abuser.
>
> Il ne faut pas croire sans qu'on ait raison de croire; autrement que ne croit on les fables et les comptes [sic] des vieilles, et pourquoy les Turcs n'ont ils point raison de croire à l'Alcoran?"[329]

Above, I already discussed Huygens's scepticism concerning knowledge of God in relation to his metaphysical ideas. Here, Hugyens offers a more straightforward reason for his sceptical position: for religion to be acceptable, it needs to be reasonable. Over twenty five years earlier, Huygens had already expressed similar ideas in a letter to the mathematician Adrien Tacquet from Antwerp who had tried to convert him to Catholicism. His attempt failed; to convince Huygens of the truth of Roman faith, more was needed than books and the authoritative arguments of theologians, people who can be deceived and corrupted. 'How far are these arguments removed from the proof of geometrical evidence!' Huygens exclaimed.[330] In a letter to the Bishop Pierre Huet dated 18 april 1691, Huygens is also explicit on the relation between faith and reason. Responding to a book by Huet on the reconciliation of faith and reason Huygens claims that it is faith that should answer to reason, and not the other way around. However, he is

328 Const. Huygens, *Journal,* 486; 493; 503-504.

329 *QD,* 342.

330 3 August 1660, Chr. Huygens to Adrien Tacquet, OC, III, 104-105. Cf. p. 105: "Si rationibus agendum est, nescio an fatis validas reperire possitis ad opiniones tanti momenti mihi persuadendas. librorum enim auctoritatem adducitis qui corrumpi potuerunt, hominum, qui decipi potuerunt; quam longe denique haec omnia absunt a Geometricarum probationum evidentia! quibus jam diu assuevi quibusque vix etiam satis quandoque consido, nisi cum optime perspectae fuerint. atque eae cum in rebus exigui momenti versentur, quid in gravioribus hisce accedere credis?"

also cautious discussing such complex matters, and chooses his words with care: “Quant à la matière, elle est d'une discussion tres difficile, et il n'est pas permis de la traiter en toute libertè. Autrement je crois qu'on pourroit mettre entierement d'accord la Raison et la Foi et soutenir sano sensu, nihil adversus rationem valere debere auctoritatem fidei, cum Rationem fidei reddi posse necesse sit.”[331]

A few years before his own passing, Huygens had also given some thought to death and eternal life in the unpublished writing. The manuscript *De rationi impervii* (1689) contains two sections that dwell on the classical themes of glory and death, *De gloria* and *De morte.* In both pieces, Huygens addresses the problem of the immortality of the soul.

Huygens first asserts that Nature has given man a useful distaste for his ruin, a fear of death, and a will to live. This inclination is so strong, that not even the religions with their promises of eternal life have been able to make people desire death.[332] The speculation about the immortality of the soul is itself no more than an expression of the desire to live, the urge for preservation. Moreover, Huygens argues, the dream of immortality is quite nonsensical. First of all, if we would live eternally, but without memory of our mortal lives, as the religions teach us, this eternal life would have little to do with us, for “Non sumus quod sumus nisi quatenus memoria res praeteritas cum praesentibus jungimus.”[333] The blessing of a life without the memories of our sufferings, is therefore no blessing at all. Nor is death a tragedy. During our whole life, Huygens explains, Nature shows us what is true and what best serves our survival. But facing death, we are deceived. For death is not some great evil that befalls us, but the relief of our suffering. When old age and sickness come, who would not agree?[334]

Huygens clearly has little belief in the immortality of the soul, and calls the idea no more than a 'promise of religion'. However, from the dislike of death and the desire to live arises not only the dream eternal life, but also the dream of eternal fame. This is clearly a notion that is more to Huygens liking. In the fragment *De gloria*, Huygens presents some classical – but not very original – thoughts about human glory. Citing Cicero and Plutarch, the piece explores the common thought that someone's happiness can only be judged after death, although there are some who are called happy during their lifetime because of they have secured their remembrance. But what is the highest goal that a man can achieve in his lifetime? And in what achievements lies the greatest glory? “Aliquibus data imperandi cupido [...] Optimis hoc datum ut alijs quam multis aut certe melioribus prodesse velint, ut utilium artium inventores.”[335]

The greatest good according to Huygens can thus be found in the scientific contribution to the welfare of mankind. The study of Nature has not been Huygens's life pursuit for futile reasons: only through science can

331 18 April 1691, Chr. Huygens to Pierre D. Huet, OC, X, 81-82.
332 *De gloria,* §1, 517.
333 *De morte,* §1, 522; 'We are only what we are in so far as our memory joins the things past and present.'
334 *De morte,* §4-5, 523. The thought is not new, and shows strong stoic influences. For an earlier but very similar example of another 'stoa-inspired' meditation on death, cf. Michel de Montaigne's *Essays*, I, 19, 20.
335 *De gloria,* §2, 517; 'Some is given the desire to rule; […] The best [men] are given that they wish to do benefit many others, or at least their own superiors [meiloribus]; they are inventors of the useful arts.'

a man gain knowledge of Nature and God; only through science can he learn to deal with everything that befalls him; only through can he overcome the fear of death; and only through science can he acquire true glory. Not surprisingly, all these elements are present in the *Cosmotheoros.*

Huygens used the concept of the plurality of worlds to address all these different aspects of his work. The *Cosmotheoros* not only discusses Huygens fundamental view of nature as determined by necessity, but all his previous scientific efforts are summed up and interpreted within this framework. His astronomical discoveries and revolutionary calculations; his work of probability; his theory of pendulum movement; his music theory; his explanation of light waves; and his work on clocks; it is all there. In one last literary effort, Huygens has presented himself to the world, so that future generations may remember him.

5.7 Conclusion: Cosmotheoros and the plurality of worlds tradition

Most of the texts that I discussed in the previous chapters of this thesis, were known by Huygens. This becomes clear not only in the Cosmotheoros itself, but also in his private writings and in his correspondence. All these different sources show that Huygens was aware of many of the key contributions on the subject of the plurality of worlds. Also, we can safely assume that he was aware of the classical sources discussing the issue. As a seventeenth-century aristocratic youth, and in particular as a son of the humanist and poet Constantijn Huygens, he was permeated with the works of the Classics. His personal familiarity with the works of such classical authors Ovid, Cicero and Lucretius forms a constant presence in his thought and can be found in his writings in countless allusions, citations and innuendo's.[336] Several of these explicit and implicit references can be found in the *Cosmotheoros* and in the 1690 writings. They are often primarily meant as a display of erudition and as entertaining hints and riddles, but at the same time, they show that Huygens was aware of classical thought and of the ideas and connotations that played a role in the ancient study of the heavens. For example, when Huygens alludes in the *Cosmotheoros* to a verse from the first book of Ovid's *Metamorphoses* that discusses the creation of human sight: “os homini sublime dedit caelum que videre iussit et erectos ad sidera tollere vultus.”[337] Huygens's words not only clearly allude to the Ovidian verses, but he also connects them to his ongoing argument of similarity between the terrestrial and planetary inhabitants: “Non caret autem verisimilitudine, erectos oculos, vultumque ad sidera contemplanda iis contigisse, quandoquidem hoc in hominum corpore providentiâ divinâ sic institutum videtur, & a Philosophis merito celebrari solet.”[338] An allusion that is even more significant to the reader that also looked up (or remembered) the context of the verses referred to, where the creation of man is contrasted with the creation of the animals. Very subtle, the existence of a human-like inhabitant is thus reinforced, as well as the place of

336 On Huygen's education and his familiarity with the Classical heritage, cf. Andriesse, *Titan kan niet slapen* (2007) especially 51-70.

337 Ovid, *Metamorphoses,* I, 85-86; 'He gave man upward eyes to watch the skies; and ordered to lift his gaze towards the stars.'

338 *Kosm.,* 741; cf. *CW,* 73-74, 'The Stature and Shape of Men here does show forth the Divine Providence so much in its being so fitly adapted to its design'd Uses, that it is not without reason that all Philosophers have taken notice of it nor without probability that the Planetarians have their Eyes and Countenance upright, like us, for the more convenient and easy Contemplation and Observation of the Stars.'

man among the animals.

Apart from the playful display of humanist erudition, the *Cosmotheoros* also relates to a wide spectrum of writings that contributed to the plurality of worlds tradition in more serious ways. Of course, many of the ideas found in the *Cosmotheoros* have been expressed many times before. Take for example the argument of analogy, or the concept of an astronomer making observations from another place than Earth.

Ultimately, Huygens's plea for the existence of planetary worlds serves a higher purpose: it is the vehicle, or the narrative structure, that is used to explain his comprehensive view of the universe. The *Cosmotheoros* is *'kosmos-theoros'* in the true sense: a contemplation of the deepest structures and principles of Nature and the universe. Huygens did not call his final work a 'philosophical' work for nothing.

Huygens's use of the plurality of worlds as a theme used to represents his personal philosophy, theology and anthropology, his deepest convictions and beliefs. It can be explained as a personal expression that is part of a long and broad literary and philosophical tradition.

Not only does the *Cosmotheoros* summarize the results of a lifetime of scientific enquiry, it also expresses a comprehensive view of reality. Huygens believes Nature and nature to be determined by the laws of nature on the basis of the axioms of conservation and necessity. In this necessary world, the place of mankind remains a place of honour, for mankind is the only creature that can truly understand Nature. He can overcome the misfortunes that befall him, and face even death. Although determined by causes beyond his own knowledge, his existence does not become meaningless. Humanity can therefore seek comfort in its own necessity.

6.

Conclusion

This thesis addressed two central questions: how should the *Cosmotheoros* be interpreted in its wider historical and intellectual context? And what new insights can the *Cosmotheoros* offer to study of Huygens's life and work in general?

The first two chapters of this thesis discussed the two main traditions that developed the ideas and concepts that were still connected to the subjects of cosmic and the plurality of worlds in the seventeenth century. First, I discussed that celestial voyages and cosmic visions in classical literature invented both the literary forms and narrative structures as well as the basic metaphorical, religious and philosophical sensitivities that remained connected to cosmological subjects throughout Western history, and that are also reflected in the *Cosmotheoros.* The idea of space travel (whether by means of magic, visions, flight, or imagination) is abundantly present in seventeenth century scientific and fictional literature. Moreover, classical ideas remained influential as well. The mythological connotation of vanity-humility and the reflective perspective found in lunar descriptions, are fundamental to the anthropological ideas expressed by for example Fontenelle and Huygens. Likewise, the sharp classical distinction between the realm of the Gods and the abode of Man is important, for its abolition in the seventeenth century implied questions about the relation between God and mankind, and even God and reality.

The second chapter addresses the philosophical tradition the plurality of worlds. Both the defence and rejection of cosmological plurality reflected fundamental convictions about physics, God, nature, and the universe. I have argued here, that the subject of the plurality of worlds is often used as a thought experiment, or as a vehicle that can convey otherwise abstract, or controversial ideas and theories. This flexibility and ambiguity of the plurality of worlds is what made the concept so attractive to the seventeenth century authors.

In the second part of this thesis, I discussed seventeenth-century cosmic fiction and discussions of the plurality of worlds. The plurality of worlds was one of those classical ideas that were revitalised and at the same time transformed by Renaissance scholarship. As the Copernican system provided the speculations about extraterrestrial worlds, and the dreams of a visit to these places with an unprecedented sense of realism, and possibility. This did not however, compromise the previous *functional* understanding of cosmological plurality and cosmic fiction. Despite, or perhaps because of, the new realism connected to

these themes, seventeenth-century examples of cosmic voyages and discussions of the strange new planets, were still primarily used to address and represent underlying ideas. In both genres, the form remained subservient to the message.

In the final chapter, I have tried to use the perspective of the discussed intellectual backgrounds to interpret the *Cosmotheoros* as more than an unscientific and irrational speculation about the existence of planetary life. I have used what we might call a 'deconstructive' hermeneutic approach to uncover the most fundamental ideas that underpin Huygens's very specific concept of a 'plurality of essentially similar worlds'.

This critical approach led to the heart of Huygens's natural philosophy, and uncovered a world view with some strong Spinozist tendencies, focusing on an absolute determinism, and a 'causality of necessity'. Here we also touched upon Huygens's ideas about God. Finally, I tried to explain that the *Cosmotheoros* can be called Huygens's 'intellectual testament': in the entertaining form of a discussion of the plurality of worlds and extraterrestrial life, Huygens once more presents the results of his scientific pursuits. Moreover, he connects them in a comprehensive world view, that explains the fundamental order in and uniformity of Nature.

6.1 Christiaan Huygens. Portrait by Caspar Netscher, 1671.
Museum Boerhave, Leiden.

Bibliography

Website abbreviations referenced in this bibliography

DBNL digitale bibliotheek voor de Nederlandse letteren, <www.dbnl.org>.
EEBO Early English Books Online, <eebo.chadwyck.com>.
ORef Oxford Reference Online, accessed via Utrecht University Library, < www.oxfordreference.com>.
SEP Stanford Encyclopedia of Philosophy, E.N. Zalta (ed.), <plato.stanford.edu>.

Other consulted website, not further referenced

'Christiaan Huygens', website about Chr. Huygens containing parts from the *OC* with Dutch translations by A. Davidse; <adcs.home.xs4all.nl/Huygens>.
'Huygensweb', website about Huygens of the Utrecht University physics department; <www.phys.uu.nl/~huygens/>.

Primary sources

Ariosto, Ludovico, *Orlando Furioso,* trans. G. Waldman (Oxford 2008,1st ed. 1974).
Aristotle, *De caelo,* trans. W.K.C. Guthrie, *On the Heavens* (Cambridge MA 1953).
Augustine, *De Civitate Dei,* trans. G. Wijdeveld, *De Stad van God* (Amsterdam 2008, 1st ed. 1983).
Aquinas, Thomas, *Summa Theologica.* Translated by the Fathers of the English Dominican Province (1947).
Bergerac, Cyrano de, *L'autre monde ou les etats et empires de la Lune,* ed. M. Alcover (Paris 1977).
Boyle, Robert, *A Free Enquiry into the vulgarly received Notion of Nature,* ed. E.B. Davis and M. Hunter (Cambridge 1996).
Bruno, Giordano, *The Ash Wednesday Supper,* trans. and intr. S.L. Jaki (The Hague 1975).
Epicurus, 'Letter to Herodotus', ed. and trans. C. Bailey, *Epicurus: The Extant Remains* (New York 1970, 1st ed. 1926) 18-55.
Epicurus, 'Letter to Pythocles', ed. and trans. C. Bailey, *Epicurus: The Extant Remains* (New York 1970, 1st ed. 1926) 56-81.
Donne, John, *An anatomy of the World Wherein, by occasion of the vntimely death of Mistris Elizabeth Drury the frailty and the decay of this whole world is represented.* Printed [by William Stansby] for Samuel Macham. London, 1611; *EEBO.*
Drummond of Hawthornden, William, *Flowers of Sion. To Which is adioyned his Cypresse grove*. Edinburgh, 1623; *EEBO*.
Fontenelle, Bernard le Bovier de, *Entretiens sur la pluralité des mondes*, A. Calame (ed.) (Paris 1966).
Galileo, *Dialogue concerning the two chief world systems. Ptolemaic and Copernican,* trans. S. Drake (Berkeley CA 1974).
Godwin, Francis, *The Man in the Moon. Or a Discourse of a Voyage thither,* London, 1638, ed. and introd. J.A. Butler (Ottawa 1995).
Huygens, Constantijn jr., *Journaal van 21 october 1688 tot 2 september 1696. Tweede deel.* (Utrecht 1877); *DBNL*.
Kepler, Johannes, *Somnium,* ed., introd. & trans. E. Rosen, *Kepler's Somnium: the Dream, or Posthumous Work on Lunar Astronomy* (Madison WI 1967).
—, *Somnium,* trans. H. Bungarten, *Der Traum, oder: Mond-Astronomie,* with an essay by B. Langner, 'Das Kugelspiel. etc.' (Berlin 2011).
Lucian, *A True Story* (*Verae Historiae*) *I & II*, trans. A.M. Harmon, *Lucian,* Vol. I (London 1913) 247-357.
Milton, John, *Paradise Lost,* ed. B. Raffel, *The Annotated Milton. Complete English Poems* (New York 1999).
Montaigne, Michel de, *Essays,* Dutch trans. H. van Pinxteren (Amsterdam 2004).
Cusa, Nicholas of, *De doctra ignorantia,* trans. J. Hopkins, *Complete Philosophical and Theological Treatises of Nicholas of Cusa* (Minneapolis 2001).
Lucian, *Icaro-Mennipus, or the Sky-Man,* trans. A.M. Harmon, *Lucian*, Vol. II (London 1915) 267-323.
Lucretius, *De rerum natura,* trans. W.H.D. Rouse, *On the nature of things* (London 1924).
Plato, *Verzameld Werk,* trans. X. de Win (Amsterdam 1978).
Plutarch, *Concerning the Face which appears in the Orb of the Moon (De facie in orbe lunae)*, trans. H. Cherniss and W.C. Helmbold, *Plutarch's Moralia,* Vol. XII (London 1957) 1- 223.
Spinoza, Baruch de, *Ethics*, ed. and trans. E. Curley, *The Collected Works of Spinoza, Volume I* (Princeton 1985).
—, *Short Treatise on God, Man, and his Well-Being,* ed. and trans. E. Curley, *The Collected Works of Spinoza, Volume I* (Princeton 1985).
—, *Complete Works,* trans. S. Shirley, ed. M.L. Morgan (Indianapolis IN 2002).

—, *Theolgical-Political Treatise,* ed. J. Israel, trans. M. Silverthorne and J. Israel (Cambridge 2007).
Swammerdam, Johannes, *Bybel der Natuure of historie der insecten,* I, Leiden 1737; *DBNL*.
Wilkins, John, *The Discovery of a World in the Moone. Or, A Discourse, tending to prove, that 'tis probable there may be another habitable World in that Planet.* London, Printed by E.G. for Michael Sparke and Edward Forrest, 1638; *EEBO*.

Dante Alighieri, *La Divina Commedia,* ed. G. Petrocchi (Florence 1994, 1st ed. 1966-1967), trans. R. Hollander and J. Hollander, *Princeton Dante Project* (v. 2.0) <http://etcweb.princeton.edu/dante/pdp/>.
Epicurus, *Epistulam ad Herodotum,* ed. G. Arrighetti (Turin, 1973), via *Thesaurus Lingua Graeca*, <http://www.tlg.uci.edu/>.
Homer, *Ilias,* ed. T.W. Allen (Oxford, 1931), via *Thesaurus Lingua Graeca*, <http://www.tlg.uci.edu/>.
Homer, *Odyssea,* ed. P. von der Mühll (Basel, 1962), via *Thesaurus Lingua Graeca*, <http://www.tlg.uci.edu/>.
Ovid, *Metamorphoses,* ed. W.S. Anderson (1981), via *Brepolis Library of Latin Texts – Series A,* <http://clt.brepolis.net/llta/>.

Secondary sources

Anderson, G., *Studies in Lucian's comic fiction* (Leiden 1976).
Andriesse, C.D., *Titan kan niet slapen. Een biografie van Christiaan Huygens* (Amsterdam 2007, 1st. ed. 1993).
—, *Huygens. The man behind the principle,* trans. S. Miedema (Cambridge 2005, originally published 1993).
Alkon, P.K., *Science Fiction Before 1900. Imagination Discovers Technology* (New York 1994).
Ayers, M., 'Theories of knowledge and belief', in: Garber et. al. (ed.) *History of Seventeenth-Century Philosophy* (1998) 1003-1061.
Beck, L.W., 'Extraterrestrial Intelligent Life', in: *Proceedings and Addresses of the American Philosophical Association,* 45 (1971-1972) 5-21.
Bell, A.E., *Christian Huygens and the Development of Science in the Seventeenth Century* (London 1947).
Bennett, J., 'Spinoza's metaphysics', in: Garrett (ed.), *Cambridge Companion to Spinoza* (1996) 61-88.
Berkel, K. van, *In het voetspoor van Stevin. Geschiedenis van de natuurwetenschap in Nederland 1580-1940* (Meppel 1985).
—, *Citaten uit het boek der natuur,* (Amsterdam 1998).
—, and A. Vanderjagt (ed.), *The Book of Nature in Early Modern and Modern History* (Leuven 2006).
Blay, M., *Les raisons de l'infini: du monde clos à l'univers mathématique* (Paris 1993).
Bogazzi, R., 'Il Kosmotheoros di Christiaan Huygens', in: *Physis: rivista internazionale di storia della scienza* 19 (1977) 87-109.
Bos, H.J.M., M.J.S. Rudwick, H.A.M. Snelders, R.P.W. Visser (ed.), *Studies on Huygens. Invited Papers from the Symposium on the Life and Work of Christiaan Huygens, Amsterdam 22-25 August 1979* (Lisse 1980).
—, 'L'oeuvre et la personalité de Christiaan Huygens', in: R. Taton (ed.), *Huygens et la France* (Paris 1982) 1-15.
Bozzetto, R., 'Kepler's "Somnium"; Or, Science Fiction's Missing Link', ed. and trans. A.B. Evans, in: *Science Fiction Studies* 17 (1990) 370-382.
Brient, E., 'Transitions to a Modern Cosmology: Meister Eckhart and Nicholas of Cusa on the Intensive Infinite', in: *Journal of the History of Philosophy* 37 (1999) 575-600.
Broughton, J. and J. Carriero (ed.), *A Companion to Descartes* (Malden, MA 2007).
Bunge, L. van, and W. Klever (ed.), *Disguised and Overt Spinozism around 1700. Papers presented at the International Colloquium held at Rotterdam, 5-8 October 1994* (Leiden 1996).
—, *From Stevin to Spinoza. An essay on philosophy in the seventeenth-century Dutch Republic* (Leiden 2001).
— (ed.), *The Early Enlightenment in the Dutch Republic 1650-1750* (Leiden 2003).
Busken Huet, C., *Het land van Rembrandt. Studiën over de Noordnederlandse beschaving in de zeventiende eeuw,* 2 parts in 3 vol. (Haarlem 1882-1884).
Campbell, M.B., 'Alternative Planet: Kepler's *Somnium* (1634) and the New World', in: C. Jowitt and D. Watt (ed.), *The Arts of 17th-Century Science. Representations of the Natural World in European and North American Culture* (Aldershot 2002) 232-249.
Carré, M.-R., 'A Man between Two Worlds: Pierre Borel and His Discours nouveau prouvant la pluralité des mondes of 1657', in: *Isis* (1974).
Chareix, F., *La philosophie naturelle de Christiaan Huygens* (Paris 2006).
Christianson, G.E., 'Kepler's Somnium: Science Fiction and the Renaissance Scientist', in: *Science Fiction Studies* 3 (1976) 79-90.
Cohen, H.F., *De herschepping van de wereld. Het ontstaan van de moderne natuurwetenschap verklaard* (Amsterdam 2007).
Cottingham, J. (ed.), *The Cambridge Companion to Descartes* (Cambridge 1992).
Cranz, F.E., *Nicholas of Cusa and the Renaissance* (Aldershot 2000).
Cressy, D., 'Early Modern Space Travel and the Enlgish Man in the Moon', in: *American Historical Review* 111

(2006) 961-982.
Crowe, M.J., *The Extraterrestrial Life Debate 1750-1900. The Idea of a Plurality of Worlds from Kant to Lowell* (Cambridge 1986).
Danielson, D. R. (ed.), *The Book of the Cosmos. Imagining the Universe from Heraclitus to Hawking* (Cambridge 2000).
Daston, L., and K. Park, *Wonders and the Order of Nature. 1150-1750.* (New York 1998).
—, *Early Modern Science* (Cambridge 2006).
Della Rocca, M., 'Spinoza's metaphysical psychology', in: in: Garrett (ed.), *The Cambridge Companion to Spinoza* (1996).
Dick, S.J., *Plurality of Worlds and Natural Philosophy. An Historical Study of the Origins of Belief in Other Worlds and Extraterrestrial Life,* Phd thesis Indiana University, 1977 (Ann Arbor MI 1984).
—, 'The Origins of the Extraterrestrial Life Debate and its relation to the Scientific Revolution', in: *Journal of the History of Ideas* 41 (1980) 3-27.
—, *Plurality of Worlds. The Origins of the Extraterrestrial Life Debate from Democritus to Kant* (Cambridge 1982).
—, 'Plurality of Worlds', in: N.S. Hetherington (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993) 515-532.
Dijksterhuis, E.J., *De mechanisering van het wereldbeeld* (Amsterdam 1977, 1st ed. 1950).
Dijksterhuis, F.J., 'Titan en Christiaan: Huygens in werk en leven', in: *Gewina* 23 (2000) 56-68.
Donagan, A., 'Spinoza's theology', in: Garrett (ed.), *Cambridge Companion to Spinoza* (1996) 343-382.
Donahue, W.H., 'Kepler', in: N.S. Hetherington (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993) 239-262.
Egmond, F., E. Jorink, R. Vermij (ed.), *Kometen, monsters en muilezels. Het veranderende natuurbeeld en de natuurwetenschap in de zeventiende eeuw* (Haarlem 1999).
Ferraro, B., 'Giordano Bruno's *Infinitely Numerous Worlds* and 'Lunar Literature', in: *The European Legacy,* 11 (2006) 727-736.
Furley, D.J., 'The Greek Theory of the Infinite Universe', in: *Journal of the History of Ideas* 42 (1981) 571-585.
Garber, D., M. Ayers, R. Ariew, A. Gabbey, (ed.) *The Cambridge History of Seventeenth-Century Philosophy,* 2 volumes *(*Cambridge 1998) .
Garrett, D. (ed.), *The Cambridge Companion to Spinoza* (Cambridge 1996).
Gatti, H., *Giordano Bruno and Renaissance Science* (Ithaca NY 1999).
Grant, E., 'Medieval Cosmology', in: N.S. Hetherington (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993) 181-199.
Guthke, K.S., *The Last Frontier. Imagining Other Worlds, from the Copernican Revolution to Modern Science Fiction,* trans. H. Atkins (Ithaca NY 1990, originally published 1983).
Harrison, P., 'The Book of Nature', in: K. van Berkel and A. Vanderjagt (ed.), *The Book of Nature in Early Modern and Modern History* (Leuven 2006) 1-26.
Hedley, D., and S. Hutton (ed.), *Platonism at the Origins of Modernity. Studies on Platonism in Early Modern Philosophy* (Dordrecht 2008).
Hetherington, N.S. (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993).
—, 'The Presocratics', in: N.S. Hetherington (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993) 53-66.
—, 'Aristotle's Cosmology', in: N.S. Hetherington (ed.), *Cosmology. Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York 1993) 95-103.
Hutton, S., '*The Man in the Moone* and the New Astronomy: Godwin, Gilbert, Kepler', in: *Etudes Epistémè,* 7 (Spring 2005) 3-13.
Israel, J.I., *The Dutch Republic. Its Rise, Greatness, and Fall 1477-1806* (Oxford 1998, 1st ed. 1995).
—, *Radical Enlightenment. Philosophy and the Making of Modernity 1650-1750* (Oxford 2001).
—, *Enlightenment Contested. Philosophy, Modernity, and the Emancipation of Man 1670-1752* (New York 2006).
Jorink, E., *Wetenschap en wereldbeeld in de Gouden Eeuw* (Hilversum 1999).
—, 'Outside God, there is nothing': Swammerdam, Spinoza and the Janus-face of the Early Dutch Enlightenment', in: L. Van Bunge (ed.), *The Early Enlightenment in the Dutch Republic 1650-1750* (Leiden 2003).
—, *Het Boeck der Natuere. Nederlandse geleerden en de wonderen van Gods Schepping 1575-1715* (Leiden 2006).
—, 'Reading the Book of Nature in the Seventeenth-Century Dutch Republic', in: K. van Berkel and A. Vanderjagt (ed.), *The Book of Nature in Early Modern and Modern History* (Leuven 2006) 45-69.
—, *'Geef zicht aan de blinden'. Constantijn Huygens, René Descartes en het Boek der Natuur* (Leiden 2008).
Jowitt, C., and D. Watt (ed.), *The Arts of 17th-Century Science. Representations of the Natural World in European and North American Culture* (Aldershot 2002).
Keesing, E., *Constantijn en Christiaan. Verhaal van een vriendschap* (Amsterdam 1983).

—, 'Les frères Huygens et Spinoza', in: *Cahiers Spinoza* vol. 5 (1984-1985) 109-128.
Klever, W., 'Spinoza's life and works', in: Garrett (ed.), *The Cambridge Companion to Spinoza* (1996).
—, 'Spinoza en Huygens. Een geschakeerde relatie tussen twee fysici', in: *Gewina* vol. 20 (1997) 14-31.
Kragh, H.S., *Conceptions of Cosmos. From Myths to the Accelerating Universe: A History of Cosmology* (Oxford 2007).
Koyré, A., *From the Closed Cosmos to the Infinite Universe* (Baltimore MD 1957).
Kuhn, T., *The Copernican Revolution* (Cambridge MA 1957).
Langner, B., 'Das Kugelspiel. Ein Leitfaden für Mondreisende', in: Kepler, *Der Traum* (Berlin 2011) 125 ff.
Lanius, E.W., *Cyrano de Bergerac and the Universe of the Imagination* (Geneve 1967).
Lerner, M.P., and J.P. Verdet, 'Copernicus', in: Hetherington (ed.), *Cosmology* (1993) 147-173.
Lovejoy, A.O., *The Great Chain of Being. A Study of the History of an Idea* (New York 1960, 1st ed. 1936).
Mason, R., *The God of Spinoza. A philosophical study* (Cambridge 1997).
Moran, D., 'Nicholas of Cusa (1401-1464): Platonism at the Dawn of Modernity', in: Hedley et al. (ed.), *Platonism* (2008).
Nadler, S.M., *Spinoza. A Life.* (Cambridge 1999).
—, *Spinoza's theory of Divine Providence. Rationalist Solutions, Jewish Sources* (Budel 2005).
—, *The Best of All Possible Worlds. A Story of Philosophers, God, and Evil* (New York 2008).
Nicolson, M.H., *Voyages to the Moon* (New York 1960, 1st ed. 1948).
North, J., *Cosmos. An Illustrated History of Astronomy and Cosmology* (Chicago 2008).
Olby, R.C., G.N. Cantor, J.R.R. Christie and M.J.S. Hodge (ed.), *Companion to the History of Modern Science* (London 1990).
Palm, L.C. (ed.), *Christiaan Huygens*, thematic issue of *De zeventiende eeuw. Cultuur in de Nederlanden in interdisciplinair persepectief* 12 (Hilversum 1996).
Parrett, A., *The Translunar Narrative in the Western Tradition* (Aldershot 2004).
Philmus, R.M., *Into the Unknown. The Evolution of Science Fiction from Francis Godwin to H.G. Wells* (Berkeley CA 1970).
Quintero, R. (ed.), *A Companion to Satire* (Malden MA 2007).
Romein, J. and A. Romein-Verschoor, *Erflaters van onze beschaving* (Amsterdam 1977, 1st ed. 1938-1940).
Rossi, P., *The Birth of Modern Science,* trans. C. De Nardi Ipsen (Oxford 2001, originally published 2000).
Rowland, I.D., *Giordano Bruno: Philosopher, Heretic* (New York 2008).
Ruestow, E.G., *The Microscope in the Dutch Republic. The Shaping of Discovery* (Cambridge 1996).
Schmaltz, T.M., *Desscartes on Causation* (Oxford 2008).
Secada, J., *Cartesian Metaphysics: The Sholastic Origins of Modern Philosophy* (Cambridge 2000).
Seidengart, J., 'Les théories cosmologiques de Christiaan Huygens', in: Taton (ed.), *Huygens et la France* (1982) 209-222.
Serjeantson, R.W. 'Proof and Persuasion', in: Park and Daston (ed.), *Early Modern Science* (2006) 132-175.
Shapin, S., *Never Pure. Historical Studies of Science as if It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore MD 2010).
Singer, D.W., *Giordano Bruno. His Life and Thought, with annotated translation of his work On the Infinite Universe and Worlds* (New York 1950).
Smith, S.B., *Spinoza's Book of Life. Freedom and Redemption in the Ethics* (New Haven CT 2003).
Snelders, H.A.M., 'Christiaan Huygens' Kosmotheoros', in: Chr. Huygens, *Cosmotheoros. De wereldbeschouwer* (Utrecht 1989).
Stewart, M., *The Courtier and the Heretic. Leibniz, Spinoza, and the Fate of God in the Modern World* (New Haven CT 2005).
Taton, R. (ed.), *Huygens et la France. Table ronde du Centre National de la Recherche Scientifique, Paris 27-29 mars 1979* (Paris 1982).
M. Tamny, 'Atomism and the Mechanical Philosophy', in: Olby, et al. (ed.), *Companion to the History of Modern Science* (1990) 597-609.
Vermij, R.H., *Secularisering en natuurwetenschap in de zeventiende en achttiende eeuw: Bernard Nieuwentijt* (Amsterdam, 1991).
—, and J.A. Van Maanen, 'An Unpublished Autograph by Christiaan Huygens: His Letter to David Gregory of 19 January 1694', in: *Annals of Science* 49 (1992) 507-523.
—, *De wetenschappelijke revolutie* (Amsterdam 1999).
—, 'Een nieuw concept: de wetten der natuur', in: Egmond et al. (ed.), *Kometen, monsters en muilezels* (1999) 105-119.
—, *The Calvinist Copernicans. The reception of the new astronomy in the Dutch Republic, 1575-1750* (Amsterdam 2002).
—, *Huygens. De mathematisering van de werkelijkheid* (Diemen 2004).
—, *Kleine geschiedenis van de wetenschap* (Amsterdam 2006).
Wilson, R., *Astronomy through the Ages. The story of the human attempt to understand the Universe* (London

1997).
Wolloch, N., 'Christiaan Huygens' Attitude towards Animals', in: *Journal of the History of Ideas* 61 (2000) 415-432.
Yates, F.A., *Giordano Bruno and the Hermetic Tradition* (London 1964).

Encyclopedic entries

Aa, A.J. van der, *Biographisch woordenboek der Nederlanden* (Haarlem 1867) Vol 8, Part 2, 1517-1526; *DBNL*.
Maas, G.S., 'Perseus and Bellerophon', in: *The Oxford Encyclopedia of Ancient Greece and Rome* (2010); *OR*.
Molhuysen, P.C., and P.J. Blok (red.), *Nieuw Nederlandsch biografisch woordenboek* (Leiden 1911) Vol. 1, 1180-1186; *DBNL*.
Whitmarsh, T., 'Lucian of Samosata', *The Oxford Encyclopedia of Ancient Greece and Rome* (2010), *OR*.

Berryman, S., 'Ancient Atomism', *SEP* (Fall 2008 Edition), <http://plato.stanford.edu/archives/fall2008/entries/atomism-ancient/>.
Chalmers, A., "Atomism from the 17th to the 20th Century", *SEP* (Winter 2010 Edition), <http://plato.stanford.edu/archives/win2010/entries/atomism-modern/>.
Di Liscia, D.A., "Johannes Kepler", *SEP* (Summer 2011 Edition), <http://plato.stanford.edu/archives/sum2011/entries/kepler/>.
Fisher, S., "Pierre Gassendi", *SEP* (Winter 2009 Edition), <http://plato.stanford.edu/archives/win2009/entries/gassendi/>.
Hatfield, G., 'René Descartes', *SEP* (Summer 2011 Edition), <http://plato.stanford.edu/archives/sum2011/entries/descartes/>.
Lennon, T.M. and Dea, S., 'Continental Rationalism', *SEP* (Fall 2008 Edition), <http://plato.stanford.edu/archives/fall2008/entries/continental-rationalism/>.
MacIntosh, J.J. and P. Anstey, 'Robert Boyle', *SEP* (Fall 2010 Edition), <http://plato.stanford.edu/archives/fall2010/entries/boyle/>.
Markie, P., 'Rationalism vs. Empiricism', *SEP* (Fall 2008 Edition), <http://plato.stanford.edu/archives/fall2008/entries/rationalism-empiricism/>.
Miller, C.L., 'Cusanus, Nicolaus [Nicolas of Cusa]', *SEP* (Fall 2009 Edition), <http://plato.stanford.edu/archives/fall2009/entries/cusanus/>.
Nadler, S., 'Baruch Spinoza', *SEP* (Spring 2011 Edition),<http://plato.stanford.edu/archives/spr2011/entries/spinoza/>.
Rabin, S., 'Nicolaus Copernicus', *SEP* (Fall 2010 Edition), <http://plato.stanford.edu/archives/fall2010/entries/copernicus/>.
Sedley, D., 'Lucretius', *SEP* (Fall 2008 Edition), <http://plato.stanford.edu/archives/fall2008/entries/lucretius/>.
Slowik, E., 'Descartes' Physics', *SEP* (Fall 2009 Edition), <http://plato.stanford.edu/archives/fall2009/entries/descartes-physics/>.
Thijssen, H., 'Condemnation of 1277', *SEP* (Fall 2008 Edition), <http://plato.stanford.edu/archives/fall2008/entries/condemnation/>.