

FICTIONS  
OF THE  
COSMOS

*Science and Literature in the Seventeenth Century*



FRÉDÉRIQUE AÏT-TOUATI

*Translated by Susan Emanuel*

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*To my parents*



## CONTENTS

Acknowledgments	ix
Introduction	i
PART ONE * COSMIC IMAGINATION	
1 Kepler Sets the Earth in Motion	17
Genealogy of the Dream: From <i>Ludus Philosophicus</i> to the Game of Fiction, 20 * The Dynamics of the Voyage: A Thought-Experiment, 27 * Vision in the Voyage, 31 * The Place of Fiction, 36	
2 Godwin, Wilkins, Cyrano: From the Optical Voyage to the Mechanical Voyage	45
<i>The Man in the Moone</i> , 46 * <i>A World in the Moon</i> , 56 * From Heavens to the Sky: Cyrano's Other World, 63 * Conclusion: Dreams and Fictions, 71	
PART TWO * CONJECTURAL MACHINES	
3 Fontenelle: Unveiling the Spectacle of the World	79
Machine and Spectacle, 81 * Order of the Narrative, Harmony of the World, 84 * Fontenelle's Visions, 87	
4 Huygens: The Theoretical Voyage of the <i>Cosmotheoros</i>	95
Hypotheses, Conjectures, Fictions, 97 * Architectonics of the Narrative, 114 * Conclusion: Hypotheses and Narratives, 125	

PART THREE \* OBSERVING MONSTERS

5	Robert Hooke: “The Armed Eye”	133
	<i>Micrographia</i> , 134 * From <i>Enargeia</i> to Evidence, 148 * Hooke the Astronomer, 158 * Poetics of Proof, 169 * Conclusion: Instruments and Images, 172	
6	Margaret Cavendish: The Battle of Instruments	174
	“A High Heel to a Short Leg,” 175 * A Teratology of Knowledge, 178 * The Empire of Fiction, 183 * Conclusion, 189	
	Conclusion	191
	Notes	203
	Bibliography	229
	Index	259

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## Introduction

In 1610, during a pause in the conflict between Emperor Rudolph and his brother Archduke Matthias, Johannes Kepler offered a description of a flake of snow to Johannes Matthias Wackher von Wackenfels as a New Year's present, entitled *On the Six-Cornered Snowflake*.<sup>1</sup> He opens it with his declared wish to offer his protector and friend something he liked more than anything else, Nothing (*Nix*). But Kepler, who had gone looking for Nothing in the snow squalls of Prague in winter, found Everything; in the snowflake he saw the structure of the universe revealed. The snowflake is an example of the architectonic force that governs the construction of forms; its hexagonal structure is a perfect geometric figure, a "cosmopoetic figure," in Kepler's words, literally "that which fashions the world."<sup>2</sup> Seeking to identify such figures in nature, one could gain access to the mystery of the world and its construction. In the seventeenth century, and especially for Kepler, cosmology was, at its core, an examination of forms, of what makes them and of what they themselves make in turn—a poieisis.

Minute yet indispensable due to its architectonic function, ephemeral but permanent in its geometric structure, the snowflake was presented to Wackenfels in the form of paradoxical praise, following the Mannerist aesthetics of the day. It was certainly meant as an entertaining game, but this game, this Nothing, contained the essential question of the construction of the universe. Thus, Kepler's New Year's offering is simultaneously and irreducibly a gift, the evocation of a perfect geometric form, a reflection on the structure of the world and the exposition of a literary form. It is the association of aesthetics, cosmology, and poetics that is of chief interest in my investigation, which is indebted to Kepler for both the term and the idea of *cosmopoetics*. A demiurgic game, a meditation both geometric and poetic on creation and on *the* Creation, a paradoxical association of nothing and

everything passing from the infinitely large to the infinitesimally small—it is in the conceptual space opened up by Kepler’s snowflake that I would like to situate this study of the poetics of cosmological discourse.

The year 1610 also saw the publication of Galileo’s *Sidereus Nuncius*. Pointing his telescope up at the sky for the first time, he discovered mountains on the Moon and spots on the surface of the Sun. With this and similar proofs and despite the trial of 1633, Galileo overthrew centuries of Aristotelianism that had maintained the incorruptibility of the superlunary world, and at the same time he confirmed the inability of the Ptolemaic system to explain the universe. Already shaken in the previous century by Copernicus, geocentrism was definitively thrown into question by the works of Galileo—*Sidereus Nuncius* (1610) and *Dialoga sopra i due massimi sistemi del mondo* (1632)—and of Kepler—especially *De Stella Nova* (1606), *Astronomia Nova* (1609), and *Dissertatio cum Nuncio Sidereo* (1610). Their efforts opened the way for other astronomers by revealing to contemporaries an immense and unanticipated field of exploration. These upheavals in the domain of astronomy constitute one of the elements of what, after Alexandre Koyré, has been called the “scientific revolution.”<sup>3</sup> Astronomy became inseparable from new thinking about the nature of the cosmos at the beginning of the seventeenth century and so became fused with cosmology. Their conjunction will be at the heart of this study, which will consider the term *cosmology* in its widest sense, so as to enable us to consider the different investigations into the structure of the universe made by the century’s natural philosophers. These investigations were not limited to astronomy; they also engaged with microscopy, optics, and, to a lesser degree, physics and cosmogony.

Interest in the interactions between science and literature is not new. In 1925, Alfred North Whitehead remarked that 1605 was the year of the publication of both *The Advancement of Learning* by Francis Bacon and *Don Quixote* by Cervantes.<sup>4</sup> Michel Serres has illuminated many aspects of the parallel development of scientific, philosophical, and literary works that made the seventeenth century one of the privileged “*passages*”<sup>5</sup> between the human sciences and the exact sciences. Thus in *Feux et signaux de brume*, he stresses the need to move beyond the barriers placed between science and literature. At a stroke, he reunites the history of science and the history of literature, both of which are subsumed under the vast movement of Western history more generally:

If there exists a history of literature and if there exists a history of science, the subject of history, in both cases, is born and develops in a society that has its

own divisions, its means of production, its customs, manners, politics, and its own biophysical environment. And I do not see how to distinguish two separate parts, for we are dealing with the same history, in the same place, taking place at the same time, and for the same social classes.<sup>6</sup>

But indeed there are two parts to this history, for which Serres gives the definition and the genealogy:

The relationship between what is commonly called science and what has been generally named literature has never been clarified. At the level of criticism, it seems clear. But the opposite is true of production. Almost no author or book is completely detached from current scientific ideas . . . . Nobody writes, hiding for his life in isolation behind a wall, but rather he operates in a compact space of communication. Later, the concept of a school—or schools—of thought arises, founded on some partition or other, in this case, the classification of the sciences. These schools are formed by separated chambers, isolated edifices, and detached libraries. Diderot had a fine wit but he knew nothing of chemistry, Montesquieu was ignorant of Newton, Montaigne wrote only about himself, and Pascal only about Jesus Christ. The only solution to this is to laugh with incredulity. Specialists, looking back at the past, retroactively create tedious imbeciles. The famous problem of the relationship between science and literature is merely an invention. There are bars between them, but we ourselves have put them there, and they are so light and fragile that banishing them requires only a flick of the finger.<sup>7</sup>

Building on these intellectual foundations, the 1970s saw the emergence of reflection on the overall relationship between the various domains of knowledge. For thirty years the study of the relations between literature and science has been a discipline unto itself, especially in the English-speaking academic world.<sup>8</sup> But for the period that interests us, the seminal works by Marjorie Nicolson (written from the mid-twentieth century onwards) have demonstrated the rich possibilities of a method that combines the histories of science and literature.<sup>9</sup> However, this approach has remained centered on the literary canon and included scientific texts only for comparison. Fernand Halpin's *La Structure poétique du monde: Copernic et Kepler* was in many respects a turning point in that it offered a poetic analysis of astronomic texts and opened the way for a series of studies, of which this book is the latest. At the same time, interest in the cosmological literature of the seventeenth century has developed in various fields of study, which have included the history of ideas and cultural history (to which the work of Marjorie Nicolson

and Arthur Lovejoy belong),<sup>10</sup> the history and birth of the novel in its combination with scientific discourse,<sup>11</sup> the vast interdisciplinary field known as “literature and science,” and the history of rhetoric.<sup>12</sup>

However, no study has been written that united these different approaches. It seemed that a fruitful approach might be not only to tackle scientific texts with the tools of literary analysis on the one hand and to study literary texts by taking into account their “scientific sources” on the other, but also to combine these two corpuses, and these two methods, in order to elucidate at least one specific poetics of the cosmologic discourse of the period. Uniting literary texts and scientific texts does not imply an attempt to reduce their heterogeneity, still less to deny their essential differences in semiotic and epistemological terms. Rather, I have attempted to approach this heterogeneous material without imposing anachronistic taxonomies of subject-matter in advance, and without assigning texts a priori to this or that corpus, in order to bring out their common traits and to reveal their unique characters. I order the texts differently in an attempt to highlight common ways of thinking and similar writing strategies, to demonstrate the appropriation of poetic ideas, and to identify themes that cut through different texts. In this way I offer an outline not of boundaries between disciplines, but of specific strategies in literary and in scientific writing and of common poetic tools.

It has therefore been necessary to call on a range of disciplines including the history of science and the history of art, which, like comparative literature, tackle subjects of study on the borders between university disciplines. Recently, the history of science has been particularly attentive to writing strategies,<sup>13</sup> to genres,<sup>14</sup> and more generally to the historical aspect of textual forms,<sup>15</sup> an approach that has proved extremely fertile in relation to the concerns of this study. Questions have emerged linked to the materiality of scientific culture—its instruments and its practices, but also its texts. Precisely those studies that have focused on the “material culture” of science have best demonstrated its “literary technologies,”<sup>16</sup> whether they have to do with enunciation, semiotics, writing strategies,<sup>17</sup> or with attention to readership. Here the sociology of the sciences comes close to certain preoccupations in the sociology of literature,<sup>18</sup> in the history of reading,<sup>19</sup> and in the history of the book.<sup>20</sup> Such approaches have profoundly influenced my conception of scientific and literary writing in the 1600s, and the intersections within seventeenth-century discourses themselves have guided my choice of combining methodologies as well as disciplines in this enquiry.

## TOOLS

The joint study of literature and science lends itself to various approaches, one of which is to study the influences of one on the other (generally of science on literature).<sup>21</sup> A different approach, the one adopted here, posits that since literary forms are used to express conceptual ideas, the concept of one distinct category influencing another is not helpful for thinking about writing in this period; in fact, the very emergence of a specific discourse of astronomy and cosmology took place in the resurgent humanism of the early seventeenth century.

A study of the transactions and interactions between scientific culture and literature presupposes an investigation of both the field of literature and the field of science, domains that are today considered to be separate. Such partitioning makes it difficult for the contemporary scholar to look back to the culture of an era when science and literature participated in the same humanist culture. So we must ask how such barriers can be crossed, and what accounts for such barriers being set up in the first place. The relationship between “the literary” and “the scientific” can appear simple if thought of solely as a kind of literary rewriting of available material, in this case, the new scientific theories. This literary effort can then be related either to the fictionalization of knowledge or else to the ornamentation of an arid discourse. Understood as such a one-way transfer, the relation between what is literary and what is scientific postulates a fixed definition of each of the two domains. However, in the period that interests us, each of the two discourses was still being established, and our texts display a confusion of categories. Science as such did not yet have its own place, and its discourse had no fixed form; it made its appearance across a heterogeneous range of texts and domains. Like science itself, its discourse was full of scraps taken from traditional marvelous tales and magic. Far from being simple material from which writers could draw, natural philosophy was in the process of developing its own discourse as well as its own methods distinct from the methods of literary writers. Weaving together the threads of these two histories means being attentive to shared motifs, whether they derive from a common source (classical literature and philosophy, rhetorical and poetic concepts inherited by the revival of humanism and taken up or transformed at the start of the seventeenth century), or else come from exchanges between the two fields during this period.

Gillian Beer has stressed a methodological difficulty that arises when

commencing this type of study: “How to explain the concurrent appearance of similar ideas in science and in literature without inevitably forging causal links?”<sup>22</sup> On the one hand, natural philosophy discovered an alternative to the strict forms of the Scholastic treatise by using available literary forms—new forms for new subjects. On the other hand, poets and “writers” (as they would soon be called) found in natural philosophy, particularly in astronomy, not only a rich source of inspiration but a whole range of new strategies of writing and techniques with which they could develop their own way of thinking about fiction or storytelling. Thus, between the two discourses—often contiguous and sometimes imbricated—of literature and science, common codes and languages were being established, precisely at the moment when the two disciplines were beginning to distinguish themselves from each other in their definition of distinct sites, institutions, and practices. In doing so, the bifurcation between what are today called “science” and “literature” took place precisely at the height of their exchanges. This is a paradox that merits exploration.

If the notion of influence is unsatisfactory because the chronology of these exchanges does not allow any unilateral movement to be detected,<sup>23</sup> the notion of a “trading zone” as defined by Peter Galison may be preferable.<sup>24</sup> In this zone, each field of discourse has its own stakes and its own enunciatory arrangements, but each interacts with the others according to common procedures, a shared language, and mutual borrowings of strategies of claims to authority and methods. These are the shared tools that I will be highlighting.

A second methodological problem has been raised by Stephen Greenblatt in his *Marvellous Possessions*, namely that the use of methods of literary analysis for the study of nonliterary texts—which is the case with a large portion of our corpus—poses the problem of suitability. While being very aware of the limitations of this analytical approach, we hope that it sheds new light on texts relating essentially to the history of science. Just as accounts of the voyage to the New World “brought close to the surface of non-literary texts imaginative operations that are normally buried deep below their surface,”<sup>25</sup> so cosmological texts demanded writing strategies and poetic procedures that make the tools of literary analysis pertinent. In this respect Gerald Holton has stressed how much the dichotomy between the scientific and literary approaches becomes blurred as soon as you look at the construction of scientific theories, especially at the time of the formation and evaluation of hypotheses.<sup>26</sup> In the same way, Thomas Pavel has shown that “the theory of fiction cannot be separated from a general economy of the imagination.”<sup>27</sup>

In this sense, cosmological texts are the perfect material for the study of the evolution of this shared imagination. Because they arise from what I will call the “cosmopoetic”—the representation of the structure of the universe and of matter in written form—the debates about cosmology, astronomy, and optics and other branches of natural philosophy are also poetic debates, prompting questions about the construction of texts and of facts. With this in mind, I approach the texts with the varied tools of discourse analysis, semiotics, the history of genres, narratology, and theories of fiction.

But other instruments will be considered alongside these poetic tools: astrolabes, globes, maps of the heavens, engravings, diagrams, telescopes, microscopes, armillary spheres, and flying machines. Such equipment might seem surprising in a study of poetics.<sup>28</sup> By granting a large place to the “material culture” of the cosmological enterprise, I wish to underline the interrelation between textual and material technologies. In the manner of travelers of the Renaissance era, natural philosophers turned to instruments to discover new paths, to measure new phenomena, and to map new worlds. Astronomers and microscopists in their turn were reporting astonishing stories and surprising images, hence the place I give to the study of the instruments and iconography that were becoming two of the central elements in the operation of experimental science as a discourse of proof during this period.

## CORPUS

The method employed implies defining a large corpus, which does not assume a priori whether texts belong either to the domain of “literature” or to that of “science.” I have chosen to bring together and often to put in opposition texts that interact across the offhand barriers usually set up between them. In the seventeenth century, texts linked to science were not ordered according to a simple typology that would distinguish between accounts of experiments, theoretical treatises, works aimed at a less educated public, and scientific novels. If works sometimes tended to be organized along these lines, especially during the second half of the century, more often such differentiation is not appropriate, and instead we find a continuum of texts going from the most theoretical to the most fictional. From among this large spectrum I have selected works to be examined on the basis of three considerations: genre, geography, and chronology.

Themes associated with the scientific imagination, especially those involving astronomy, abound within the literature of the period. Consider

references to recent discoveries and to contemporary scientific controversies found in the works of playwrights Molière and Aphra Behn and poets Milton and La Fontaine.<sup>29</sup> However, works in the traditional established genres of poetry and theater mention such matters only indirectly, and the texts making explicit reference to them usually belong to this new genre being erected and in quest of legitimacy: *literary fiction* that will soon be called the *novel*. No doubt the alliance of fiction and knowledge was not new: there are many Renaissance stories similar in theme and content to encyclopedic and scholarly novels.<sup>30</sup> Nevertheless, the particular interest in astronomy that is expressed in the fictions of the seventeenth century involved a particular imaginary field. I have therefore not included discussion of texts that take a topic from science but not its modes of expression, for example French and English plays from the end of the century treating the spectacular theme of the world in the Moon<sup>31</sup> or “scientific poetry,”<sup>32</sup> in order to focus exclusively on narrative treatises and fictions.

I have limited this study geographically to France, England, Germany, and the Netherlands, and include texts in English and French, as well as two in Latin. The English and French texts form a coherent ensemble whose unity comes from intense currents of exchange from one language to the other; the important texts were rapidly translated, read, and reprinted. In addition, the philosophical and scientific texts that were read and discussed among educated communities were written just as much in English as in French, German, Dutch, Italian, and especially Latin, which remained the language of knowledge throughout Europe. We must, then, be particularly attentive to translations of each of these texts and to their reception throughout Europe. In the classical age, science was—perhaps even more than literature—a European enterprise that transcended national boundaries. The richness of this exchange justifies a comparative approach whose aim is to determine reciprocal influences and the movements of ideas, themes, and literary forms among the three countries, and most particularly between France and England, where the majority of the authors under discussion were located.

It might have seemed logical to include Galileo in such a study, and in fact, many references to *Sidereus Nuncius* will be found in the pages that follow, but I have not included his works in the principal corpus for two reasons. The first is chronological: this study concentrates on the second half of the seventeenth century; the period of the Galilean revolution, properly speaking, and the poetic and rhetorical questions linked to Galileo’s trial in 1633

exceed our scope.<sup>33</sup> The second reason is poetic. In the *Sidereus Nuncius* Galileo prudently avoided the question of the plurality of worlds, that is to say, the question of whether other planets might be inhabited, while Kepler mentions this topic at the outset of his *Dissertatio cum Nuncio Sidereo* published the same year. This avoidance is the sign of a refusal to make the imagination and fiction the tools of cosmological thinking and to focus instead on the telescope. From Kepler to Huygens, though, a particular use of these tools of the imagination was being developed and this new method will be at the center of our enquiry. The chronological boundaries of the study are taken from the standard divisions of period in the history of science. Our texts are situated in the interval between the “astronomical revolution” led by Galileo and Kepler in favor of Copernicanism and the “Newtonian revolution” at the end of the seventeenth century. They appeared between 1634 (Kepler’s *Dream*) and 1698 (Huygens’s *Cosmotheoros*, which still works largely on the basis of the Cartesian physics challenged by Newton’s *Principia* in 1687). Stretching across more than sixty years, the corpus is thus situated in the more general context of the period going from Kepler to Newton: Kepler’s *Dream* (1634), *The Man in the Moone* by Francis Godwin (1638), *The Discovery of a World in the Moone* by John Wilkins (1638), *The States and Empires of the Moon and Sun* by Cyrano de Bergerac (1657 and 1662), *Micrographia* (1665) and *An Attempt to Prove the Motion of the Earth* (1674) by Robert Hooke, *Observations upon Experimental Philosophy* and *The Blazing World* by Margaret Cavendish (1666), *Conversations on the Plurality of Worlds* by Fontenelle (1686), and *Cosmotheoros* by Christiaan Huygens (1698). Other actors, both known and unknown, occasionally appear to respond to the aforementioned: Bacon, Henry Power, Thomas Muffet, and Descartes, to mention only a few.

By taking such a range of texts this study shifts the focus that has characterized previous studies in order to put into relief other aspects of the cosmological discourse.<sup>34</sup> This corpus is thus not constituted a priori, but as determined by the study of texts, each referring to another, or more often to several others, thereby constituting a list, not closed but sufficiently integrated to justify their being studied together. Despite their formal, epistemic, and generic divergences, these texts comprise a “corpus” given the constant current of intertextuality: Wilkins cites Kepler but also Godwin’s fiction in his treatise; Margaret Cavendish reads Hooke; Cyrano knows Kepler and Godwin; all three of them cite Lucian; Huygens critiques all four; and Fontenelle has read everything.

## APPROACH

The particular link that fiction has with astronomy might be attributed to the very nature of this science. Astronomy, even when it becomes a science of observation thanks to the telescope, makes deliberate use of the imagination. In effect it has the characteristic of treating phenomena that are inaccessible or difficult to observe. Consequently, the scholar, like the writer, is obliged to call on his imagination in order to have a working conception of the phenomenon under study, be it the movement of the stars or the functioning of eclipses. But even more than the difficulty of observation, it is the dangers involved in resisting received doctrine that sometimes makes it necessary to turn to the imagination. Only the imagination can give form to the “new world” of Copernican cosmology in a context where political and religious upheavals make suspect any overly innovative discourse. With this in mind, it is possible to outline three lines of enquiry for this study:

- the question of fiction and its heuristic role: this entails a consideration of the strategies used to construct a credible and convincing world through invention and the creative power of verbal expression;
- the question of the description and representation of the unknown and the unprecedented: this area relates to attempts to accede to a new visible world and the conditions of its depiction in words; and
- the question of discourses and genres, and in particular of the recurrence of the narrative form, which deals with the reconstruction and description of this world specifically in the context of narratology.

These three lines of enquiry can be reformulated as more precise questions of poetics:

- The place and role of fiction in the cosmological discourse. Starting with the claim that fiction in this period is one of the principal areas in which cosmological discourse can be framed, I will investigate the ways in which it combines with the scholarly discourse of the new astronomy. I want to show that the central role of the hypothesis in astronomical questions allows us to explain how and why the history of the notion of fiction overlapped and became intertwined with the history of astronomy over a period of several decades. The aim of this work is to retrace part of this encounter, and indeed to explore a whole episode in the shared history of literature and science, a history so often misunderstood.

- The evolution of a poetics of the credible in literature and in natural philosophy. We will see to what extent the texts demonstrate a common effort and shared strategies in the construction of what is probable scientifically and what can be represented credibly in literature.
- The development of scientific genres as distinct from the literary genres from which they borrowed their techniques: observations, allegories, dialogues, letters, accounts of experiments; little by little they start to define the contours of a poetics particular to scientific discourse.

By their very diversity, the chosen questions will make possible the investigation of well-defined historical developments, such as the defense of heliocentrism in the first half of the century, the polemic around the use of optical instruments in 1665–1666, the development of the experimental method in England starting in the 1660s and 1670s, and the cosmological syntheses of Fontenelle and Huygens in the 1680s and 1690s. However, this investigation will not be shaped primarily by the chronology of these episodes; it will prefer a synthetic plan that articulates the issues logically while retaining the chronology as much as possible within each chapter.

In such an inquiry, an approach by monographs was not desirable, so I have opted for a more flexible structure of three parts comprising six chapters in total, each offering a focus on one or two texts for each of the issues treated, in order to avoid both a succession of monographs and the truncation of texts. This synthetic approach proceeds by bringing authors together and contrasting them. Each part is presented in the form of a comparative study that aims to elucidate the uses and transformations of shared motifs in strongly linked texts.

Part 1 studies the articulation of fiction and theoretical knowledge in tales of lunar voyages by Kepler, Godwin, Wilkins, and Cyrano. Lunar fiction suggests an optical journey that allows the reader to observe, if only in their imaginations, the movements of the Earth's rotation as described in Copernicus' *De Revolutionibus*. The emergence and implications of new instruments considerably inflect the status of the lunar fable. Enabled by the telescope, the optic voyage becomes the means of a "new astronomy" as much as of a new fable. With the mechanization of the lunar voyage, the very idea of lunar flight moves from the category of a fable in the tradition of Lucian that is utterly impossible, to the category of possible conjecture, implying an upheaval in the very notion of fiction. In passing from the impossible to the possible, lunar fiction slips from a poetics of wonder to a poetics of the

credible. We will be able to speculate about the relationship between these two concepts by contrasting texts that are explicitly fictional and texts that are theoretical while interrogating the nature of those two textual methods of expressing ideas.

When the journey takes in not just the Moon but indeed the whole cosmos, the narrative structure becomes crucial. Part 2 continues discussion of the relationship between fiction and scientific hypothesis by turning to the strategies used to construct “machines of conjecture” in order to describe the universe. The analogy of the “machine of the world” confirms the Copernican worldview and strengthens its claims to reality. With Fontenelle as with Huygens, cosmological machines become the basis of a logical and narrative journey that reworks the space of the cosmos along the lines of a Copernican model of space. However, the analyses in the *Conversations* and in *Cosmotheoros* also reveal profound disagreements on the issue of the language and arguments suitable to cosmological discourse. We see here the outlines of competing poetics in which credibility may refer to either the epistemic incertitude of fiction or the solid construction of a theory.

In both of these cases, however, we remain within the framework of a poetics of the credible. In the second half of the century, experimental philosophy sought the means to reach a higher level of certitude using optical instruments. Part 3 will look at textual and pictorial techniques established by Robert Hooke in the fields of microscopy and astronomy. The issue of the representation and transcription of those images here becomes acute. Hooke made himself the herald of an experimental method whose aim was to replace text with image, probability with proof. With this method, the image gradually acquires the status of proof, through the gradual development and eventual displacement of previous textual techniques and iconographic traditions. Fictions, visions, and credible conjectures are banished in favor of a visualization enabled by scientific instruments that explores the efficacy of a new type of scientific authority. This use of scientific instruments in the investigation of nature was the target of Margaret Cavendish’s attacks. The sixth and final chapter treats the controversy that opposed Cavendish to Hooke on the subject of the use of optical instruments. But the diverse strategies deployed by Cavendish in opposing the experimental discourse of the Royal Society are less a counterpoetics than themselves the operation, in an inverted manner, of the tools of that experimental discourse, notably discourse around optical tools appropriated and recycled in the writing of fiction.

Situated between the philosophical fictions of the Renaissance and those of the Enlightenment, our texts constitute an important but little-known episode in the history of scientific and philosophic uses of fiction and narrative. They are important because they negotiate the relations between scientific discourse and literary discourse at the very moment when these two are distinguishing themselves from each other, and they are perhaps misunderstood because of their apparent technicality, which has long been the reason given for their neglect in the sphere of literary analysis.

One method currently employed in literary study is to leave the field of literature in order to understand it better, a kind of decentering that recalls that of the astronomers who left the Earth the better to observe it. In leaving the field of literature, or at least a certain canon transmitted to us, I hope to contribute to the much wider enterprise of redefining our understanding of discourses, a project that has been under way for several years. Cosmological texts, in which the boundaries of abstract and conceptual thought in the sphere of fiction and narrative are explored, thus invite us to perceive the richness of the “literary” found beyond the institutional boundaries of literature.



PART ONE

*Cosmic Imagination*



The view from above leads us to consider the whole of human reality, in all its social, geographical, and emotional aspects, as an anonymous, swarming mass, and it teaches us to relocate human existence within the immeasurable dimensions of the cosmos.

Pierre Hadot, *Philosophy as a Way of Life*, 245

You know a great many virtuosos that can fly, but I am so much advanc'd in the art of flying that I can already outfly that ponderous animal call'd a bustard . . . Nay, I doubt not but in a little time to improve the art so far, 'twill be as common to buy a pair of wings to fly to the world in the moon as to buy a pair of wax boots to ride into Sussex with.

Thomas Shadwell, *The Virtuoso*, 95–182





## Kepler Sets the Earth in Motion

From the philosophical flight evoked by Pierre Hadot to the burlesque of it dramatized by Thomas Shadwell, we can notice how the theme has spread. If Shadwell mocks it, it is because the motif had been constantly taken up throughout the century and closely associated with the defense of the Copernican system; moving away from the Earth through the fiction of lunar flight allows one to observe it and to demonstrate, fictionally, the Earth's movement. In the cosmological corpus, the theme of flight has a particular role to play, on the one hand because it is the bearer of a philosophical tradition that astronomers can usefully claim and on the other because it allows a provisional response to one of the major questions posed by the polemic over the Copernican system: what makes the Earth turn? I would like to start with the paradox that the most powerful texts for establishing the truth of the new astronomy are fictions. In other words, the truth and the credibility of the cosmological discourse are not constructed (only) *in opposition to* but *with* fiction. These two first chapters come back to the classic issue of the combination of knowledge and fiction<sup>1</sup> by interrogating it on two levels:

- within texts, when they mix knowledge and fiction, by examining the combination of the two discourses and the presence of their respective markers or limits; and
- external to texts, in the confrontation of texts that present themselves at first sight as fictional or as theoretical.

The tales of lunar voyages provide a good focus for my exposition, since they are the site of a kind of knowledge still to be fully established: the new astronomy and Copernican cosmology. The genre of the Scholastic treatise, as unsuitable as a method as it is as of a vision of the world, became inadequate and so the traditional astronomy treatise no longer sufficed. It is in this context that fiction intervenes; it allows the adoption of a distanced

viewpoint in order to describe the cosmos afresh. Such is the origin of the singular poetics of the cosmological journey, heir of the tradition started by Lucian and the Italian Renaissance, but reactivated by the cosmological debates and the necessity of finding new arguments in favor of Copernicanism. This first section will show how the poetics of the cosmological journey took shape as it attempted to transform the fabulous tradition of the lunar voyage into a possible journey, in order that it be associated with the defense of the Copernican system.

\* \* \*

In the cosmology of Ptolemy, following Aristotelian physics, the world is composed of two regions: an elementary sublunar region that includes the four elements ordered from lowest to highest (earth, water, air, and fire) and an ethereal supralunar region that surrounds the sublunar and includes nine heavens or crystalline spheres—that is to say, solid and transparent orbs—turning around the Earth. Beyond that lies the Empyrean, the dwelling of the blessed. The materiality of these orbs was the subject of numerous discussions in the sixteenth century, but it was generally accepted; Copernicus conserves in his system the structure of solid orbs.<sup>2</sup> It was the observation of the comet of 1577 by Tycho Brahe that enabled the definitive refutation of this conception of the universe: by observing a body in movement between planets, Tycho rendered the old model of solid orbs obsolete.<sup>3</sup> In the Copernican system as it was understood and interpreted in the seventeenth century, spheres are no longer present, fixed stars are an infinity of other Suns situated at an extraordinary distance from the Earth, the space beyond the fixed stars is no longer an inconceivable space, but rather an infinite distance (“indefinite,” as Descartes put it rather prudently) separates worlds, as far as thought can reach. Alexandre Koyré has described our period as that of the shift from the closed world to the infinite universe.<sup>4</sup> From our perspective here, the question might be reformulated, very concretely, as the shift from the heavens to the sky, from the solidity of the Aristotelian cosmos to the planets moving along the intangible orbits of Keplerian cosmology.

But if Tycho overturned the Aristotelian cosmos, he himself did not accept any of the three movements of the Earth postulated by Copernicus (diurnal rotation, annual rotation around the Sun, and oscillation on its axis).<sup>5</sup> So how could the Earth be put into motion against the upholders of geostatism? This was one of the principal labors that preoccupied Copernican astronomers at the start of the seventeenth century. To accomplish such an upheaval, the tools of traditional astronomy were not sufficient, for in the

domain of astronomy, recourse to the immediate experience of the senses was misleading—everybody could “see” that the Sun turned around the Earth—and recourse to physical experiment was impossible. In this context, visual and fictional figuration played a central role, substituting a new mental image of the cosmos for the old one. Nothing could be ruled out that might contribute to the vast enterprise of this restructuring of cosmology—which was above all a restructuring of the representations of the cosmos.

In 1609, when Kepler began to write the *Dream* based on elements of his dissertation written in Tübingen in 1593, seventy-five years had passed since the publication of *De Revolutionibus*, but heliocentrism had not yet been accepted among astronomers.<sup>6</sup> In fact, Kepler was one of the first, along with Galileo, to defend it openly. An astronomer had to grapple not only with the theoretical space of Copernican cosmology, but also with a tangible space, not an abstract space of hypotheses, but a very concrete space through which the planets move.<sup>7</sup> This issue runs through Kepler’s whole oeuvre. We will see that the *Dream* is inseparable from this context and belongs to the vast Keplerian enterprise of defending Copernicanism,<sup>8</sup> while occupying a singular place that must be elucidated. Kepler himself gives some clues in his footnotes about the specific bearing of this text on others: given the pointlessness of logical arguments to convince certain obstinate anti-Copernicans, there remains only derision or fable. In one of his jokes (which were quite serious and to which we shall return), he wittily lambasts those who wanted to read *De Revolutionibus* “after first removing discussion of the Earth’s movement. This amounts to the same thing as saying that it must not be read before it has been reduced to ashes.”<sup>9</sup> Faced with anti-Copernican astronomers, any kind of logical argument is in vain: “It occurred to me that these people should be refuted not with arguments but through mockey, and so I composed the following epigram:

They were able to castrate  
The bard lest he fornicate;  
He survived without any testicles.  
Alas, O Pythagoras,  
Whose thinking wore out iron chains;  
They spare you your life,  
But first they get rid of your brains.”<sup>10</sup>

This is an important clue to the *Dream*’s enunciative strategy: ridiculing one vision of the world before demonstrating a new one. An “argument” can have more than a logical form.

It is within this framework that the recourse to fiction must be understood. From the start, we may rule out the hypothesis of Kepler's prudent dissimulation:<sup>11</sup> he had already published *Astronomia Nova* (1609) and *Epitome Astronomiae Copernicae* (1617–1621) and had no need to veil his Copernicanism or to adopt a cautious rhetoric about a hypothesis that he had already openly defended at length. On the contrary, the *Dream's* thesis—the Earth's movement—was explicitly formulated many times: “The purpose of my Dream is to use the example of the Moon to build up an argument in favor of the motion of the Earth, or rather to overcome objections taken from the universal opposition of mankind.”<sup>12</sup>

#### GENEALOGY OF THE *DREAM*: FROM *LUDUS PHILOSOPHICUS* TO THE GAME OF FICTION

As he had done with his previous astronomical texts, Kepler included his sources in the *Dream*, a treasure for the commentator who finds among the many notes references to books, anecdotes, explanations of onomastics, and astronomical theory—but the notes also complicate the reading enormously. From the second note, the issue becomes confused. Kepler states that he wrote his *Dream* “in imitation of philosophical writings,”<sup>13</sup> in particular works that by means of a myth or dream make the nature of the universe known. While he mentions in passing two founding models of the philosophical dream genre, Plato and Cicero, he lingers over two other authors whose use of this genre is at least questionable: Plutarch and Lucian.

#### The Genre of the *Dream*, or Philosophical Flight

The first classical tradition alluded to is the philosophical fable: the *ludus philosophicus* of Plato's Atlantides in the *Timeas* and *Critius*, and of Scipio's dream in book 6 of Cicero's *De Republica*. Cicero has Scipio, one of the speakers in the dialogue, recount the dream he had when he was in Africa. He thinks he sees his father, Scipio Africanus, the victor over Hannibal, who tells him that there exists in heaven a place reserved for all those who have served their country well, and then explains the structure of the universe and the harmony of the spheres. On the threshold of his own *Dream*, Kepler claims the lineage of a “genre” (*genere scriptiois*, he calls it) whose conventions might well illuminate his choice of writing style.

Known essentially through the commentary given by Macrobius, the Dream of Scipio invites a neo-Platonist interpretation. “The neo-Platonic

perspective,” explains Sylvie Ballestra-Puech, “justifies the allegorical character of the dream. Furthermore, because it belongs to the category of *somnium*, one of five types of dream that Macrobius differentiates in his prologue, it is susceptible to interpretation.”<sup>14</sup> In the poetics of the allegorical dream as it developed over the course of the Middle Ages and Renaissance, it seems that the production and the interpretation of the allegory go hand in hand, and in fact are part of the expectations of the genre. Thus understood, the genre to which Kepler’s text belongs explains the importance granted to the commentary. Not only—as Macrobius indicates—does the allegorical dream require an explanation, but over time this explanation gradually becomes part of the genre itself. A second aspect of the Macrobian interpretation of the genre might shed light on Kepler’s use of it. Macrobius stresses the proximity of the *somnium* to the *fabula*, thus inscribing Scipio’s Dream in the line of Platonic myths (and this is how Kepler understands it). Thus the dream becomes the paradigm of a particular type of fable that is related to the truth; it is partly the tradition in which the *Dream* belongs that explains and justifies the inclusion of an extended hermeneutic apparatus and the recourse to fable as access to truth.

If Cicero’s explicit model is the myth of Er the Pamphylian at the end of book 10 of Plato’s *Republic*, one of the differences from the Greek source lies in the introduction to the dream, which replaces the direct vision of Er in Plato. According to Macrobius, Cicero substituted the dream for a vision in order to escape the critiques that were targeted at Plato’s text (Cicero preferred waking up his narrator to resuscitating him). According to Georges Forestier, the dream was a means of safeguarding appearances, in that it “ensures an acceptable shift from the human world to supernatural worlds.”<sup>15</sup> But Kepler does not introduce a supernatural world; he is making the link between two “natural” worlds that are equivalent, even if not similar from a physical viewpoint. In adopting the dream genre, right away Kepler alters the stakes. The two authoritative references are mentioned only as a point of departure, in the primary sense of the term: they justify the choice of an island for launching the story of Duracotus. For the dream itself and for the flight, Kepler calls upon two other models, especially Plutarch, whose *De Facie in Orbe Lunae* he translates as an appendix to his own text.

Plutarch serves as a model in several respects. First, he offers the example for a “geographic” study of the Moon. If in Aristotelian physics the Moon has a central place as boundary between the sublunary and superlunary worlds, this position makes it not only incorruptible, but also unknowable. For Plutarch, on the other hand, the Moon is studied in the same way as the Earth,

whose relief and climate can be described. Moreover, Plutarch is a rare example of the association between such a physical discussion and fiction, and it is with respect to Plutarch that Kepler makes the link between the dream and the fable: “Every time I reread this book by Plutarch, I am exceedingly amazed and keep wondering by what chance it happened that our dreams or fables coincided so closely.”<sup>16</sup> But the articulation of fable and knowledge is even more complicated, because Kepler places alongside these Roman tutelary figures the Greek author Lucian of Samosata.

### Lucian as Paradoxical Source

Lucian takes aim precisely at such a tradition associating the extraordinary voyage with philosophy when in the opening of the *True History* he mocks the philosophers who resort to fables:

However, when I read all these writers I didn't blame them greatly for their lying, as I'd already seen that it was habitual even to those professing philosophy. But what did surprise me was that they thought they could report untruths and get away with it. So, as I too was vain enough to want to leave something to posterity, and did not want to be the only one denied the right to flights of fancy, and since I had nothing truthful to report (not having experienced anything worth recording), I turned to lying. But I am much more honest in this than the others: at least in one respect I shall be truthful, in admitting that I am lying. Thus I think that by freely admitting that nothing I say is true, I can avoid being accused of it by other people. So, I am writing about things I neither saw nor experienced nor heard about from others, and which, moreover, do not exist, and in any case could not exist. My readers must therefore entirely disbelieve them.<sup>17</sup>

Such a provocative declaration was to leave a significant legacy in the history of fiction. Denying the historians their autopsy, and refusing the strategies of falsehood of the first sophists, Lucian's fiction opens the way to modern fiction by exhibiting its status *as* fiction.<sup>18</sup> Kepler offers a surprising reading of this famous overture: “this highly daring tale, which nevertheless offered some indications about the nature of the entire universe, as Lucian himself announces in his introduction.”<sup>19</sup> If Plutarch's story followed a treatise on different conceptions of the Moon, it is difficult to attribute such scholarly content to Lucian's *True History*. Lucian was sometimes considered as a “serious” author in the Renaissance, but this was for the elements of Cynic philosophy present in his satires, not for his astronomical or physical reflections.<sup>20</sup>

Kepler directs his reading of Lucian toward philosophy and renounces the satiric and utopian part of the tradition of the lunar voyage. Such an interpretation makes sense given that Kepler is trying to combine two contradictory traditions: a philosophical flight by means of a dream, and a fictional flight in the tradition of the trip to the Moon. Kepler's originality lies in his combination of the two, to make the fabulous voyage to the Moon in the mode of Lucian the basis for real astronomical reflection. In doing so, he gives the lunar fable an epistemic weight—and ontological weight, as we shall see—which it did not have before.

As he did with other sources—notably with Tycho<sup>21</sup>—Kepler transforms radically what he takes from them. It is possible to take material from an authority without slavishly reproducing the earlier writer's ideas. So, for example, he makes an emphatic homage in the *Dream* to Tycho Brahe and simultaneously refutes his geostatic conception of the world; similarly, he cites the tradition of the imaginary and fantastic voyage while he refashions it. His literary sources, like his astronomic sources, do not emerge untampered with; on several levels, a conception of a tradition illuminates Kepler's relation both to literary sources and to scientific ones. Whether regarding the method of observation or the literary model, while Kepler inherits and borrows he also displaces and transforms his source material. It has often been said that what characterizes Kepler's cosmology is the reworking of ancient structures that become displaced and distorted, like a circle that has become an ellipse.<sup>22</sup> From the standpoint of genres, a comparable phenomenon takes place: by superimposing the philosophical dream and the lunar fable upon the new astronomy, Kepler confers on fiction not only a role of transferring knowledge but also an ontological significance in explaining the physical world.

### The Cosmic Game

Kepler borrows from Lucian not just a way of philosophizing, but also a way of writing: the *spoudogeloion*<sup>23</sup> (“serio-comical”); he takes the oratorical precaution of the *jocemur* (“this is a joke”) from Plutarch and the tradition of *ludus philosophicus* from Platonic myth. The point these three references have in common seems to be *the game*.

The theme of play is recurrent in the *Dream*. For example, it is tempting to see a metatextual indication in note 48: “I used to include the same kinds of games too, which the spectators enjoyed all the more for realizing that they were games”<sup>24</sup> (he refers here to his performance of an optical experiment

as a spectacle). This praise for such a critical and ludic posture undoubtedly refers to those inadequate readers whose naïve reading Kepler deplores in note 8.<sup>25</sup> For Kepler's poetics presupposes a savvy reader, as well as an author who is not the dupe of his own game. Several texts by Kepler mention the game devised by the person writing. Ultimately this kind of play is the equivalent to the demiurgic game of the Creator:

For my part, I say that God himself, who in His infinite goodness could not remain idle, played at signing things and printed his image in the world. In the same way it is one of my thoughts that all of nature and celestial splendor is symbolized in geometry. . . . As God the Creator played, he taught the game to Nature, his image. . . . As God and Nature once played, so the soul of man in turn should play and regard the signatures of things.<sup>26</sup>

Because it reiterates the divine gesture, the game, understood as the duplication of symbols and geometric forms of nature, designates both the literary game of constituting a form and the play of interpreting it. We rediscover the geometric game and poetics—properly poietics—of *The Snowflake*, a text that Kepler also calls *De nive sexangula jocus physiologicus, Francofurti 1611 4to. Recedit Dornavius in ludicris* (“On the hexangular snowflake, a natural history entertainment . . . reprinted by Dornavius as one of his jokes”). The metatextual track proves fruitful in helping to interpret several notes in the *Dream*: later, Kepler asks whether “physical explanation underpins and is merged with the joking justification of the reason why eclipses of the Sun and Moon bring so much misfortune”<sup>27</sup> and admits that “here, of course, I am indulging in a joke; looking straight ahead, I concentrate on physical reasoning, while out to the side, I shoot satirical arrows in all directions at spectators who feel sure of themselves.”<sup>28</sup>

By means of the theme of play and decoding the game, the central question of interpretation is posed—and crucially the opposition of the Church to the Copernican hypothesis. Putting himself on stage in a rowdy discussion with an anti-Copernican theologian, Kepler reports his own speech:

If the usefulness, necessity, and possibility of this teaching were understood by your narrow mind, you yourself would long ago have discounted the force of the arguments drawn from Scripture, and sought out a suitable interpretation.<sup>29</sup>

Incapable of discerning the importance of play in divine creation, the theologians Kepler is targeting are bad players as much as bad readers. You have to know how to distinguish the letter from the spirit of Scripture, a herme-

neutic effort of which the text of the *Dream*, split between the story and explanatory notes, is an example. But the allegorical game is not fixed, and Kepler seems more attached to showing the functioning of the interpretation than to giving us a specific interpretation. Allegory for Kepler is only a supplementary game.<sup>30</sup>

### Description and Hypotyposis: The Upsides of Fiction

However, if the *Dream* is woven of literary references, it seems that neither the genre of the philosophical dream nor the functioning of the allegorical fable is sufficient to account for Kepler's enterprise. The astronomer is developing other possibilities at the juncture of the fable and astronomical reflection.

Because it offers a particularly concentrated version of Kepler's method, the "Selenographical Appendix"<sup>31</sup> shows the singular use Kepler made of fable. Presented as the "fruit" of a "remarkable gift" that he was given—the telescope—the appendix offers a description of lunar cities. But as Kepler stresses in his dedication to the Jesuit Paul Guldin, these astronomical observations are "some fruit of literary enjoyment, derived from experience with this gift."<sup>32</sup>

The description opens with surprisingly circular logic: "If you direct your mind to the towns on the Moon, I shall prove to you that I see them."<sup>33</sup> In other words, you have first to accept that visualizing these cities is possible before having it demonstrated. Vision precedes proof. This is in effect the very structure of the appendix, and more generally the functioning of the *Dream*.

In the first part of the appendix (which he calls "literary"), Kepler imitates the style of his most orthodox astronomical observations, from which he provides extended extracts, including entirely conventional topographic (or even chorographic) descriptions, using the technical terms for describing terrestrial topography in order to describe reliefs of the Moon (peninsula, cove, coastline, isthmus, gulf, lake, shore). But there are two notable differences between "literary" description and traditional "astronomical" description. First, the literary description of "towns on the Moon" is in the present tense, while the astronomical descriptions are in the past tense, as are most of the experimental and observational accounts of the day: "In the year 1623, on July 17 . . . I watched the Moon from 1 A.M. to 2 A.M., using Father Niccolo Zucchi's lenses."<sup>34</sup> Second, all the literary description is oriented by a deterministic viewpoint that starts from the premise of the existence of

“Endymionides,” or inhabitants of the Moon, and tries to account for the “lunar hollows” observed from their perspective and their interest in them: “In them the Moon-dwellers usually measure out the areas of their towns for the purpose of protecting themselves from the mossy wetness as well as from the heat of the Sun, and perhaps even from enemies.”<sup>35</sup>

The interest of resorting to the literary register, here a fictional one, is to short-circuit the oratorical precautions that normally accompany hypothetical discourse. “To direct your mind to the towns on the Moon” means to offer them to immediate view without the obstacle of heavy formulations of hypotheses or axiomatic demonstration. What Kepler calls the “pleasure of the literary form” is essentially the association of a traditional descriptive style and a deterministic point of view incarnated in the inhabitants of the Moon, ending in a lively and striking description of the lunar surface: a *hypotyposis*. This is the originality of the *Dream* in relation to philosophical fables and to previous celestial voyages—and Kepler’s essential contribution to the constitution of a singular poetics of the cosmological journey.

Of course, in the appendix notes, Kepler apparently bows to the logical demonstration that he avoids in the first part. However, in one final flourish this apparent concession to the genre of the astronomical treatise (a list of “phenomena” explained by “axioms”) is itself presented as a game: “Consider these assertions placed before you as a problem to be resolved point by point on the basis of phenomena discovered by the telescope, to see if those phenomena are brought into agreement with these conclusions by means of the axioms of optics, physics, and metaphysics. But this is a game.”<sup>36</sup> This is a way of signaling that the most demonstrative part of the text is not necessarily more serious than the “pleasure” of the first page. It is also a way of inscribing his text in the vast poetics of play that presides over any representation of Creation.

We can interpret the *Dream* within the same analytical framework. In a series of theses defended at Heidelberg in 1582, Michael Maestlin, Kepler’s mentor, had formulated the difficulty specific to astronomical demonstrations within the limited framework of the terrestrial viewpoint:

We judge that the investigation of the circles and celestial spheres must be begun *a posteriori*, that is from the particular appearances of the motions, . . . but, not *a priori*, since no-one is able to ascend into the aethereal region, where he would see everything in person.<sup>37</sup>

In proposing in the appendix notes to demonstrate each phenomenon by axioms, Kepler follows precisely the *a posteriori* method advocated by Maestlin.

But as we have seen, Kepler first offers to “direct [his] mind” to the celestial region. The *Dream* is the development of this change in mental direction: the fictional application of the celestial voyage that alone allows seeing “*all things by oneself*,” in Maestlin’s phrase. Through the game of a fable, Kepler proposes nothing less than the inversion of Maestlin’s method, thus giving to the astronomical discourse, even if provisionally and fictionally, the force of proof.

But how does Kepler achieve this detached and aerial point of view, dreamed by so many astronomers before him? How can the impossibility of aerial transport, dismissed by Maestlin, be transformed into a valid tool in astronomical thought? How, in other words, can the fictional tradition of the aerial voyage become the basis of a demonstration?

#### THE DYNAMICS OF THE VOYAGE: A THOUGHT-EXPERIMENT

While taking up the classical tradition of the philosophical dream and the lunar fable, Kepler modifies the relationship between fiction and knowledge and contributes to the formation of another genre of philosophical fiction, or rather, to a new philosophical and scientific use of fiction. Having found it in Plutarch and Lucian, Kepler affirmed the use of fable for imparting knowledge. But really his articulation of reality and fable is quite new. If myth served as a veil of hidden knowledge, the fiction of the *Dream* serves to dramatize, to visualize, an experiment that cannot be performed on Earth, by imagining the physical consequences of the displacement of a body in space. In this sense, the *Dream*’s fable is a thought-experiment.<sup>38</sup> The role of lunar fiction is then a textual test of two propositions: What would be the consequences of sending a human body into space? What would the traveler see from the Moon? These are the two aspects of a journey, dynamic and optical, that such a thought-experiment combines. While it can be realized only in the form of a game of fiction, this is a game played according to the laws of physics rather than a *ludus philosophicus* in the tradition of Cicero.

#### Shock

Tycho Brahe had thought that any experiment whose aim was to prove the diurnal rotation of the Earth implied by Copernican cosmology would be impossible.<sup>39</sup> The experiment of cannonballs shot from East to West—made famous by Galileo’s dialogues—enabled him to assert that “as a result of

the extremely rapid diurnal movement of the Earth (if it existed), the ball shot toward the East could never traverse as much space over the surface of the Earth, since the Earth (by its own movement) is coming toward it, than the ball that in the same manner is launched to the West.” By means of the *Dream*, Kepler tries to counter Tycho’s argument. To the argument of the cannonball’s flight, Kepler responds by launching another missile. But rather than projecting a cannonball parallel to the ground, he imagines sending a human body up vertically. It is the body of the lunar traveler that becomes the cannonball in the terrestrial experiment. It should be stressed that Kepler never directly opposes Tycho, either in the narrative (where he plays an essential role in Duracotus’s intellectual formation) or in the notes (where he is deferentially mentioned several times). However, the comparison with the ball seems to gesture toward his text, which Kepler knew better than anyone else. I must quote the flight of the traveler-projectile as a whole, as recounted in the voice of the Daemon of Levania (the Moon):

Great as the distance is, the entire trip is consummated in four hours at the most. For we are always very busy, and agree not to start until the Moon starts becoming eclipsed on its eastern side. Should it regain its full light while we are still in transit, our departure becomes futile. Because the opportunity is so fleeting, we take few human beings along, and only those who are most devoted to us. A man of this kind, then, is seized by us as a group and all of us, pushing from underneath, lift him up into the heavens. In every instance the take-off hits him as a severe shock, for he is hurled just as though he had been shot aloft by gunpowder to sail over mountains and seas. For this reason at the outset he must be lulled to sleep immediately with narcotics and opiates. His limbs must be arranged in such a way that his torso will not be torn away from his buttocks nor his head from his body, but the shock will be distributed among his individual limbs. Then a new difficulty follows: extreme cold and impeded breathing. The cold is relieved by a power which we are born with, and breathing is made possible by applying damp sponges to the nostrils. After the first stage of the trip is finished, the passage becomes easier. At that time we expose their bodies to the open air and leave them alone. Their bodies roll themselves up, like spiders, into balls which we carry along almost entirely by our will alone, so that finally the bodily mass proceeds toward its destination of its own accord. But this onward drive is of very little use to us, because it is too slow. Hence it is using our will-power, as I said, that we increase the body’s speed, and we propel the body onwards to prevent it suffering any harm by colliding too hard with the Moon.<sup>40</sup>

Because it includes bodies in the scenario, the fable is an excellent means of testing physical hypotheses in celestial space, that is to say, performing a thought-experiment. According to the law of Galilean relativism (that any movement depends on its plane of reference), the experiment of the horizontal shot is doomed to failure. Only a vertical shot, by managing to break through the Earth's atmosphere, can effectively make its movement observable. As we see, Kepler employs the cosmic voyage primarily as an opportunity for an experiment on the physics of bodies. Note 65 states this clearly: "Here I return to thinking about the nature of bodies."<sup>41</sup> In framing an experiment that relates to hypotheses of physics more than anything else, the lunar fable makes it possible to achieve what was impossible on Earth, proving the Earth's movement by removing oneself from its influence.

How then can we explain the intervention of demons in this ascension of bodies? Following the allegorical interpretation proposed by Kepler, the demons represent astronomy, and the volunteers ("only those who are most devoted to us") are the astronomers. The notes imply praise of the astronomer as a brave traveler, accustomed to the rigors of sleepless nights and the difficult labors of the mind, as revealed by the allusion to Tycho's sarcasm about men who are "lethargic, fat, or tender,"<sup>42</sup> and *a contrario*, the reference to the frail Maestlin, whose lightness was reflected in the "fine delicacy of [his] mind."<sup>43</sup> A second interpretation, this time mechanical, makes the demons the means of flight: "If it is true, as most courts hold with regard to witches, that they are transported through the air, I say that maybe it will be possible, also, for some body to be violently removed from the Earth and carried to the Moon."<sup>44</sup> In fact, as we shall see, the demon is one of the "mechanical" means enumerated by Wilkins. But in the economy of this text, the demon has another function: he is bearer of a scholarly voice. In his thought experiment, Kepler (to use Stuart Clark's title phrase) "thinks with demons": as relays of philosopher's thinking, as allegories of astronomy, but also as representatives of superhuman knowledge,<sup>45</sup> demons help "to enlarge the boundaries of astronomy."<sup>46</sup>

### Bodies

Kepler never forgets that he is dealing in his experiment with a human body and not a cannonball. As note 57 indicates, the whole passage on aerial flight has to be interpreted "physically":<sup>47</sup> men are literally risking their lives, notably due to the shock of acceleration, of speed (twelve thousand miles an hour), and of the lack of air. The rest of the text and notes describe how to

alleviate the principal dangers and the pain of flight: he advocates a means of anesthesia through narcotics and indicates the best position of the body. The physical details of this traveling through sublunary space are much more than provisional decor, a mere precursor to the exposition of the new science of selenography. Alongside astronomical reflection, it marks the inalienable presence of the body. It signals, in short, the reunion of physics and astronomy, long separated in the Ptolemaic conception of the universe. For Kepler, a fiction conceived as a thought-experiment inscribes the place of matter and physics in the space of the Copernican cosmos, a space no longer merely theoretical, but concrete.

Note 72, trying to resolve the question of cold by means of the demons' "innate power," gives another indication of the passage's importance. This midflight intervention is required by the impossibility of resolving a physical problem that weakens the whole enterprise of the demonstration.

This is merely for the sake of formality. Nature fails me. I do not know whether it is agreeable to pass over into a joke in the midst of a serious discussions. The allegory, too, is becoming chilly.<sup>48</sup>

What is striking (as above with the celestial traveler as a metaphor for the astronomer) is the combination of a physical demonstration and an allegorical meaning, and the shifts from one to the other; the notes sometimes offer the physical resolution of an allegorical phrase, but they can also propose an allegorical interpretation of a question of physics.

### Forces

Meanwhile, the Aristotelian physics that postulated the layering in sublunary space of four elements (earth, water, air, fire) was swept away, for the flight describes a fluid passage of the body from one magnetic force to another, the attraction of the terrestrial globe to the lunar globe, following a magnetic conception of the influence of stars that owed much to Gilbert's *De Magnete*: "When the magnetic forces of Earth and Moon are canceled out by their opposing attractions, it is as though nothing pulled the body in any direction."<sup>49</sup> The lunar voyage is an application of an essential postulate: the same physical forces are at play on Earth and elsewhere. As Gerald Holton explains, "Kepler set out to unify the classical picture of the world, one which was split into celestial and terrestrial regions, through the concept of a universal physical *force*."<sup>50</sup> For Kepler, terrestrial physics and celestial physics are one and the same science. This is why in the *Dream* the Moon's magnetic force

relays the Earth's magnetic force, and "Moon landing" requires the particular attention of the demons.

Because it can transpose the physical characteristics of the Earth to the Moon, that frontier of Aristotelian sublunary space, lunar fiction proves to be an essential tool of Keplerian "physical astronomy."<sup>51</sup> In a playful mode, Kepler fictionally achieves here what he had undertaken to demonstrate elsewhere, thereby laying (in Holton's terms) "the bridge that leads from the old conception of the world—the immutable cosmos—to the new one—a theater dedicated to the play of dynamic, mathematical laws."<sup>52</sup>

#### VISION IN THE VOYAGE

The flight of astronomers, therefore, is not merely metaphorical—and this distinguishes it from the earlier flight of the philosophers. As well as being a thought-experiment in physics, flight also makes it possible to shift the optical power of the telescope into space, permitting a demonstration of the Earth's diurnal movement. Once the voyage has been accomplished, the physics-based thought-experiment becomes one of optics concerning the Daemon of Levania, Duracotus's mother Fiolxhilde explains:

Thanks to him [the demon, an allegory of astronomy] I am not often whisked in an instant to other countries, as I instruct him, or if the distance is too great, I learn as much about them by asking him as if I were there in person. Most of the things which you saw with your own eyes or learned by hearsay or absorbed from books, he related to me just as you did.<sup>53</sup>

Familiarity with astronomy is here added to three other possible methods of acquiring knowledge: first-hand witness, hearsay, and book learning. It is like seeing it oneself because by astronomical observation "our eyes were directed in our imagination" to the Moon.<sup>54</sup> Since his *Astronomiae pars Optica* (*Optical Part of Astronomy*) of 1604, Kepler had presented optics as an essential tool for the astronomer interested not only in the movement of celestial bodies, but in their physical nature. While Kepler performed his first observations of the Moon before the invention of the telescope<sup>55</sup> during his student years in Tübingen, the new instrument only confirmed his interest in optics for astronomical investigation.

Several times the notes refer with some satisfaction to the correctness of the reasoning first proposed and then confirmed by telescopic observations: "So much more delightful is this anticipation of the truth, made years in advance, and clearly conceived and expressed."<sup>56</sup> The extended timeframe

within which the *Dream* was elaborated makes it a particularly interesting document, spanning two periods: before and after the telescope. Thus Kepler asserts that the mountains of the Moon belong to a draft written prior to the invention of the telescope: this was one of the theses formulated by his teacher Maestlin back in 1582, confirmed later by Galileo's telescopic observations.<sup>57</sup> After the invention of the telescope, an idea that was only sketched in the *Dream* was articulated fully in the "Selenographical Appendix": the hypothesis of a subterranean world is confirmed by telescopic observations and extended in the description of cities.

But even before the support of the telescope, optics played a central role in astronomy as Kepler conceived it and as he presents it in the *Dream*. Thus the strange rites that precede the lunar voyage correspond to the preparation of the *camera obscura*, from which Kepler, inspired by the *Magia Naturalis* by Giambattista della Porta, had taken elements in his *Optics*: the operator blocks the light to darken the room, puts up a screen, covers his head with a coat—and the image of objects appears in reverse. It is tempting to read this scene with its fictional demons<sup>58</sup> and genuine optics as an allegory of the whole journey, which might be understood as a huge inversion of perspective,<sup>59</sup> for the geocentrism that makes us believe that the Earth is immobile at the center of the universe is effaced by the "selenocentrism" of the inhabitants of the Moon.

### The Double Perspective

From the lunar perspective, the Moon seems immobile and the Earth mobile: "Levania seems to its inhabitants to remain just as motionless among the moving stars as does our earth to us humans."<sup>60</sup> For Kepler, the change in perspective is also a change in name: "What we Earth-dwellers call 'Earth' I chose to call 'Volva' from the point of view of the people on the Moon."<sup>61</sup> Seen from the sky, Earth offers an ever-changing spectacle; "Volva" means "it turns."

For even though it does not seem to have any motion in space, nevertheless, unlike our moon, it rotates in its place and displays in turn a wonderful variety of spots, as these spots move constantly from east to west. . . . On the eastern side it looks like the front of the human head cut off at the shoulders and leaning forward to kiss a young girl in a long dress, who stretches her hand back to attract a leaping cat. The bigger and broader part of the spot, however, extends westward without any apparent configuration. In the other

half of Volva the brightness is more widely diffused than the spot. You might call it the outline of a bell hanging from a rope and swinging westward.<sup>62</sup>

Notes 154 to 172, a sort of map of the world in palimpsest, decode each of these forms by naming the corresponding countries and continents: the girl with the long train is Europe, the cat that jumps are the Scandinavian countries, the bell is South America, etc. The spectacle of the Earth seen from the sky borrows from the traditional motif of a map's overview, or here a globe rotating in the sky—a demonstration of the first type of movement: diurnal rotation.

The second type of movement is not immediately perceptible, since for the inhabitants of the Moon, the Earth does not move in the sky. But it is also the object of an optical “demonstration” that is somewhat more sophisticated than the first. But it should be stressed that what can be reconstructed of lunar astronomy—meaning what one can see of the solar system from the Moon—is not in itself more accurate or informative than what could be seen from the Earth. It is the conjunction of both viewpoints that makes sense of it all and literally makes it possible for the Earth to move:

Of course, we Earth-dwellers think that the plane on which we stand, and together with it the cupolas on our towers, remain stationary, but around those cupolas the heavenly bodies revolve in their travels from east to west. Yet this thought subtracts nothing from the truth, nor does it impose any rule on it. For in like manner the Moon-dwellers, too, believe that their lunar plane and the ball of Volva hanging up high over it remain in one place, although we know for a certainty that the Moon is one of the movable heavenly bodies.<sup>63</sup>

The parallels in sentence structure and lexis underline the equivalence—and inanity—of the two points of view considered alongside each other. Lunar fiction serves as much to offer a description of a new world as to construct the counterpart of ours, demonstrating the relativity of perception. It is the incompatibility between the terrestrial viewpoint (the Earth is immobile and the Moon moves) and the lunar viewpoint (the Moon is immobile and the Earth turns on its axis) that provokes the movement. Copernicus had already explained this: we think that the Earth is immobile and the skies move because we are placed on the Earth's surface:

This situation closely resembles what Virgil's Aeneas says: “Forth from the harbor we sail, and the land and the cities slip backward” [Aeneid, III, 72]. For when a ship is floating calmly along, the sailors see its motion mirrored

in everything outside, while on the other hand they suppose that they are stationary, together with everything on board. In the same way, the motion of the Earth can unquestionably produce the impression that the entire universe is rotating.<sup>64</sup>

In placing an observer on each side—on the ship and on the shore, that is to say, on the Moon and on Earth (except of course that in our case both are in movement)—lunar fiction (through a movement of optics) validates the Copernican hypothesis.

Due to the very complexity of its movements (“compounded by the Earth’s annual motion and the Moon’s monthly motion”),<sup>65</sup> the Moon constitutes an excellent argument for Kepler: it demonstrates both the illusion of a fixed viewpoint (Copernicus’ ship) and the cause of visible motion. It is able to show, in other words, that the apparent motion of fixed stars or the Sun (seen from the Earth or the Moon) stems from their own motion: “In itself the Sun does not move at all. The daily motion of the Earth on the ‘great circle’ is attributed to the Sun by the Earth-dwellers.”<sup>66</sup> As for planets, the motion attributed to them is in reality a *composite* of their own motion and terrestrial motion. This all goes to explain the Earth’s second motion: its annual revolution around the Sun.

### Lunar Visions

The choice of the Moon is strategic.<sup>67</sup> If it primarily promises a confirmation of the Copernican hypothesis by testing it, it is above all a radical contestation of the whole Aristotelian cosmological model. For the Moon, which in the physics of Aristotle was a border between two radically different universes, is not only a new useful astronomic viewpoint, supplanting the former, it is also a new Earth to be charted.

Apparently following the “geographers” he takes as his model, Kepler finishes the *Dream* with a description of lunar fauna and flora. This description follows the astronomic description without any pause and depicts monstrous plants and strange animals in the same mood and tense (the present indicative): “Whatever is born on the land or moves about on the land attains a monstrous size. Growth is very rapid. Everything has a short life, since it develops such an immensely massive body.”<sup>68</sup> The continuity in the flow of the text seems to give this final page the same status as the preceding astronomical descriptions, but their difference should be stressed. Kepler can no longer deduce from the arrangement of planets the nature of the lunar fauna,

following the same method he had used for the eclipses. The notes continue to give astronomical and physical explications, but their nature has changed; now they are “probable conjectures” and “lines of reasoning” founded on analogy or on sources in books. Starting with note 210, he emphasizes that he will now describe things “which no eye has ever seen”; this is a clear shift to a conjectural type of discourse—the inverse, in short, of the firsthand observation (autopsy) that was so central to the cosmographic discourse of the Renaissance.

It is worth noting that the techniques of conjectural reasoning adopted here by Kepler would be used throughout the century, for instance in the technique of logical extrapolation developed by Fontenelle and in the principles of analogical reasoning on which Huygens based his *Cosmotheoros*, as we shall see later.<sup>69</sup>

At the same time, however, Kepler was relying on methods of asserting authority that had been in use since the Renaissance in traditions ranging from travel writing to demonology, notably the use of anecdote<sup>70</sup> and literary sources; Kepler’s notes refer to works such as Martin Del Rio’s *Investigations into Magic*, in which we learn of an imaginary species that dies in the heat of the day and is reborn at night,<sup>71</sup> and Scaliger’s *Exercises*, where he tells of ducks springing out from the resin of ships’ beams, as an example used to support the conjecture that living beings can emerge from inert forms shaped like pine cones.<sup>72</sup>

It is hard to understand Kepler’s daring use of conjecture, so unrelated to the astronomical arguments that precede it, unless we take into account the passage’s visual impact. For by describing a lunar world that is hyperbolically changing, Kepler destroys the very foundation of Aristotelian physics: the postulation of two irreconcilable kinds of physics, the sublunary and corruptible world of the Earth, and the superlunary and incorruptible world of the Moon. Hence the evocation of a world where “things born in the ground generally begin and end their lives on the same day,” and where living beings undergo strange daily mutations: “If anything is exposed during the day, it becomes hard on top and scorched; when evening comes, its husk drops off.”<sup>73</sup>

Kepler’s aim here is not so much to describe another world as to suggest to the reader’s imagination the vision of a lunar world that is infinitely changing and mobile, characterized by the fluctuation and impermanence of its phenomena. Doing so, the Keplerian fable makes Galilean objects visible and concrete, a lunar chorography that *Sidereus Nuncius* had only sketched. Before our eyes rise the walls of craters, whose shadows shelter swarming cities.

Monstrous vegetation grows and withers in the space of a lunar day, a striking image of hyperbolic corruptibility:

The Privolvans have no fixed abode, no established domicile. In the course of one of their days they roam in crowds over their whole sphere, each according to his own nature: some use their legs, which far surpass those of our camels; some resort to wings; and some follow the receding water in boats.<sup>74</sup>

The gigantism of the plants in the lunar world is a veiled reference to their essential similarity to terrestrial flora. The line of argumentation cunningly conceals its motive: by emphasizing the strangeness of the Moon's inhabitants and the extraordinary nature of its vegetal and animal forms, Kepler is also asserting that while the Moon is a world of otherness, it is first and foremost a whole other world.<sup>75</sup> When brought together in the same narration, the terrestrial world and the lunar world are no longer distinguishable in terms of their quality, but of their quantity. Now the difference is one not of nature but of degree.

Using narrative fiction offers Kepler the means of weaving the disparate elements of lunar astronomy together into a single narrative thread, thereby creating a striking image of the Copernican cosmos. Mingling poetic techniques with astronomical demonstrations, the *Dream* provides the vivid description and imaginary narrative of the Copernican hypothesis.

#### THE PLACE OF FICTION

"In a dream," Kepler explains, "it is necessary to have the freedom sometimes to invent even that which was never perceived."<sup>76</sup> This means that in the *Dream*, fiction is not opposed to knowledge but takes part in the construction of different kinds of knowledge: it confirms, anticipates, or develops them. In this sense, the *Dream* is inseparable from the rest of Kepler's oeuvre and should be interpreted within the intratextual framework of his other writings constantly mentioned in the notes. For example, note 209 indicates that the porous nature of the Moon has already been explained as being due to the weak density of the lunar globe in the *Commentaries on Mars*; the immense size of lunar inhabitants is taken from page 250 of the *Optics*, explains note 212; the Moon's mountains are described long before *Sidereus Nuncius*, in *Epitome Astronomiae Copernicae* on page 23, as note 207 reminds us; the table of the Moon's eclipses can be found in the *Optics* and that of the Sun's

eclipses in the *Ephemerides*, as signaled by notes 194 and 191; the interpretation of light and dark zones was corrected after reading Galileo, in the *Dissertatio cum Nuncio Sidereo*, and this correction is further developed in note 154. In short, the *Dream* synthesizes and delves deeper into questions about the Moon dispersed throughout Kepler's whole oeuvre.

If this list suggests that the *Dream* should be integrated into Kepler's astronomical corpus, it might be objected that there is a major contradiction between this fictional work and the efforts he made to counter what has been called the fictionalist interpretation of astronomical hypotheses. In order to situate the role and place of fiction in this text more precisely, this contradiction must be resolved.

### A Fiction against Fictionalism?

Until the Renaissance, the physical description of heavenly space arose from natural philosophy and not astronomy, which was considered an ancillary discipline whose principal task was to furnish mathematical models to account for, and predict, the apparent movements of stars. Kepler was one of the first astronomers to affirm the legitimacy of astronomical descriptions of the real nature of the cosmos, which meant bringing together its physical interpretation and mathematical (particularly geometric) description. Kepler was one of the most fervent defenders of this movement (which is now sometimes called "realism," although the anachronism of the term has led to its contestation) against those who claimed that astronomical hypotheses, serving only to "save the phenomena," were mere useful fictions (a position called "fictionalism" or "instrumentalism").<sup>77</sup> How indeed then can someone who was opposed to the fictionalist interpretation of astronomical hypotheses be the author of an astronomical fiction? Does this make the *Dream* a marginal work, an astronomer's amusement? Everything leads us to think otherwise: the long history of the text's composition, from the *Dissertatio* at Tübingen in 1593 right up to the astronomer's death in 1630, the importance that Kepler gave it, his frequent redrafting of it, and finally the declaration: "I therefore decided to avenge the slights made to this dream of mine by publishing it, which will be another punishment for my adversaries."<sup>78</sup>

The links between astronomical hypotheses and fiction are as ancient as astronomy itself, and the debate over the nature of these links is almost as ancient. I will confine myself to sketching briefly the major stages of this history in order to illustrate what was at stake for the history of fiction.

Up until the Renaissance, astronomical hypotheses had had the status of mathematical models: they served to “save the phenomena” rather than to describe the physical reality of celestial phenomena, which were inaccessible. Astronomers themselves were considered above all as mathematicians whose task was to offer geometric tools that would account for the appearance of celestial movements whose true nature remained unknowable.<sup>79</sup>

The delicate issue of hypothesis and fiction, of the assimilation of the former to the latter, arises in the preface that Andreas Osiander added to Copernicus’ *De Revolutionibus* against the latter’s advice. I will not return to the circumstances of this well-documented episode in the history of science,<sup>80</sup> but I should recall the stakes for the history of fiction. In this preface, Osiander explains that the hypotheses presented in the text—starting with the hypothesis that the Earth turns around the Sun—did not claim at all to describe the real organization of the cosmos: “Nor is it necessary that these hypotheses should be true, nor indeed even probable, but it is sufficient if they merely produce calculations which agree with the observations.”<sup>81</sup> His argument relies on the traditional definition of astronomical hypotheses as simple mathematical models.

Copernicus’ treatise was at first understood in the light of this preface, although he asserted several times in the body of the text of *De Revolutionibus* that his hypotheses corresponded to physical phenomena. Not until the end of the century did Tycho Brahe, then Kepler, point out the deception involved in Osiander’s preface and assert the full significance of the Copernican hypothesis. Kepler attacked Osiander as a philologist, demonstrating the contradiction between two types of astronomical discourse, the “fictionalist” one of the preface, and the “realist” one in the body of the text. The discussion led him to review the status of the astronomical hypothesis, which led him to a profound modification of its definition and its scope.

Opposing the traditional definition of hypotheses, Kepler proposes in effect a fundamental distinction between two sorts of hypotheses: on the one hand, the “geometric hypotheses” of the ancient astronomers, simple geometric models that do not claim to describe the real world; on the other hand, “astronomical hypotheses” that do describe the actual movements of the planets. By making such a distinction, Kepler conferred on “astronomical hypotheses” an ontological value and a significance in terms of physics that they did not have previously. It is worth citing a passage from Kepler’s *œuvre* where this distinction is clearly formulated. At the beginning of *Astronomia Nova*, on the verso of the title page, even before the dedication to Rudolph II,

Kepler responds to the famous challenge launched by Ramus half a century earlier, promising to offer his professorship to anyone who could produce an “astronomy without hypotheses.”<sup>82</sup> Kepler replies:

Conveniently for you, Ramus, you have withdrawn both from life and from your post. Had you not, I would come and claim the prize you promised as I have, in this work, risen to the challenge and met it, even according to the your own Logic. . . .

It is an absurd fable, I admit, in that it demonstrates truths of nature by means of false causes. Copernicus’ writing, though, is no fable, since he believed his hypotheses to be true, just as much as in your account the Ancients believed theirs to be, and not only did he believe them, but he demonstrated them to be true. I offer this work as proof.

But would you like to know who was really responsible for the fable you attack so viciously? It was Andreas Osiander whose notes are found my copy of the work [“Of Copernicus’s *De Revolutionibus*”], in the hand of Hieronymus Schreiber of Nurnberg. This Andreas, when he was in charge of publishing Copernicus, thought most prudent this preface that you consider so absurd (as may be gathered from his letters to Copernicus), and placed it upon the frontispiece of the book, Copernicus himself being dead, or certainly unaware of it. Copernicus, however, does not mythologize, but seriously presents paradoxes; that is, he philosophizes. Which is what you wish of the astronomer.<sup>83</sup>

While for Ramus hypotheses still designate simple geometric models, Kepler affirms the “truth” (*veras hypotheses suas*) of Copernican hypotheses;<sup>84</sup> we have moved from “geometric hypotheses” to “astronomical hypotheses.” Because he is determining the characteristics of the orbits of planets and explaining their physical causes, Kepler proclaims in the *Astronomia Nova* an astronomy “without hypotheses” in the sense of the “fables” given by Ramus. Still more interestingly, Kepler takes up and displaces the concept of “fable” and shows that it applies not to Copernicus, whose hypotheses refer to a physical reality, but to Osiander, whose preface is disqualified as a mendacious fable. For Kepler, hypotheses are no longer simple mathematical fictions to save appearances; they describe the physical world.<sup>85</sup> How then can we explain the recourse to fiction by an astronomer who most forcefully advocates the nonfictionalist interpretation of astronomical hypotheses?

The contradiction is resolved if one notes that Kepler is distinguishing what we normally confuse: the false and the fictional, in other words, fiction

as unreal and fiction as an invention that might introduce a kind of knowledge. In this sense, the *Dream's* fiction corresponds to “astronomical hypotheses” and not to “geometric hypotheses”: it is the description, in a hypothetical mode, of physical phenomena and not an invention without any relation to the real world. This explains Kepler’s choice of the philosophical dream as his genre: because it arises from *narratio fabulosa* (which Macrobius distinguishes from the simple *fabula*), it offers a generic precedent for the alliance between fiction and knowledge. We have seen the transformations made by Kepler to enable the representation of physical and astronomical knowledge rather than philosophical.

The paradox that we recalled in the introduction is thus illuminated, if not resolved: fiction becomes the space in which truth of astronomy can be formulated as it allows false geometric hypotheses to be transformed to become the astronomical hypotheses of physics.

But throughout the century, as we will see, the misunderstanding persisted, since the terms *fable* and *fiction*<sup>86</sup> referred interchangeably to notions that were not only distinct but actually opposite. The term *fiction* has a negative connotation linked to its etymology: fiction is what is constructed, fabricated, it involves trickery, illusion, it is deceptive and therefore is opposed to any discourse of knowledge. But it could just as well mean the heuristic fiction of the philosophical tradition that Kepler was reviving by transforming it into a thought-experiment. Because they carry both of these meanings, the terms *fable* and *fiction* remain ambivalent in our texts, and cosmological discourse plays on them throughout the century by making fiction oscillate between its function as a heuristic tool and its function as a sign of the failure to grasp truths.

### The Semiotic Structure of the *Dream*

Despite all of this, fiction and knowledge are not confused in the text of the *Dream*. If the former can be used to convey the latter, this is due to a complex operation that must be elucidated. It is important to stress that the text adopts two distinct methods of representing information. The first is narrative and breaks off at the moment of the arrival on the Moon, when the second mode, that of description, takes over. The issue is whether the fictional tone of the narrative part of the text also characterizes the description of the Moon that is central in all respects; it is the heart of the text as much as the heart of Kepler’s demonstration. But this selenographic description tends to erase the signs of fictionality. The successive narrative voices are effaced and

yield to a didactic voice almost totally denuded of context, and the reader almost forgets that it belongs to a character in the text, the Daemon of Levania. This is achieved through a series of shifts to move the narration along using three types of change—actantial, temporal, and spatial:<sup>87</sup>

1. First speaker
- > 2. Bohemian Chronicles containing the story of Libussa
- > 3. Dream of the book brought from Frankfurt
- > 4. Story of Duracotus
- > 5. Tale of Fiolxhilde
- > 6. Tale of the Daemon of Levania

There are then six levels involving five intermediate stages: the interlocking of the five shift operations immediately evokes the interlocking of the five regular polyhedrons between the six planets in *Machina coelestis* (Fig. 1). This interpretation is not as daring as it might appear; it is only an additional formal game on the part of someone who is using literary forms and genres to reflect their content. It seems that poetics and cosmology, literary forms and forms of the world, are inseparable for Kepler: paradoxical praise is the genre that suits the description of the snowflake, and the philosophical dream is fitting for lunar astronomy. This is not only a concession to the Mannerist aesthetics of the day, but a cosmopoetic conception of works created by humans as an aesthetic duplication of the forms of divine creation.

The particularity of the *Dream* is to make such shifting particularly visible: first, by means of a series of rapid breaks in the opening and then, through clear typographic and enunciative breaks inside the text at the fifth and sixth levels:

(1) In the year 1608 there was a heated quarrel between the Emperor Rudolph and his brother, the Archduke Matthias. Their actions universally recalled precedents found in Bohemian history. Stimulated by the widespread public interest, (2) I turned my attention to reading about Bohemia, and came upon the story of the heroine Libussa, renowned for her skill in magic. It happened one night that after watching the stars and the Moon, I went to bed and fell into a very deep sleep. (3) In my sleep I seemed to be reading a book brought from the air. Its contents were as follows.

(4) My name is Duracotus. My country is Iceland.

From History to his story, from 1608 to “one night,” from Bohemia to Iceland, these few lines condense all the sophistications of our entry into the world of fiction and have the striking effect of focusing on the character of

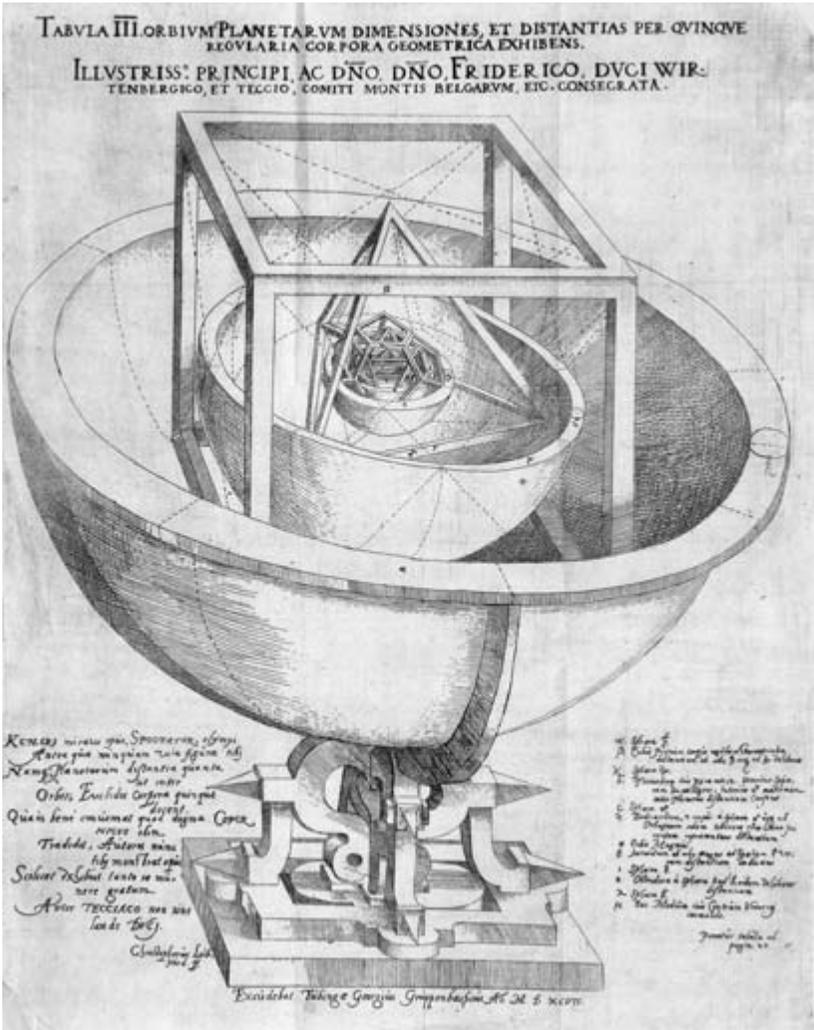


FIGURE I \* Model of the cosmos (*Machina mundi artificialis*).

Johannes Kepler, *Mysterium Cosmographicum* (1596).

the second narrator, Duracotus. The enunciative rupture performed by this fourth level (and third shift operation) is underlined in the original text by the introduction of a new typeface. The story of Duracotus then unfolds until the direct speech by Fiolxhilde (level 5), who decides to reveal to her son what she knows. This episode leads to the summoning of the Daemon of Levania, whose speech provokes a new enunciative rupture, this time marked by a title in the center of the page:

(6) The Daemon from Levania.

Fifty thousand German miles up in the ether lies the island of Levania. The road to it from here or from it to this Earth is seldom open.

We are presented once again with a new beginning: a new speaker, a new spatiotemporal framework. Each shift is total (actantial, temporal, and spatial), and therefore each level of the narrative framing, right up to the Daemon's discourse, is potentially complete. The phrase that introduces the fifth level is another sign of this: "Then one day, she took some time to speak to me and to explain everything from the very beginning."<sup>88</sup> In this succession of five shifts, we find six texts that are potentially complete and are imbricated, like the six planets and five solids of the Keplerian cosmographic model.<sup>89</sup>

Fernand Hallyn interprets this multiple framing as a way to underline and protect the center of the text, that is lunar astronomy itself.<sup>90</sup> A semiotic analysis confirms his conclusion. The staggered structure that I have just described is abruptly interrupted by a brusque engagement to return to level 1. The narrator is suddenly awakened by rain:

When I had reached this point in my dream, a wind arose with the rattle of rain, disturbing my sleep and at the same time stopping me from reading the end of the book brought from Frankfurt. Therefore, that is where I left the demon still talking to his audience, Duracus and his mother, Fiolxhilde, who had her head covered, I returned to myself and found my head really covered with the pillow and my body with the blankets.<sup>91</sup>

In a single final movement, all the enunciative levels are condensed (we are told again in a chaotic manner about the dream, the book, the demon, Duracotus, and Fiolxhilde) and literally thrown down onto the narrator's head. This abrupt engagement of all the levels simultaneously interrupts the lunar astronomy and closes the text. By dramatizing the end, the abrupt collapse of the semiotic structure elaborately erected at the beginning of the text concentrates attention on the enunciator of the first level, the "I" who functions here as the authorial voice. But it is also the authorial voice that explicitly governs the notes (as made plain by the numerous intratextual references to Kepler's other works). Thus the fiction is clearly situated: it is not only framed, above and below, by two discourses of knowledge, but constantly clarified by the authorial voice, insistently reminding us of his presence in his 223 notes. From a structural point of view, the voyage serves essentially to pass from one level to another, from the authorial voice of the notes to the

demon's voice transmitting knowledge. The place of fiction, in other words, is well defined: it manages a passage from acquired knowledge, that of the notes, to the unprecedented astronomical knowledge uttered in the voice of the demon.

Therefore Kepler's astronomic revolution is just as much a poetic revolution. The lunar fable he invents is not merely a metaphorical flight toward a new heaven of knowledge, nor is it the fabulous site of a satire or a utopia. Instead, it is the extension of the domain of physics to all the stars "floating" in the space of the sky like so many islands, of which the Moon is the paradigm. If until then the motif of aerial flight primarily referred to texts that used it as fiction, Kepler performs an essential displacement by exploring the materiality of flight. We see that his thought-experiment of aerial flight operates, as we have seen, through the extrapolation and exploration of the physical implications of flying. When he takes up the images and *topoi* of lunar stories, Kepler invests them with new signification, and ontologizes them by conferring on them their full physical and mechanical meaning—as he does, in parallel, with astronomical hypotheses. Because they present the materiality of the journey in a manner unprecedented in the literary tradition of the aerial flight, they underline its capacity to account for physical phenomena and thereby enable a "realist" interpretation of the lunar voyage. From philosophical flight and the fabulous lunar journey we have moved to a thought-experiment in physics, conferring on fiction an ontological weight that classical and renaissance tradition did not enjoy. Yet the fable does not lose its allegorical and metaphysical meaning; the very association of these different levels makes the *Dream's* poetics idiosyncratic and strange to us. Astronomical and physical observations add weight to the fictional discourse of a physical meaning that imposes itself on the allegorical meaning of the *Dream*, as if the new astronomy had just validated a posteriori the fable of the Ancients and the poets.

## Godwin, Wilkins, Cyrano

### *From the Optical Voyage to the Mechanical Voyage*

It has often been said that Kepler's work did not have the influence in its day that its later importance would have led us to expect. However, the reception of the *Dream* does bear witness to a vast readership throughout Europe and throughout the century, from Wilkins to Fontenelle, from Cyrano to Huygens. It is a founding text in more than one respect, since it not only influenced cosmological discourse in the direction of the story and of figurative representation, but at the same time it precipitated an evolution that would prove of vital importance in the tradition of the imaginary journey, a genre that it totally transformed even while making use of it.

Above all, Kepler invented a strategy of employing a new imagined vantage-point for making optical observations that would become a significant trait of the cosmological discourse of the century, and which we will find in all the works of our corpus, from Wilkins to Huygens. It thus defines a particular poetics in which the lunar voyage is the condition for a re-description of the world. But from this new poetics of cosmological discourse two principal paths will branch off: the first explores the physical character of the lunar voyage (Wilkins, Godwin, Cyrano), whereas the second rejects the overly implausible materiality of the flight while keeping the fruitful possibilities offered by using the new perspective it presented (Fontenelle and Huygens).<sup>1</sup>

In his famous "Digression of Ayre" (1621, 1628) Robert Burton had suggested:

Some new fangled wits, me thinks, should some time or other finde out: or if that may not be; yet with a *Galelies* glasse, or *Icaro-menippus* wings in Lucian, command the Spheares and Heauens, & see what is done amongst them.<sup>2</sup>

Here he formulates two essential postulates of the lunar narrative: the optical voyage and the mechanical voyage. Kepler had chosen to be transported

to the Moon by means of the optical voyage, first on the basis of observations with the naked eye, then using those made with Galileo's telescope. In the second part of the mechanical alternative, Burton seems to suggest the very traditional resort to Lucianesque fiction. But in the seventeenth century the wings of Icaro-menippus had become a very serious subject of technical and philosophical discussion. Mersenne includes in his *Questions inouïes* an "Art of Flying" (1634),<sup>3</sup> John Wilkins tackles the question several times, from his *Discourse concerning a new world & another planet* in 1640<sup>4</sup> to the *Mathematical Magick* in 1648. Robert Hooke, his disciple at Oxford, is also interested in the possibility of human flight. The question cuts across the cosmological debates as well as the literary fortune of the lunar fable. What interests us here is that in many respects the issue of flight blurs the boundaries between these two discourses.

In 1638, the first edition of John Wilkins' *Discourse* and Francis Godwin's *The Man in the Moone* appeared a few months apart.<sup>5</sup> The coincidence of dates is striking, all the more so because both texts seem to divide up the subject precisely according to the distinction between fiction and knowledge. *The Man in the Moone* offers the action-packed story of Domingo Gonsales and his journey from Salamanca to Antwerp, from Antwerp to the Indies, from the Indies to the Island of Saint-Helena, from the island to the Moon, and from the Moon to China. For his part, Wilkins proposes making both Copernican astronomy and Galileo's telescopic discoveries known to the educated reader, as well as the idea of the plurality of worlds. And so while both texts tackle the voyage to the Moon, they do so using quite different perspectives. The contrasts seem clear: on one side we have a fictional text, and on the other a scientific one.

#### THE MAN IN THE MOONE

This initial characterization of the genres breaks down under analysis, however. In effect, Godwin uses fiction to "make it seen" that the Earth turns, whereas Wilkins endeavors to demonstrate the possibility of a lunar voyage such as that undertaken by Godwin's character, Domingo Gonsales. The issue of the articulation of knowledge and fiction arises anew in these texts, but in a very different way than it does for Kepler. It is hard to know if Godwin had read the *Dream* when he was writing *The Man in the Moone*.<sup>6</sup> Without entering into a discussion of sources, what interests us here is the difference in strategies of expressing ideas. The interweaving of discourses of knowledge and fiction in Godwin owes nothing to Kepler's narrative method in the

*Dream*; rather it constitutes a new way of presenting a theoretical argument through fiction.

### Learned Fiction

As in Kepler's work, it is during the trip to the Moon that the demonstration of the similarity of nature between the Earth and the Moon occurs. Having passed the midpoint of his trajectory, Domingo starts to understand the Moon as an immense planet, and the Earth as a Moon that reflects light and shows visible spots. The description is deeply kinetic, as it progressively takes attributes from one and applies them to the other. Three attributes pass from the Earth to the Moon, or from the Moon to the Earth: the hugeness of our planet becomes an attribute of the Moon, luminosity becomes an attribute of the Earth. The lunar trajectory achieves the visual transformation of Earth into Moon and of Moon into Earth. Above all, the voyage enables it to be established that the Earth revolves:

But whereas the forme of those spots in the Moone continue constantly one and the same; these by little and little did change every hower. The reason thereof I conceive to be this, that whereas the Earth according to her naturall motion, (for that such a motion she hath, I am now constrained to joyne in opinion with *Copernicus*.) turneth round upon her owne Axe every 24. howers from the *West* unto the *East*.<sup>7</sup>

Observation comes first; the theories available to explain the visual stimuli are then discussed. The narrator exemplifies the ideal reader who becomes gradually convinced by the narration. If he hesitates between two possible interpretations, he formulates *in fine* the evidence for the Copernican interpretation: "for that such a motion she hath I am now constrained to joyne in opinion with *Copernicus*." Theoretical explanations and justifications will follow, promises the narrator,<sup>8</sup> but they are usually postponed, such that storytelling takes the place of demonstration: the peregrinations of Domingo and the chronological progression of the narration mimic the theological peregrination of the reader, who becomes gradually convinced. Thus, the theoretical discourse is clearly subordinate to the logic of the story. Describing the extraordinary fauna and flora that he discovers, the narrator declares, "but of these novelties, more hereafter in their due place." Arriving on the Moon, the narrator proposes a whole program of observations and commentary that he does not deliver, constantly postponing the theoretical developments to a hypothetical "Second Book" that will never come:

The statelinese of the building whereof I wil leave unto the second part of this worke, as also many other particulars, which will minister more pleasure to the reader, then yet I may afford him, being desirous in this first part to set down no more then what the processe of my story concerning my Journey doth necessarily draw from me.<sup>10</sup>

Reserving the theoretical developments for a future second part, Godwin gives his text a theoretical *tone*, while skipping over the lines of argument themselves. As in Kepler's text, it is direct "experience" of the lunar journey that enables the assertion of the magnetic properties of both Earth and Moon:

I found then by this Experience that which no Philosopher ever dreamed of, to wit, that those things which wee call heavie, do not sinke towards the Center of the Earth, as their naturall place, but as drawn by a secret property of the Globe of the Earth, or rather some thing within the same, in like sort as the Loadstone draweth Iron, being within the compasse of the beames attractive.<sup>11</sup>

This passage contrasts two statements about how bodies fall and thereby two theoretical frameworks for physics, first that of Aristotle, for whom each element has a proper site toward which it tends and then the new physics of *De Magnete* by Gilbert, for whom the fall of bodies is explained instead by the magnetism of each planet. If there is really an optical thought-experiment using the fiction of the lunar journey as Kepler does, the implementation of this experiment is quite different.

### Knowledge in Fiction

The first address to the reader sets up the double mode, fictional and theoretical, of the text: "Thou hast here an essay of *Fancy*, where *Invention* is shewed with *Judgment*."<sup>12</sup> If the text presents itself as fiction, it becomes clearer and clearer that this particular lunar fiction is the vehicle for a new kind of knowledge. But we have to distinguish carefully three types of knowledge: the knowledge acquired by the narrator in the course of the "experiment" of the journey, on the one hand, and the kinds of knowledge available from books, on the other, which in turn can be divided into two categories: that of the Scholastics, which will be mocked, and that of modern philosophers. Godwin uses the latter, all the while asserting the preeminence of knowledge acquired by experience. It is the interaction of these three types of knowl-

edge that interests us here (experience against old knowledge, old knowledge against new astronomy, knowledge of experience against knowledge of the new astronomy).

The first confrontation is very clear: the knowledge of the experience of lunar flight makes it possible to refute Scholastic knowledge. Against the old astronomical knowledge of the “Scholastic Philosophers,” Godwin does not arm himself with another kind of book learning, but rather, as with the travelers of the Renaissance, the evidence of the senses:

Who is there that hath not hitherto beleevd the uppermost Region of the Ayre to be extreame hot, as being next forsooth unto the naturall place of the Element of Fire. O Vanities, fansies, Dreames! After the time I was once quite free from the attractive Beames of that tyrannous Loadstone the Earth, I found the Ayre of one and the self same temper, without Winds, without Raine, without Mists, without Clouds, neither hot not cold, but continually after one and the same tenor, most pleasant, milde, and comfortable, till my arrivall in that New World of the Moone. As for that Region of Fire our *Philosophers* talke of, I heard no newes of it; mine eyes have sufficiently informed me there can be no such thing.<sup>13</sup>

Here crossing sublunary space makes possible the definitive refutation of Aristotle’s physical model that postulated a “region of fire” near the Moon, fire being the lightest of the elements, hence the most distant from Earth and the last element before the superlunary world. When Gonsales achieves his ascension from Earth to Moon he also discovers how wrong the philosophers were about the question of the Earth’s movement:

*Philosophers* and *Mathematicians* I should now confesse the wilfulnesse of their owne blindness. They have made the world beleevd hitherto, that the Earth hath no motion. And to make that good they are fain to attribute unto all and every of the celestial bodies, two motions quite contrary each to other; whereof one is from the *East* to the *West*, to be performed in 24 howers; (that they imagine to be forced, *per raptum primi Mobilis*) the other from the *West* to the *East* in severall proportions.<sup>14</sup>

But this “experiential knowledge,” in this case coming from lunar voyage, is itself the result of the condensation of available knowledge into a story. Witness the description of the Earth seen from heaven, already concerned with place, which merely rehearses images already available in maps and globes:

Againe, the Earth (which ever I held in mine eye) did as it were mask it selfe with a kind of brightnesse like another Moone; . . . The reason thereof I conceive to be this, that whereas the Earth according to her naturall motion, (for that such a motion she hath, I am now constrained to joyne in opinion with *Copernicus*;) turneth round upon her owne Axe every 24. howers from the *West* unto the *East*: I should at the first see in the middle of the body of this new starre a spot like unto a Peare that had a morsell bitten out upon the one side of him. . . . After that succeeded a spot almost of an Ovall form, even just such as we see *America* to have in our Mapps. Then another vast cleernesse representing the *West Ocean*; and lastly a medly of spots, like the Countries of the *East Indies*. So that it seemed unto me no other then a huge Mathematicall Globe, leasurely turned before me, wherein successively, all the Countries of our earthly world within the compasse of 24. howers were represented to my sight.<sup>15</sup>

This use of the terrestrial means of visualization inscribed in maps and globes shows that this experiential knowledge is constructed and borrowed. Thus, Godwin actually contrasts the knowledge of experience with book knowledge less than he contrasts the new and the old astronomy, but he hides the second contrast under the first. This skillful narratorial strategy is applied in two ways.

First, when knowledge of the new (Copernican) astronomy is mentioned explicitly, it is still presented as less convincing than the experience of the senses. The elements of astronomical knowledge are never substituted for experimental demonstration:

O incredible thing, that those same huge bodies of the fixed stars in the highest orbe, whereof divers are by themselves confessed to be more then one hundreth times as bigge as the whole Earth, should as so many nayles in a Cart Wheele, be whirled about in that short space, whereas it is many thousands of Yeares (no lesse, I trowe, they say, then 30 thousand) before that orbe do finish his Course from *West* to *East*, which they call the naturall motion. Now whereas to every of these they yeeld their naturall course from *West* to *East*; therein they doe well. The *Moone* performeth it in 27 daies; the *Sunne*, *Venus*, and *Mercury* in a Yeare or thereabouts, *Mars* in three Yeare, *Jupiter* in twelve Yeares, and *Saturne* in 30. But to attribute unto these celestially bodies contrary motions at once, was a very absurd conceit, and much more, to imagine that same Orbe, wherein the fixed stars are, (whose naturall course taketh so many thousand of yeares) should every 24. howers be turned about.<sup>16</sup>

Taking a position on the debate over the Earth's movement, the narrator denounces the illogicality of attributing two contrary movements to the stars. We recognize here one of the principal arguments in favor of the Earth's diurnal rotation. In fact, the questions that are tackled clearly situate our text in the context of the astronomical and cosmological discussions of the years 1600–1620 and attest to Godwin's familiarity with these debates.<sup>17</sup> But like the travel stories that inspired him, Godwin gives only a secondary place to this borrowed astronomical knowledge. What really convinces the reader is the evidence of sensory experience, as shown by the insistently repeated use of vocabulary relating to sight.<sup>18</sup> Hence the possibility of accepting only a part of Copernicanism:

I will not go so farre as *Copernicus*, that maketh the Sunne the Center of the Earth, and unmoveable, neither will I define any thing one way or other. Only this I say, allow the Earth his motion (which these eyes of mine can testifie to be his due) and these absurdities are quite taken away, every one having his single and proper Motion onely.<sup>19</sup>

Here it is the experience of the senses that makes it possible to refute the new astronomy. Thus, while he defends the movement of diurnal rotation and contests space's partition into sublunary and superlunary, and while Gon-sales' traversal of heaven shows there are no solid orbs, Godwin does not embrace the other implications of Copernicanism, heliocentrism and the annual rotation of the Earth. As William Poole makes clear, Godwin is one of a number of thinkers in this period who accepted diurnal movement but objected to or ignored the other kinds of movement implied by the Copernican system.<sup>20</sup> But this cautious attitude towards Copernicanism is also the sign of the preeminence of visual proof over textual proof, in other words, of the privileging of the "tale of the voyage" over the discourse of knowledge; one asserts only what one "sees." But from the Moon, one does not see the Earth turn around the Sun (Kepler had indeed explained that due to the Moon's movement, the Earth appears fixed in the sky), but only that it turns itself.

The second strategy is to separate off astronomical discussions with markers that signal the return to the "tale of the voyage" itself—for example, this vocal intervention by the narrator: "But where am I? At first I promised an History, and I fall into disputes before I am aware."<sup>21</sup> The question "Where am I?" from a narrator who at this moment of the tale is between the Earth and the Moon makes us smile. The double meaning, spatial and logical, underscores the inappropriate nature of the scholarly discourse within a story

that ought to ignore Scholastic “disputes,” and the astronomical discourse clearly appears as a digression from the tale of the voyage. We remember, thanks to his notes, that for Kepler, by contrast, the astronomical discourse was the permanent bedrock of the fictional discourse. While both Godwin and Kepler use markers for the passage from scholarly to fictional discourse, their functions are quite different. For Kepler, the successive introductions of new passages allow us to situate the fiction, and at the same time, to guarantee the integrity of the scholarly discourse by keeping it separate. For Godwin, the markers of the start and the end of a scholarly digression serve rather to preserve the autonomy of the tale of the voyage. Following the strategy of Renaissance travelers, the narrator dismisses the available knowledge in order to advance the demonstrative evidence of his experience. But what is the effect or indeed the effectiveness of such a strategy in the case of the tale of a lunar journey?

#### Authority and Modes of Expression

Placed within a fiction that presents itself as such (“It was not the *Authors* intention (I presume) to discourse thee into a beleife of each particular circumstance”),<sup>22</sup> various strategies of authority that are mentioned are irremediably cast into doubt. Several elements contribute to this undermining of the reliability of the narrative voice. First, there is the game with the status of the text; appearing anonymously and presenting itself as the translation of an account in Spanish (“the faithfull relation of the little eye-witnesse”), it throws some doubt on the identity of the author and the reliability of the narrative voice, playing with the conventions of the genre of the travel tale.<sup>23</sup> Of course, the pretense is barely kept up for long at all. With the *Address to the reader*, any ambiguity about the fictional status of the text is dispelled in the first sentence, already quoted: “Thou hast here an essay of *Fancy*, where *Invention* is shewed with *Judgment*.”<sup>24</sup> This *Address to the reader* stresses another ambivalence, not between the tale of a real journey and tale of an imaginary voyage, but between fiction and learned discourse, “Judgment.” The tension between the denial of any claim to authority (this is a fiction) and the presence of learned discourse is not resolved.

But there is something more serious: the narrative voice itself scarcely seems credible. After all, it is the word of a Spaniard, that is to say an enemy of England in the historical period in which the action takes place (1559–1601). By placing an unreliable narrator at the heart of his claims for the status of his text, Godwin throws into question the reliability both of the tale and of the

knowledge enclosed within it: who and what should be believed? To which voice should learned discourse belong?

We remember the sophisticated arrangement by which Kepler ensured the formulation of a knowledge that was literally unheard of. The body projected into sublunary space was the basis of a thought-experiment described in the overarching narrative of the Daemon of Levania. For Godwin (and for Cyrano, as we shall see), the narrative voice belongs to the traveler himself, thereby borrowing the mode of expression of the picaresque novel. Here there is no more separation between the experience of flight and the commentary on that experience, no more dispersion of claims to authority such as produced by the complex framing arrangement and notes of the *Dream*, but instead we see a tale in a picaresque tone with a linear structure, linking the episodes in a paratactical fashion, and placing the three sites in question—Europe, the Moon, and China—on the same plane so that the demonstration relates only to the testimony and voice of the person who, having traveled and seen, now recounts. Thus it is an unreliable and moving voice, following as it does the main character's sinuous tour to credible and incredible places. No particular marker signals the lunar episode, and the corresponding astronomical discourse, as different; it is neither more false nor more true than the tale of the journey through Europe and remains in that narrative framework of a reality both possible yet incredible that seems to characterize the whole text.

#### A Chiasmus: The Incredible yet Possible and the Credible yet Impossible

For the writing of fictions, Aristotle recommended that “credible impossibilities are to be preferred to credible possibilities.” The possible and impossible here do not have a logical meaning, but refer to the likelihood of a given object or an action, which can then be interpreted as credible or incredible (according to common opinion). It indeed seems that with Godwin the lunar fable involves these categories: the voyage is made possible through the technology of the flying machine but remains incredible, that is to say, opposed to what common opinion is prepared to accept as true. But this is precisely how *To the Reader* presents the new astronomy:

That there should be *Antipodes* was once thought as great a *Paradox* as now that the *Moon* should be habitable. But the knowledge of this may seem more properly reserv'd for this our discovering age: In which our *Galileusses*,

can by advantage of their spectacles gaze the Sunne into spots, & descry mountaines in the *Moon*.<sup>25</sup>

This preliminary reference to Galileo stresses the paradoxical nature of knowledge of the new astronomy—paradoxical because true but, like the myth of the Antipodes, opposed by common opinion. Therefore, what better means than a paradoxical fiction to formulate this paradoxical discourse of the new astronomy? The intervention of new knowledge reactivates the old problem of fiction: the play with Aristotelian categories of the possible and the impossible, the credible and the incredible. Godwin, it seems, plays with two particular combinations of these notions: the possible yet incredible and the impossible yet credible.

By borrowing the strategies from the genre of travelers' accounts, Godwin modifies the traditional partition between "real" and imaginary voyages. If it is understood that the text is indeed about an imaginary voyage (it is clear that the voyage did not take place), the text still plays with its sources to construct a borrowed credibility. We see how the two sources reinforce each other: the formerly incredible travels across the seas that have become commonplace since voyages to the New World now serve to lend authority to the incredible, but now theoretically possible, interplanetary voyages.

Playing on this confusion of the true value that it contains, Godwin's fable transforms the incredible lunar flight into a possibility, thereby passing from a poetics of wonder to a poetics of the possible. This shift is particularly visible during an intervention by the narrator announcing spectacularly the flights of "gansas" (wild geese) to the Moon:

But what then, O Reader? *Arrige aures*, prepare thy selfe unto the hearing of the strangest Chance that ever happened to any mortall man, and that I know thou wilt not have the Grace to beleewe, till thou seest it seconded with Iteration of Experiments in the like, as many a one, I trust, thou mayest in short time.<sup>26</sup>

Acts of emphasis such as this are traditionally used to introduce the wondrous into a story. But here the movement is double: what is at first announced as wondrous is going to be simultaneously recharacterized as possible, therefore credible. The incredible flight to the Moon is merely an "ordinary voyage"—the migration of wild geese:

It was now the season that these Birds were wont to take their flight away, as our Cuckoes and swallowes doe in *Spaine*, towards the Autumne. They (as after I perceived) mindfull of their usuall voyage, even as I began to settle

my selfe for the taking of them in, as it were with one consent, rose up, and having no other place higher to make toward, to my unspeakable feare and amazement strooke bolt upright, and never did linne towring upward, and still upward, for the space, as I might guesse, of one whole hower; toward the end of which time, mee thought I might perceive them to labour lesse and lesse; till at length, O incredible thing, they forbare moving any thing at all! and yet remained unmoveable, as stedfastly, as if they had beene upon so many perches, the Lines slacked; neither I, nor the Engine moved at all, but abode still as having no manner of weight.<sup>27</sup>

The immobility of the machine and the “gansas” is explained in the following paragraph by the absence of terrestrial attraction beyond a certain distance (Gilbert’s magnetic theory). The text simultaneously presents the spectacular episode of the flight of the birds beyond the Earth’s atmosphere and its theoretical justification. The “possible” is not given from the start, but is gradually constructed by the fiction itself and by the scientific knowledge that it presents over as it progresses. If Gonsales’s journey does appear as an imaginary voyage, it does not spring from the wondrous nature of the old lunar fables either; it is not, unlike Lucian’s voyage, a purely fictional pretext for a satiric decentering, but rather a possibility that the fiction explores in a playful fashion.

Here, it is indeed the encounter between narrative elements marked as impossible (lunar flight) and credible hypotheses, and inversely, between narrative elements marked as possible (the travel tale) and an astronomical knowledge that is incredible because paradoxical, that comprises the originality of Godwin’s text. The paradoxical discourse of the new astronomy finds itself given authority by the “experience” of the voyage, and reciprocally, the impossible lunar flight is given authority by the presence of this new knowledge. We see that the demonstration rests on circular logic, or more precisely, on a chiasmus between the possible yet incredible and the impossible yet credible. The insertion of astronomical knowledge introduces here a disturbance in the traditional categories. It disturbs the traditional relation of fiction to the true, organized according to a clear boundary between the possible and the impossible.

We recall that with Kepler such an encounter was avoided by the successive shiftings between the discourse of knowledge and the discourse of fiction, keeping each hermetically sealed off from the other. *The Man in the Moone* clearly operates along different lines. In Godwin’s text no fixed point occurs to guarantee the epistemic stability of learned discourse, no semiotic

construction occurs to differentiate between fiction and knowledge and to protect specificity of each discourse by assigning them precise places; because fictional discourse and knowledge discourse are united in a single narrative strand, the latter is carried off by the traveler and taken to an undiscovered country.

#### A WORLD IN THE MOON

John Wilkins was one of the first readers of Godwin to emphasize the double truth claim of the text as both fictional but possible. In the third edition (1640) of his *Discourse* he mentions Godwin for the first time in a new section devoted to lunar journeys: "I chanced upon a late fancy to this purpose under the fained name of *Domingo Gonsales*, written by a late reverend and learned Bishop."<sup>28</sup> Although he recognizes the fictional nature of Godwin's text, "a pleasant and well-contrived fancy,"<sup>29</sup> Wilkins takes the idea of going to the Moon by means of a chariot of flying swans seriously, as the chapter title indicates: "That 'tis possible for some of our posterity, to find out a conveyance to this other world; and if there be inhabitants there, to have commerce with them."<sup>30</sup> In other words, he tries to render probable the possible flight of Godwin's fiction:

It is easily conceivable, how once a year a man might finish such a voyage; going along with these birds at the beginning of winter, and again returning with them at the spring.<sup>31</sup>

#### Wilkins' Argument for Probability

Of course, to make the possible and the probable coincide means to remove the fictional status of the text presupposed by the chiasmus in the nature of expression described above. We find in Wilkins the principal motifs of lunar fiction formulated in the probable mode: the voyage to the Moon enabled by the absence of earthly gravity beyond its sphere of attraction; the speed of the flight; the lack of need for food and sleep due to the absence of attraction. Does this mean that the learned discourse can simply take up and integrate the discourse of fiction? It is not so simple. What authorizes the incorporation of elements of lunar fiction is both the demonstration of their credibility and the particular mode of discourse adopted here: probabilism.

It is useful at this stage to recall briefly the importance of the notion of the probable in the seventeenth century, developed around Gassendi in

France and the Royal Society in England. The seventeenth century witnessed a modification of an ancient tradition that distinguished between (on the one side) science, certitude, philosophy, and logic; and (on the other side) opinion, the probable, appearance, and rhetoric.<sup>32</sup> The erosion of this essentially binary schema (even if it was called *gradus certitudinis*) inherited from the Greeks and revived by the Scholastic tradition had gradually altered the way in which knowledge was understood and constituted. Barbara Shapiro explains how the nondemonstrable character of a large part of scientific practice in the seventeenth century sparked a new interest in the probable.<sup>33</sup> The English *virtuosi*, notably those involved in the Royal Society, of which Wilkins was one of the founders, agreed that the natural and moral sciences were incapable of a priori demonstrations and that proofs in these domains were of another nature. This realization led them to define and divide kinds of science and knowledge according to a scale of degrees of probability, in a continuum going from the lowest degrees (fiction at the bottom, then simple opinion, then conjecture) to the highest degree of “moral certitude” via the intermediary degree of the “probable.”

In fact, the argument of the *Discourse* is not apodictic but probable. *To the Reader* alerts us right away: “Thou shouldst not here looke to find any exact, accurate Treatise, since this discourse was but the fruit of some lighter studies—and to remember that I promise onely probable arguments for the proove of this opinion.”<sup>34</sup> The complete title of the first edition also increases the terms of uncertainty and the modulations: *A discovery of a new world, or a discourse tending to prove that 'tis probable there may be another habitable world in the moon*. But these many markers of uncertainty are less an accumulation of prudent modulations than the text’s way of situating itself at the level of the probable: “Either you will agree with me on this assertion, or at least not think it to be as far from truth, as it is from common opinion.”<sup>35</sup> We encounter again the idea found in Godwin that the discourse of the new astronomy is a paradoxical discourse, removed from common opinion, certainly, but not from truth. The probable discourse is not judged to be definitively either true or false, but rather according to the degrees on the scale of probability. In these circumstances, Wilkins’ ambition can be understood as an effort to shift Copernican theory from the weakest degree of certitude (Godwin’s possible fiction) to a higher degree, the probable.

The redefinition of the lunar fable as a probable discourse takes place first through the changing of the importance of its different elements. It is especially the telescope that enables a move from the imaginary fable to what

might be real, for it makes it possible for considerations that were formerly fictional to enter the domain of the possible:

'Tis related by Eudoxus, that he wished himself burnt with Phaeton, so he might stand over the Sun to contemplate its nature; had he lived in these days, he might have enjoyed his wish at an easy rate, and scaling the heavens by this glass, might plainly have discerned what he so much desired.<sup>36</sup>

This is quite clear in the identification of the nature of the Moon. In chapters 4 and 5 of the *Discourse*, we find an inventory of all the known theories: is the Moon the “Mirror of Pythagoras”? Is it “transparent or diaphanous, like Crystall or glasse, as Empodocles thought, who held the Moon to be a globe of pure congealed ayre”?<sup>37</sup> Or else is it a “spongie and porous substance” or “of the same kind of nature as a Pumice stone,” as Diogenes affirmed?<sup>38</sup> The list ends with the assertion that the Moon is a planet, that is to say, a solid body like the Earth. The method followed for the description of the Moon, announces Wilkins, will be taken from *De Mundo*, falsely attributed to Aristotle. The skillful technique borrows from pseudo-Aristotle the organization of his treatise on the geography of the Earth (the lands, seas, seasons, atmospheric phenomena, plants, animals, inhabitants) but applies it to the Moon, proving in advance that which will be demonstrated, that the Moon is a world like the Earth.

The frontispiece of the 1640 edition gathers the principal arguments of redefinition of sublunary space as a geographical space to cross. By the juxtaposition of a geographical map and a heavenly map, the engraving embraces geography and cosmology and aims to superimpose, in the reader's imagination, two iconographies that are traditionally distinct. The novelty lies in bringing together two traditions: the detailed and chorographic representation of terrestrial space on the one hand, and the representation of heavenly space by means of diagrams and astronomical models on the other.<sup>39</sup> By superimposing them, the frontispiece implies that there is no difference of nature between them but a simple difference of scale. The simultaneous presence of two scales in the same drawing is thus a visual representation of Wilkins' argument: the Moon is another Earth.

The other elements of the engraving illustrate Copernican theory. At the center, the Sun proclaims that it is the sole source of light, heat, and the movement of the planets (“*omnibus do lucem, calorem, motum*”). The angles of the rays of light between Sun, Earth, and Moon show that the Earth and the Moon are similar bodies reflecting the Sun's light. “*Mutuo se illuminant*”: they illuminate each other. The representation of an infinite universe is given

by the stars, extending beyond the last sphere right out to the engraving's frame. The tutelary figures of the new astronomy are represented: Copernicus, Galileo, and Kepler. Copernicus holds a model of his heliocentric conception of the universe, Galileo is equipped with his telescope, and Kepler leans on the shoulders of Galileo. Kepler's words already allude to a possible lunar voyage: "*Sic itur ad astra*": thus we reach the stars. But by putting Virgil's famous verse<sup>40</sup> metaphorically evoking the glorious apotheosis of Caesar or Augustus into Kepler's mouth, Wilkins brings out its literal meaning. Through this superimposition of references, the frontispiece combines the intellectual blessing of the great astronomer and the daring hypothesis of the lunar voyage. A final element tries to make a trip to the Moon even more conceivable: the horizontal lines represent (according to the conventions of the period) the sea, evoking a possible voyage of discovery. Such a pictorial element (absent from the frontispiece of the first edition, in which the hypotheses of the voyage to the Moon is not developed) evokes the frontispiece of Bacon's *New Atlantis* and the idea of a voyage beyond the boundaries of the known universe.

By redefining the lunar landscape as a geographical rather than a fabulous landscape, the initial setting aside of old beliefs opens up a space for the possibility of the lunar journey: "I do seriously, and upon good grounds affirm it possible," concludes Wilkins at the end of book 1, "to make a flying-chariot; in which a man may sit, and give such a motion to it, as shall convey him through the air."<sup>41</sup>

### The Means of Flight: John Wilkins' Possible Machines

It should be noted that not all of the text's assertions can receive, *in fine*, the same degree of certitude, but are spread out along the scale of probability described above, in such a way that there is no longer an opposition between fiction and knowledge, but a continuum going from one to another, passing through various degrees, the possible being a degree inferior to the probable. Thus the most adventurous conjectures of proposition 14, those concerning the trip to the Moon, belong to the domain of the possible and not the probable. In this context we may perceive the reading Wilkins offers of two previous accounts of the voyage, the *Dream* and *The Man in the Moone*.

Without being in any way tricked by how Godwin's "very pleasant and well contrived" essay functions, Wilkins accepts a priori the most fictional element: the flying machine. It is the clearest example of what is the possible yet incredible in *The Man in the Moone*: it combines the incredibility of the

flight and the technical description that makes this flight possible. It is therefore both a marker of fiction and the sign of the ambivalent status of this fiction. But this machine is one of the four means of going to the Moon, according to Wilkins: (1) “by the strength of spirits or angels,” (2) “by the help of fowls,” (3) “by wings fastened immediately to the body,” and (4) “by a flying chariot.” That this list corresponds precisely to the chronological appearance of flying machines<sup>42</sup> in lunar fictions of the century seems to be more than a coincidence: from Kepler’s demon to the chariot that Cyrano will imagine, passing via the geese or “gansas” of Godwin,<sup>43</sup> Wilkins transforms the machines of lunar fictions into possible machines. Now mechanized, the lunar fable can be integrated into the probable discourse of natural philosophy, as demonstrated by its reappearance in the treatise published in 1648, *Mathematical Magick; or the Wonder That May Be Performed by Mechanical Geometry*. The treatise contains a chapter “Concerning the Art of Flying. The several ways whereby this hath been or may be attempted,”<sup>44</sup> which proposes a probabilist interpretation of Godwin’s fiction:

2. There are others who have conjectured a possibility of being conveyed through the air by the help of fowls; to which purpose that fiction of the *Ganza’s*, is the most pleasant and probable. They are supposed to be great fowl of a strong lasting flight, and easily tamable. Divers of which may be so brought up as to joyn together in carrying the weight of a man, so as each of them shall partake his proportionable share of the burden; and the person that is carried may by certain reins direct and steer them in their courses. However this may seem a strange proposall, yet it is not certainly more improbable, then many other arts, wherein the industry of ingenious men hath instructed these brute creatures. And I am very confident, that one whose genius doth enable him for such kind of experiments upon leisure, and the advantage of such helps as are requisite for various and frequent trials, might effect some strange thing by this kind of enquiry.<sup>45</sup>

The technical explication of flight empties the tale of any aspect of inexplicability and transforms the fictional into the possible, with the further result that the status of fiction is changed. We can see move from the old definition of fiction as falsehood to a more nuanced conception in which the fiction tells us something about the world. Wilkins appropriates from fiction the idea of the physical reality of the journey, while integrating fiction into his framework of what is credible: the demon, the birds, or the machine are no longer markers of the fictional but rather the mechanical means of crossing the tangible space from the Earth to the Moon.

This redefinition of fiction as probable discourse appears still more starkly in the *Discourse's* presentation of Kepler's *Dream*. Wilkins does not mention that it is a fictional account of a journey to the Moon: the title is not cited, nor the fiction of lunar travel. The book is presented as a treatise by a renowned astronomer, and associated with Galileo's *Sidereus Nuncius*, which contains no fictional element whatever. The two texts serve as references in proposition 6, titled, "That there is a world in the Moone, has been the direct opinion of many ancients, with some modern Mathematicians."<sup>46</sup> If the fictional character of the *Dream* is then evoked, it is in the concessional mode, and by the single term "trifle": "'Tis true indeed, in some things they do but trifle, but for the main scope of those discourses, 'tis as manifest they seriously meant it, as any indifferent reader may easily discern."<sup>47</sup> Wilkins' bibliographical note carefully avoids the problem of the conjunction in Kepler's text of learned discourse and the fictional discourse, retaining only the former. Wilkins thereby subtly moves the *possible* discourse of lunar fiction (in Kepler and Godwin) towards being a *probable* discourse, challenging the separation of fiction and knowledge. But there remains one domain where only fiction can venture: the precise description of another world, with its inhabitants and its customs. And it is precisely there that Wilkins' probable discourse stops: "But such imaginations as these, I shall leave to the fancy of the reader."<sup>48</sup>

### The Truth of Fables

In the texts of Godwin and Wilkins, we are witnessing a reevaluation of fiction. In Wilkins' work, the old fictions are revealed as truthful and are verified by the new philosophy. The optical voyage enabled by the telescope, affirms Wilkins, is no mere fable:

So that what the ancient Poets were faine to put in a fable, our more happy age has found out in a truth, and we may discern as far with these eyes which Galileus has bestowed upon us, as Lynceus could with those which the Poets attributed to him.<sup>49</sup>

Wilkins thus sketches a conceptual trajectory going from the incredible to the possible, from the fable to the true, a trajectory that recalls the one described by Sir Walter Raleigh a century earlier with regard to his voyage to Guyana: "Such a nation was written of by Mandevile, whose reports were holden for fables many yeers, and yet since the East Indies were discovered, we find his relations true of such things as heretofore were held incredible."<sup>50</sup>

It is indeed a disjunction between the incredibility of the lunar fable and the truth of the new astronomy that Wilkins' possible flying machines have succeeded in fusing.

With Godwin, the opposite phenomenon takes place: the old theories, judged fallacious, are dismissed as fictions in the sense of falsehoods. We remember that at the moment of reaching the Moon, the space traveler notes the absence of the region of fire foreseen by Aristotle. Aristotelian theory, invalidated by the narrator-witness's experience, is demoted to the domain of fiction and the imagination:

O vanities, fancies, dreams! . . . As for that region of fire our philosophers talk of, I heard no news of it; mine eyes have sufficiently informed me that there can be no such thing.<sup>51</sup>

The old theories appear false, and therefore imaginary (produced by the philosophers' "fancy"); meanwhile, Wilkins redefines the fables of poets and the modern fictions of Godwin and Kepler as probable discourses. We may understand this phenomenon as a chiasmus: the old fables of poets are reread and reinterpreted as valid discourse because they speak a truth recognized by the discourse of new philosophers; the old invalidated theories are gradually pushed back into the domain of fiction understood as error.

It is the very uncertainty of their subject (the lunar voyage) that makes these texts escape their ostensible generic boundaries. Lunar fiction becomes "possible," scientific discourse is inflected toward the "probable," and certain topics toward a simple "possible." With respect to the voyage to the Moon, the fictional and the theoretical mingle within the category of the possible. Reading Wilkins' and Godwin's texts in light of the two categories that they themselves place at the center, the possible and the probable, we see that the line of demarcation dissolves between learned discourse and the discourse of fiction. Basically, it is the very dichotomy between fictional discourse and scientific discourse that these texts categorically explode.

The probable is now part of science, which makes it possible to tackle scientifically areas of study that are nondemonstrable mathematically and also beyond the scope of experimentation. Fiction finds itself recharacterized as probable, thanks to its heuristic virtues. The philosophical and literary field itself becomes transformed. Scientific discourse comes gradually to include fiction in the form of hypothesis, and fiction integrates theoretical elements, to the point of proposing a way of understanding the world. In this way, our two texts occupy textual spaces that are not opposite but proximate on the scale of probability: the possible and the probable. In addition, they seem to

be legitimizing each other. Wilkins finds in Godwin a precedent, not very serious of course, but one that offers a first formulation of certain theses that he is defending. And Godwin's text finds itself retrospectively legitimized by the probabilist argument of the *Discourse*. It is clear why intertextuality is so present in the corpus of voyages to the Moon: Kepler cites Plutarch, Godwin cites Galileo, Wilkins cites everybody and will himself be taken up by Cyrano. These constant echoes from one text to another carry by repetition an effect of intertextual stratification that ends up bearing fruit: the multiplication of textual interventions substitutes for the testimony of improbable voyagers.

FROM HEAVENS TO THE SKY:  
CYRANO'S OTHER WORLD

In *L'Autre Monde ou Les Etats et Empires de la Lune et du Soleil*, Cyrano pays homage to his two predecessors. Kepler is cited at the start among the astronomers who have asserted the similarity of the Earth and Moon. Godwin is mentioned via the character of Gonsales, whom the narrator meets on the Moon:

The little man told me he was European, a native of Old Castile. He had found a way to have birds carry him to the Moon, where he fell into the hands of the Queen. She took him for a monkey, because in that country they happen to dress monkeys in Spanish-style clothing. . . . He then beseeched me to tell him how I had dared to venture to the Moon in my machine, which I had mentioned to him. I said because he had already taken the birds I had been planning to use. He smiled at the joke. About a quarter of an hour later, the King ordered the monkey's keepers to take us away, and he gave the express order that the Spaniard and I be made to sleep together in order to multiply our numbers in the kingdom.<sup>52</sup>

Cyrano's fable has often been interpreted as a prudent dissimulation of cosmological opinions that were still considered heterodox after Galileo's trial in 1633, or as fictional experimentation with the Copernican hypothesis. Does this mean that Cyrano reiterates Kepler's thought-experiment, or does it mean that he is writing a lunar fiction after Godwin to conceal what his model had exhibited by the same means? Placing Cyrano in the context of the two lunar voyages that inspired him ought to enable us to nuance these interpretations. Without claiming to synthesize the immense critical literature devoted to *L'Autre Monde*,<sup>53</sup> I would like to situate the text in the con-

text of the other Moon travel-narratives of the time. If Cyrano draws the major part of his astronomical information from ancient and modern philosophers, notably Gassendi and Descartes, whom he read directly,<sup>54</sup> he borrows from the lunar fictions of Kepler and Godwin a number of strategies to defend the Copernican hypotheses by means of the fiction of lunar flight.<sup>55</sup> It would be excessive to list every single one of these borrowings, and I would here prefer to focus on the translocations that Cyrano performs in order to verify a hypothesis: Cyrano is interested in cosmological discourse only to the extent that it serves his free-thinking agenda.

### Possible and Credible

Making the fable of the lunar voyage possible seems to be the common aim of texts that use lunar fiction as a defense of Copernicanism (the *Dream's* thought-experiment), which mechanizes flight through the invention of machines in fiction (the category of the possible-incredible in Godwin's lunar fiction) or by demonstration (the category of the probable in Wilkins' *Discourse*). By exploiting this triple heritage, as we shall see, Cyrano's novels exploit the tension provoked by the juxtaposition of fiction and knowledge. In *Les Etats et Empires de la Lune et du Soleil*, the narrative mode and the conceptual/theoretical mode alternate—and often contradict each other. Thus the place of fiction and its relationship with epistemic modes of expression are again subjected to examination.

We start with the same realization found in Godwin: for whoever remains prisoner of his senses, the new astronomy appears as a “paradox.” It seems at first sight that the first flight takes up Godwin's strategies: it is flight that enables the Earth's movement to be established. But Cyrano divides both the subject and the modes of discourse differently. In *To the Reader* Godwin, we remember, had signaled the “paradox” of an inhabited Moon. Cyrano reformulates this paradox in a phrase that mimics the overthrow of common opinion: “the Moon is a world like this one, and our world is its moon.”<sup>56</sup> Following this, the term itself is the catalyst for the discussion with Montmagny: “isn't the motion you attribute to the Earth a fine paradox?”<sup>57</sup> But whereas Godwin defended this paradox by using the visual experience of the Earth in rotation during his flight to the Moon, integrating the elements of recent astronomical knowledge along the way, Cyrano separates them. The first flight implies that the Earth turns, but it is the discussion with Montmagny that tries to establish the “*vraisemblance*” (credibility) of the Copernican hypothesis. It should be stressed that the flight does not make the Earth's

movement any more credible either in *Cyrano* or *Godwin*. With *Cyrano*, it is the discussion with Montmagny that takes this role, adducing logical argumentation to the evidence of the senses: “what evidence do you have to think that the Sun does not move when we see that it does? Or that the Earth whirls around it so fast when we feel the ground motionless beneath our feet?”<sup>58</sup> The aim of this argumentative strategy is to move Copernicus’ hypothesis from the status of being a paradox (the Earth’s movement is opposed to common opinion because it is opposed to sense-experience) to the status of “common sense”: evidence for the centrality of the Sun, the Earth’s ability to “spin” due to its form.

The second movement, that of the Earth around the Sun (denied by *Godwin*), will be demonstrated only in the second book, during the flight to the Sun. It seems that *Cyrano* has remembered *Godwin*’s lesson; from the Moon, one can “see” only the Earth’s diurnal rotation. It is only by going beyond the framework of the lunar voyage that *Cyrano* will be able to produce a “visual” demonstration of the second movement.

### Dreams of Flight

But this credible illustration of the Copernican hypothesis and this representation of the possibility of flight are undermined by the motif of the dream, constantly associated with that of the flight, which complicates the articulation of fiction and knowledge, of “the possible” and “the real.”

The two first flights are thus placed after a daydream that is clear evidence of an interaction with the text of Kepler’s *Dream*. *Cyrano* keeps some elements from the earlier work’s framing arrangement, redistributed playfully in the foreword to the first novel:<sup>59</sup> the book, the falling asleep, the appearance of the demon—the distinct narrative levels by which Kepler, as we saw, protected the central discourse spoken by the demon, here appear out of order. The foreword opens with “barbed” jokes on the subject of the nature of the Moon and on the paradox of the Moon as Earth, with the apparent support of a list of astronomers including Kepler: “I told them that Pythagoras, Epicurus, Democritus and, in our time, Copernicus and Kepler had been of the same opinion, but it was no use.”<sup>60</sup> The story continues with the “miraculous” appearance of Cardan’s book, the eruption of two “old men” sent from the Moon (whose passage through the doors of the room and sudden disappearance seems to indicate their demonic nature), after which the narrator’s “daydreams” lead to the launch of his flight. Thus there is a rearrangement of the motifs of the *Dream* leading to their attendant transformation into bur-

lesque, but the setup here is quite different. There is no point of rupture in the mode of expression in *Cyrano*: the elements are integrated into a “chain linkage” of events that astonishes the narrator and enables him to stay at the same level of narration, which explains why the dream is not a threshold nor a marker of fictionality, but seems to govern the ensemble of motifs in the text linked to flight.

The “experimental” function of Dyrcona’s many flights has often been noticed.<sup>61</sup> But we must not overlook the singularity of an experiment that does not merely reiterate the thought-experiment of the *Dream*, or the flight of the gansas in Godwin. As we saw, in *Cyrano*’s works this “demonstration by fiction” is distributed between the two novels: the *Moon* demonstrates the movement of diurnal rotation of the Earth, and the *Sun* the movement of annual revolution around the Sun. Here we rediscover the motif of shift in vision that enabled Kepler to adopt a second point of view that was essential to his demonstration. But the credibility of the Copernican hypothesis is established in the first novel only as the foundation and the point of departure for more unbridled invention; the lunar voyage opens onto another voyage, and potentially onto an infinity of voyages and journeys and a opens up new realms for what is possible, which *Cyrano* uses to great effect in the second novel. The result of these two successive voyages is thus not only a shift in the viewpoint, but also more widely an investigation into the multiplication of viewpoints. The progression of the two novels and the multiplication of flights of fancy involve a multiplication of centers, a “multipolar world” in Isabelle Moreau’s phrase,<sup>62</sup> rather than the establishment of a new epicenter.

As with Kepler, here we see a thought-experiment taking place. *Cyrano* and Kepler both test a situation that is impossible in relation to the technological possibilities of the day. But while Kepler uses fiction locally and controls it by using the shifting up and down of the narrative framing, fiction is allowed free rein in *Cyrano*. “Where does the function of revelation, of spreading knowledge, stop—and where does the gratuitous play of imagination and chimerical excess begin?”<sup>63</sup> asks Jean-Charles Darmon. In fact, no note indicates how much belief the speaker should invest in the fictional inventions of his narrative. We remember that Kepler’s notes always signaled the alethic positioning of any element of the fiction. Kepler repeatedly signaled: this bit is my proposition, this bit is “credible conjecture,” this bit comes from such and such specific book. In so doing he provided as much evidence of the conceptual framework lying behind the fiction as he had included in the *Astronomia Nova* to outline the construction of his theory down to its smallest points of detail. Whereas Kepler ceaselessly tried to distinguish what related

to philosophical argument and what to allegory, the arrangement in Cyrano's novels makes it impossible to situate fiction and learning in relation to each other. Nor is there, as in Godwin, an integration of the learned discourse into the narrative tissue of the tale. In Cyrano, the various theories are incarnated by the various orators, stopping the reader from situating the learned knowledge in relation to the discourse of the narrator.

Similarly troubling discursive ambiguities are also found around the ir-reality of another essential motif of the flight of fancy: the flying machines,<sup>64</sup> whose invention is most often preceded by a vision or a dream. Elias builds his chariot after the appearance "in a dream" of "the Lord's angel."<sup>65</sup> These dreamed machines are also machines of dreams, first because they issue from the narrator's "daydream" but still more because they appear to be an impossible montage of heterogeneous elements and images.

Let us take the famous example of the *icosahedron*, an astonishing flying machine with which Cyrano undertakes his voyage to the Sun. Bérengère Parmentier has rightly compared the flying *icosahedrons* with the elementary geometric figures that Plato associates in *Timeas* (55d–56d) with each element. In Plato, the cube is the figure of the Earth and the icosahedron, a polyhedron with twenty faces, is the figure of water. "We might say that the machine of the Narrator, who uses the energy of fire and air, is composed of the figure of the Earth surmounted by the figure of water; thus by the mediation of technology, it brings into harmony the fundamental elements of the universe."<sup>66</sup>

However, the *icosahedron* invites and juxtaposes other images. Cyrano mentions Kepler several times and might have been aware of his cosmological interpretation of Platonic solids; in Kepler's *Machina coelestis*, the icosahedron is one of the five regular polyhedrons that explain the structure of the machine of the world.<sup>67</sup> It is tempting to see a play on the cosmological interpretation of the icosahedron as an additional layer of meaning in the physical interpretation of the machine's functioning. Taking the figure situated between Earth and Venus, Cyrano makes it the means of movement in this space. A third interpretation involves optics and can be added to the previous two. This is the one that was generally favored by Cyrano's contemporaries and explains the movement of the machine through the concentration of rays of light on the icosahedron made of crystal. Cyrano's *icosahedron* thus juxtaposes cosmological, physical, geometric, and optical images. A further layer of technical capabilities is added to the machine as it becomes a flying dragon. At first it is a simple "machine" about which we are told nothing; over the course of the narrative, it becomes a machine in which a "spring" is

discovered, to which are added more and more “artifices,” in both senses of the term, until it has been transformed into a flying dragon. Here again the image is gradually *constructed* by an accumulation of technologies over the course of the narrative.<sup>68</sup>

The result of such a juxtaposition is not a “credible machine” in Wilkins’ sense. In fact, Cyrano’s machines remain in the domain of the dream, therefore phantasmagorical rather than technical machines that make flight possible. What should, though, alert us to the peculiar status of these machines is their ineffectiveness: they fail each time, leaving the narrator unaided to play “the role of the bird,”<sup>69</sup> only thanks to the special powers of the marrow with which he was endowed by chance, or else when this new artifice is lacking, by the sole force of his will and his desire: these dreamed machines can easily be replaced by the dynamic force of the dream itself. Cyrano’s text is distinctive in that it juxtaposes the effect of the credible nature of the mechanization of flight and the totally Lucianesque claim of the fictional nature of such a voyage. Lucian crops up here less as an antecedent for the philosophical fable (as used by Kepler) than as the model for a fiction that affirms itself as such.<sup>70</sup>

Once the flying machines are abandoned, the body traveling through space becomes the support for even more cataclysmic images. It shatters the solid orbs of the old astronomy by “piercing”<sup>71</sup> the space between planets, and especially explodes the most pious images of ascension to heaven. For the body in space topples the very possibility of the “miracle” of ascension, the term being ironically used as a counterpoint for the technical descriptions of flights of fancy that have nothing miraculous about them. The irony of the term is patent, for example, when it is used with a negative connotation about Enoch’s flight:

The All-Wise . . . granted Enoch permission to leave the company of mankind, whose innocence had become corrupted. This holy personage considered that no retreat was secure against the ambition of his relatives . . . except that happy land whereof Adam, his grandfather, had formerly talked so much. Yet how was he to get there? Jacob’s Ladder was not yet invented! The grace of the Most High supplied the deficiency by causing Enoch to observe that the fire from Heaven descended upon the sacrifices of the just and of those who were acceptable before the face of the Lord, according to the word of His mouth: ‘The savor of the just man’s sacrifices has reached me.’ One day when this divine flame was fiercely consuming a victim which he offered to the Eternal, he filled two large vessels with the vapor it gave off, sealed them hermetically and attached them under his arm-pits. The smoke immediately had a tendency to rise straight up to God and, not being able

to penetrate the metal save by a miracle, bore the vessels upwards and in the same way carried with them this holy man.<sup>72</sup>

Reworked into a burlesque, the miraculous ascensions reported by the Bible become wholly material ascensions. The episode of a flight enabled by phials of dew has already prepared the reader for the use of such a mechanism. In the case of Enoch, each element of the ingenious invention becomes profoundly impious: from the scarcely respectful evocation of the saint's armpits with their infernal heat as the source of the steam necessary for takeoff, via the holy ascension as "abandoning" the "boring" company of others, to the mention of a "fortunate Earth" (our own)—everything concurs to turn the innocent and ingenious machine mentioned at the start of the novel into one that is dangerous, blasphemous, and iconoclastic.<sup>73</sup> Machines have an effect at another level: they explode pious images through their juxtaposition with physical images that are unmistakably profane.

We see the benefit Cyrano draws from including Christian imagery and the materiality of the body in space,<sup>74</sup> a materiality already present in Kepler and Godwin, but stripped of course of any blasphemous connotation. Here each pious motif becomes physical: "the nearer I came to this flaming world the stronger I felt . . . an unsuspected gladness flowing with my blood took me completely out of myself."<sup>75</sup> The "holy elevation" is related to the moment when Dyrcona approaches the Sun (which is the phallus of the world, as is indicated at the beginning of the discussion with Montmagny in the beginning of the *Moon*), in an "ecstasy" that is quite physical. "Words indeed are too weak to express the happiness with which I trembled when at last I perceived my head crowned with the light of the Heavens."<sup>76</sup> Here we witness a parody of sanctification in heaven.

Freethinking fiction is not a simple dissimulation of astronomical knowledge judged to be heterodox, although in France Copernicanism at the time was still numbered among philosophical positions seen as scandalous.<sup>77</sup> Cyrano's fiction does not disguise a dangerous Copernicanism as much as it merely exploits it as a destabilizing and iconoclastic image, for the disguise actually operates on a second level: one heterodox position actually conceals another one underneath it.

### From Motion to Vertigo

Because it orders the ensemble of motifs linked to aerial flight, the dream remains the principal mode of Cyrano's lunar fiction: Dyrcona, in contrast

to Duracotus, does not wake up during the course of the narrative. In other words, no gear shift takes place that might yoke the fiction to an authoritative learned discourse. This is a total reversal of Kepler's position. Fiction as a philosophical, mechanical, liberating, and iconoclastic dream integrates the learned discourse and uses it as its primary mode of operation. Because it is not situated in a fixed reality, and not even capable of being situated, this kind of fiction makes it impossible to treat the knowledge as fixed and stable. Thanks to the juxtaposition of images and thoughts, any univocal learned discourse is precluded.

The dream is at the same time a mode of learned discourse: the "philosophers who are called Dreamers" encountered by Dyrcona in the Sun are notable in that they propose images rather than arguments:

The greater part of the philosophers do not even speak with the tongue but, when they desire to communicate their thought, they purge themselves by a Sally of their fantasy of a dark vapor under which their conceptions are generally hidden; (. . .) their body becomes diaphanous and there can be perceived through their brain what they remember, what they imagine, what they judge; and in their liver and their heart what they desire and what they resolve.<sup>78</sup>

Jean-Pierre Cavaillé is right to note that in that era the supreme philosophical "dreamer" was Descartes, with whom Cyrano was fascinated, and in the *Sun* it is possible to read an allusion to the Kepler of the *Dream* as capable of prompting the lunar visions studied above. But the philosophy in question is not at all like the didactic discourse of the Daemon of Levania. One of the books offered by Socrates' demon to Dyrcona, a work written by one of the philosophers of the Sun, explains

that all things are true and shows the way to unite physically the truths of each contradiction; for example, that white is black and black is white, that you can be and not be at the same time, that there can be a mountain without a valley, that nothing is something and that all things which exist do not exist. But notice that he proves these unheard-of paradoxes without any sophistry or captious reasoning.<sup>79</sup>

Kepler and Godwin tried to resolve the paradox of the new astronomy; Cyrano proposes a reunion of contradictions. This is a second type of paradox, more radical than the first, which results in logical, mathematical, and physical *insolubilia*.<sup>80</sup> We see that Cyrano's fiction does not attempt to resolve or to soften the "paradox" of the new astronomy; rather, he manipulates and amplifies it in order to allow him greater scope for fictional invention.

Read in the context of other lunar voyages that preceded them and to which they lay claim, the novels of Cyrano appear by contrast rather unconcerned about defending the Copernican system. Or rather, it seems that this defense serves another purpose; the shattering of the Aristotelian solid orbs is simultaneously the liberation of the body and of the mind. While he takes up themes found in Kepler and Godwin (the experimental validation of the Copernican hypothesis and the optical voyage), Cyrano puts them to new uses. He fashions a dynamic and kinetic conception of literary fiction of which the flight of fancy is itself the metaphor. In addition, the combination of images serves as the tool of an iconoclastic arsenal with which to take aim at the imagery of the past, whether Biblical or Ptolemaic cosmology. Cyrano's novels are also constructed on an essential reversal: it is no longer fiction that serves to set the Earth into motion (as with Kepler), but philosophical discourse, and principally cosmological discourse, that becomes a means of creating a new mode of fiction and of thought.

## CONCLUSION: DREAMS AND FICTIONS

### Fiction and Knowledge

We must tell you a tale of the Man in the Moone, which if it seeme ridiculous for the method, or superfluous for the matter, or for the manner incredible, for three faults we can make but one excuse. It is a tale of the Man in the Moone.  
— Lyly, *Endimion: The Man in the Moone*, 20

A ridiculous method, treating an irrelevant subject totally incredibly. To believe John Lyly in *Endimion* (1591), the Man in the Moon is irretrievably tainted by impossibility.<sup>81</sup> In the context of the new astronomy, however, this character, like the lunar voyage, is no longer the hyperbolic marker of the fictional that he had been from Antiquity to the Renaissance. The tale of the trip to the Moon is no longer merely the “caprice” described by Baudoin, translator of Godwin, or by Sorel, a reader of Cyrano, but a possibility. Wilkins aptly says that the optical voyage permitted by the telescope has transformed the most ancient lunar fables into truths, and the flying machines developed in them will soon take us to that place. The effectiveness of these cosmological discourses—fictional, possible, or probable—that make lunar flight their principal theme play precisely on the materiality of the flight of fancy, on accounting for its physical and technical aspects. By shifting the lunar fable from the impossible to the possible, the mechaniza-

tion of the trip to the Moon modifies the very status of the fiction. For in describing such a journey as possible, fiction is entrusted with an ontological and cognitive weight that at the same time transforms the relation between fiction and knowledge.

In the cosmological discourse post-Kepler, the flight motif is based on the bringing together of heterogeneous elements: a classical heritage (philosophical or satiric flight), from Cicero to Lucian; a contemporary technique (the optical voyage enabled by the telescope); and a writing strategy (the fictional construction of a tangible universe in which one can move concretely). The poetics of the lunar voyage, therefore, cannot be reduced to the fictional dramatization of a theory to be defended, still less to a fantastic extrapolation of this theory. Beyond the permanence of certain motifs—flight, the view from the Moon, and machines—what is striking is the plasticity of motifs capable of serving very different literary and philosophical projects, and the variety of the interactions between fiction and knowledge. We can distinguish three principal modes of articulation:

- Kepler sets up an arrangement that ensures that the two discourses are hermetically sealed off from each other: the fiction is clearly localized and controlled by the *Dream*'s thought-experiment. The *Dream* assigns its fiction a precise place and role, for it makes the link between the two types of learned discourse, that of the authorial voice and the selenographic knowledge of astronomy, allegorized in the demon's speech. It is not a matter here of constructing a coherent fictional world, but rather of offering a new astronomy, taking the alternative route of fiction.
- Godwin, by contrast, unites the scholarly discourse and the fictional discourse into a single narrative voice that leads to an intermingling of the two discourses, and a paradoxical discursive mode: the possible yet incredible. Placed within the narrative framework of the picaresque story, the learned discourse is constantly undermined and at the same time given authority in the fiction by flight's status as possible.
- Cyrano's novels seem on the one hand partly to prove the possible status of the Copernican hypothesis with their use of fiction, and on the other to support its credibility by use of the discourse of different characters, but the truth-value inherent in the whole enterprise is significantly weakened by its status as a dream. The relationship of fiction and knowledge is inverted. It is no longer fiction that allows the Earth to move but rather the presence of knowledge within the fiction that entails a new dynamic

in fiction. Defense of the Copernican system is not the goal but rather the means of unleashing the destabilizing movement of freethinking fiction.

### Fiction and Hypothesis

Finally, a paradox must be stressed: in the seventeenth century, cosmological discourse used fiction to establish the truth of the new astronomy. This is the new route of the fable that gives Kepler's meditation on the Moon the physical material that it needed, the traveler's body as support for a physical and optical experiment. Constructing fictional machines for Godwin, and even for Wilkins, allows them to escape "fictions" of geocentrism. In this sense, the optical and mechanical journeys of the seventeenth century are not simple metaphors. From the recent cosmographic model inherited from Kepler they have retained an attention to the body and to the conditions of the voyage that redefines the crossing as a journey through physical rather than mythic space.

What would happen if a human body were sent into space? This is how the question at the origin of the *Dream's* thought-experiment could be formulated. Because it adds to the Copernican hypothesis a *hypotyposis*, because it enables the testing of the physics of bodies outside the Earth's influence, thus proving the hypothetical universality of physical laws, lunar fiction is at the heart of Kepler cosmology. Kepler is the founder because he carries out a radical transformation of the very nature of the lunar fable and inaugurates a reciprocal fiction and hypothesis to enact a mutual granting of authority. By taking inspiration from the philosophical tradition of the *narrationes fabulosae* of the Renaissance and the Platonic tradition, Kepler establishes one of the first thought-experiments; he inaugurates a mode of scientific writing in which fiction plays a role. This mode of writing was developed throughout the century in cosmological hypotheses that employ the register of fiction to varying degrees.

Between the Ramusian ideal of astronomy without hypotheses and the Newtonian ban on hypotheses,<sup>82</sup> the cosmological debate of the seventeenth century seems to have oscillated between fact and fiction, between the necessity to grant authority to cosmological discourse and the impossibility of establishing the truth of the new astronomy other than by fiction. This is why the question of the status and role of fiction is at the center of the Copernican debate. During the period between Copernicus to Newton, the astronomical hypothesis occupies an unstable epistemological place, between

the fictive status that some attribute to it and the “realist” status advocated by Kepler. This debate may be interpreted from the standpoint of astronomical discourse as the effort to distinguish the fictional register of the hypothesis from the fictive register of the falsehood. Two major responses offer solutions to this confusion; one could choose like Kepler to revive the cognitive and epistemic value of fictions, or on the contrary try to keep the domains of science and fiction wholly separate (which, as we shall see, was attempted by Huygens).

A major problem remains, however. Even while fiction was gaining currency as a heuristic and philosophical tool, the term *fiction* continued to be used in its negative sense as untruth and so the cognitive usage of fiction in cosmological discourse remains a risky choice. Each generation discredits the hypotheses of the preceding generation by calling them *fables* or *fictions*, by rendering them wild flights of fancy or fallacious theories. Godwin, author of a lunar fiction following Kepler, denounces the “fictions” of the ancient Aristotelian astronomers; Huygens will reproach Descartes for wanting “*to have his fictions taken for truths*” and denounce Kepler for his incredible inventions. Willingly associated with philosophical and astronomical thinking, fiction becomes at the same time science’s Other, that by which it can define itself through its opposition. But in its heuristic use, fiction remains closely associated with scientific discourse because it is one of the privileged sites for the formulation of hypotheses. Hence the paradox with which we opened this chapter (the truth of the new astronomy finds its formulation in fictions) is redoubled: the ontologization of fictions takes place precisely at the moment when astronomical hypotheses are presented as real (see table).

	<b>Ptolemaic Cosmology</b>	<b>New Astronomy (Keplerian)</b>
<b>Hypotheses</b>	“geometric hypotheses”	“astronomical hypotheses”
<b>Fictions</b>	Lucianesque lunar fictions (impossible)	heuristic lunar fictions (possible)

Ultimately, during the seventeenth century, the motif of flight remained an element of fiction that rendered it profoundly *unreal*. Even when ontologized and mechanized, fiction designates itself as fiction by the very use of the motif of the cosmic voyage. Throughout the century, astronomy had to face the major accusation of being nothing more than pure fiction. Margaret Cavendish, whom we will meet in the final chapter, remarked:

The truth is, My Lord, that most men in these latter times, busy themselves more with other worlds, than with this they live in, which to me seems strange, unless they could find out some art that would carry them Into those celestial worlds, which I doubt will never be; nay, if they did, it would be no better than Lucian's, or the Frenchman's art, with bottles, bladders, etc. or like the man's that would screw himself up into the Moon.<sup>83</sup>

Behind Margaret Cavendish's contempt for what comes from art and technology—to which we will return later—we can perceive a profound skepticism about the possibilities of developing knowledge by means of technical improvements. In one stroke her ironic rebuttal sweeps away various “artifices,” the fictions of men of letters as well as those who invented machines. Cavendish was correct to condemn them together: fictions and machines in the seventeenth century had a relationship that was far from merely metaphorical. They were skillfully constructed devices invented to allow us to see beyond the immediate vision that is given to us, to transcend the limits of our own nature, by imitating it, mimicking it, repeating it in order the better to understand it.

Even when made possible by the sophisticated machines of Godwin and Cyrano, the trip to the Moon remained profoundly incredible. If their goal was to defend the Copernican system, they had to try to efface its paradoxical character, to erase what could be shocking to the *doxa*. This is where the notion of credibility intervenes. How is it possible to hold on to the conceptual benefits of the lunar voyage (optical voyage, thought-experiment) without being encumbered with the heavy machinery of the fanciful flight? In other words, how can you make the reader forget the paradoxical, hence incredible, nature of the new astronomy? With Huygens and Fontenelle, the credible will become a central tool of the Copernican argument, leading to a profound recasting of the lunar tale as a theoretical trip through the space of the machine of the world.



PART TWO

# *Conjectural Machines*



All true history has a capital advantage over every work of fiction. Works of fiction resemble these machines which we contrive to illustrate the principles of philosophy, such as globes and orreries, the use of which extend no further than the views of human ingenuity; whereas real history resembles the experiments by the air pump, condensing engine and electrical machine, which exhibit the operations of nature, and the God of nature itself.

Joseph Priestley to his students at the Warrington Academy in 1761,  
quoted by Simon Schaffer, “Natural philosophy as public spectacle,” 1

I have sought to offer humanists a detailed analysis of a technology sufficiently magnificent and spiritual to convince them that the machines by which they are surrounded are cultural objects worthy of their attention and respect.

Bruno Latour, *Aramis or the love of technology*, viii

Every machine account is a story, a kind of picaresque novel, with a bundle of energy as hero.

Peter Galison, “Structure of crystal, bucket of dust”





## Fontenelle

### *Unveiling the Spectacle of the World*

The metaphor of the machine of the world significantly predates what has been called “the mechanization of the world picture.”<sup>1</sup> We already find it in Aristotle and Plato, then in the Renaissance, in Nicholas of Cusa especially.<sup>2</sup> In Copernicus, the expression is linked to a conception of the Creator as *opifex*, meaning constructor and artist:

I began to be annoyed that the movements of the world machine, created for our sake by the best and most systematic Artisan of all, were not understood with greater certainty by the philosophers, who otherwise examined so precisely the most insignificant trifles of this world.<sup>3</sup>

Criticizing the current cosmologies, Copernicus insists on the necessary harmony and beauty of the world. Against the complex Ptolemaic machinery, he proposes a machine whose movements are coordinated and proportioned: a system.<sup>4</sup> But while the metaphor of the machine of the world was constantly adopted by the heirs of Copernicus, it is nevertheless not conceived as a means of elucidation, still less as a proof of the system’s validity, as shown by the prudent position of Murelus, in charge of the third edition of *De Revolutionibus*:

What good does it do us to linger over hypotheses, which are nothing other than the fictions of men trying in vain to discover the system of world through analysis . . . We have to recognize the supreme wisdom of God the Creator and the weakness of our intelligence, which admires the machine of the world more than it understands it.<sup>5</sup>

Let us recall that Kepler writes precisely against the double assertion that sees astronomical hypotheses as fictions and that urges contemplative retreat faced with the unintelligibility of the machine of the world. With the gradual acceptance of Copernicanism and the “physicalization” of heaven, of

which Kepler was a principal advocate, the metaphor is reinvested with a very concrete meaning. The abstract machine of the heavens becomes a machine that can be understood because one can reproduce it. The multiplication of seventeenth-century cosmological models, no longer simple geometric models but physical models claiming to reproduce the physical reality of the cosmos, demonstrates this.<sup>6</sup> Priestley's statement, cited as an epigraph to this part of the book, however, allows us see at the outset a contradiction, a sense of suspicion. What is the share of human ingeniousness in these fabricated models? Are not the seventeenth-century cosmologists' machines also just fictions? For, as Simon Schaffer stresses, "fabrication, fashion, cookery, confection, and forgery all refer to the production of such mundane commodities as cloth, metal, or food. They also signal something suspect, the deceitful enterprise of the fake. They help the move between fashioning facts and feigning fictions."<sup>7</sup> In recalling the etymology common to the terms *fact* and *fiction*, Schaffer underlines the persistence of a suspicion about such human constructions, but he also defines a space *between* facts and fictions, *between* fabricating and forging. The questions that are examined in this second part of our enquiry are situated in this space.

In order to transform the heavens into sky, we saw how cosmological writings of the start of the seventeenth century reworked fictional material founded upon imagined aerial flight. When they took on board the tradition of tales of imaginary voyages in the defense of the Copernican system, writers and astronomers transformed the status of this tradition, shifting it from a poetics of wonder to a poetics of the possible. Yet from Godwin to Cyrano, the machines invented for a bold crossing of the heavens immediately signal these texts as fictions. As *possible* fictions, certainly, as shown by the sanction bestowed by Kepler and Wilkins, but at the same time incredible according to the *doxa* of their time. Although Godwin and Cyrano attractively exploit the tension between the possible and the incredible, recourse to this type of fiction weakened the enterprise of Copernican persuasion. Faced with a suspicion of the fictional, the Copernicans of the second half of the century transformed the modes of the cosmological journey. They kept the useful optical voyage, but they erased its physical and technical character, seen as too incredible. Rather than forge possible flying machines, they worked on the construction of a credible machine of the world.

Astronomical texts constantly examined the question of a discourse proper to the new science, and they continued to borrow from the existing techniques and literary genres. In these two chapters, we will try to understand the links between three elements that were used to form the construc-

tion and defense of Copernican space: a philosophical and aesthetic principle (harmony), a poetic and epistemological notion (the credible), and a mode of organizing discourse (the narrative). These three elements compose a set of criteria that are simultaneously aesthetic, poetic, and epistemological, criteria that govern the ordered reconstruction of the world. By studying the articulation of these notions in the *Conversations on the Plurality of Worlds* by Fontenelle, then in the *Cosmotheoros* by Huygens, we will see how they are modified according to whether the authors agree to integrate fictional elements. Meanwhile, we will pursue the two threads from the preceding chapter, namely the evolution of the relationship between fiction and hypothesis, and the different forms of the cosmological narrative. For if the narration takes the form of a fable in Descartes<sup>8</sup> and then in Fontenelle, Huygens tries to exploit the narrative form while rejecting fiction. Moving from the poetically credible to the epistemologically credible, from the fictional narrative to the conjectural narrative, cosmological discourse seemed to have found one of its principal instruments in the literary format of narrative, a tool forged and transformed according to the needs of the demonstration.

#### MACHINE AND SPECTACLE

“All philosophy is founded on two things; an inquisitive mind, and defective sight.”<sup>9</sup> It is with this paradox that the Philosopher of the *Conversations* begins his philosophical exposition; a paradox that is immediately reformulated into a chiasmus: “Thus philosophers pass their lives in disbelieving what they see, and endeavoring to conjecture about what is concealed from them.”<sup>10</sup> Fontenelle works with this disjunction characteristic of cosmological discourse, a disjunction between seeing and believing, between visibility and intelligibility. Casting doubt on the visible and resorting to the imagination in face of the invisible, astronomical discourse seems fated to a discursive register that is particularly uncertain—the riddle.

This fundamental incertitude governs the poetics of the *Conversations* and leads to the use of original and idiosyncratic strategies for presenting astronomical conjectures. Using the metaphor of the spectacle, Fontenelle undertakes the construction of Copernican space in front of an imaginary Marquise. The metaphor of the opera organizes and combines the motifs of the machine, of artifice, and of the credible, and even supplies a scripted plotline—the gradual unveiling of the world—for the Philosopher’s explanation.

Fontenelle allows us to take up the motif of the cosmological journey

where we left it. We saw with Kepler, Wilkins, Godwin, and Cyrano how diverse strategies had made the incredible cosmic flight possible. Fontenelle's strategy is quite different; there is no longer takeoff or violent acceleration, but rather what we might call a "conjectural journey" emptied of mechanical and physical considerations. The absence of physicality is not a simple concession to the rules of *bienséance*.<sup>11</sup> We will see how with Fontenelle the motif of the trip to the Moon (and even to the planets) is transformed to serve as a defense of Copernicanism founded on the *spectacle* of the machine of the world rather than on the disassembly of its inner workings, based on the story of a purely *conjectural* journey rather than on the material possibility of the lunar voyage. It relies rather on explicitly fictional *visions* than on credible conjectures.

Starting with the preface, the ideas of physics are presented as a "spectacle" for the imagination; the first evening opens with a starry night, described as a backdrop for a stage where the concerted arrangement of each element and each color contributes to the perfection of the whole. The first evening's association of the spectacle of the world with that of opera provides one of the most important keys for reading the work because it combines two images; the world is a machine but a machine that can be observed from afar, a spectacle:

In thinking on this subject, nature always appears to me in the same point of view as theatrical representations. In the situation you occupy at the opera you do not see the whole of its arrangement: the machinery and decorations are so disposed as to produce an agreeable effect at a distance, and at the same time the weights and wheels are hidden by which every motion is effected. You behold all that is passing, without concerning yourself about the causes; and so perhaps do all the other spectators, unless among the number some obscure student of mechanics is puzzling himself to account for an extraordinary motion which he cannot understand. You see the case of this mechanical genius resembles that of the philosopher studying the structure of the universe. What, however, augments the difficult with respect to philosophers is, that nature so entirely conceals from us the means by which her scenery is produced, that for a long time we were unable to discover the causes of her most simple movements.<sup>12</sup>

The sustained metaphor of the opera establishes several essential ideas: the problem of viewpoint, the illusion due to distance, the idea of hidden machinery and the idea of a voluntary artifice that presupposes the existence of a machinist—in Fontenelle it is Nature rather than God. But the machines

that nature presents to our eyes have “hidden” mechanisms that no philosopher had managed to perceive until the arrival of Descartes: “In the end Descartes and some other modern thinkers appear: they tell you that Phaeton rises in because he is pulled by cords, fastened to a descending weight, which is heavier than himself.”<sup>13</sup> The history of astronomy is the history of these successive attempts to understand “the mechanism of nature.”<sup>14</sup>

Hence, the metaphor of opera underscores both the wonder of the spectacle and its simplicity, even its triviality: “Confess the truth, until now have you not entertained a more exalted idea of the works of nature? Have you not allotted them more veneration than they deserve?”<sup>15</sup> This is a rhetorical and strategic question, of course, inviting the Marquise to formulate the principle of the wondrous-but-true — “I contemplate the universe with more awful delight now I find that such wonderful order is produced by principles so simple”<sup>16</sup> — against the “false wonder” of the incomprehensible. As often in Fontenelle, the removal of the falsely wondrous leads to the reintroduction of an idea of wonder emptied of occult content: the wonder of the machine of the world composed of mechanical devices, the explicability of which is the very condition of its capacity to be a wonder.

Because it empties cosmology of any possible association with the occult while conserving its share of wonder, the metaphor of opera is particularly effective. But this is a new kind of wonder, not one that causes fascination and the loss of the critical faculties of intellectual and moral judgment described by the philosophers,<sup>17</sup> but an aesthetic wonder, a provisional incomprehension before the mystery of the mechanical spectacle, that one savors and accepts as incomprehensible, because deep down, at some level, it can be explained.

The device of the machine of the world, far from inspiring doubt, is the guarantor of a logical and simple functioning in which everything depends on the “mutual relation of its parts”: “the universe is but a watch on a larger scale; all its motions depending on determined laws and the mutual relation of its parts.”<sup>18</sup> This is a Cartesian conception of the world, and Fontenelle borrows its physics and *topos*. As Jean-Pierre Cavaillé notes, “During the baroque period, the theatrical metaphor becomes the way of expressing the suppression of nature in favor of technology and the substitution of *techné* for *physis*, of *ars* for *natura*. The new science of nature is primarily the science of machines, it is mechanics. . . . ‘One only understands what one knows how to do’ became the adage of the new era.”<sup>19</sup>

The theatrical metaphor is not new in the discourse of natural philosophy,<sup>20</sup> but Fontenelle directs it toward a particular elite and worldly audi-

ence. At a time when public demonstrations in the scientific salons of the time drew their legitimacy from the diversity and quality of the audience, Fontenelle's scientific discourse is not a discourse designed for specialists. Until the end of the century, science in France was practiced in spaces of aristocratic sociability such as salons and private academies, of which Fontenelle's scientific discourse is a faithful reflection. He offers the ideal and achieved formulation of a science that conceives of itself above all as pleasant and entertaining. We recognize in the two types of readerships mentioned in his preface, the varied audiences for the demonstrations of proof in the preacademic context, on the one hand scholars and the educated, men and women of science, and on the other the simply curious or enlightened amateurs. Understood in this way, Fontenelle's effort is related less to popularization than it is a rhetorical effort to make his enterprise of scientific proof public through an exposition of scientific facts that is not direct but mediated and textual. His mode of discourse enables a curious and refined audience to access an elegant and figurative scientific discourse. This context explains the use of the theatrical metaphor, for it combines a cosmology that is both mechanical and aesthetic, with the expression of philosophical ideals that frames man as the spectator of the world.

#### ORDER OF THE NARRATIVE, HARMONY OF THE WORLD

Given man's status as spectator the gaze, or more precisely the viewpoint, constitutes the guiding thread of the presentation: "I have only to pull back the curtain, and present the world for your viewing pleasure."<sup>21</sup> The theatrical metaphor governs the whole text, presented in a logical sequence of questions and sites that one after another unveil the various parts of the system of the world, according to an underlying narrative logic: "Women may understand this system of philosophy by giving it as much attention as they would bestow on *La Princesse de Clèves*, in order to understand the story and see all the beauties of the work."<sup>22</sup> He refers to the plot and beauty of the text—but also of the cosmos. The narrative structure reveals the essential harmony and perfection of the world; the order of the world and the order of the discourse each validate the other: "The next thing was to imagine the arrangement of the different parts of the universe; that is what the learned call making a system."<sup>23</sup> This double problem of the *dispositio*—how to structure the different parts of the universe and how to structure the different parts of discourse—is resolved both at the textual and conceptual levels by the use of the travel-

narrative. The reference to the novel *La Princesse de Clèves* is another clue, like the division into “evenings,” of a narrative structure, of a “plot” that is an adventure of thought occurring over the course of an imaginary journey.

However, it is an essential point that the journey takes place only in the imagination:

I sometimes imagine myself raised above the surface of the Earth, and remaining motionless whilst its daily rotation continues. All the different inhabitants pass in review.<sup>24</sup>

The rhythm of the writing accords with that of the diurnal motion: the Earth’s rotation is dramatized by the enumeration of various places offered in turn to be viewed. The use of extended lists to describe what is being seen mimics the speed of the voyage and its ease, inescapably fictional. In a second catalogue of descriptions, the narrative attempt is still more visible, since the various peoples successively mentioned are put into movement in micro-scenes comprising so many colorful and picturesque vignettes. The Earth’s rotation is completed in the time of the enumeration, the imaginary journey being completed with the return to the point of departure, in one final flourish: “Finally us, who will perhaps produce further dreams.”

Fontenelle refuses to invent flying machines to make it possible to see the spectacle of the universe. He proposes an imaginary voyage within the limits of both *bienséance* and analogical reasoning. Fontenelle’s readers (male and female) are spectators of the machine of the world rather than bodies brusquely catapulted out in a flying engine. The theatrical imagery serves to establish a distance between the observer and what is observed, a distance that picaresque and mechanical stories of the trip to the Moon tended to efface. We find no technical considerations about the flight’s conditions of possibility, still less its physical description. There are no physical obstacles; the trip to the Moon is invoked only as an ideal viewpoint, which would be placed “between the Earth and the Moon to really see well.”<sup>25</sup> As we saw in the preceding chapter, a text that signals itself as being properly fictional, a status confirmed by the inclusion of a flying machine or a dream, predisposes the reader to understand the philosophical and scientific truths being offered differently. In order to preserve the credibility of the demonstration, Fontenelle’s strategy is to ensure that his reader is always aware of the virtual, rather than the actually enacted, nature of the journey.

In fact, direct references to previous trips to the Moon are rare, but we find their trace in narrative motifs, for example the *topos* of the maritime voyage, the idea of inhabitants with “extraordinary faces,” and the reversal of

viewpoint of which Cyrano was so fond. Following Kepler, Wilkins, Godwin, and Cyrano, Fontenelle adopts the principal motifs that unsettled the stable Aristotelian image of the world. From his predecessors, Fontenelle incorporates the idea of a difficult passage through the Earth's atmosphere to the lunar atmosphere, the image of subterranean cities on the Moon, an allusion (skeptical, in his case) to demons that populate sublunary space, and finally, the differing conditions between the inhabitants of the two hemispheres imagined by Kepler. In the *Dream*, one of the hemispheres, Subvolva, contemplates a luminous satellite, Volva (Earth); the other one, Privolva, is deprived of light. Fontenelle modifies this idea: "the inhabitants of the other side must be much less agreeably situated in that respect."<sup>26</sup> With regard to lunar cities, the subject of the *Dream's* selenographic appendix, the philosopher makes Kepler's hypothesis his own, by asking, "How do we know whether the inhabitants, oppressed by the perpetual radiance of the Sun, may not take refuge in these caverns? Perhaps they even build towns, and constantly reside in these parts."<sup>27</sup>

The division of the narrative structure into evenings also reproduces the narrative structure specific to lunar stories, but not their contingencies. The reflection to which the philosopher invites the Marquise takes the form of an abstract itinerary that leads them farther and farther away from the Earth, and at the same time farther from clichés. We can no doubt interpret the structure of the book in this sense: the succession of conversations replicates a progression that is as logical as it is spatial. It is a matter of enlarging the Marquise's conception of the universe by making her travel from the Earth to the Moon, then to other planets, in order to arrive at the formulation of an idea of the infinity of the universe and the plurality of worlds: "Now, madam, let us pursue our journey to the different planets; we have been long enough at the Moon."<sup>28</sup>

In the Fifth Conversation, the voyage is completed in an exponential movement of spatial expansion, in the notion of infinity expressed in the vertiginous multiplication of planets:

How will you count them when I tell you there are many more fixed stars than you can see; that with telescopes an endless number are seen which are invisible to the naked eye; and that in a single constellation, where we might before have counted a dozen or fifteen, there have been found as many as we were accustomed to observe throughout the heavens?

Have pity on me, cried she; I give up; you have overwhelmed me with worlds and whirlpools.<sup>29</sup>

## FONTENELLE'S VISIONS

The conjectural voyage is an initial solution, but it does not give information about the inhabitants and landscapes of these other planets. For the reader wishing to know more, there is no option other than the “riddle” of the philosophers—whether it be treated as analogy or fiction—the lunar fable of Lucian and Ariosto. The two modes actually occupy the same place in the text of the *Conversations*: they compensate for (without really correcting) the myopia of philosophers, and provisionally resolve the problem of the deficit of images and information.

### Analogical Construction of Worlds

Proceeding by means of transpositions and by analogies, Fontenelle constantly appeals to the imagination when sight provides no access. One can infer the unknown on the basis of the known, he affirms, for nothing can be fundamentally heterogeneous to what we already know: “We have always represented the unknown in the form of what was known to us; but fortunately there are all the subjects in the world to believe that the unknown cannot fail to be like what is presently known.”<sup>30</sup> Such confidence in the legitimacy of analogical reasoning is an inheritance from Descartes, and, more remotely, the Renaissance use of analogy, from Belon<sup>31</sup> to Bacon.<sup>32</sup>

As the central question of the *Conversations*, the plurality of worlds is demonstrated gradually with the Moon as the touchstone for an analogical construction. If the Moon is also a planet, then all those that we cannot see are likewise planets. Through a game of successive analogies we pass from the Moon to all the planets, all being ultimately assimilated to the Earth. The succession of images enables the incremental formulation of the theory of the plurality of worlds. This analogical chain is legitimated during the Fifth Evening of the *Conversations* in a formula that makes comparison the essential tool of a description of the unknown:

You must own that when two things are similar in all that I know of them, I may reasonably think them similar in what I am unacquainted with in respect to them.<sup>33</sup>

This, then, is the condition of a valid comparison, founded on bringing together similar objects, a formulation reminiscent of Descartes.<sup>34</sup> Fontenelle stresses that all his visions, even the most daring, “are not without founda-

tion.<sup>35</sup> And his astronomical conjectures are founded on astronomical data brought to light over the course of successive editions of the text. While the philosopher ensures the solidity of the foundation of his conjectures, he admits several times his lack of the scaffolding that would guarantee the stability of the construction. He possesses in effect only the fragile tool of metaphor, which transfers images from one domain to another. A flexible tool for the construction of analogy, metaphor proves to be the central rhetorical figure of the *Conversations*. The link between analogy and metaphor is demonstrated by Fernand Hallyn, who explains that

there are affinities between the analogical model and the stringed metaphor in as much as both presuppose the confrontation of two coherent sets of features (qualities, relations) that refer to two different objects.<sup>36</sup>

The metaphor, a figure that can transpose properties from one domain to another, is particularly useful in the domain of astronomy. It enables the provisional attribution of the physical properties of the Earth to all planets, the unknowns of the universe, in order to further the argument in favor of the theory of the plurality of worlds,<sup>37</sup> in a process already particularly employed by Bruno and Cyrano. A tropological technique of displacement, it relies on what is already known, providing familiar images that will be enlarged, transformed, lightly altered, or modified in order to produce something new, unheard of, or never seen. The unknown is constructed on the basis of old material that is renewed thanks to a radical change in viewpoint.

Whereas Descartes made many drawings to explain his analogies, Fontenelle offers neither figure nor diagram to back up the imagination. The analogies remain solely verbal.

Shall I shew it you by tracing a figure on the Earth?

No, said she, I can dispense with that; it would give my park too learned an appearance. I think I have heard that a philosopher, shipwrecked on an island with which he was unacquainted, cried out to his companions on perceiving some lines and circles drawn on the sand; courage, my friends, the island is inhabited; here are the footsteps of men. You must consider that such footsteps ought not to be seen here.<sup>38</sup>

By refusing any visualization, Fontenelle's Marquise expresses her fear of pedantry as much as her adherence to the conventional view that geometry is an occupation little suited to her sex. But there is no doubt a deeper reason for this refusal; if the universe is indeed a great machine, as Fontenelle

asserts according to the mechanistic interpretation of his day, it is also a vast spectacle. But in Fontenelle's aesthetic, it would be just as improper to draw the mechanisms of the universe as to bring a lady backstage after watching a play filled with special effects. One admires the spectacle, one can guess at how it has been accomplished, but one does not need to be concerned with the mechanics of the whole enterprise. This preference of Fontenelle for the metaphoric image over technical visualization shows a theatrical aesthetic that separates the effect of the staged spectacle from its material and technical workings.<sup>39</sup>

It is especially here that he deviates from the Cartesian method.<sup>40</sup> Fontenelle is not content simply to compare comparable objects. He translocates motifs of one world to another, altering them from the minuscule to a cosmic scale, in order to create incongruous images that defamiliarize the real and attempt to make sense of the strangeness of the unknown. In this sense, Fontenelle's analogical method is close to the technique of *concetto* and possibilities that it offered. An Italian genre that was in fashion in France<sup>41</sup> and in England<sup>42</sup> throughout the century, the *concetto* encouraged unusual juxtapositions. While being an analogy, it lacked the rigor required by Descartes. Despite a solid foundation, the Philosopher admits that he has built his construction without scaffolding. Fontenelle's method is a philosophy of the "why not?," an echo of Cyrano's "why not?" whose "points" are also *concetti*. In this framework, analogy is a tool used to explore and construct bold images rather than a systematic method of reasoning. Relying on known images that are transformed, modified, and displaced, the visions thereby produced attempt to grasp the unprecedented in unknown worlds:

In one of the planets, I shall not at present tell you which, there is a people that are very active, laborious and skilful. Like some of our Arabs, they live by pillage, and that is their only fault. They live together in the most harmonious manner, labouring incessantly and in concert, for the common good: above all their chastity is unexampled; it is true they have no great merit in it; they are all sterile.

... Have you done? enquired the Marchioness. Thank heavens! Let us now resume a little common sense, if we can. Where have you picked up this romance? What poet is the inventor of it?

The Marquise does not hide her disappointment when the Philosopher reveals that the astonishing extraterrestrial community that he has just depicted is only a simple beehive.

I again tell you, answered I, that it is no romance. All this takes place on our globe, even under our eyes.—If I must explain the mystery, These Arabs are no other than bees.<sup>43</sup>

On top of the analogy with the bees comes a comparison with Arabs, which complicates the picture and makes it even more disturbing. But here the extraplanetary society is not convincing, despite the concatenation of images. Where the analogy fails, one has to either accept ignorance or else trust in the fictional imagination of writers.

### From Analogy to Fiction

While proclaiming his strict use of the imagination as a unifying faculty, Fontenelle often yields to the temptation to use it in a figurative and fictional way.<sup>44</sup> He replaces the impossible observation with a kind of representation extended into a fictional micro-story. For example, mentioning the Moon, the Philosopher of the *Conversations* effaces himself before the storyteller when it comes to giving a precise description of the lunar landscape. The shift to “detail,” from geography to chorography, can be achieved only by resorting to fiction. “The gentlemen of the observatory are not able to give it you, I replied; you must make enquiry of Astolfo,”<sup>45</sup> declares the Philosopher. There follows a summary of the story of Astolfo, hero of Ariosto’s romance epic *Orlando Furioso*.

Chorography requires combining the skills of a surveyor and a painter. With respect to the first book of Ptolemy’s *Geography*, Frank Lestringant reminds us that “geography is in the purview of the mathematician or the astronomer, while chorography is the domain of the artist, painter or engraver, . . . Chorography is a kind of calligraphy that requires that the surveyor’s compass be allied with the artist’s brush and pen.”<sup>46</sup> Or, one might add, with the writer’s pen. For here fiction seems to occupy the place of the vision that is lacking. For Fontenelle, the task of the writer is to confer color and details on the abstract space delimited by the surveyor or by the astronomer. Just as chorography and geography complement rather than oppose each other, so the work of fiction and the imagination are presented here as possible and ludic extensions of cosmological reflections. The desire to see the invisible is realized in a fantastic and imaginary way through writing. Drawing on literary and fictional resources, the imagination creates images where the eye is incapable of discerning any.

However, an obsessively insistent question remains: what do extraterrestrial trials look like?

Are you satisfied, madam, said I? Have I given your imagination room to exert itself? Do you not already see the people of different planets?

No, answered she, with a sigh: all you have been saying is so vague and unsatisfactory; there is nothing in it for the mind to fix on. I want something more determined; more marked.<sup>47</sup>

### Making and Unmaking Worlds: Conjecture According to Fontenelle

Because conjectures take the place of observation in the case of distant objects that cannot be seen (or only seen badly), they assume the form of visions:

Since we find that there is motion in the parts of the Moon, either internal, or produced by foreign causes, we may again people it, as we have the means of affording them subsistence; of producing fruit, corn, water, and every thing that is needful.<sup>48</sup>

Fontenelle proposes a leap into the unknown into which he propels his reader, incidentally reactivating the etymological meaning of the term *conjecture*. The demiurgic power of philosophical speech is loudly asserted. What counts is not the veracity of this reasoning but its usefulness in the sphere of the imagination. Descartes's "long chains of reasoning" become long chains of imagination in the hands of his unfaithful disciple Fontenelle. The hypothetical construction of an inhabited lunar world appears to be a hedonistic act with the sole aim of providing pure pleasure: "I will not leave the Moon without inhabitants then, said I; for your pleasure it shall be re-peopled."<sup>49</sup> The association of pleasure and philosophical invention was already a trademark of Descartes's *The World or a Treaty of Light*, one of the works whose intertextuality is acknowledged in the *Conversations*.<sup>50</sup> The fictional construction of *The World* is erected on the foundation of a thought-experiment,<sup>51</sup> which Fontenelle seems to have in mind when he suggests to the Marquise that she suspend herself in mid-air and make that position between the planets the ideal position from which to philosophize. The echo is clearer still when cosmic space is fused with an imaginary space created by and for philosophers:

For a short time, then, allow your thought to wander beyond this world to view another, wholly new one, which I shall cause to unfold before it in

imaginary spaces. The philosophers tell us that these spaces are infinite, and they should very well be believed, since it is they themselves who have made the spaces so.<sup>52</sup>

It seems there is only one step from Cartesian “imaginary spaces” to the “great invisible countries” of Fontenelle, who borrows not only the generic plural “the philosophers” but also the idea of the creative pleasure that comes from the philosophical imagination.

You may place more worlds or not; just as you are disposed. These invisible countries should, in propriety, be left to the philosophers: they may imagine them to exist, or not exist, or to exist in any way they chuse.<sup>53</sup>

The conjunction of word and action produces (with Fontenelle as with Descartes) a performative and demiurgic mode of expression that describes the creation of a world. However, the fragility of this construction is constantly exhibited in Fontenelle in an incessant creation and destruction of worlds. For example, at the start of the Third Evening, new observations and deductions undermine the theory expounded the night before:

What sort of beings do you think could inhabit these barren rocks; this country without water? Ah! cried she, you forget that you have assured me the seas in the Moon were distinguishable. It was a mere conjecture, I replied; I am sorry to have led you astray. These dark places that have been taken for seas are probably only deep cavities: at so great a distance it is excusable if we don't always guess aright.<sup>54</sup>

The hypothesis of an inhabited Moon is reevaluated in the light of new lines of reasoning: “we should give but half an assent to an opinion of this nature, and reserve the other half in case we should find the opposite idea better supported.”<sup>55</sup> The to-ing and fro-ing between affirmation and denial of a lunar hypothesis causes trouble in the Marquise's mind, as in the reader's. Having affirmed the existence of inhabitants of the Moon, the Philosopher in a final twist effects a radical reversal and claims to want only to demonstrate the possibility of the demonstration itself: “I only wished to shew you the possibility of maintaining an extravagant opinion, so as to embarrass, though not convince, a person of sense.”<sup>56</sup> Here the demiurgic mode of expression is also ironic, for the demiurgic gesture is reversible. The word effaces the created world with the same ease with which it had brought it about.

Moreover, the details of the model appear in many respects to be arbitrary. “Perhaps some angry astronomers would tell you they are farther still,”<sup>57</sup>

threatens the Philosopher about the stars. Here reason seems subject to human passions: anger takes over from any rational factor that can measure the distance of the planets. At the other extreme of the panoply of passions, pleasure is a creative passion capable of producing worlds. "I have taken it in my head that every star may be a world. I would not positively assert the truth of my opinion, but I believe it because it affords me pleasure; it has possessed my mind with irresistible force; and I consider pleasure a needful accessory to truth."<sup>58</sup> The power of speech is enough to create other worlds, as in Genesis and in Descartes's *World*.<sup>59</sup> But whereas Cartesian demiurgic speech is confirmed by the laws of physics that governed the construction of the world and that operate in the world around us, thanks to the reciprocal validation of discourse and conjecture in his text, Fontenelle's fiat multiplies worlds in the mode of fiction.

\* \* \*

Faced with uncertainty, there remains only the "riddle," an explicitly fictional mode of conjecture that can only provide provisional enlightenment: "To console ourselves let us guess all we can about it."<sup>60</sup> Fontenelle does not use conjecture to construct his cosmic models or to provide solid proofs. This, as we will shortly see, is not the case in Huygens's *Cosmotheoros*. Conjecture is rather the sign of the essential fragility of astronomical discourse.

In line with Kepler and Descartes, Fontenelle makes fictional invention the privileged mode of astronomical conjecture. Fiction is primarily a means of whetting curiosity, the passion essential to the scientific spirit. But unlike his illustrious predecessors, Fontenelle undermines the argument he constructs by revealing its reversibility at the very moment he articulates it. We witness a vertiginous succession of conjectures, each envisaged and then dismissed with disconcerting speed. Fontenelle uses the ontological and semi-otic proximity between fiction and conjecture not to construct a solid theory of the world, but to signal the vulnerability of any hypothetical construction. By this logic, the book culminates in a declaration that casts doubt over all of the astronomical expertise transmitted to the Marquise: "Ah! she exclaimed, then I am acquainted with the whole system of the universe! how learned I am! Yes, said I, you are learned enough in all reason, and your knowledge is attended with this convenience,—you may extract your belief of all I have told you whenever you think proper."<sup>61</sup>

Because the method of Cartesian fiction can lead to the fictional poetics illustrated by Fontenelle, a strong reaction took place at the end of the cen-

tury. The reaction was less against conjectures themselves than against their fictional interpretation that suggested ontological proximity between fiction and conjecture, apparently advocating a radical skepticism. Playing on the resemblance between these two modes and on the breaking of ontological boundaries between fiction and reality, the text of the *Conversations* works to maintain its ambiguity. Paradoxically, it is by voluntarily blurring the frontier between conjecture and fiction that Fontenelle intends to convince his reader. Huygens was to write against this elision of conjectures into fictions. While for Fontenelle, analogy, fiction, and conjecture are instruments of unstable and provisional constructions, Huygens will construct a vast edifice based on “credible conjectures” of a quite different kind.

## Huygens

### *The Theoretical Voyage of the Cosmotheoros*

In Fontenelle's text, scientific and literary discourses share the same images, the same lexicon, and the same origin. The imaginary spaces of the philosophers are not fundamentally different from the spaces of fiction; the history of astronomy proves to be the same as that of the novel; the philosopher is a poet, the novelist is a philosopher, conjectures are fictions. Differentiation between the literary and scientific spheres was slight. The last cosmological text by the Dutch natural philosopher Christiaan Huygens (1629–1695) presents a direct response to this conflation. Rather than denying any role for conjectures and tales, however, Huygens tried to integrate them by distinguishing them clearly from fiction. As with Fontenelle, the theoretical distance enabled by means of imagining the journey is the point of departure for speculation:

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 Countryes, 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.<sup>1</sup>

The metaphor of the traveler was already circulating in Huygens's letters to his friend and mentor Jean Chapelain. This is how Huygens announced the forthcoming publication of his *Systema Saturnium* to Chapelain in 1659:

I have just returned from the land of Saturn, after having noted everything there that was worthy of consideration. In other words, you will soon see the system that I promised long ago.<sup>2</sup>

Chapelain replied:

It seems to me that you intended to make a thirty-six-foot-long telescope in order to penetrate even further into the sky and to bring us even more information about it.<sup>3</sup>

The metaphor of the voyage, a materialization of the process of astronomical observation by means of the cosmic voyage, is a *topos* of astronomical discourse that we find throughout our corpus. But for Chapelain, writing almost thirty years before the publication of the Fontenelle's *Conversations*, the metaphor suggests an ambitious program in the tradition of Kepler:

I had hoped to find more in your system, not so much concerning the possible inhabitants of the planet, but more of an explanation of its diverse properties in relation to other bodies that compose the world, as, for example, Kepler did with Mars and the Moon.<sup>4</sup>

When he mentions Kepler, the poet is not thinking of a lunar fiction or of a treatise on the inhabitants of Saturn in the manner of the lunar inhabitants imagined by Kepler. Chapelain had taken the theoretical content from the *Dream* that could also be found in the less accessible *Astronomia Nova* by Kepler, which was then usually called his book on Mars. In the tradition of *theorica* reformed by Kepler,<sup>5</sup> the *New Astronomy* (1609) is a systematic description of the universe with Mars as the starting point. Chapelain expected Huygens to propose not just a system explaining Saturn but a "Theory of Saturn," which would explain Saturn and its ring within the context of the whole solar system.

While from this perspective the *Systema Saturnium* remains incomplete, at the end of his life Huygens wrote a book that seems to have met the expectations of his poet-friend much better. This is the *Cosmotheoros*, published posthumously in 1698, in which Huygens portrays the finally unified space of a harmonious cosmos in a narrative that is conjectural, but not fictional. The *Cosmotheoros* is in effect a "philosophical treatise" offering a complete theory of the universe, in other words a *cosmology* expounded by means of a logical trajectory in the first part, a spatial one in the second. "But a while ago thinking somewhat seriously of this matter (not that I count my self quicker sighted than those great Men, but that I had the happiness to live after most of them) methoughts the enquiry was not so impracticable, nor the way so stopt up with Difficulties, but that there was very good room left for probable Conjectures."<sup>6</sup> At the end of his career, the former astronomer to the

king found out that journeying to distant planets is both worth undertaking and possible to recount.

#### HYPOTHESES, CONJECTURES, FICTIONS

Huygens not only proposes a cosmology but also provides what he calls a “philosophical” demonstration of the existence of inhabitants on other planets. Huygens’s final cosmological text is also an intellectual testament and a “meditation” on mankind. After the revocation of the Edict of Nantes in 1685, the Protestant Huygens could not return to France; he de facto quit his office as astronomer to the king.<sup>7</sup> In this text he reviewed the century and the body of work he had achieved, and offered a final evaluation and interpretation. A strategic text in many respects, the *Cosmotheoros* has as its aim establishing Huygens’s supremacy in the field of astronomy and responding to the objections of his principal adversaries. As a defense of Copernicanism against anti-Copernicans such as Kircher and Cassini, it is propaganda rather than presentation of a new theory, but the *Cosmotheoros* also contests the views (and even more so the methods) of certain Copernicans, notably Fontenelle and Descartes.

The *Cosmotheoros* is disturbing. For a long time, people wanted to see it as a work of popularization in the spirit of Fontenelle’s *Conversations*. But Huygens severely criticizes Fontenelle’s work, and at the start of his treatise is careful to distance himself from it. Taking his own assertions seriously, we will attempt to find other ways of understanding his text than by using the dichotomies of serious and playful, and fiction and nonfiction, which clearly are of little help in grasping the precise nature of Huygens’s text.

#### Against Fiction

Resorting to conjecture is both a necessity and a constant of astronomical speculation in the seventeenth century. It is common to the *Conversations* and the *Cosmotheoros*, but also is one of the points of divergence between the two texts, for the method offered by Huygens excludes the techniques of fiction. In this sense, the difference is less theoretical than it is methodological and stylistic. Fontenelle, as we have seen, interprets credible conjectures in a clearly fictional way. It is precisely against this use that Huygens is reacting in the *Cosmotheoros*.

Due to the narrative structure of the text (to which we will return), the

*Cosmotheoros* has sometimes been compared to the *Conversations* under the same term: “narrative fictions.” The patent similarity of the two projects is shown in the titles of the French translations of the *Cosmotheoros*: the first one calls Huygens’s book a “treatise,”<sup>8</sup> while in the second translation the publisher wanted to keep the commercial benefits of alluding to Fontenelle while stressing the serious nature of Huygens’s text: *On the plurality of worlds, a book in the style of Monsieur De Fontenelle on the same subject, but in which rather than being merely the occasion for the demonstration of wit, wholly credible conjectures are established by means of philosophical reasons.*<sup>9</sup> Using a widely used editorial strategy, these titles confer on Huygens’s text the status of “new *Conversations*” in the manner of Fontenelle, in order to profit from the fame and to repeat the commercial success of that work. However, Huygens several times stresses the specificity of his text:

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 as to affirm, that 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. Nay, *Cusanus* and *Brunus* have allow’d the Sun and fixed Stars theirs too. But this was the utmost of their boldness; nor has the ingenious French Author of the Dialogues about *the Plurality of Worlds* carry’d the business any farther. Only some of them have coined some pretty Fairy Stories of the Men in the Moon, just as probable as *Lucian’s* true History; among which I must count *Kepler’s*, which he has diverted us with in his *Astronomical Dream*.<sup>10</sup>

By asserting that he has avoided the “stories” of his predecessors, Huygens demands that the logical status of his “conjectures” be recognized, and simultaneously he categorizes those of Kepler, Wilkins, and Fontenelle as belonging to the realm of fiction. In opposition to the fictions of his predecessors, Huygens calls for a method founded on the systematic linking of conjectures. The reference to Lucian here retrospectively characterizes the cited texts as fables whereas, as we saw earlier, Kepler had included Lucian among his sources alongside Cicero and Plato. The exclusion of the fictional register marks a desire to establish an independent scientific discourse. Independence is asserted as much at the pragmatic level of the reception by a chosen readership as in the type of discourse judged as adequate—an independence made all the more necessary because the difference between conjecture and fiction is not always clear, as Huygens recognizes:

There's one sort who knowing nothing of Geometry or Mathematicks, will laugh at it as a whimsical and ridiculous undertaking. It's mere Conjuraton to them to talk of measuring the Distance or Magnitude of the Stars: And for the Motion of the Earth, they count it, if not a false, at least a precarious Opinion; and no wonder then if they take what's built upon such a slippery Foundation for the Dreams of a fanciful Head and a distemper'd Brain. What should we answer to these Men, but that their Ignorance is the cause of their Dislike, and that if they had more Sense they would have fewer Scruples? But few people having had an opportunity of prosecuting these Studies, either for want of Parts, Learning, or Leisure, we cannot blame their Ignorance; and if they resolve to find fault with us for spending time in such matters, because they do not understand the use of them, we must appeal to proper Judges.<sup>11</sup>

In many respects, cosmological discourse was faced with a problem comparable to that of travel literature, namely the absence of textual criteria to guarantee the distinction between fictional and nonfictional accounts. Such resemblance in form explains the need to exclude fiction from scientific discourse explicitly. In the *Cosmotheoros*, Huygens establishes a type of nonfictional discourse that uses the narrative form and sometimes even resorts to the use of figuration. However, as with Fontenelle, the tale of the voyage remains theoretical. With their similar hypothetical constructions, the *Conversations* and the *Cosmotheoros* both defend the theory of the plurality of worlds, which leads them to suggest images and description of the inhabitants of distant worlds. Yet the paths taken to get to such narrative strategies are very different. This methodological divergence can be interpreted as an episode in the epistemological separation of fiction from hypothesis, on the one hand, and of what is credible in literature from what is credible epistemologically, on the other. The *Cosmotheoros* works to define the specific functioning of scientific hypotheses in a way that rejects their conflation with fiction.

In order to understand better the stakes in Huygens's exclusion of fictional techniques, his text has to be read within the context of a vast enterprise of fashioning an autonomous scientific discourse. The problem is both rhetorical and poetic. Huygens says the *Conversations* were not valid scientific discourse because they lack an effective rhetoric and because they give a central place to the fictional mode of discourse. The difference in the two methodologies is profound and involves both the definition of the ethos and the choice of genre. While Fontenelle, by his reference to the *Princesse de Clèves*,

invited a comparison of his text with fiction, Huygens undertakes to differentiate scientific discourse from a learned discourse that accommodates the fictional. One of the direct consequences of this rejection of fiction was the profound change in how conjectures were constructed and expressed.

Fontenelle and Huygens produce comparable hypothetical constructions and in the course of their parallel explorations both recount the observations of extraterrestrial astronomers, but their conjectural approaches are very different. Huygens follows a rigid path of deductions, a long chain of conjectures; Fontenelle, on the other hand, offers a practice of conjecture that moves from fact to fiat, from authenticated observation to demiurgic invention, with a freedom for which he would be reproached by Huygens. While for Fontenelle conjecture was always provisional and revocable, for Huygens it is sufficiently grounded to lead to a new development in inductive reasoning. Against Fontenelle's poetics of appearance, the theatricalized unveiling of the machine of the world, Huygens offers a style that entails logical connections in order to present narrative and argumentative continuity.

The definition of a scientific discourse involves the redefinition of science itself, of the area it covers and its institutional practices. While he participated willingly in the refined culture of the salons during his first visits to Paris in the 1650s and 1660s, at the end of the century Huygens defended a conception of science as an autonomous domain, removed from "polite science" such as it was practiced in Montmor's salon. From a poetic standpoint, this involved three claims: for a specialized author, for an educated and select readership, and finally for an autonomous scientific discourse.

At the outset of his treatise, Huygens establishes an ethos of the "expert" (*savant*) that is opposed to the larger notion of the "amateur." By evoking the hours spent with his brother in observing the sky in the first paragraphs of the treatise, he constructs a self-portrait of the devoted observer, reinforced by mentioning his former position as astronomer to the king. In doing so, he makes a claim for his status as a specialist author and uses this status as a guarantee of credibility. The inscription in his text of the numerical results of his observations and measurement and the choice of Latin are additional clues of this specialization. Unlike Fontenelle, Huygens literally chooses *not* to translate. Having begun the writing of the *Cosmotheoros* in French, Huygens changed his mind midway through and continued in Latin. In 1697, the refusal of the vernacular was a clear declaration in favor of an audience of specialists, to the exclusion of the worldly public incarnated by the Marquise of the *Conversations*. Huygens alerts us: "I could wish indeed that all the World might not be my Judges, but that I might chuse my Readers, Men like

you, not ignorant in Astronomy and true Philosophy.”<sup>12</sup> Αγωμεζβητος γδεις ξσιτω. “*Let nobody ignorant of geometry enter*,” Copernicus had warned at the opening of *De Revolutionibus*.

These poetic choices are of course inseparable from the context of the Royal Academy of Sciences and its various epochs. In juxtaposing the *Conversations* and the *Cosmotheoros*, we have to remember an important chronological fact: the *Cosmotheoros* appeared a decade after *Conversations*, but actually belongs to a previous historical period, that of the first years of the Academy. Invited in April 1666 by Colbert to live in Paris as founding member, Huygens was an influential presence at the Academy from its inception. He occupied a privileged position there until his departure in 1685. Fontenelle was to occupy the same position several decades later, as permanent secretary of the Academy; from that period onwards, being this central figure of the Academy meant being its spokesman rather than being the most famous of its scholars. In fact, in the period between Huygens’s and Fontenelle’s occupations of the post, the Academy had changed not only its location but its tone and its practices. Originally established as an exclusive circle meeting in the intimacy of the King’s Library, it became a more independent institution, communicating the accounts of its work to the Parisian elite by means of its *Mémoires (Minutes)*, whose composition was entrusted to Fontenelle. Christian Licoppe has clearly described the evolution of the Academy between these two periods:

The publication of minutes marks the shift from a centripetal Academy, debating significant scientific problems in private, to a centrifugal Academy that sought to disseminate its work to the public outside. In the earlier incarnation, the unpublished paper was simply the account of a philosophical practice whose legitimacy was established within the academic group in advance of its writing and any reading of it. In the second case, the text is explicitly destined to be read outside the coterie, and it is important that it be read. Part of its authority is thus transferred to the writing itself, ideally persuasive enough to convince the potential reader that it is a text worthy of conveying such authority. This authority will ultimately be open for examination and tested in each act of reading.<sup>13</sup>

In the reconstituted Academy, it was writing that served as proof and enabled the dissemination of ideas. The construction of proof took place in a centrifugal fashion and required a mode of expression that accorded with the codes of politeness required in gallant discourse. Huygens, faithful to the earlier practice of internal legitimation, presented in the *Cosmotheoros* a

learned discourse for a learned audience. A separation between scientific and literary discourses and milieux was taking place, a distinction that Huygens was reaffirming where Fontenelle had infringed it. The dispute concerning the mode of expression proper to scientific discourse can be interpreted as the desire to single out natural philosophy from within the general sphere of intellectual writing. The requirement for a specialist discourse is indicative of an interest in staking out an independent field of scientific practice, a field that would not be strictly defined until the eighteenth century. There was no more proof of the existence of inhabitants on other planets in Huygens's *Cosmotheoros* than in there was in Fontenelle's *Conversations*. The difference lies in Huygens's attempt to define a discourse as well as a differentiated field of knowledge and an audience suited to it.

However, the opposition between Fontenelle and Huygens is not a simple opposition between the writer of literature and the writer of learned knowledge; it crystallized the debate around the use of two types of possible scientific discourses. At the time when the *Cosmotheoros* appeared, the type of discourse defended by Huygens no longer corresponded to that of the Academy; his discursive style was that of the 1670s, not that of the century's end. One of the essential points in the separation of discourses towards which Huygens was working was his desire to distinguish scientific conjectures from the freer and more fictional use of hypothetical speculation. While Fontenelle conceived of astronomical conjectures as a type of credible fiction, Huygens undertook to define a register for conjectures proper to science and distinct from literary fictions.

### Credible Conjectures

In *Systema Saturnium*, the technique of visualization permitted Huygens to avoid fiction. What could be seen only imperfectly if at all was gradually elaborated by means of successive hypotheses, often confirmed by observations:

Here I do not arbitrarily construct a hypothesis due solely to my imagination, as Astronomers construct their epicycles that do not appear anywhere in the sky, but [it is] with my eyes.- and it is also with our eyes that we distinguish the forms of all other objects—[that] I see [Saturn's] ring rather distinctly.<sup>14</sup>

The astronomer's "I see with my eyes," successor of the argument from observation ("autopsia") used by the cosmographers of the Renaissance,<sup>15</sup> is an es-

sential element of the claims for authority for the hypothesis,<sup>16</sup> even though Huygens had constructed the model of Saturn *before* being able to observe the ring.<sup>17</sup> The argument of visualization is thus advanced a posteriori in a retrospective account of the discovery. The importance of this argument cannot be stressed enough. At the turn of the century, visualization (notably using optical instruments) is what distinguished serious hypotheses from the simple “fictions” of cosmologists. Henry Power, whom Huygens had read,<sup>18</sup> puts it clearly:

Without some such Mechanical assistance, our best Philosophers will but prove empty Conjecturalists, and their profoundest Speculations herein, but gloss'd outside Fallacies; like our Stage-scenes, or Perspectives, that shew things inwards when they are but superficial Paintings.<sup>19</sup>

Given that Power was writing more than twenty years before the publication of the *Conversations*, we can only be struck by the pertinence of the metaphor; unveiling the theater of the world from a fictional point of view would indeed be the goal of the Philosopher's speculations in the *Conversations*.

Following Descartes and the English experimentalists, Huygens expresses an immense confidence in the possibility of making visible the invisible world of the infinitely distant thanks to constant improvement in instruments of observation: “if one could reach one or two hundred feet, one would doubtless see the planets turn around their axis.”<sup>20</sup> While one could actually see the ring of Saturn—observations performed after 1660 with more powerful telescopes all confirmed the hypotheses about the ring—it remained impossible to ascertain the characteristics of other planets with enough precision to know whether they were inhabited. In the place of this still impossible vision Huygens proposed use of “credible conjectures”:

I must acknowledge still that what I here intend to treat of is not of that nature as to admit of a certain knowlege; I can't pretend to assert any thing as positively true (for that would be madness) but only to advance a probable guess, the truth of which every one is at his own liberty to examine.<sup>21</sup>

He writes “probable guess” (*conjecture*) and not hypothesis, for Huygens is not confusing the two terms: while he uses the latter in *Systema* to refer to Saturn's ring, he reserves the former for his remarks on the plurality of worlds in the *Cosmotheoros*. As indicated by the way they are used in each book, hypothesis is a model that can be described, whereas conjecture is only an approximate vision.<sup>22</sup> The optical metaphor is explicitly used by Huygens to distinguish clearly between three modes of conveying ideas: hypothesis, con-

jecture, and fiction. Hypothesis is a theory explaining the images obtained by observation; conjecture is a still blurry image for which an interpretation is offered; fiction is an image wholly created in the imagination. If fictions are visions of the imagination, conjectures are visions that arise from reason, replacing a vision impossible for the human eye, even with a telescope:

Not having the means to go farther along this path, our curiosity still not being satisfied, and trying to see these bodies more closely, the best we can do is to use our reasoning instead of our telescopes, and thereby survey them not 10 times or 100 times closer, but a hundred thousand times and more.<sup>23</sup>

Reasoning, that is to say conjectures, supplements defective telescopes and resolves the contradiction already pointed out by Fontenelle that “all philosophy is founded on two things; an inquisitive mind, and defective sight.”<sup>24</sup> It seems that progress in optics and astronomical instrumentation contributes to a gradual distinction between the three concepts of hypothesis, conjecture, and fiction.

If Huygens undertook to make clear distinctions among the three registers of astronomical discourse, notably the particularly porous boundary between fiction and conjecture, we still must note throughout this work the permanence of *credibility*. In his critique of Kircher, for example, Huygens says that he “cast off the only Foundations of Probability in such matters, which we have all the way made use of.”<sup>25</sup> Situated at the heart of Huygens’s conjecturalism,<sup>26</sup> this notion designates that which approaches certitude asymptotically, whether hypotheses or conjectures. Let us recall the defense of conjecturalism that Huygens places at the start of the *Cosmotheoros*:

If any one therefore shall gravely tell me, that I have spent my time idly in a vain and fruitless 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 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 it self rewards the pains. But there are many degrees of Probable, some nearer Truth than others, in the determining of which lies the chief exercise of our Judgment.<sup>27</sup>

Now, the difference between hypotheses and conjectures is not of kind but of degree. This is why in the *Cosmotheoros* Huygens wonders, “how likely is it that they may be stock’d with Plants and Animals as well as we?”<sup>28</sup>

On the question of inhabited planets, the notion of credibility is crucial, since the internal coherence of the system is the sole means of validating a

conceptual construction that corresponds neither to sense-experience nor to immediate intuition. Not being able to rely on our normal methods of establishing truth as in the case of Saturn's ring, the conjectural construction of the *Cosmotheoros* is cumulative, resulting in a series of conclusions about "planet-dwellers" that are surprisingly audacious: planet-dwellers have feet, hands, a face, and five senses; they are endowed with reason and cultivate the sciences, living in organized society regulated by institutions, protecting themselves from the climate with buildings. They possess the compass and even the principle of the pendulum discovered by Huygens. But far from giving his conjectures the fragile status of fables, Huygens insists on a necessary chain from one conjecture to another. The text progresses by transforming each conjecture into an affirmative proposition that can then itself be the basis for a new conjecture: "there would be no doubt I say, but that their Reason here must be exactly the same, and go the same way to work with ours, and that what's true in one part will hold true over the whole Universe."<sup>29</sup>

Thus the *Cosmotheoros* explores the productivity of an internal credibility capable of producing a series of conjectures based on a solid foundation. But the assimilation of conjectures to fictions is rejected and strongly condemned in a text whose aim is to be conjectural but nonfictional; the notion of credibility is used in this text in an explicitly nonfictional sense. Huygens affirms the possibility of constructing a credible textual machine that describes another machine and its cosmological model as well as including a redescription of the world. Such "credibility" is remote from its use in literature, where the credible becomes the central element in the poetics of the novel.<sup>30</sup> In the literature of the time, the sealing off of the story from external reality in order to focus in its own internal credibility aims at the creation of an autonomous universe that has to be recognized as fiction. The "truth-making" aspect of the credible novel that characterized the eighteenth century aimed more at keeping the writing of fiction within a coherent fictional sphere rather than at establishing a referential link to the world. In the domain of natural philosophy, on the other hand, the credible, in the sense of the "probable," is what makes it possible to differentiate between a believable statement and a fictive statement. The end of the century witnessed a specialization in the two usages of the term *vraisemblable*. While the literary credible tends to designate the internal coherence of an independent fictional world, the credible as Huygens conceives it aims at both internal coherence and a vision that approaches the real.

From the formal point of view of the written form, though, there is no contrast between how truth is conveyed by novelists and in the theoretical

works of the learned. This formal resemblance between the production of both scientific truth and the truth of novels leads to the scientific discourse's need to reaffirm its necessary specificity. Between the *Systema* of 1659 and his last text, the *Cosmotheoros* of 1698, Huygens's position hardened with respect to the proper use of hypotheses in astronomy. Attacking the fictional usage of hypotheses that he denounced in Fontenelle especially, he again uses notions of credibility and harmony to justify the "credible conjectures" of his *Cosmotheoros*, thus contributing to the distinction between conjecture and fiction at the end of the century.

### Conjectural Construction in *Cosmotheoros*: Credibility and Necessity

"Why not?" Fontenelle's conjectures relied upon a method of metaphorical association, because for him there was no possible demonstration of the plurality of worlds. Huygens contests this when he proposes to deduce these worlds using "philosophical reasons":

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?<sup>31</sup>

Although the final rhetorical question seems to paraphrase the "why not?" of Fontenelle, it has particular characteristics. Huygens is not opening the field to the imagination, but founding an argument *a contrario*: since it is difficult to deny a certain conjecture, therefore it must be true. Whence the multiplication of double negations, or negations of the improbable: "it cannot really be doubted that . . ." "it does not appear to me improbable that. . ." By making the credible the very register of scientific discourse, Huygens authorizes the use of a discourse that is *both* conjectural and scientific. Consequently, the first part of *Cosmotheoros* takes the form of a vast conjectural construction, the principal stages of which are worth recalling.

Huygens starts by asserting the impossibility of resolving the issue of the existence of inhabitants on other planets by means of observation: "But we were always apt to conclude, that 'twas in vain to enquire after what Nature had been pleased to do there, seeing there was no likelihood of ever coming to an end of the Enquiry."<sup>32</sup> Most of the workings of the machine of the world are invisible. How then can one make the reality of the machine of the world be seen without resorting to visions such as Fontenelle's? Huygens resolves the problem of transdiction<sup>33</sup> using a logical demonstration. Since

he cannot *show* the inhabitants of other planets, the astronomer *demonstrates* their necessity:

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?<sup>34</sup>

Huygens's conjectural demonstration relies on a limited number of principles, constantly reaffirmed in the course of the text: divine providence, the harmony and perfection of the world, and the equal dignity of the planets:

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.<sup>35</sup>

Thus the first part of the *Cosmotheoros* can be summarized as a simple syllogism. Through providence, our Earth is the best of all possible worlds. This same providence has created all planets equally perfect; hence the beauties and perfections that we know on Earth must also exist on other planets:

'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 the Nature and Circumstances of that Planet which we see before our eyes, we may guess at those that are farther distant from us.<sup>36</sup>

This method of analogy takes the place of defective vision, and through reasoning it approaches what one does not perceive by sight. Huygens produces a meta-physics, in all senses of the term. If the result of such a method is an indistinct vision, a provisional approximation, it is also a necessary result in order to complete the image of a perfect cosmos. Huygens's method combines credibility and necessity.

This systematic approach of demonstration by logical steps is then applied to a variety of questions: the utility (thus the perfection) of each earthly attribute serves as proof of its existence in other worlds, according to the principle of equality mentioned above. This second premise (equality among all

planets) is what authorizes the conjectural picture of the other planets. Because being equal does not mean being the same, Huygens proposes successive pictures, offering subtle variations on the same perfect model. For each planet he describes its equivalent of perfections found on Earth, showing how each one's particular characteristics modify the elements necessary for perfection. Every conjecture is the result of an intersection between a strictly metaphysical deduction (or in the case of providence, a theological deduction) and known astronomical data, such as the distance of each planet from the Sun, the duration of its orbit around the Sun, its size, and presence or not of satellites.

With this in mind, the disconcerting mode of expression found in the *Cosmotheoros* can be more clearly understood. It is both an attack on the use of imagination in the service of cosmology, as seen in fictional discourse from Kepler to Fontenelle, and an attempt to make other worlds seen with the mind's eye.

If many questions remain open, or without a definitive answer, this does not prevent Huygens from pursuing his construction by speculating ever more precisely about the characteristics of planet-dwellers: "Our next Enquiry shall be concerning those Animals in the Planets which are furnish'd with the greatest Reason, whether it's possible to know wherein they employ it, and whether they have made as great advances in Arts and Knowledge as we in our Planet."<sup>37</sup> The principle that the planets all share the same level of perfection allows us to infer what is for him of supreme value: the practice of astronomy. The development of conjecture continues: "This supposition of their Knowledge and Use of Astronomy in the Planetary World, will afford us many new Conjectures about their manner of life, and their state as to other things."<sup>38</sup> With these two principles, he can begin to populate his world by running through the whole of creation, successfully positing the necessary existence of planetary flora and fauna, then the existence of thinking and observing beings. According to a frequent procedure, the move from one conjecture to another is established as necessary, even if the conjectures themselves are merely credible. It is not the conjectures themselves but their logical sequencing that is established as necessary.

However, the incomplete character of such a scheme did not escape Huygens, who was very aware of its fragility:

But I know some will say, we are a little too bold in these Assertions of the Planets, and that we mounted hither by many Probabilities, one of which,

if it chance to be false, and contrary to our supposition, would, like a bad Foundation, ruin the whole Building, and make it fall to the ground.<sup>39</sup>

Like a house of cards or an architectural work, the stability of the whole depends on the robustness of each element. Here is where Huygens differs most from Fontenelle, who (as we saw) made the reversibility of conjectures the very principle of their articulation. With Huygens, by contrast, the credible is not accepted as a conceptual tool without the condition that it is continually tested to see if it still holds. Hence his desire to constantly buttress conjectures using a recurrent line of argument that reinforces the initial strategy of deduction:

For supposing the Earth, as we did, one of the Planets of equal dignity and honor with the rest, who would Venture to say, that no where else were to be found any that enjoy'd the glorious sight of Nature's Opera? Or if there were any fellow-Spectators, yet we were the only ones that had dived deep into the secrets and knowlege of it? So then here's a proof not so far fetch'd for the Astronomy of the Planets, the same which we used for their having rational Creatures, and enjoying the other advantages we before talk'd of, which serves at the same time for the confirmation of our former Conjectures.<sup>40</sup>

Another strategy is to provide support for his construction on the basis of new foundations: "All I have said of their Knowledge in Astronomy, has proofs enough, antecedent to those we now produc'd."<sup>41</sup>

Huygens's cosmology is thus the necessary result of the principles of harmony and equality applied to heavenly bodies as a function of their position in the space of the solar system. Their inhabitants, flora and fauna, the existence of organized societies, the development of science and the arts follow necessarily, but their description is conjectural and can offer only an approximate yet credible vision of a society on Saturn, of astronomy seen from the surface of Jupiter, or of plant life on Mars. Each characteristic of earthly perfection is extended to all the planets by virtue of the universal perfection of the universe. Each belongs by right to the Earth as to the other planets, which are consequently similar but do not look the same, each alike in dignity but not in form, conceivable because logically necessary but not imaginable in their particularities. In short, they are commensurate.

"I think there can be no better, nay no other, than what we here experience."<sup>42</sup> The argument of the *Cosmotheoros* tends to minimize possible difference and to postulate a vast harmony of nature, in the sense of the proportion of parts—the *symmetria* or *commensuratio* of Vitruvius' aesthetic, the impor-

tance of which has already been stressed in Copernican and Keplerian cosmology.<sup>43</sup> This essential commensurability is what prevents the conception of other worlds as being radically different. Differences can be thought of only in terms of form, not of matter. If, for example, the existent state of the “form” of water on Saturn cannot be known, we can conceive of its matter, for it is essentially the same as water on Earth. In Huygens’s logic, the homology of structures containing variation of forms constitutes a philosophical category of the “nonrepresentable yet conceivable.” Contrary to Fontenelle’s centralist cosmology, the ensemble of worlds is not organized into a hierarchy that puts the Earth at the center but into an infinite variation of forms that testifies to the scope of God’s creation.

### Harmony and Hierarchy

As Geoffrey Sutton has shown, the methodological difference between Fontenelle and Huygens stems from their differing conceptions of the hierarchy of planets. For Fontenelle the Earth represents the ideal, perfection, the golden mean—just as at a human rather than a planetary level, it is better to be (like the Marquise) a young and beautiful Frenchwoman, rich and intelligent (Fontenelle, always polite, never provides an explanation of what the less than perfect might be like). For Fontenelle, the imaginary voyage leads to a hierarchy of planets in which the Earth, at an ideal distance from the Sun, has the prime place. With Huygens, on the other hand, the harmony of the world implies a commensurability of planets. Reevaluated by the standard of the solar system, the Earth is only one planet among others—an inversion of perspective upon which Huygens insists:

Now can any one took upon, and compare there Systems together, without being amazed at the vast Magnitude and noble Attendance of there two Planets, in respect of this little pitiful Earth of ours? Or can they force themselves to think, that the wise Creator has disposed of an his Animals and Plants here, has furnish’d and adorn’d this Spot only, and has left all those Worlds bare and destitute of Inhabitants, who might adore and worship him; or that all those prodigious Bodies were made only to twinkle to, and be studied by some few perhaps of us poor fellows?<sup>44</sup>

The cosmic perspective, a lesson in humility enables us to reevaluate the Earth: tiny in the context of the solar system, no better than other planets, the Earth cannot claim any privileged position. Geoffrey Sutton’s analysis is illuminating. He shows how Fontenelle’s centralist and monarchist concep-

tion is transposed to his hierarchical vision of the solar system; conversely, the radical egalitarianism among planets upon which Huygens founds his own cosmology reflects his attachment to the political organization of the Republic of the United Provinces, in which each state keeps its sovereignty.<sup>45</sup> It is in effect the absolute equality of planets that provides one of the essential philosophical premises of Huygens's conjectural construction, while Fontenelle describes a diversity of planets founded on a strictly hierarchical conception of social classes and countries. Huygens, in other words, tends to think of the difference in a way that is neither hierarchical nor discriminatory.

This radical reevaluation of the size and the value of each planet is enabled in the *Cosmotheoros* by means of the theoretical rather than the fictional journey. Both a narrative and an optical distortion, the voyage achieves the re-establishment of proportions. Like an anamorphosis, revealed in its correct form when it is observed from the proper angle, the solar system as unveiled by Huygens claims to be the most faithful representation possible of the size, distance, proportion, and value of planets. Thus, Fontenelle's hierarchization of planets (as a function of their distance from the Sun) is contradicted by a new hierarchy of size illustrated by scale diagrams. The four diagrams in Huygens's text thus each offer the same demonstration: the Earth is only one planet among others.

After the first part of the treatise has made it possible to assert the equality of planets, the reevaluation of size enables an argument a fortiori. Since the Earth is tiny with respect to other planets, everything leads us to believe that it is not the only one endowed with the perfections of inhabitants, fauna, and flora. The optical transformation effected by the theoretical voyage serves a radical transformation in the value and place of each planet within the solar system:

What a wonderful and amazing Scheme have we here of the magnificent Vastness of the Universe! So many Suns, so many Earths, and every one of them stock'd with so many Herbs, Trees and Animals, and adorn'd with so many Seas and Mountains! And how must our wonder and admiration be increased when we consider the prodigious distance and multitude of the Stars?<sup>46</sup>

If one can observe variations among planets, they pertain to the forms of things, not their nature. Hierarchy is replaced by a harmonious—and harmonic—conception of the world:

It's the same with Musick as with Geometry, it's every where immutably the same, and always will be so. For all Harmony consists in Concord, and Concord is all the World over fixt according to the same invariable measure and proportion. So that in all Nations the difference and distance of Notes is the same, whether they be in a continued gradual progression, or the voice makes skips over one to the next.<sup>47</sup>

As with Kepler, Huygens's cosmology is founded on the concept of the harmony of the universe. Albert Van Helden explains that "the *Cosmotheoros* is a composition in which the variations on the theme of the 'harmony of the system' are explored at length, showing how deeply this notion was embedded in Huygens's thought."<sup>48</sup> Again as for Kepler, the concept of harmony is indissolubly linked with the notion of divine Providence. Plants and animals, the "ornaments" of all the planets, signal the grand plan of the divine Architect, in operation on Earth as it is in the cosmos. In this sense, the cosmology of Huygens is also a work aiming at beauty; it is a philosophical and aesthetic conception of the cosmos.

Thus the *Conversations* and the *Cosmotheoros* present two alternative models of the mental construction of new worlds, two distinct defenses of the plurality of worlds, as well as two opposing political models. With Fontenelle, conjecture entails the free creation by the imagination of images, using the diversity—and inequality—of the peoples on Earth as its model. With Huygens, conjecture is the result of a strict use of philosophical deduction on the basis of principles considered as certain, enabling a conception of planets peopled with inhabitants different from mankind but alike in dignity and in perfection. We see that this is less a divergence between "literature" and "science" than between two attitudes towards what cannot be seen. For the former, the inability to see something licenses the creation of visions and fictions, while for the latter, it necessitates the elaboration of reasons. We perceive here two conceptions of the imagination that run throughout the century, either as a faculty for representing the unknown as seen with Fontenelle or as a uniquely composite and therefore limited faculty as seen with Huygens.<sup>49</sup> Huygens's imagination must admit defeat when faced with the unimaginable:

But when we come to meddle with the Shape of these Creatures, and consider the incredible variety that is even in those of the different parts of this Earth, and that *America* has some which are no where else to be found, I must then confess that I think it beyond the force of Imagination to arrive at any knowledge in the matter, or reach probability concerning the figures of these Planetary Animals.<sup>50</sup>

The refusal to resort to the fictional imagination leads Huygens to a surprising return to our own world. Thanks to the commensurability of the essential similarity of planets, he seeks in our world the universal characteristics that inform him about other worlds in a discourse that is less astronomical than ethnological:

The Animals then in the Planets must make use of one or more of these, like our amphibious Birds, which can swim in Water as well as walk on Land, or fly in the Air; or like our Crocodiles and Sea-Horses, must be Mongrels, between Land and Water. There can no other method be imagin'd but one of these.<sup>51</sup>

Running up against the impossibility of knowing the individual characteristics of other worlds, Huygens's cosmology takes the form of a hallucinatory enumeration of the perfections of our own world in a reiteration of Renaissance ethnographic and cosmographic discourses expanded out to the level of the universe:

Among the Beasts we may take notice of the great distance between the Horse, the Elephant, the Lion, the Stag, the Camel, the Hog, the Ape, the Porcupine, the Tortoise, the Cameleon: in the Water, of that between the Whale, and the Sea-Calf, the Skait, the Pike, the Eel, the Ink-Fish, the Pour-control, the Crocodile, the flying Fish, the Cramp Fish, the Crab, the Oister, and the Purple Fish.<sup>52</sup>

The infinite variety of our world becomes the model for the infinite variety of plants and animals of other worlds, for "be they never so many, there is no reason to think that the Planets cannot match them."<sup>53</sup>

On the difficult issue of the appearance of inhabitants, a matter that even Fontenelle's visions did not manage to grasp, Huygens's method makes him reject the portrait of the Other as absurd:

For when I do but represent to my Imagination or Eyes a Creature like a Man in every thing else, but that has a Neck four times as long, and great round sawcer Eyes five or six times as big, and farther distant, I cannot look upon't without the utmost aversion, altho at the same time I can give no account of my Dislike.<sup>54</sup>

To imagine a thinking being different from us, he says, amounts to a grotesque disfigurement. Here we see the argument underlying the critique of recourse to imagination and fiction in order to think about what cannot be seen. From this critical, and deliberately skeptical, perspective, the imagina-

tion merely reduces the unknown to the known, adopting images of the visible and clumsily applying them to the invisible.

#### ARCHITECTONICS OF THE NARRATIVE

The first part of the *Cosmotheoros* ends with the realization of the impossibility of the encounter with this Other, and even of the cosmic voyage:

We have allow'd that they may have rational Creatures among them, and Geometricians, and Musicians: we have prov'd that they live in Societies, have Hands and Feet, are guarded with Houses and Walls: yet if a Man was but carried thither by some powerful Genius, some *Pegasus*, I don't doubt 'twould be a very pretty sight, pretty beyond all imagination, to see the odd ways, and the unusual manner of their setting about any thing, and their strange methods of living. But since there's no hopes of a *Mercury* to carry us such a Journey, we shall e'en be contented with what's in our power: we shall suppose our selves there, and inquire as far as we can into the Astronomy of each Planet, and see in what manner the Heavens present themselves to their Inhabitants.<sup>55</sup>

However, the tale of the voyage remains present as the underlying structure of the discourse and the spatial organization of succeeding descriptions. This tale, though, as we saw, is not at all fictional, but rather it governs the organizational framework of the discourse. Given such a choice, two questions remain. Why employ such an organizational strategy and, having chosen to employ it, what is the place of fiction (if it has one) in such a conjectural tale?

#### Why the Narrative?

The context of Galileo's trial might have explained the choice of a fictional narrative in the 1630s and 1640s: this was the case for Descartes, who chose not to publish *The World*. The same cannot be said for the *Cosmotheoros*, which was written and published at a time when both Copernicanism and Cartesianism had become the embodiment of orthodoxy among philosophers and astronomers:

Then he (the skeptical reader) may impartially weigh those Answers that *Galileus*, *Gassendus*, *Kepler*, and others have given to all Objections proposed, which have so satisfied all Scruples, that generally all Astronomers now adays are brought over to our side, and allow the Earth its Motion and Place among the Planets. If he cannot be satisfied with all this, he is either

one whose Dulness can't comprehend it, or who has his Faith at another man's disposal, and so for fear of Galileo's fate dare not own it.<sup>56</sup>

Neither the Earth's motion nor its relative position among the six known planets was at issue. They were well-established theories, widely accepted, that anyone could defend without fearing the persecution suffered by Galileo at the beginning of the century. By the time Huygens was writing, the use of the tale and figuration characteristic of the *Cosmotheoros* could not be explained by prudence. The narrative structure was chosen because it was appropriate for the task of representing the Copernican cosmological model.

In the wake of cosmographers, astronomers resorted to the narrative, and more precisely to the travel narrative that enables space to be organized in an ordered progression. The narrative becomes a strategically chosen discursive scheme of the new cosmology, especially with Kepler. At the outset of the *Cosmotheoros*, Huygens describes his approach as a journey, tracing the metaphor of paths and obstacles surmounted, just as Kepler had done in the opening of *Astronomia Nova*:

But a while ago thinking somewhat seriously of this matter (not that I count my self quicker sighted than those great Men, but that I had the happiness to live after most of them) methoughts the enquiry was not so impracticable, nor the way so stopt up with Difficulties, but that there was very good room left for probable Conjectures. As they came into my head, I clapt them down into common places, and shall now try to digest them into some tolerable Method for your better conception of them.<sup>57</sup>

It is important to understand the role played by the narrative form not only in establishing the theoretical space necessary to make the Copernican system convincing, but also to make the concrete space of this system comprehensible. In other words, it is important to understand the narrative strategies used to try to reconstruct the system of the world on new Copernican foundations. We saw with Kepler that through the narrative the Copernican hypothesis could be invested with an ontological weight that mere geometric modeling could not confer. We can now turn to the scope of the tale to demonstrate truth and its architectonic function.

### The Spatial logic of the Narrative

Huygens was a Cartesian. Van Helden reminds us that the explanation for Saturn's ring owed much to the physics of whirlwinds.<sup>58</sup> Over the course of

his career, however, Huygens distanced himself from Cartesianism,<sup>59</sup> in his poetics (inseparable from his method) even more than in his physics. At the end of his life, what Huygens denounced as Cartesian “fiction” has become his anti-model:

Mr Des Cartes had found the way to make his conjectures and fictions be taken for truth. And what happened to those who read his Principles of Philosophy was something similar to those who read the Romans, who are pleasing and make the same impression as veritable histories. The novelty of the figures of his little Particles and whirlwinds is charming. It seemed to me that when I read this book *The Principes* for the first time that everything was going as well as possible, and I believed when I found some difficulty in it, that it was my fault for not fully understanding his thinking. I was only 15 or 16 years old. But having since discovered from time to time things that are visibly false, and others that are scarcely plausible, I have considerably revised my opinion, and at the present moment I find almost nothing of which I can approve as true in all of physics, metaphysics, or meteors.<sup>60</sup>

For Huygens, freeing himself from Cartesianism was freeing himself from its seductive fictions. The critique of the fictional register at the start of the *Cosmotheoros* should be understood in the framework of Huygens’s rejection of Cartesianism as fiction and of fiction as a Cartesian mode of writing. If the *Systema* of 1659 still presented Saturn in the framework of Cartesian cosmology and physics,<sup>61</sup> the *Cosmotheoros* of 1698 claimed an alternative cosmology, not (totally) Cartesian.<sup>62</sup>

As we saw, the formation of Huygens’s conjectures differs from the creation of fictions in that instead of resorting to invention by the imagination, he uses philosophical deduction based on a limited number of principles established as true. But this definition might also suit the method Descartes adopted in *The World*. To understand Huygens’s attempt to distinguish himself from the Cartesian cosmological enterprise, this definition needs to be recast. The major difference lies, it seems, in the logic of the narrative. Descartes had adopted a chronological logic; the reconstruction of *The World* is a second genesis, as readers at the time indeed noted.<sup>63</sup> In this sense, Cartesian cosmology is essentially a cosmogony, an attempt to explain and conceive of the world on the basis of its origin. Huygens denounces this approach:

But indeed all the whole story of Comets and Planets, and the Production of the World, is founded upon such poor and trifling grounds, that I have often wonder’d how an ingenious man could spend all that pains in making such fancies hang together. For my part, I shall be very well contented, and

shall count I have done a great matter, if I can but come to any knowlege of the nature of things, as they now are, never troubling my head about their beginning, or how they were made, knowing that to be out of the reach of human Knowledge, or even Conjecture.<sup>64</sup>

Against the profoundly fictional character of Descartes's logic of time, Huygens adopts a logic of space. Rather than showing his reader an imaginary reconstruction of the genesis of the world, he outlines a voyage in the concrete space of the solar system. One might object that the spatial voyage is no more achieved than the return to the past, that Huygens's cosmology is thus as fictional as Descartes's cosmogony, and that his journey through space is only a metaphor. But we must remember the particular status of the cosmographic metaphor in the astronomical discourse of the seventeenth century. The travel narrative, as we saw in the two preceding chapters, is an essential element in the actualization and *physicalization* of the astronomical discourse. With Huygens the narrative is not physical but geometric: it enables the synchronic description of the machine of the world.

In this sense, the use of verbal tenses is illuminating. The tense used in the conjecture is most often the future indicative, which is not only a sign of its status as credible, but the sign in the text of a sort of chronology of conjecture, of a methodological temporality. If a first thing is posed, then a second thing will flow from it. The future is the sign of logical implication in the text and just as in the experimental narratives of the same period it indicates a sequence of two events.

A logical narrative rather than a chronological one, the *Cosmotheoros* offers a unified perspective and the circular narrative of a geometric journey through a harmonious cosmos, confirming Archytas's saying

that tho a Man were admitted into Heaven to view the wonderful Fabrick of the World, and the Beauty of the Stars, yet what would otherwise be Rapture and Extasie, would be but a melancholy Amazement if he had not a Friend to communicate it to.<sup>65</sup>

The narrative appears as a step that logically and necessarily follows from a discovery. After the solitary marveling at the novelty, the astronomer aspires to communicate his knowledge. The Aristotelian category of the wondrous (or the marvelous) only reaches its full epistemological scope when it is shared and narrated. But the reference to Archytas should alert us: Huygens is not looking to Lucian or Plato for the legitimation of his enterprise but to a mathematician. Again we find again the recurrent motif of optical displace-

ment that has made it possible for the cosmic journey to offer a Copernican description of the world (and especially of the double motion of the Earth). But this motif is systematized in order to allow the reorganization of the whole solar system. For Huygens it is less important to defend the Copernican cause—which is no longer disputed—than to offer his own, complete, theory of the cosmos. The cosmic narrative, untainted by fiction, offers the theoretical framework for a reorganization of the space of the solar system on the basis of a perspective that, while useful, is also quite extreme, namely, the view from Saturn, the most distant planet then known. In Huygens's treatise, Saturn, on the margin of the solar system, replaces the formerly central viewpoint of the Earth. Rather than envisage the solar system seen from its center, now occupied by the Sun, or from the Earth, now decentered, or even from a traditional imaginary point of view, the "Olympian viewpoint" of the maps of the heavens, Huygens offers a moving viewpoint from within the system, a visual journey.

#### Images, Models, and Machines: Representing Copernican Space

In order to understand the use made of the narrative form—even if reduced to its simplest spatial expression—we have briefly to touch on earlier representations of Copernican space. It seems that Huygens's text combines the text with a tradition of cosmological modeling in order to explain it.

Between Copernicus and Huygens, the conception of cosmic space underwent profound modifications, even within the camp of the Copernicans. From the uniform circular motion of the stars in their orbits that Copernicus still maintained, in Kepler's text we progress to a nonuniform motion of heavenly bodies in elliptical orbits.<sup>66</sup> From the diagrammatic representation of a regular model, seen in the figures of *De Revolutionibus*, we move onto an irregular model that takes into account the proportional sizes and distances of planets in the solar system. But how can the principle of harmony be kept while taking into account all the recently discovered irregularities of movements and distances?

Such was the problem that Kepler endeavored to resolve by imagining a complex fabric of the world, the *Machina coelestis* (see Fig. 1), his famous geometric model explaining the distances between the six planets by five regular polyhedrons fitted into each other. This engraving, presented in the *Mysterium Cosmographicum*, provides a good point of departure for understanding both the specific problems of this new organization of the cosmos, and the

combination of different architectonic techniques, including the narrative form, in the construction and development of the new model.

In the Keplerian model of the machine of the world (a perspective drawing of a *solid model* to be constructed, rather than a simple astronomical diagram), Kepler attempts to explain the irregular distances between planets by using a geometric model that is perfectly logical and harmonious. Geometry provides a rationale for otherwise inexplicable distances; in other words, it supports the “harmony of irregularity.” Kepler replaces the old organic nature of the Ptolemaic system of layered concentric spheres, sometimes compared to an egg, with the mechanism of a machine. It is striking to realize that someone who had contributed to shattering the idea of solid orbs uses in turn a solid and material image to present his own model; as he shatters the solid orbs, Kepler replaces them with an architectural visualization of purely geometric orbits.

The materiality of their pictorial representation serves an explicitly architectural function, to support a tottering edifice. This engraving borrows from the iconography of astronomical instruments that Tycho Brahe, the teacher of the young Kepler, had developed to an unprecedented degree. As Martin Kemp has shown,<sup>67</sup> the relation that is suggested between the cosmos and the instruments that serve to observe and measure it, is more than a simple analogy. There is a striking homogeneity between the machines one uses to see, describe, and measure the universe and the universe itself represented as a machine. The drawing of a physical model alleviates the difficulties inherent in pictorial representation in two dimensions of so complex a schema. Kepler’s model allies the tradition of the iconography of scientific instruments, the Mannerist taste for strange and precious objects (Kepler had proposed making a goblet in precious stones able to contain different liquids separated by solids), and an architectonic conception of Creation as a construction. As Nicholas Jardine has shown, constructing a model was useful for astronomers at two levels: as a pedagogic instrument of demonstration, but also as a gift for patrons. The performance of constructing a machine that is simultaneously harmonious, aesthetic, and credible makes it the ideal gift within the courteous aesthetics of Mannerism.<sup>68</sup> It is from this perspective we have to understand the “gift” that Huygens makes to the Medicis when he dedicates his *Systema Saturnium* to Prince Leopold, offering him not only a book but an ingenious machine.

How can one represent the complex movements of stars, given the impossibility of a simple diagrammatic representation? Following on from Kepler’s

*Machina coelestis*, in his “Planetary,” Huygens presents a cosmological model that he describes and then travels through in a “tale” of space. The description of the synchronic functioning of the model in space provisionally resolves the difficulties of representing the new space for two reasons: first, because the narrative form possesses specifically architectonic virtues; second, because it can take the place of an inadequate diagrammatic representation to enable a mental representation of complex spatial configurations. With Huygens, the narrative form is what will enable a more refined and precise representation of the new cosmological structure.

### Voyage through the Planetary

As Huygens suggests, the correct approach is to start from his Planetary and thence try to understand the link between the narrative form and its mechanistic conception of the universe—in other words, the link between the tale and the machine.<sup>69</sup>

This Planetary is not a static cosmological model but a moving machine incorporating wheels and gears that he also called his “Automaton.” As in the case of Saturn’s ring, the simplicity of the machine validates it as a representation of the world.

And now because 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, I shall here first of all draw two Figures. The first is a Description of the Orbs the Planets move in, in that order that they are placed round the Sun, drawn as near as can be in their true Proportions, like what you have seen in my Clock at home. The second shows the Proportions of their Magnitudes in respect of one another and of the [12] Sun, which you know is upon that same Clock of mine too.<sup>70</sup>

The role of illustrations in the text is to make the “Idea of the world” present in the reader’s mind. This is scarcely a Platonic idea since it is composed of wheels and gears. At the start of the text Huygens places two diagrams (representations of the Planetary, which is to say representations of a representation), thereby indicating a theoretical program as much as a geographical itinerary. Two figures are necessary to offer the graphic equivalent of the cosmographic model in three dimensions. By means of this reduced model of the universe, the reader is led step by step along a theoretical journey. The

structure of the text corresponds to different places that Huygens labels instructively and explains sequentially. The examination of the “astronomy” of each planet—that is to say the spectacle of the universe as it appears from each planet’s perspective—begins with the lesser planets, then gradually moves away from the Sun, goes past the Earth, and reaches Saturn, the furthest planet. On the return trip, Huygens looks at the satellites of Saturn and Jupiter before coming back to the Moon.

The terms used by Huygens confirm the demonstrative role of this *dispositio*: mentioning the process of the “organization” of his thoughts, the astronomer explains that the final text is a retrospective composition that corresponds both to the order of the planets and to the imaginary voyage from one to the other. As we see, the text follows an itinerary that is both logical and spatial, the narrative defining itself more in relation to space than to time. By adding the narrative form to the model, the former elucidates the latter and produces a mental representation that would be difficult to conceive by simply looking at a diagram or a solid model:

Which we can't possibly do in so small a space as one of our Leaves will but admit of, because the Bodies of the Planets are so prodigiously small in comparison of their Orbs. But what is wanting in Figure shall be made up in Words.<sup>71</sup>

This narrative strategy proves particularly useful in the case of the new system, in which each step of the voyage involves a change of perspective and a total change in the configuration of the stars in relation to each other. The narrative involves traveling around within the cosmographic model in a way that makes it possible to describe the complex relative motions of the planets, which cannot be grasped by pictorial visualization alone, as shown by the changing descriptions of the particular view seen from each planet. From Saturn, the view of the ring should be particularly spectacular, as Huygens imagines it, or rather deduces it:

From all other parts it is continually to be seen for fourteen years and nine Months, which is just: half their year. The other half it is hid from their view. Those then that dwell between the Polar Circle CD, and the Equator TV, all that time that the Sun enlightens the part opposite to them, have every night the sight of a piece of it HGL, much in the shape of a shining Bow, which comes from the Horizon, but is darken'd in the middle by the shadow of *Saturn* GH, which reaches most commonly to the outermost rim of it. But after midnight that Shadow by little and little begins to move towards the right

hand to those in the Northern, but the left to those in the Southern Hemisphere. In the morning it disappears, leaving behind it a likeness indeed of a Bow, but much paler and weaker than our Moon is in the day-time.<sup>72</sup>

The description of this surprising spectacle is accompanied by a diagram. Thus two types of representation are combined, the textual description of a spectacular vision and the visual representation by diagram. It is paradoxical that the capacity to express the spectacular seems reserved to words, whereas the directly visual tool, the diagram, is limited to a representation that offers information rather than conveying sight.

Imitating the structure of the universe, the structure of the text sketches a new space that is both geometric and concrete. As we have seen, Huygens's model is not fixed but a machine, a construction whose mobile elements act upon each other and alter their position in time and space. Because it allows us to follow the stages of the itinerary, ideally the narrative form enables the description of processes such as transformation, giving an image of a complex machine whose various elements are permanently undergoing variations. While the planetary models used in the teaching of astronomy until Kepler were conceived as fictions that allowed predictions to be made,<sup>73</sup> Huygens's model strives to be a representation of the physical space of the solar system. The model shows what cannot be seen. Combined with the narrative, it makes it possible to go beyond what had previously been impossible to measure and thereby to establish the commensurability and harmony of the world.

### Conceptual Personae and Ambassadors

The strict equality of planets makes it possible for the demonstration to unfold and to attribute equivalent characteristics to each one, each being neither inferior nor superior to any other. Huygens's cosmos is not a succession of identical Earths, but a series of variations that display both equality and variety. Hence conjectures result from the intersection between a given model—the Earth—and a principle of equality that presupposes equivalence to (but not similitude with) this model. We understand that the characteristics that Huygens attributes to each planet can only be abstract. With Huygens, there is no giant vegetation as with Kepler, still less are there inhabitants described in the manner of Godwin or Cyrano. The inhabitants, since they must logically exist, remain unrepresentable and are merely conceivable. In other words, they escape the imagination but can be grasped by thought. This is

how we must understand Huygens's rejection of fictions and "visions," as well as his insistence on the strictly "philosophical" nature of his treatise.

Huygens is writing against the cosmological imagination of the fictions studied in the preceding chapters; by excluding fiction, he solves the problem of the use of the literary and the fictional in thinking about the plurality of worlds. To establish the credibility of his philosophical and astronomical conjectures, Huygens must distinguish himself from this fictional heritage. This approach appears clearly in the reprise of many motifs inherited from the *Dream*, which is followed by a refutation of those of Kepler's conjectures judged to be "most fanciful": a radical separation of what can be accepted as a viable method with which to construct credible conjectures from what is dismissed as the false product of the misguided imagination.

However, it is the motion of the traveler through space that defines and marks the stages of an enlarged cosmic space. If this journey, and hence its narrative form, remains a constant characteristic of cosmological texts, the textual status of the traveler changes considerably from Kepler to Huygens. This modification of the figure of the traveler—first a fiction, then a metaphorical figure, and finally a simple conceptual support—confirms the shift from a fictional cosmological discourse to a nonfictional discourse (or at the least, one granting a reduced place to fiction). If the figuration by astronomers of Saturn and the narrative of a circular journey from Mercury to Saturn and back to Earth does paint the New Copernican World with a vivacity that the traditional astronomical genres did not permit, this is not sufficient to make the *Cosmotheoros* a narrative fiction. The astronomer's "figures" of Saturn are not, in fact, fictional characters.

The example of the Lunarians will illustrate this important distinction. Huygens, having observed the work of previous generations, can affirm that no living creature is to be found inside the Moon. Despite a strong inclination in favor of affirming the existence of "planetarians" on each planet, the first premise of the syllogism on which the whole *Cosmotheoros* is based, the astronomer is forced by his observations to conclude that the Moon does not contain either water or an atmosphere, and consequently contains no life.<sup>74</sup> Yet this conclusion does not prevent him from using the perspective of lunar inhabitants to describe the Earth seen from the sky:

This Position of the Moons, in respect of their Planets, must occasion great many very pretty, wonderful sights to their Inhabitants, if they have any: which is very doubtful, but may for the present be suppos'd. An enquiry into our Moon may serve for all the rest. Its Globe is divided into two parts,

after that manner, that those who live on one side never lose the sight of us, and those on the other never enjoy it. Only those who live on the Confines of each of these lose us, and see us again by turns. The Earth to them must seem much larger than the Moon doth to us, as being in Diameter above four times bigger. But the best of it is, that night and day they see it always in the very same part of the Heaven, as if it never moved: some of them as if 'twas falling upon their heads: others somewhat above the Horizon, and others always in the Horizon, still turning upon it self, and presenting them every twenty four hours with a view of all its Countries, even of those that lie near the Poles (I could wish my self in the Moon only for the sight of them) yet unknown and undiscover'd by us. They have it in its monthly Wane and Increase, they see it half, and horned, and full, by turns, just as we do their Planet.<sup>75</sup>

How can we understand the reference to “them” in a treatise that demonstrates the impossibility of inhabitants on the Moon? The “lunarians” are a simple *figuration* of a theoretical position—a *fiction*, so to speak, but of a new kind. They supply a perspective—a strategy to extend our own field of vision—but they are not either *characters* in the literary sense of the term, nor do they represent a serious *hypothesis* on the astronomer’s part. In contrast to the incarnated creatures described by Kepler or Godwin—characters in the sense that they have names, histories, or at least a physical appearance—the inhabitants of the Moon evoked by Huygens are a pure function, a tool in his demonstration—“conceptual personae,” to adopt the expression of Deleuze and Guattari,<sup>76</sup> characters devoid of their costumes and restricted to their function.

In Huygens’s text we already seem to have found several levels of “conceptualization” of figures. The inhabitants of Saturn and Jupiter, considered as credible, constitute a first level: they are both characters (in Huygens’s demonstration) and figures that allow the representation of the perspective from their planet. The second level is that of lunar “Geoscopes,” the fictional (and impossible) inhabitants of the Moon who can see the Earth. A third level of conceptualization is reached when it is no longer a matter of inhabitants but of a simple “Person, disinterested in his Judgment, and equally ignorant of the Affairs of all the Planets,” for if he were “to give his Opinion in the matter, I don’t doubt he would give the cause for Astronomy to those two Planets rather than us.”<sup>77</sup> This allows Huygens to prove by a thought-experiment that the art of astronomy necessarily exists on Saturn. Here it is not conjecture that leads to a thought-experiment, but the thought-experiment that confirms a conjecture.

If the imaginary is excluded, then, it is to better allow its reintegration into the functioning of the scientific imagination, in the sense Gerald Holton gave this term.<sup>78</sup> But the fiction of conceptual personae is signaled by its distinctive traits: it is localized, framed, and controlled. It is localized because it occurs at a precise moment in the discourse and controlled because it functions within rules that are fixed in advance. Huygens's bone of contention with Kepler was that the latter used fiction to create visions in order to confirm the Copernican hypothesis. Huygens differentiates himself from Kepler, reproaching his illustrious predecessor for having exceeded the acceptable limits for the use of the imagination in astronomy.

Indeed, Huygens's lunar inhabitants and cosmic traveler more resemble Maxwell's demon and Einstein's figure of the traveler<sup>79</sup> than they do Kepler's Duracotus or Godwin's Gonsales, the costumed Spaniard. Still, it is tempting to discern a family tree and to pursue the genealogy. Are the conceptual personae of contemporary scientific texts not the heirs of the first travelers of lunar fictions? Do the "delegates" described in the frameworks of meaning found in scientific texts seem akin to the *cosmo-theoros* of Huygens? In Greek, *theoros* refers to the ambassador sent by the city to consult and report back on their answers or on any other secret information. In the *Cosmotheoros* the idea of a secret to transmit to a select audience corresponds to the figure of the ambassador of the Cosmos. Galileo used the same political and travel-related metaphor in his *Sidereus Nuncius* (the Messenger of the Stars) in 1610.<sup>80</sup> We may therefore interpret the recurrent narrative form of the cosmological discourse in semiotic terms. The circular tale put in place by Huygens proceeds from a gradual distancing from the domain of the known, which allows new observations to be reported, while ensuring at each new stage that these new pieces of information are kept and incorporated into a framework. An article by Albert Einstein uses the same strategy for the circulation of information, according to Bruno Latour.<sup>81</sup> With Huygens, the circulation and conservation of information is ensured by the circular structure of the tale, and by the retention of a consistent viewpoint as he passes from one planet to another and from one frame of reference to another.

## CONCLUSION: HYPOTHESES AND NARRATIVES

### Transforming the Cosmological Narrative

Reading the cosmic voyages of Fontenelle and Huygens, one is struck by the contrast with the voyages studied in the preceding chapter. Here there

is neither brutal acceleration nor painful landing on the Moon; Fontenelle's Marquise and Philosopher imagine "they are suspended in the air" while they serenely continue their elegant conversation. Similarly, while Huygens proposes a trip as far as Saturn and back, his trajectory is not slowed by any collision. How can we explain this transformation in the motifs of the cosmological voyage? The *gansas* and flying machines of Gonsales and Dyrcona have given way to a philosophical dialogue in a garden. The unknown celestial space through which brave travelers move has mutated into a distant backdrop for this genteel scene. If one adventures into cosmic space, such a voyage now takes place through thought. The foundational thought-experiment of Descartes's *The World* is renewed and extended in that of Fontenelle into an unveiling of the great machine of the theater of the world, put into a dramatic and narrative form. But it is in Huygens's text that abstraction reaches its summit. In the *Cosmotheoros* there is no longer a Philosopher nor a Marquise, but a simple gaze capable of moving across the machine of the world and describing its changing perspectives. The association of a narrative technique (the geometric travel narrative through the Planetary) and an optical technique (the anamorphosis of the solar system) allows him to construct a heliocentric and nonhierarchical system.

In this shift from the imaginary voyage to the theoretical voyage, these transformations of the cosmological narrative are accompanied by considerable transformations in the mode of expression that affect not only the interaction between fiction and hypothesis but also the narrative form.

### Fiction and Hypothesis

At the end of the seventeenth century, the plurality of inhabited worlds was no longer a story in the manner of Lucian, nor a baroque fiction. The charmingly playful idea had become credible thanks to the development of telescopes and the advent of the new cosmology. It had acquired, in short, the status of conjecture. If Fontenelle chooses to present his conjectures in an explicitly fictional mode, Huygens, in contrast, insists on the systematic and logical nature of his reasoning. The former sees fiction as a useful means for getting at the truth, while the latter carefully removes fiction, preferring to present "credible conjectures." The confrontation between these two texts lets us see a nascent boundary between hypothesis and fiction. At this moment in the history of astronomy, the conjecture of inhabited worlds has the same ontological status as a fiction, insofar as they are both "fabricated."

Huygens aims to differentiate between the two categories through the form and style of his writing as well as his methodology.

My analysis of texts by Fontenelle and Huygens has focused on several levels of figuration that situate the cosmological writings of the century not according to a dichotomy between fiction and nonfiction, but rather on a continuum going from more to less figuration. Over the course of the century, astronomical conjectures are drawn up all along this continuum from fiction to nonfiction, leading to notional and lexical uncertainty. The fragile ontological status of the astronomical hypothesis gave rise to continual fluctuation in the meanings of the terms *fictions*, *fables*, *hypotheses*, and *conjectures*, leading to a need for clarification that became more pressing at the end of the century.

It is possible to see the origins of fiction better when one takes into account notions of credibility, hypothesis, and conjecture in astronomical discourse and how they changed over time. In the various roundabout means used by writers from Kepler to Huygens to explore the cosmos, I have tried to follow the transactions that occurred between these notions. From fiction signaled as being false to a heuristic fiction able to participate in the construction of a theory, the astronomical hypothesis sheds light on the history and genealogy of modern fiction. It is this question that explains why the cosmological tale changed so much after the journeys written by Godwin and Cyrano. It is the defictionalization of the cosmological voyage that enables it to serve as a tool of demonstration, as it does in the theoretical narrative of the *Cosmotheoros*.

### The Machine of the Narrative

Huygens attempts to convince his readers of both the artificial and constructed nature of his astronomical hypotheses and their truthfulness. It is precisely the machines he fabricates, “the artificial representations” of the solar system, that validate the hypothesis out of which they grew. In the *Cosmotheoros*, though, the theory of Saturn’s ring is not a hypothesis at all; it has been confirmed by its definitive integration into a vaster machine. The illustrations attached to the text represent not the system of Saturn, but Saturn in the solar system.

From the *Systema Saturnium* to the *Cosmotheoros*, the level of fiction has changed, but the method of demonstration remains essentially the same; Huygens constructs machines—the model of Saturn’s ring, the Planetary—

whose workings *as machines* guarantee their credibility *as models*. The model of Saturn enables the construction of a credible narrative about the nature of Saturn's revolutions, whereas the Planetary accounts for the complex motion of planets in relation to each other. From the hypothesis of the ring to the credible conjectures of the *Cosmotheoros*, the connected notions of credibility and harmony remain essential to demonstration.

By providing a different textual framework from the conventional order of astronomical treatises, the narrative form abandons the closed and circular structure of the Aristotelian treatise that in turn reflected the closed structure of the Aristotelian-Ptolemaic cosmos.<sup>82</sup> More than being a simple metaphor for the expansion of knowledge, the travel narrative outlines the new space of Copernican cosmology and furnishes the generic cosmographic model used to express news come from far-off space. The role of temporal organisation of the narrative has been stressed by theorists from Ricœur to Genette, but within the sphere of reconstructing cosmological space discussed here the capacity of a narrative for *spatial* organization is just as essential. It seems as if a new space suddenly opened up. The travel narrative helps to signpost this new space, providing the means to traverse it, to measure it, to map and to mark its different regions. In short, it makes it possible for the reader to accept (and even embrace) the mental picture of the universe's geocentric space.

Nevertheless, the type of demonstration used in the *Cosmotheoros* is not always convincing. Even when credible, the astronomical conjectures are susceptible to severe criticism. They are still founded on postulates that have not in fact been demonstrated: the harmony and symmetry of the machine of the world. If the machines constructed by Huygens make it possible to explain "*the harmony and the irregularity*" of the apparent motion of the stars (in Reinhold's phrase) they do not explain why this irregularity is supposed to be harmonious.

In the last third of the seventeenth century, attempts to ground astronomical discourse not on the credible but on a sure and experimental basis proliferated. The use of models facilitated passing from fictions to credible conjectures, but not to attaining certitude. We should go back to Priestley's statement given the epigraph:

All true history has a capital advantage over every work of fiction. Works of fiction resemble these machines which we contrive to illustrate the principles of philosophy, such as globes and orreries, the use of which extend no further than the views of human ingenuity; whereas real history resembles

the experiments by the air pump, condensing engine and electrical machine, which exhibit the operations of nature, and the God of nature itself.<sup>83</sup>

Fontenelle and Huygens build machines of the world, eminently human constructions that Priestley reproaches for their tautological character: cosmological models demonstrate only the ingeniousness of the constructor. To go farther—to pass from fiction to history, in his terms—we have to move from models to instruments, from mechanistic philosophy to experimental philosophy. It is experimentation, affirms Priestley, that makes it possible to go beyond deceptive reconstructions of the world. Only the establishment of new protocols allows us to attain the farthest reaches of the cosmos, not in the fictional mode (even if ontologized and mechanized as we saw in the first section), nor in the hypothetical mode (even if carefully distinguished from fiction)—but rather by means of *proof*. It was this final stage, the passage from the credible (or probable) to the visible, that the astronomers of the last quarter of the century would try to reach. In England, Robert Hooke claimed to dispense with the merely probable arguments advanced by the various cosmological systems of his age. Only experiments made with the aid of optical instruments, he asserts, authorize such an ambition. The use of experiments with increasingly developed instrumental technology would lead to the transformation of the “literary technologies”<sup>84</sup> that had, until then, been the common property and the common history of astronomers, orators and poets.



PART THREE

*Observing Monsters*



*Ne miremur tam tarde erui quae tam alte jacent.* (It is no wonder I took so long to discover what stands so high.)

Seneca, *Quaestiones Naturales*, book 7, chapter 30, 2, quoted by  
Robert Hooke at the beginning of *An Attempt to prove the Motion  
of the Earth by Observation*





## Robert Hooke

### *“The Armed Eye”*

What can be observed? All things remote, affirms Robert Hooke, confident in his optical instruments and their capacity to reach the infinitely large as well as the infinitely small. Throughout his career, the “Curator of Experiments” at the Royal Society ceaselessly and explicitly reasserted that the role of optical tools is to compensate for the weakness of our senses, to aid to “their infirmities with Instruments, and, as it were, the adding of artificial Organs to the natural.”<sup>1</sup> His numerous writings illustrate the central role of instruments in an experimental project that does not distinguish between philosophy and technique.<sup>2</sup> His œuvre occupies an important place in our enquiry, for it undertakes to make visible and readable a cosmos enlarged beyond the known frontiers of the infinitely small and infinitely large. Combining fundamental texts in the realms of microscopy and astronomy, his work is emblematic of an epistemological project that founds the progress of knowledge upon advances in the visible. The second text sponsored and published by the Royal Society,<sup>3</sup> *Micrographia* (1665) illustrates the confidence of the Society in the achievements of natural philosophy by means of instruments. In many respects, Hooke pushed this confidence to its height. The experimental philosophy that he employed did not remain within the boundaries of the probable whose functioning we have described with Huygens and Fontenelle. With Hooke, instruments serve an ambitious program to transform experimental practice in the direction of demonstrations. This practical reform was accompanied by a reform of scientific discourse; Hooke endeavored to guarantee its efficacy as well as its credibility, and shifted scientific discourse from a poetics of the probable to a poetics of proof.

To be interested in the field of the invisible not only risks shifting the frontiers of knowledge, but also questions the very modes of its construction and enunciation. The integration of the invisible into the domain of science poses the question of its techniques, its formulation, and especially

its accreditation. Here we are going to study the competing modes of representation of new worlds discovered by optical instruments on the one hand, and the strategies of authentication and accreditation of these representations on the other. How to reach distant places and how to remove the doubt inherent in such an enterprise? When it comes to the infra-visible of the microscopic world, the question is even more radical and can be reformulated as one of how you give an image to what does not have one, and how you guarantee the veracity of this image obtained by optical instruments. The philosopher Maurice Mandelbaum has called this problem, which was posed in an acute manner in the seventeenth century, the “transdiction problem.”<sup>4</sup> Transdiction means inferring a property of the unobservable on the basis of what can be observed. This formula reflects both the problem of credibility that is posed by the passage from one domain to another (from the visible to the invisible), and the question of enunciation ensuring the reverse transition (from the invisible to the visible).

#### MICROGRAPHIA

Fifty years after the publication of Francis Bacon’s *Novum Organum*, the microscope appeared to be a major conquest on the way to realizing Bacon’s quest; it transformed the inaccessible and unknowable into a new terrain of investigation. The first natural philosophers to use the instrument, such as Robert Hooke and Henry Power, were very aware of the limitations of their predecessors and stressed that they were tackling virgin territory. Henry Power cites an aphorism taken from *Novum Organum* in the preface to his *Experimental Philosophy*:

The knowledge of Man (saith the learn’d Verulam) hath hitherto been determin’d by the view of sight, so that whatsoever is invisible, either in respect of the fineness of the Body it self, or the smallness of the parts, or of the subtilty of its motion, is little enquired; and yet these be the things that govern Nature principally: How much therefore are we oblig’d to modern Industry, that of late hath discover’d this advantageous Artifice of Glasses, and furnish’d our necessities with such artificial Eys, that now neither the fineness of the Body, nor the smallness of the parts, nor the subtilty of its motion, can secure them from our discovery?<sup>5</sup>

The microscopic world revealed by the microscope is a terra incognita that experimental philosophers must discover, conquer, and map. Gathered un-

der the heading “Optical Glasses,” the telescope and the microscope were celebrated by Hooke in the same laudatory terms:

The next care to be taken, in respect of the Senses, is a supplying of their infirmities with Instruments, and, as it were, the adding of artificial Organs to the natural; this in one of them has been of late years accomplisht with prodigious benefit to all sorts of useful knowledge, by the invention of Optical Glasses. By the means of Telescopes, there is nothing so far distant but may be represented to our view; and by the help of Microscopes, there is nothing so small, as to escape our inquiry; hence there is a new visible World discovered to the understanding . . . By this the Earth it self, which lyes so neer us, under our feet, shews quite a new thing to us, and in every little particle of its matter, we now behold almost as great a variety of Creatures, as we were able before to reckon up in the whole Universe it self.<sup>6</sup>

The “new visible World discovered to the understanding” is clearly unitary as shown by the use of the singular noun. Of course, the telescope’s entry into science preceded the microscope’s by several decades,<sup>7</sup> but joint investigations into both kinds of invisibles were common. The considerable progress that the two instruments permitted in the domain of natural philosophy was inaccessible to the Ancients, as Henry Power points out:

The want of which incomparable Artifice made them not only erre in their fond Coelestial Hypothesis, and Crystalline wheel-work of the Heavens above us, but also in their nearer Observations of the minute Bodies and smallest sort of Creatures about us, which have been by them sleightly and perfunctorily described, as being the disregarded pieces and huslement of the Creation; when (alas!) those sons of the Sense were not able to see how curiously the minutest things of the world are wrought, and with what eminent signatures of Divine Providence they were inrich’d and embellish’d, without our Dioptrical assistance.<sup>8</sup>

The microscope does more than enable the discovery of a new world; it rectifies an injustice with respect to the minuscule universe, despised in favor of the intrinsically noble objects of study, the celestial bodies. By introducing symmetry between the infinitely distant and the infinitely small, the microscope presaged discoveries just as important as those of astronomy.

## The Galileo of London

When in 1609 Galileo directed his eyeglass toward the sky for the first time, he discovered mountains on the Moon and spots on the surface of the Sun. His *Sidereus Nuncius* opens with a striking description in text and image of an unexpectedly irregular lunar surface. By visual proof Galileo reversed centuries of Aristotelian support of the incorruptibility of the supralunar world. In many respects, Hooke replays at the microscopic level what Galileo had accomplished in the skies. Like Galileo, Hooke discovers a terra incognita; like *Sidereus Nuncius*, *Micrographia* presents a series of spectacular images conceived by means of a new optical instrument and a concerted use of available pictorial techniques. The reference to Galileo appears in the very epigraph of *Micrographia*,

*Non possis oculo quantum contendere Lynceus,  
Non tamen idcirco contemnas lippus inungui.*

You may not be able, with your eyes, to see as far as Lynceus,  
Yet you would not on that account scorn to anoint them, if sore.<sup>9</sup>

Extracted from Horace's *First Epistle*, the epigraph makes a direct homage to the Lynx of Rome, the Accademia dei Lincei, of which Galileo was the most famous member. The homage continues more indirectly in the text and engravings that open *Micrographia*. The first plate can be read as a pictorial citation of Galilean iconography at the microscopic level. Analysis of the text of the two first observations shows several direct references to *Sidereus Nuncius*. The surface of the point of a needle is scattered with "holes," the typographic period is "*scratched and deformed*" as is the surface of the Moon according to Galileo's description. The edge of the razor presents "a multitude of scratches," a "black spot," and seems "a plow'd field, with many parallels, ridges, and furrows, and a cloddy, as 'twere, or an uneven surface:"—again like the surface of the Moon. Here are two extracts taken respectively from *Sidereus Nuncius* and *Micrographia* :

Anyone will then understand with the certainty of the senses that the Moon is by no means endowed with a smooth and polished surface, but is rough and uneven, and just as the face of the Earth itself, crowded everywhere with vast prominences, deep chasms, and convolutions.<sup>10</sup>

The surface of [the point of a needle], though appearing to the naked eye very smooth, could not nevertheless hide a multitude of holes and scratches

and ruggednesses from being discovere'd by the Microscope to invest it, several of which inequalities (as A, B, C, seem's holes made by some small specks of Rust; and D some adventitious body) were casual.<sup>11</sup>

The lexical similarities and the reprise of the structure of the argument, are indices of this unexpected intertextuality. Both authors formulate a paradox, in the strict sense of the word—a reversal of an accepted opinion. In both cases, the surface that one supposed to be smooth is revealed as being dented and irregular. In the engravings Hooke plays most clearly with the Galilean reference, making use of the “pictorial wit”<sup>12</sup> of which he was fond. The typographic period resembles a globe bristling with protuberances—an effect produced by the work of shadows on the right half of the globe, throwing into relief the irregularities, in the manner of Galileo in his engravings of the Moon.<sup>13</sup> The second figure has the form of a large circle that frames the engraving of the razor; the vertical orientation of the blade dividing the circle into a black part and a grayish part evokes the famous engravings of the lunar surface at the start of *Sidereus Nuncius*, especially the description of the irregular meridian of the Moon. This is indeed a “new world” that Hooke is discovering, equaling with his microscope the great work of Galileo, rendering homage to the Florentine astronomer as he reiterates his spectacular gesture at the microscopic level.

More generally, Galileo's enterprise is the implicit frame for the whole work. We find this intertext in the final observations, this time explicitly astronomical. In order to demonstrate the power of his instruments, Hooke offers a new observation of the Pleiades (another Galilean object par excellence, already taken as an example in *Sidereus Nuncius*), which allows him to unveil a multitude of stars of which Galileo was ignorant. The Florentine master is not just equaled but surpassed on his own ground—astronomy.

The final observation (Fig. 2), supposed to fill the “void” left by the Pleiades in the upper left corner of the plate, is the ultimate proof of the instrumental mastery of the Curator: he is studying in detail a “point” on the surface of the Moon. Figure X represents this point according to Hevelius (the Mons Olympus), figure Y the same point according to Hipparchus, and figure Z reveals what Hooke sees in this point: valleys and hills, a whole lunar landscape of craters and mountains. Thanks to exceptional enlargement, figure Z refutes and corrects figures X and Y. Thus Z is the final letter, the final figure, as well as the ultimate demonstration of the superiority of Hooke's instruments. But Hooke off-handedly offers this astronomical observation:

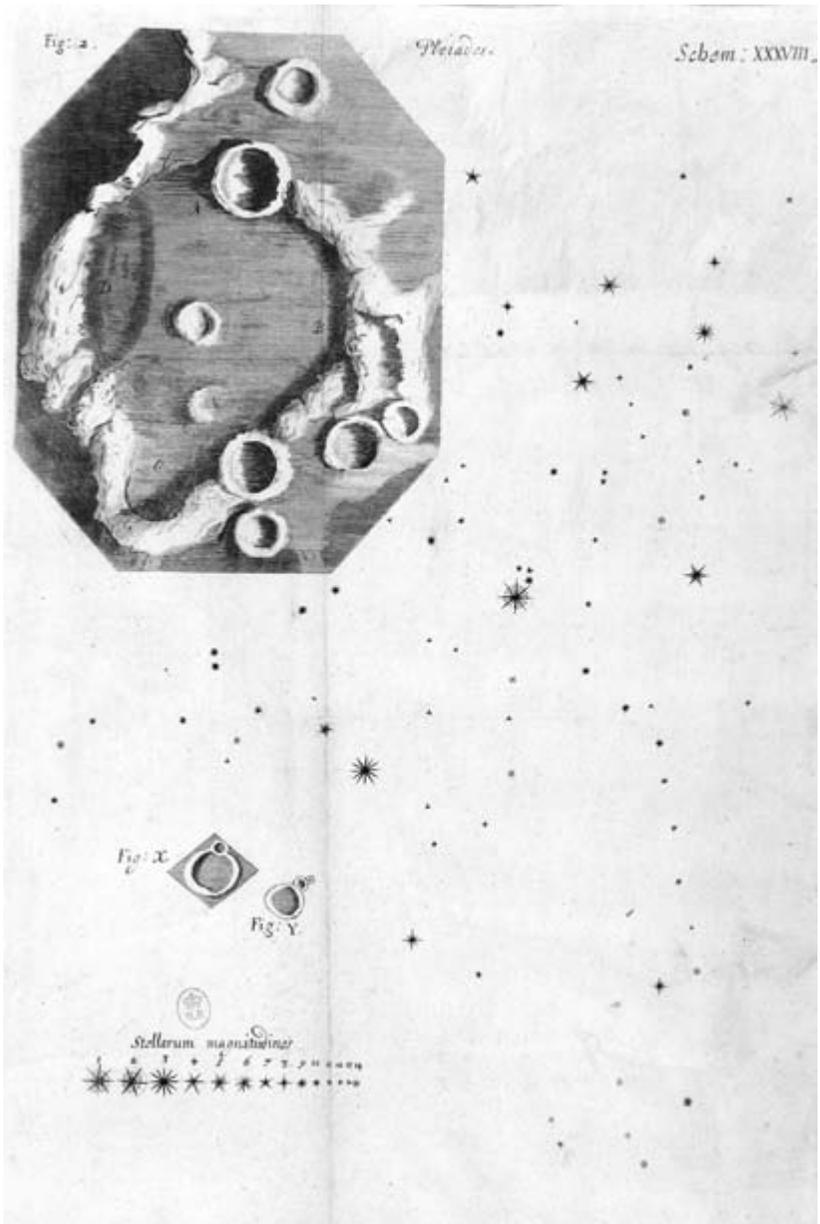


FIGURE 2 \* Hooke, *Micrographia*, scheme 38.

Having a pretty large corner of the Plate for the seven Starrs, void, for the filling it up, I have added one small Specimen of the appearance of the parts of the Moon, by describing a small spot of it.<sup>14</sup>

Adding a word or thought to a text that is already complete is a rhetorical technique to draw emphasis to the addition. Hooke's final observation is as a perfect hyperbaton. The advocate of the use of visual images rather than metaphorical images was obviously himself a master of rhetorical figures.

A principle of coherence emerges from the sequence of plates that unites the microscopic world and cosmological distances. This coherence is both structural and pictorial; as John Harwood explains, it connects "the first observation (the point of a needle) and the last (the Moon as a point in space)."<sup>15</sup> This coherence among different scales is reinforced throughout the book by Hooke's habit of playing with pictorial conventions. For example, the typographical period, represented by a circled point in the first plate, is simultaneously a globe. In the Pleiades plate, the various stars appear as points, according to the same convention of the circled point. The symmetry is perfect: the point is a globe, the stars are points, and everything is just a matter of scale.

### The Alphabet of Nature

The comparison of two scales, however, has implications more important than a simple analogy between the microcosm and the macrocosm. While symmetry already existed in the medieval tradition of correspondences between microcosm and macrocosm, as the dual epigraph of the *Astronomiae instauratae mechanica* by Tycho Brahe indicates magnificently—the chiasma *suspiciendo despicio* ("by looking upward, I look downward") and *despiciendo suspicio* ("by looking downward, I look upward")—, the new symmetry established by optical instruments seeks less for correspondences than for a continuity between the two systems. The symmetrical effort<sup>16</sup> to extend the boundaries of the visible can be read as the desire to discover the essential structures of matter, especially with Hooke. A cumulative logic fosters the understanding of the shift from one scale to another without disrupting continuity.

As Michael Aaron Dennis has shown,<sup>17</sup> the governing idea of *Micrographia* is the search in the microscopically visible for the paradigmatic forms of nature. The forms discovered in the microscope might offer the elements of a sort of physical geometry,<sup>18</sup> the primitive language that Nature uses to com-

pose our macroscopic experience. The title of the book now becomes clear: *Micrographia* means the writing about the small, but also small writings. Hooke seeks in the elementary figures of Nature an elementary and divine language:

Who knows but Adam might from such contemplation, give names to all creatures? If at least his names had any signficancy in them of the creature's nature on which he impos'd it; . . . And who knows, but the Creator may, in those characters, have written and engraven many of his most mysterious designs and counsels, and given man a capacity, which, assisted with diligence and industry, may be able to read and understand them.<sup>19</sup>

We see here the fascination with a “real language,” which John Wilkins championed and which Hooke was the only member of the Royal Society to adopt.<sup>20</sup> *Micrographia*, in this sense, does not just sketch a minuscule cosmography but tries to draw a whole map:

We must first endeavour to make letters, and draw single strokes true, before we venture to write whole Sentences, or to draw large Pictures. And in Physical Enquiries, we must endeavour to follow Nature in the more plain and easy ways she treads in the most simple and uncompounded bodies, to trace her steps, and be acquainted with her manner of walking there, before we venture our selves into the multitude of meanders she has in bodies of a more complicated nature.<sup>21</sup>

Several metaphoric threads are woven together here. One notable one is the geographic metaphor of the “meanders” and “treads” and “steps” of Nature, where the microscopist “ventures,” reminds us that this is indeed the exploration of an unknown country of undetermined topography. To the topical metaphor of the Book of Nature is added the metaphor of a vast tableau, a superimposition characteristic, according to Svetlana Alpers, of the cartographic art that was then developing.<sup>22</sup> It is not only a matter of decoding this book and this tableau but also of reproducing them. To follow in the footsteps of Nature is a teaching of Bacon that Hooke applies to the letter. The double metaphor, scriptural and pictorial, of letters and traits that one has to know how to read and trace, follow and reproduce, enables us to grasp how in Hooke, Nature and the registering of it are articulated. One has to imitate to understand. The relation is cartographic, to the extent that it is the scrupulous pictorial reproduction of each detail (each elementary letter and trait) that subsequently enables embracing in a single gaze the observed

object and thus grasping it in both senses of the term. In short, Nature herself supplies the tools for her elucidation.

Fernand Hallyn has shown the centrality of letters in the construction of a theory of the infinitely small. Atomism, he proposes after Michel Serres, undoubtedly found in the analogy of the alphabet a seminal schema. He shows how Lucretius' *De rerum natura* replays, illustrates, and also incarnates this fertile analogy:

To be sure, Lucretius did not invent his atomism. But his poem re-enacts the invention for its reader and, as such, it is revealing for the thought process in which it was invented and developed. Indeed, Lucretius' text illustrates the analogy by applying its principle to itself. The *De rerum natura* does not simply state a comparison. . . . Playing constantly with anagrams, paronomasias and other related figures, the text of *De rerum natura* itself enacts graphically and phonetically the model to which the comparison refers semantically. It performs the analogy.<sup>23</sup>

We find in *Micrographia* this same interplay among letters, the elementary forms of nature, and the materiality of the book. The link between the former, the "alphabet of the real," in Philippe Hamou's felicitous expression,<sup>24</sup> and the use of letters in engravings is not fortuitous. The forms revealed through the microscope represent the "real" alphabet utilized by Nature to compose the book of the world. This is a conception of Nature that Hooke shares with many of his contemporaries.<sup>25</sup> From the Book to the book of the world, then from this book to the book we are reading, letters indicate a path—a *deixis*—that guarantees the permanence of information from one domain to another. In fact, the insistent *deixis* of Hooke's book does not permit any inattention or ambiguity. Each described element is immediately referred to a lettered pictorial element. Hooke's letters are a recurrent metaphor and an indication of the structure of the book as well as the structure of Nature. Writing up the small reiterates the small writings of Nature, in a constant to-and-fro that guarantees the deictic power of the lettered image.

In order to decode the alphabet of Nature, Hooke searches in the microscopic world for recurrent motifs that might be interpreted as a primordial natural language. This is why he constantly stresses the relations among various encountered forms, "so conspicuously *various* and *curious*," while they "arise onely from three or four several positions or postures of Globular particles."<sup>26</sup> The first observations of natural objects (cork, carbon) all reveal

the existence of “microscopic pores,” sometimes called “globules,” which Hooke considers to be the first level of matter. The apparently infinite diversity of natural forms thus has a common and definable origin, most often globular.

From the emergence of this elementary globular form up to the complex structures of “animated bodies,” Hooke conceives the structure of his book as the result of a cumulative knowledge of forms, a “Pyramid of natural knowledge.”<sup>27</sup> Such paradigmatic research, while it exceeds the admitted and immediate goal of *Micrographia*, produces a constant effort of synthesis and systematization. Stylistically, it manifests itself by the progression in the use of comparisons in the course of the book. To a certain extent, we find the Cartesian practice of macroscopic comparisons aiding the description of microscopic objects. But as the stock of observations increases, Hooke tends to replace these external comparisons with internal comparisons. Comparisons to macroscopic mechanisms give way to references to previous observations. Thus the bee’s sting, which reveals a mechanism very comparable to that of the stinging nettle, confirms the explanation of how a sting works: a tube deposits the poison under the skin. Comparable or identical textures are found among apparently very different matters and kingdoms—for example, sponges, mushrooms, and leather. By revealing recurrent structures, these internal references to the microscopic world tend to make the infinitely small a structured and organized world with its own mechanisms, which have only to be unveiled in order to be imitated.

#### Praise of the Minuscule

While he inscribes the invisible world among the “new worlds” of seventeenth-century science, Hooke at the same time stresses its specificity and value, which is not easy when it comes to the tiniest and most common fauna and flora, and so he has to accomplish a radical inversion. The invisible world, he explains, is the most unforeseen and most spectacular of new worlds, to the extent that it contains the unknown and the novel inside what we think we know the best. Thus the invisible world is not just a new unknown world to discover; it is our own world that must be rediscovered.

To his contemporaries’ attempts at an impossible chorography of planets, Hooke replies by unveiling with a flourish the fauna and flora of the microscopic world. The theatrical coup of the shift to visualization merits examination. As Lorraine Daston and Katharine Park have shown, one of the strat-

egies of the new science is to arouse wonder and then curiosity in a sequence of “philosophical passions,”<sup>28</sup> and *Micrographia* is exemplary in this respect. To make commonplace plants and insects the site of discovery of the new, the rare, and the uncommon (according to Bacon’s injunction in the *Novum Organum*)<sup>29</sup>—that is the project and success of *Micrographia*.

The preface is intended to confer grandeur on what only possesses smallness by building on paradoxical praise, which lauds what ordinary opinion deprecates. A facetious genre in fashion in the century (we remember Kepler’s praise of the snowflake), paradoxical praise signals the author’s linguistic mastery and guarantees his belonging to the community of fine minds (the “Wits”). Ordinary substances (cork, cloth, and wood) and common arthropods (fleas, lice, spiders, flies, and gnats) parade under Hooke’s microscope. Such objects oscillate between mundaneness and repulsiveness. The rhetorical strength of *Micrographia* lies in their transformation into remarkable, surprising, and extraordinary objects—comparable to “the greater and more beautiful Works of Nature.” The preface thus ends with a rhetorical twist: “a Flea, a Mite, a Gnat” are no less valuable than “an Horse, an Elephant, or a Lyon.”

The rhetoric and paradoxical praise that are in the preface are then repeated on the scale of the whole book, becoming a rhetoric of wonder produced by the engravings and commentaries. When he wishes to draw attention to mold, Hooke presents it like an exotic and rare plant, and the trivial becomes wonderful. This process was of the utmost importance for Hooke as for all the “fellows”: the second official publication of the Royal Society aimed to persuade the English Restoration society that the New Philosophy was tackling the most vital intellectual, social, and technical issues. Hooke had learnt to captivate large and diverse audiences when speaking before the members of the Society in Gresham College: indeed, Margaret ’Espinass notes that there were twice as many nonspecialist fellows as natural philosophers in 1663.<sup>30</sup> Hooke is thus structuring his book with a rhetoric of wonder that he had tried and tested in front of both laymen and specialists. The microscope brings about a reversal of values in both a literal and a figurative sense. It makes despicable objects worthy of admiration and tiny objects grandiose. For both the experimenter and the reader, the images and pictorial reproductions lead to a double “enlargement,” both literal and symbolic, that echoes the polysemy of the expression “magnifying glasses.” To magnify something is to enlarge it but also to make it magnificent.

### *Micrographia* as a Wonder Book

Hooke's microscope reveals a surprising, invisible world that thanks to the visual emotion it arouses, pertains to the aesthetics of wonder. This aspect of Hooke's natural philosophy has been the subject of many debates and a recent reevaluation by historians of science.<sup>31</sup> As Michael Hunter has shown, Hooke is an exemplary witness to the permanence of a spirit inherited from natural magic and a taste for wonder, at the same time as he develops a critique of any occult explanation of natural phenomena.<sup>32</sup> Poetic analysis of the text confirms this interpretation, detecting a clear filiation with "wonder books"—a medieval tradition that lasted until the seventeenth century. These books were catalogues of strange phenomena and proposed to explain the secret properties of animals, plants, and minerals.<sup>33</sup> From this tradition of books of marvels, Hooke retains the paratactic construction (each observation functions as a closed descriptive unity) and the logic of the itinerary<sup>34</sup> (from the point to the star). The collections of marvels also share with *Micrographia* three essential characteristics: a rhetoric of unveiling, a pedagogy of pleasure, and the central place given to iconography.

In order to dramatize *Micrographia's* revelations, Hooke first of all redefines tiny objects as secret ones. The preface underlines the invisibility and inaccessibility of a microscopic world that can only be revealed by instruments. He thereby appropriates the aura of mystery that had always surrounded "wonder books" since the medieval tradition of the *De Secretis Naturae*—attributed to Albertus Magnus—and attaches it to the new philosophy, a philosophy capable of explaining the secret mechanisms of nature. But for this new epistemology, secrets and mysteries are only rhetorical means. All Hooke's endeavors aim at stripping off the occult qualities of nature and bringing to light its hidden causes. As he writes in the Preface, instrumental observation gave him "some reason to suspect, that those effects of Bodies which have been commonly attributed to qualities, and those confessed to be occult, are performed by the small machines of Nature, which are not to be discerned without these helps, seeming the mere products of motion, figure, and magnitude."<sup>35</sup> And this revelation is entirely due to the microscope, for it both unveils the wonders of "the small machines of nature" and naturalizes them.<sup>36</sup>

Wonder books were usually intended for leisure and pleasure, as were the travel tales and chivalric romances they were often associated with. But their writers always reminded the reader that their works were instructive as well as agreeable. In *Micrographia*, Hooke constructs a similar pedagogy of plea-

sure. He often points out the pleasure afforded by the observation of nature's secret interiority and compares the "satisfaction of finding out new things" not only to the "contentment of contemplation, but even to that which most men prefer of the very Senses themselves."<sup>37</sup> And his successive observations do indeed suggest the sensual pleasure of discovery—a pleasure that can be seen in the aestheticized vocabulary of his descriptions. He describes the wing of a fly poetically:

Those small parts are not onely shap'd very much like the feathers of Birds, but like those variegated with all the variety of curious bright and vivid colours imaginable; and those feathers are likewise so admirably and delicately rang'd, as to compose very fine flourishing and ornamental paintings, like Turkie and Persian Carpets, but of far more surpassing beauty, as is evident enough to the naked eye, in the painted wings of Butterflies, but much more through an ordinary Microscope.<sup>38</sup>

There is no need to gather such things in Cabinets of Curiosities, for the "Cabinet of Nature" contains the most incredible marvels: for example, sand is as varied in form and color as precious stones,<sup>39</sup> and seeds are veritable jewels:

We come at last to the Seeds; and here indeed seems to be the Cabinet of Nature, wherein are laid up its Jewels. The providence of Nature about Vegetables, is in no part manifested more, than in the various contrivances about the seed, nor indeed is there in any part of the Vegetable so curious carvings, and beautifull adornments, as about the seed; this in the larger sorts of seeds is most evident to the eye; nor is it less manifest through the Microscope, in those seeds whose shape and structure, by reason of their smalness, the eye is hardly able to distinguish.

Of these there are multitudes, many of which I have observ'd through a Microscope, and find, that they do, for the most part, every one afford exceeding pleasant and beautifull objects. For besides those that have various kinds of carv'd surfaces, there are other that have smooth and perfectly polish'd surfaces, others a downy hairy surface; some are cover'd onely with a skin, others with a kind of shell, others with both, as is observable also in greater seeds.<sup>40</sup>

The engravings' graphic precision is also intended to produce this kind of erotic pleasure.<sup>41</sup> Indeed, the central position of illustrations is another characteristic that *Micrographia* shares with wonder books. The latter mostly contained illustrations revealing monstrous births, and often developed

closely related themes of generation, reproduction, and sexuality. The controversy surrounding Ambroise Paré's text, *Des monstres et prodiges*, shows that this book—amongst other abundantly illustrated books bearing on the same topics—was considered to be poorly veiled pornography.<sup>42</sup> Though we cannot accuse Hooke of similar intentions, we can point out that the association of detail and pleasure, very frequent in *Micrographia*, partakes of the contemporary eroticization of sight.<sup>43</sup>

The precision of the Curator's accounts—both in his text and in his illustrations—does of course set his work well apart from its popular ancestors. Nevertheless, both genres clearly share a taste for rarity and singularity, and a rhetoric designed to arouse curiosity and astonishment in the reader. But unlike the wonder books that it sometimes resembles, *Micrographia* refrains from calling its extraordinary creatures monstrous. On the contrary, we are asked to admire the most ordinary creatures.

Along with the aesthetic gains of magnification came its persuasive power. By enlarging the object observed, the microscope permits a change in scale and provisionally transforms the relation between observers and observed. It is precisely this phenomenon that Swift was to exploit in *Gulliver's Travels*. The fascination of the images in *Micrographia* comes in part from the fact that they place the reader (after the observer) before an unknown creature by transporting them to its own scale. The pictorial techniques serve this effect of a confusion of scales: the drawings are presented as decontextualized on plates that give no indication of scale and no caption. One has to refer to the text, sometimes far away, to discover what it is. By passing from the microscopic to the macroscopic scale, the images rival those of the cosmographers and surpass those of the astronomers. Where the chorography of the lunar landscape ran up against the imprecision of observations (were the dark spots seas or ditches?), Hooke unveils a landscape, a flora, a fauna, and even (a frightening encounter) a fly whose head, enlarged to the size of a human head, fixes the observer with its eyes of a thousand facets. This frontal view of the head of a fly is one of the most celebrated plates in *Micrographia* (Fig. 3). The "composite eye" is a globe resulting from the assemblage of hundreds of small globes (eyelets). In a more detailed engraving of the same eye (Fig. 4), Hooke tries to show what is reflected in these ocular globes. In each of them, he discovers an extraordinary image:

Every one of these Hemispheres, as they seem'd to be pretty neer the true shape of a Hemisphere, so was the surface exceeding smooth and regular, reflecting as exact, regular, and perfect an Image of any Object from the

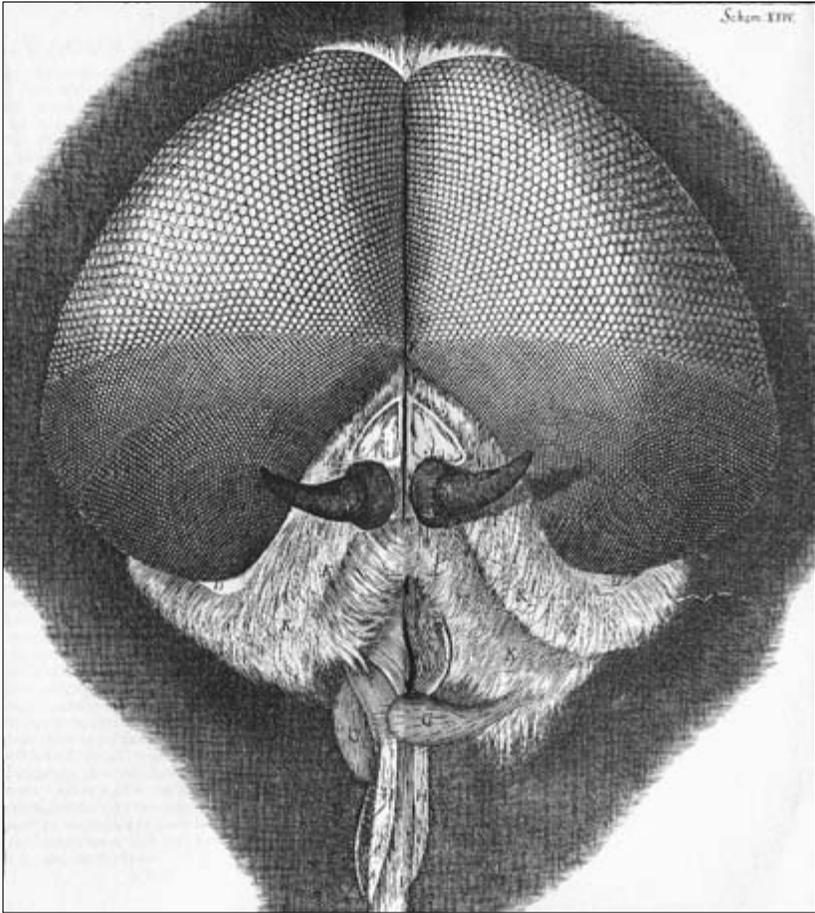


FIGURE 3 \* Hooke, *Micrographia*, scheme 24.

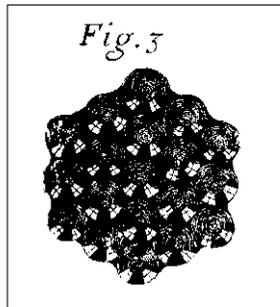


FIGURE 4 \* Hooke, *Micrographia*, scheme 23.

surface of them, as a small Ball of Quick-silver of that bigness would do, but nothing neer so vivid, the reflection from these being very languid, much like the reflection from the outside of Water, Glass, Crystal, etc. In so much that in each of these Hemispheres, I have been able to discover a Land-*scape* of those things which lay before my window, one thing of which was a large Tree, whose trunk and top I could plainly discover, as I could also the parts of my window, and my hand and fingers, if I held it between the Window and the Object; a small draught of nineteen of which, as they appear'd in the bigger Magnifying-glass to reflect the Image of the two windows of my Chamber, are delineated in the third Figure of the 23. Scheme [Fig. 4 of the present volume].<sup>44</sup>

The strangeness of such a description and such an engraving combine the infinitely small and the infinitely distant in a minuscule landscape that evokes the Mannerist miniatures of the day.<sup>45</sup> The nineteen hemispheres of the insect's eye reflect, multiply, and distort the two windows of the room in a kaleidoscopic anamorphosis. The two engravings are worth comparing although they are located several pages apart. In the drawing of the whole head, the observer (and the reader of *Micrographia*) find themselves face to face with the fly. In the miniature landscape of the eye facets, the observer tries to grasp what the insect sees. It is a vertiginous game of gazes.

#### FROM *ENARGEIA* TO EVIDENCE

As experimental science was based on observation, the interest in the "invisible" challenged not only the bounds of knowledge, but also the terms of its construction, practice, and communication. The epistemology of proof for the new experimental science was confirmed by equating the observation of natural phenomena with the visibility of the experimental protocol. The very foundation of the new science would be compromised if doubt were cast upon the absolute visibility of natural phenomena or of experimental protocol.<sup>46</sup> In the case of the microscopic and telescopic, however, observation was an individual experience. The fact that it was impossible to make a public demonstration of what was observed under the microscope and telescope condemned the study of both the extremely small and the extremely remote to the weak stature of a philosophy yet to be proven.

In response to this considerable snare, the fellows of the Royal Society called upon Hooke to create a weekly collection of sketches of his microscopic observation to be displayed in place of the public demonstrations

he led in other natural philosophical domains. Before this happened, however, microscopic inquiry had already been attempted in England by Henry Power, as mentioned earlier, who published his *Experimental Philosophy* one year before Hooke's *Micrographia*. An advocate of what he called the "experimental" method, an avowed Baconian and an admirer of both Descartes and Boyle—the latter having "demonstrated" what the former had only conjectured upon, Hooke's preface states—Power was nevertheless not chosen to provide the first Royal Society's publication on microscopy. This might be explained, I suggest, when one takes into account Power's method and main reference within the text: Thomas Muffet.

Power found most of his images, comparisons, and anecdotes in Muffet's *Insectorum sive Minimorum Animalium Theatrum*.<sup>47</sup> When Hooke turned to the undertaking Power had begun, he used some of his predecessor's findings, methods, and objects of interest. In this process, however, one central feature became dramatically modified: the role, place, and understanding of images<sup>48</sup> in scientific texts throughout the century. As Scott Montgomery explains:

By that time [early seventeenth century], it had become common to include in scientific books many naturalistic drawings, artistic decorations, visual aids . . . , for both the instruction and the entertainment of the reader . . . textuality was no longer sufficient; images now carried a weight of demonstration and evidence.<sup>49</sup>

Power's literary techniques of *enargeia* and Muffet's entomologic drawings were replaced by striking images that combined the accuracy of anatomic iconography and the detail of Flemish painting in the seventeenth century. Hooke had turned images into proof, *enargeia* into evidence.<sup>50</sup>

### Giving Life: Ekphrasis and Naturalistic Drawing

*Enargeia*, in Latin *evidentia*, may be defined as "the power of language to create vivid presence"—the vivid presence of that which is set forth in words.<sup>51</sup> *Enargeia* amounts to visual clarity, immediacy, and strong emotional appeal, while what is represented verbally becomes, as it were, self-evident in the minds of both speaker and audience. "Energetic speech" has a vivid appeal to the senses, in particular to vision. The effect of "seeing," through words, that which is represented is intended to invoke in the reader a sensation of presence at the described scene.

Non enim satis efficit neque, ut debet, plene dominatur oratio, si usque ad aures valet atque ea sibi iudex, de quibus cognoscit, narrari credit, non exprimi et oculis mentis ostendu.

For oratory fails of its full effect, and does not assert itself as it should, if its appeal is merely to the hearing, and if the judge merely feels that the facts on which he has to give his decision are being narrated to him, and not displayed in their living truth to the eyes of the mind.<sup>52</sup>

*Enargeia* is achieved by *ekphrasis*, i.e., a full, exhaustive description that is capable of vividly corporealizing subject matter before the eyes of the reader (“*sub oculos subjectio*”). While Henry Power explored the various textual means of *ekphrasis* (metaphors, apologues, anecdotes), Hooke operated a spectacular shift. He transferred the rhetorical techniques of “giving life” from text to image, from rhetorical figures to visual figures.

In his *Experimental Philosophy*, Henry Power blended literary devices, in particular analogy and literary references, with scientific observation. The work is replete with anthropomorphic metaphor and classical references: the spider is “Ovid’s Lydian spinner” or “noble rival of Pallas,” and the industrious ant boasts “Herculean strength” and moreover acts as a model of morality. The flea is a fortress enclosed in “living walls of Jet,” protected by its “blackish armour-work, shining and polished with jemar’s,”<sup>53</sup> and according to Muffet’s apologue, could tug a chain of gold.

We have heard it credibly reported, saith [Muffet], that a Flea hath not onely drawn a gold Chain, but a golden Chariot also with all its harness and accoutrements fixed to it, which did excellently set forth the Artifice of the Maker, and Strength of the Drawer; so great is the mechanick power which Providence has immur’d within these living walls of Jet.<sup>54</sup>

Power’s apologues and metaphors were mostly provided by references to Muffet’s *Insectorum sive Minimorum Animalium Theatrum*, which he deferentially and frequently quoted. Turning a description into a brief narrative or striking scene was supposed to allow it to become enlivened. Hence the moving image of a flea pulling a golden chariot. Hooke, however, produced such a lifelike effect by drawings of living animals, rather than by lively written description. It has often been noted that Hooke took care to preserve the life of the animals he observed.<sup>55</sup> This formed, I suggest, part of his pictorial strategy. The anecdote of the drunken ant is well-known: a little brandy was the strategy found by the microscopist to keep the ant alive but still while he was drawing it. By contrast, Power recalled, in most of his observations, the dissection he operated before or during his observation. *Micrographia* thus

reveals nature not only as it is, but as it lives. Successive steps<sup>56</sup> of observation were aimed at creating the effect of nature captured true to life, as in a photograph, or rather, as in a Dutch painting.<sup>57</sup> Hooke's animals are "still lives"—rather than "*natures mortes*."

References to classical texts and mythology formed another technique of *ekphrasis*. In classical texts, *ekphrasis* was generally indicated by a double level of description. The descriptive mode was heralded by describing an object that was already a descriptive work of art—painting, shield, or medal—rather than nature itself. This was, I suggest, the effect of Power's mythological references. They set the observations of nature within a profound cultural imagery, enriching each "observation" with many artistic references, whether pictorial or poetic. Accordingly, the mythological comparisons operate as an intermediary level of representation. Hooke's endeavor, however, became precisely to avoid any kind of mediation. It was therefore necessary to free the descriptive mode of observations from any antecedent pictorial and poetic reference. The classical technique of *ekphrasis* to create images through texts was replaced by direct and graphic depiction.

In the preface to *Micrographia*, Hooke calls for a "reform of Philosophy," with the object of purging experimental science of its dependence on the use of the imagination. He proposes that the problematic use of the imagination be replaced by the detailed observation provided by the microscope. With optical technology, Hooke suggests that he is recovering a pre-Adamic vision of the world. In a way he fulfills Bacon's goal of an understanding of the visible world as suspended between two realms of the invisible. Nothing is inconceivable because nothing is truly invisible, or at least nothing will remain invisible for long.<sup>58</sup> After *Micrographia*, it seemed, there was no longer a need to buttress weak analogies with mythological imagery. No more was required than a single observation by the microscope, recorded, in Hooke's words, by "a sincere Hand and a faithful Eye"<sup>59</sup> to unveil the true composition of reality.

Observing the magnificence of the butterfly, Power expressed his admiration for the "Coelstial pencil" capable of drawing such wonderful colors. Drawing was considered a divine gesture. Such a gesture was reenacted by Hooke in his drawings.<sup>60</sup> The demiurgic character of drawings had in fact already been perceived by Power himself, when he announced in his conclusion the continuation of his work by Hooke and Wren: "You may expect shortly from Doctor Wren, and Master Hooke, two Ingenious Members of the Royal Society at Gresham, the Cuts and Pictures drawn at large, and to the very life of these and other Microscopical Representations."<sup>61</sup>

## Making Visible: Anecdotes and Images

The primary difference between Power and Hooke lies in their definitions of visual proof. Paradoxically, the “ocular demonstration” that Power claims to offer is not visible at all: illustrations are few and unconvincing, and the text bears the burden of transmitting a visual experience. In Hooke’s *Micrographia*, on the other hand, the “*ad oculum*” proof is the image itself; it becomes epistemologically necessary if it is to constitute evidence. The microscopist has not only seen; he also shows. Declining the conventional succor of imagination or analogy, Hooke took it upon himself to present his discoveries “directly.” Like a Renaissance voyager, he therefore collected exotic material from the foreign lands the microscope offered and brought them to his people. Hooke’s discourse depends heavily on these drawings, while Power’s reliance upon illustration is marginal compared to his continued use of *ekphrasis*. Hooke himself underlined the change when he referred to Power’s work at the end of the preface: Power’s “design was only to print Observations without Pictures.” Hooke’s arguments make it seem as if the simple act of showing the invisible suffices as proof: *monstration* is in itself a manner of *demonstration*. Hooke’s images defy the dubious science of the invisible; to see a thing is a powerful step toward understanding it. A continual touchstone of his arguments, Hooke’s use of visual images created a link between the visible and the invisible (or at least the infra-visible), by exhibiting an infra-level of visibility.<sup>62</sup> Hooke indeed strove to achieve continuity between the visible and invisible realms, a continuity that could partly resolve the problem of transdiction. As this created an intermediary level between the visible and invisible scales, the microscope validated the shift from one to the other. Predecessors such as Descartes attempted to explain mechanisms of the minute world by analogy to man-made machines;<sup>63</sup> Hooke reversed the process. He could see and describe directly the mechanisms of animals and plants: this is the stinging nettle, he writes, and here are the poison sacs that fill tubular structures depending on the pressure of the hand. Hooke’s reversal of the Cartesian method was strikingly exemplified in his attempt to build new instruments based upon the mechanisms of nature.

Muffet’s work permits, even at the first glance, an evaluation of the gap between the entomological tradition and Hooke’s endeavor. The *Insectorum sive Minimorum Animalium Theatrum* begins with a four-page list of “authors.” The engravings (wooden engravings, allowing for the inclusion of images within the text) are used either as ornaments, as on the title page (Fig. 5), or as taxonomic tools. Most of the book is indeed an entomologic

# INSECTORVM SIVE Minimorum Animalium THEATRVM:

*Olim ab*

EDOARDO WOTTONO.

CONRADO GESNERO.

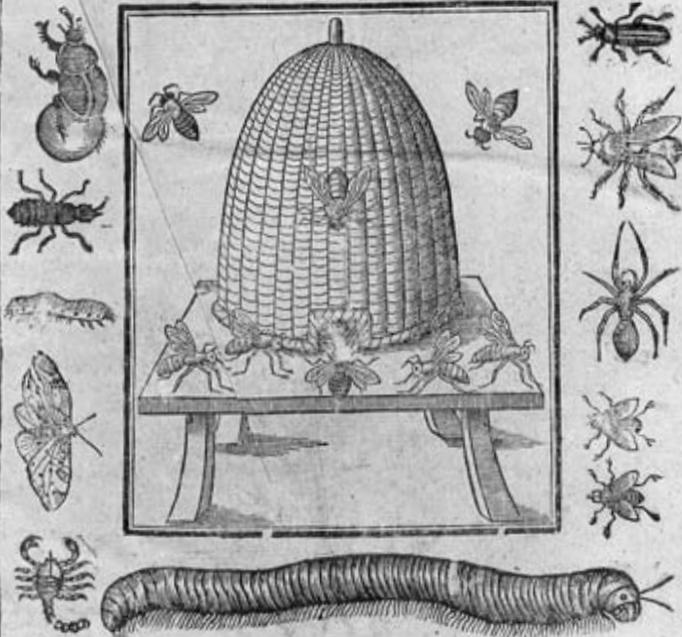
THOMAQUE PENNIO

*inchoatum:*

Tandem

— THO. MUFFETI Londinatis operâ sumptibusq; maximis concinatum,  
auctum, perfectum:

Et ad vivum expressis Iconibus supra quingentis illustratum.



Londini ex Officinâ typographicâ Thom. Cotes. Et venales extant apud Benjam. Allen,  
in diverticulo, quod Anglicè dicitur Popes-head Alley. 1634.

FIGURE 5 \* Thomas Muffet, *Insectorum sive Minimorum Animalium Theatrum*, cover page. London, 1634.

treatise on the model of the *Kunstammer*. The preface acknowledges the model of Quiccheberg's *Theatrum*.<sup>64</sup> Muffet's aim was indeed to classify the visible in a collection rather than to search the invisible. The history, habits, and utility of insects, rather than their "physiological description," remained the main interests. Each observation begins with the names of the insect in each language and proceeds, after a brief "*descriptio*" illustrated by a small engraving, through the comments, tales, and anecdotes accumulated since Virgil, Homer, and Aristotle.

Unlike Muffet in his *Theatrum*, however, Power offered more than mere imagery and taxonomy: he also proposed "experimental" confirmation of his contemporaries' theories, namely William Harvey's theory of the circulation of blood and Descartes's theories. The microscope, he holds, allows us to verify the Cartesian vortex theory, showing microscopic movement within matter.

The innumerable number and complicated motion of these minute Animals in Vineger, may very neatly illustrate the Doctrine of the incomparable Des-Cartes, touching Fluidity: (viz.) That the particles of all fluid bodies are in a continual and restless motion, and therein consists the true nature of fluidity: for by this ocular example, we see there may be an intestine restless motion in a Liquor, notwithstanding that the unassisted eye can discover no such matter, which likewise is evinced by Observ.<sup>13</sup> Of the Mites in Meal.<sup>65</sup>

The "ocular example" of the little vinegar animals is proof of the continual movement within (fluid) matter, hidden from the naked eye but visible under the microscope. Power's plan was to confirm the theories that apply to subjects that escape the human senses. However, to turn this "ocular example" into an "ocular demonstration" required yet another step, which Hooke took: the rationalization of the image.

#### To Prove: From Description to Inscription

What is striking about *Micrographia* is the variety of images and yet the great visual homogeneity produced by respect for the rules of perspective and of graphic norms. For Hooke, it was of course a matter of making the unknown visible, readable, and plausible, and presenting it according to the era's aesthetic norms. But he also benefited from the accumulation of available pictorial techniques. Martin Kemp shows how, during the Renaissance, perspectivist techniques influenced both anatomy (notably Vesalius) on the one hand, and the iconography of scientific instruments (notably Tycho Brahe)

on the other. Hooke inherits both these traditions and combines them. He offers lettered images (like Vesalius) that describe how a machine works (like Tycho), by exploiting all the resources of perspective and of optics as they had been developed by Alberti, and later by Flemish painters.<sup>66</sup>

From anatomy, Hooke takes the association of the aesthetic with the descriptive: the discovery of the infinitely small carries a spectacle comparable to the discovery of the secrets of the human body. We find the same taste for dramatization and an attention to detail signaled by the use of small letters on the engravings, permitting a precise reference to the corresponding passage in the text. Such precision confers on the engravings an unparalleled demonstrative weight and allows the microscopist to offer much more than an indeterminate cartography of the contours of his “new world”—the chorography on top of the geography of this terra incognita.

The science of perspective aims to determine rationally the principles necessary for systematic description. If one follows these principles, then the accurate form, position, and motion of an object can be determined without hesitation on the basis of the correct analysis of the image. With Hooke, perspective serves both the naturalist effect and the geometrization of observed objects, which guaranties the exactitude of the pictorial account and responds to a mechanist conception of microscopic organisms. Hooke’s engravings are not only considerably larger and more precise than Muffet’s; they are also distinguished by their symmetry and regularity. Plants and animals seem like ingenious living machines. An optical comparison thanks to the microscope unveils recurrent geometric figures.<sup>67</sup> While schemas sufficed for Descartes to explain the mechanical *functioning* of invisible phenomena in comparison to known macroscopic mechanisms, Hooke’s project is to reveal extremely sophisticated *natural* machines. We can understand the interest provided by superimposing techniques: the perspectivist techniques of the anatomists, the aesthetics of detail of the Flemish painters, but also the iconography of instruments such as those illustrated in the first plate of *Micrographia*, which shows the microscopes that were used. The link between the small machines of nature and the instruments of observation is suggested visually by their juxtaposition on a single page, but also developed by the hypothesis of the future development of technologies modeled on nature.

Unlike Power and the anatomists who dissected the objects they were studying, Hooke leaves the animals intact (as much as possible): he wants to show how they function as mechanisms. In the case of insects, for example, Hooke tries to understand the articulation and movement of each member in relation to the others, as in the case of the fly’s wing, which he draws both

folded and then unfolded. To understand how the different parts of animals function (wings, pincers, feet) means to have access to an extraordinary repertoire of technologies to perform movements of which humankind's rudimentary machines are incapable: to fly, to swim underwater. We can understand the Curator's enthusiasm when he thought he had found in the microscopic world the secrets of the technical marvels his age dreamed of: a flying machine, a submarine. Alongside the representations of the whole body of the insect, we often find drawings detailing one mechanism, just as in Vesalius there were illustrations demonstrating one structural principle.<sup>68</sup> It is also from anatomical tradition that the lettering of drawings comes; again, Hooke gives them a mechanical turn. The letters not only designate an organ but also indicate a kinetic logic, thanks to repeating the same letter to signify the coordination of two elements in performing a single movement.

The tradition of Dutch painting of the seventeenth century is added to the traditions of anatomic and instrumental iconography. Svetlana Alpers has shed light on the link between Hooke's engravings and Dutch still lifes, especially those of De Gheyn. Hooke himself compared his engravings of seeds of thyme to a "plate of lemons placed in a tiny room." The fertility of combining the two techniques, optical and pictorial, had been formulated a few years previously by Constantijn Huygens (Christiaan's father) with respect to Drebbel's microscope:

Indeed, material objects that till now were classified among atoms, since they far elude all human eyesight, presented themselves so clearly to the observer's eye that when even completely inexperienced people look at things which they have never seen, they complain at first that they see nothing, but soon they cry out that they perceive marvellous objects with their eyes. For in fact this concerns a new theatre of nature, another world, and if our revered predecessor De Gheyn had been allotted a longer lifespan, I believe he would have advanced to the point to which I began to push people (not against their will): namely, to portray the most minute objects and insects with a finer pencil, and then to compile these drawings into a book to be given the title of the New World, from which examples could be incised in metal.<sup>69</sup>

This program set by Constantijn Huygens strikingly evokes the achievement of *Micrographia*. Given both the wonderment of objects discovered through the microscope and the talent necessary to represent them, Constantijn Huygens seems to have prefigured, if not inspired, Robert Hooke.

The latter, as we saw, radically transformed the genre of the *Theatrum* as represented by Muffet into a description of a “new world.” The “finer pencil” of De Gheyn would indeed be used by Hooke with an accuracy permitted by the shift from woodblock engraving to copper engraving. From *Theatrum* to *Micrographia*, the images underwent important modifications in their form as well as their function.

Whereas Power proposed solely textual descriptions of his observations and resorted to poetic imagery, Hooke makes the drawn image the touchstone of his argument. In showing not the invisible (properly speaking) but what one might call the infra-visible of the microscopic world, he descends one level down the scale of the visible, thereby guaranteeing the inference from the visible to the invisible. His use of images is a turning point: that Hooke’s engravings are both technical drawings and naturalist drawings is explained by his allegiance to the Baconian conception of an artisanal god. But in Hooke the comparison reaches a pinnacle: the authenticity of the image serves a radically mechanistic philosophy. We may also detect one of the first uses of *inscription* in the sense given by Bruno Latour:<sup>70</sup> a technique of visualization specific to scientific discourse, providing an internal referent. In effect, the engravings of *Micrographia* are what the text constantly refers to, thus conferring on the techniques of visualization the same role of accreditation that experimentation had with Boyle.<sup>71</sup> Moreover, their inscription in *Micrographia* moves beyond Boyle’s probabilism: the beautiful images gathered in the text are not a herbarium, but data that underpin the reflections,<sup>72</sup> commentaries, and conjectures of the text. While the descriptive techniques of Muffet and Power relied on a cumulative rhetoric and an encyclopedic knowledge to produce a text mingling original observations and secondhand anecdotes, Hooke’s drawings establish a new type of equivalence between nature, engravings, and textual descriptions. Hooke thereby suppressed the mediated scheme of communication that was typical of *ekphrasis* and replaced it with a scheme of equivalence, allowing for the circulation of evidence from nature’s proof to the gaze of the observer, from the senses to the intellectual faculties, from reason to the hand, from the hand to the drawing, all in an uninterrupted chain:

So many are the links, upon which the true Philosophy depends, of which, of any one be loose, or weak, the whole chain is in danger of being dissolved; it is to begin with the Hands and Eyes, and to proceed on through the Memory, to be continued by the Reason; nor is it to stop there, but to come about to the Hands and Eyes, again, and so, by a continual passage round from one

Faculty to another, it is to be maintained in life and strength, as much as the body of man is by the circulation of the blood through the several parts of the body, the Arms, the Flat, the Lungs, the Heart, and the Head.<sup>73</sup>

To the canonic list of faculties (vision, memory of imagination, reason), Hooke adds the hand, which not only fully participates in the construction of knowledge, but is also its first stage—one has to touch the object to understand it—and then an intermediate and recurrent stage in the circulation of knowledge, since the drawing again requires the intervention of the hand. The shift from the conventional use of “perception” to refer to the work of the gaze to the work of the “eye” signals attention to the organic character of perceptive work, putting eye and hand on the same plane. This organicist metaphor had been topical since the Renaissance (for example, Copernicus used it at the start of *De Revolutionibus*),<sup>74</sup> but here it is less aesthetic than organic. The circulation of the blood demonstrated by Harvey<sup>75</sup> in 1628 becomes the central metaphor to describe the circulation of ideas. It is only thanks to a “continual passage from one Faculty to another” that the body of Philosophy is kept alive. Like the circulation of the blood, the circulation of information through all the faculties, including bodily ones, is the precondition of the vivacity of a *natural* philosophy: a study of nature in which the body is fully involved.

The solidity of the chain that depends on each link, the conservation of data *thanks to* the transformations (enlargement, geometrization) necessary for the images to make a proof—this is precisely the definition of what the sociology of science has called a “network.”<sup>76</sup> That you have to transform in order to visualize, to superimpose artificial techniques in order to remain faithful to the object “in itself”: this is what experimentalists were discovering—and also their readers, whether they were alarmed, frightened, skeptical, or enraptured.<sup>77</sup>

#### HOOKE THE ASTRONOMER

*Nec miremur tam tarde erui quae tam alte iacent.* This epigraph by Seneca<sup>78</sup> opens Hooke’s *An Attempt to Prove the Motion of the Earth by Observation*<sup>79</sup> and can be translated as follows: “It is no wonder I took so long to unearth what lies so deep.” Yet the meaning of the sentence should be reversed. In the context of his astronomical tract, Hooke played upon words by using the double meaning of *alte*: high and deep.<sup>80</sup> Thus the sentence should read: “It is no wonder I took so long to discover what stands so high.” At the outset of

his astronomical *Attempt*, Hooke thus indicated that he had somehow found the means to reach and see what had hitherto remained inaccessible. With his telescopic observations of apparent motion in the position of gamma Draconis, he could show and measure the stellar parallax of the globe of the Earth. This was the long-sought-for proof, he asserted, of the motion of the Earth around the Sun.

The *Attempt* was one of Hooke's famous Cutlerian Lectures, delivered in 1670 and published in 1674.<sup>81</sup> The general context of this publication was the debate with Hevelius over the use of telescopic sights in astronomical observation.<sup>82</sup> The controversy had started in 1668 with Hooke sending to Hevelius through Oldenburg instructions on how to build and use a telescopic sight, and Hevelius declaring himself radically against it. It is no coincidence that both the *Attempt* and the *Animadversions On the first part of the Machina coelestis of . . . Johannes Hevelius* (another Cutlerian Lecture) were published in 1674, when the dispute was raging, following the publication of Hevelius's *Machina coelestis* in 1673. Hooke's two Cutlerian Lectures could therefore be construed as a double attack: first, a demonstration of the power of telescopic sight for angular measurement in the *Attempt*, and second, a direct engagement with Hevelius in the *Animadversiones*.

However, the epigraph suggests one should look for a greater ambition. Beyond the immediate context of the controversy over a new type of astronomical instruments, I shall suggest that Hooke engaged with two major astronomical traditions: the Copernican conception of celestial harmony and the Tychoenic procedures of astronomical observation. This section explores Hooke's ambition to radically reform astronomical practice, against the weakness of current cosmological discourse. The textual descriptions of astronomical and microscopic observations were, more than any other, subjected to the problem of proof and veracity. As Albert Van Helden has shown, this was due to the fact that telescopic observation was limited to one single observer, and depended strongly on the quality of the observer's vision as well as the reliability of the instrument:

The problem was that although the observatory could be made into a public space, the actual telescopic observation remained, with some exceptions, a private act. Seventeenth-century practitioners employed a mix of strategies for convincing their public of the truth, or at least trustworthiness of their observations. These included demonstration when possible; witnessing; virtual witnessing by means of pictorial representations; and, most important, appeals to the superiority of one's telescopes. Although they were on the

whole successful in this endeavor, no completely satisfactory method for assuring the reliability of an observation was found until the twentieth century, with the advent of space astronomy.<sup>83</sup>

The use of an archetypal astronomical question—the debate over heliocentrism—was a case in point and a way for Hooke to spectacularly demonstrate the efficiency of his experimental method. No wonder no one succeeded in discovering the parallax before Robert Hooke: he was the first, so he said, to possess a telescope that was sufficiently accurate to allow the required measurements.

### The Question of Harmony

By 1650, Copernicanism had become a broadly accepted hypothesis among British astronomers. The rationale for this acceptance, however, was not grounded on demonstration. While Hooke's prime and most easily identifiable opponents were the anti-Copernicans, I suggest that the Copernicans themselves and their current observational methods and practices were of at least equal concern to Hooke. The beginning of Hooke's *Attempt*, however, announced and circumscribed a seemingly archetypal debate over heliocentrism and geocentrism:

Whether the Earth move or stand still hath been a Problem, that since Copernicus revived it, hath much exercised the Wits of our best modern Astronomers and Philosophers, amongst which notwithstanding there hath not been any one who hath found out a certain manifestation either of the one or the other Doctrine. The more knowing and judicious have for many plausible reasons adhered to the Copernican Hypothesis: But the generality of others, either out of ignorance or prejudice, have rejected it as a most extravagant opinion.<sup>84</sup>

This first paragraph clearly set out the problem: there was no “certain manifestation” to help one decide between the two hypotheses. In this matter, Hooke remonstrated, “the controversy . . . remains yet undetermined.”<sup>85</sup> The heliocentric theory was still as hypothetical as the geoheliocentric hypothesis that Tycho Brahe had upheld and that even such contemporary astronomers as Riccioli still adhered to. Hooke dismissed with equal contempt the illiterate and the anti-Copernican learned men (prejudiced “by nature or education”).<sup>86</sup> But he also moved on to dismiss members of the camp that he himself belonged to: the Copernican astronomers.

On the other side, some out of a contradicting nature to their Tutors; others, by as great a prejudice of institution; and some few others upon better reasoned grounds, from the proportion and harmony of the World, cannot but imbrace the Copernican Arguments, as demonstrations that the Earth moves, and that the Sun and Stars stand still.<sup>87</sup>

Tracing their conviction back to the same prejudices as the anti-Copernicans, Hooke undermined the notions of the Copernicans themselves. His deterministic—and Baconian<sup>88</sup>—interpretation of the origin of men's errors spared neither side. Upon closer inspection, most Copernicans seemed to have embraced heliocentrism for rather inconclusive reasons. While the notion of harmony was initially presented as the most rational of all the Copernican arguments, it soon became clear that it may well itself be another prejudice, albeit widely accepted.

I confess there is somewhat of reason on both sides, but there is also something of prejudice even on that side that seems the most rational. For by way of objection, what way of demonstration have we that the frame and constitution of the World is so harmonious according to our notion of its harmony, as we suppose? Is there not a possibility that the things may be otherwise?<sup>89</sup>

By revealing the somewhat prejudiced belief of the Copernicans in the concept of harmony, Hooke was undermining one of the most commonly accepted foundations of Copernicanism.<sup>90</sup> While accepting the notion of cosmic harmony, Hooke suggested that it might well be different from what was conceived as such:

Though we have a Chimera or Idea of perfection and harmony in that Hypothesis we pitch upon, may there not be a much greater harmony and proportion in the constitution it self which we know not, though it be quite differing from what we fancy?<sup>91</sup>

For early Copernicans, to some extent, the concept of harmony meant the conformity with the principles of Aristotelian celestial motion secured by the elimination of the equant and, more importantly, the commensurability of the planetary spheres secured by identification of the Earth's orbit around the Sun with the deferent of the inferior planets and the epicycle of the superior ones, and the avoidance of the need for an ad hoc cause of such phenomena as retrograde motion and the restricted elongation from the Sun of the inferior planets—a kind of explanatory economy. Hooke seems to have appreciated that this concept might provide good but not perfect

grounds to prefer heliocentrism. Harmony was the best argument in favor of Copernicanism so far. Yet it was a weak one, the Curator argued. For this notion induced an argumentation based merely upon probability that was ineffective against geocentric arguments:

To one I say, thus prejudiced with these and a thousand other fancies and opinions more ridiculous and absurd to knowing men, who can ever imagine that the uniformity and harmony of the Celestial bodies and motions, should be an Argument prevalent to perswade that the Earth moves about the Sun: Whereas that Hypothesis which shews how to salve the appearances by the rest of the Earth and the motion of the Heavens, seems generally so plausible that none of these can resist it.<sup>92</sup>

As long as the debate remained in the realm of probability, the Tychonic Hypothesis may, on the balance of probability, win. The destabilization of the traditional Copernican argument “by way of objection”<sup>93</sup> resulted in a paradoxical defense of the geocentrism of Tycho and Riccioli:

may not the Sun move as Ticho supposes, and the Planets make their Revolutions about it whilst the Earth stands still, and by its magnetism attracts the Sun, and so keeps him moving about it, whilst at the same time [Mercury] and [Venus] move about the Sun, after the same manner as [Saturn] and [Jupiter] move about the Sun whilst the Satellites move about them?<sup>94</sup>

Here Hooke went so far as to provisionally adopt the view of his adversaries. The presentation of the Tychonic hypothesis—which was put forward on the basis that no parallax had been observed—was a way to precisely circumscribe his task: to demonstrate that there was a parallax of the orb of the Earth. To establish the certainty of the Copernican hypothesis, it would be necessary to replace the traditional argumentation based on the vague notion of harmony with physical evidence. Clearly, the discussion had shifted from the question of heliocentrism to another kind of dispute, over the correct method for Copernican astronomers to adopt. In order to eschew any recourse to the prejudiced argument of harmony, Hooke promoted experimental proof:

Probable Arguments might thus have been urged both on the one and the other side to the Worlds end; but there never was nor could have been any determination of the Controversie, without some positive observation for determining whether there were a Parallax or no of the Orb of the Earth.<sup>95</sup>

These two successive sentences clearly mark an opposition between two methods and indeed two discourses. By dismissing probable arguments as

the mere equivalent of anti-Copernican rhetoric, Hooke was pressing for a new method, a new standard of proof, and a new style of writing. Instead of a general concept, he proposed an “*experimentum crucis*,” in this case a controlled observation that would provide definitive evidence. The traditional Copernican argument being disqualified, Hooke presented the measurement of the parallax by a new type of instrument—his zenith telescope—as the only way to reach “unquestionable certainty.”<sup>96</sup>

### *Experimentum Crucis*

Though Hooke’s method and instruments were following from the general Tyconic tradition of observational astronomy, they were in fact radically new. Already in *Micrographia*, Hooke had disapproved of the observational method employed by his fellow astronomers. This method, he explained, allowed them to interpret their measurements at their convenience.<sup>97</sup> In order to put an end to such “curious subterfuge,” Hooke prescribed a rigorous experimental procedure. His aim was to radically reform the current practice, and he developed his undertaking through a detailed experimental narrative that, as Simon Schaffer and Steven Shapin have shown, was aimed both at “virtual witnessing” and at securing the production of matter of fact.<sup>98</sup> In this respect, Tycho Brahe had been a major pioneer and the main advocate of precise methodological procedures through detailed narratives and drawings of instruments. Hooke, however, castigated the astronomical observational procedures of Tycho as well as those of such Tychonians as Riccioli and Hevelius on two counts: the variability of measurements due to the alteration of instruments in wood and metal (“the shrinking and stretching of the materials,” “the bending and warping of an Instrument by its own weight”)<sup>99</sup> and the inaccuracy of the division of quadrants.<sup>100</sup> The uncertainty of material conditions led to the uncertainty of results and to the blockage of the authenticating process:

Their performances thereby were far otherwise then what they would seem to make us believe. . . . it doth necessarily follow that this *experimentum crucis* was not in their power, whatever either Ticho or Riccioli have said to the contrary, and would thence overthrow the Copernican System, and establish their own.<sup>101</sup>

Such therefore was the project Hooke undertook: “to furnish the Learned with an *experimentum crucis* to determine between the Tychonick and Co-

pernician Hypotheses.”<sup>102</sup> Taking the Baconian notion of *instantia crucis*, which Boyle had changed to the phrase *experimentum crucis*,<sup>103</sup> Hooke placed it at the core of an observational procedure based on controlled and accurate instrumentation: the combination of telescopic sight and of extremely accurate measuring devices. Such a procedure would permit the shift from mere observation to *experimentum*—from experience to experiment—thus allowing for the first time the certain determination between the Tychonic and the Copernican hypotheses. Admittedly, Tycho used careful method and good instruments. Yet he had no telescopes. The central notion of “unarmed eye” was what enabled Hooke to assert that he had emulated, indeed surpassed, the grand master of astronomy:

But there was one inconvenience which was worse then all the rest, which they seem not to have been sufficiently sensible of, from whence proceeded all their own mistakes, and their imposing upon others, and that was from their opinion that the sight of the naked eye was able to distinguish the parts of the object as minutely as the limb of the Quadrant (of what largeness soever) was capable of Divisions; whereas 'tis hardly possible for any unarmed eye well to distinguish any Angle much smaller then that of a minute: and where two objects are not farther distant then a minute, if they are bright objects, they coalesce and appear one.<sup>104</sup>

Although the *Attempt* stemmed from a lecture given in 1670, it is clear that, in the text of 1674, the reference to the “naked eye” was a direct rejoinder to the defense of open sight that Hevelius had made in his *Machina coelestis* in 1673.<sup>105</sup> Hooke advocated the development of a second generation of astronomical instruments that combined lenses and measuring devices. Hevelius did not oppose the use of telescopes as such but he was against the use of telescopic sights for measurements. Yet, Hooke answered, the naked eye was a misleading instrument and did not allow reliable measurements: “it proceeds from a radiation (that is, from reflection and refraction together) in the air and in the eye, whereby the body thereof is represented to the naked eye some hundred times bigger then it really is.”<sup>106</sup> Hooke was thus defining the limit to the natural resolving power of the human eye.<sup>107</sup> This deficiency could be repaired only by a prosthetic use of instruments. With optical technology, he suggested that he was recovering a pre-Adamic vision of the world.

Hence I judged that whatever men's eyes were in the younger age of the World, our eyes in this old age of it needed Spectacles; and therefore I resolved to assist my eyes with a very large and good Telescope, instead of the

common sights, whereby I can with ease distinguish the parts of an object to Seconds.<sup>108</sup>

This was both a confirmation and a playful reversal of Glanvill's famous saying: "Adam needed no Spectacles."<sup>109</sup> For Glanvill too had denounced, as Shapin and Schaffer have shown, "both unassisted sense and . . . the hypotheses erected upon unassisted sense," in the context of another astronomical phenomena, the ring of Saturn:

And perhaps the newly discovered Ring about Saturn . . . will scarce be accounted for by any system of things the World hath yet been acquainted with. So that little can be looked for towards the advancement of natural Theory, but from those, that are likely to mend our prospect of events and sensible appearances; the defect of which will suffer us to proceed no further towards Science, then to imperfect guesses, and timorous supposals.<sup>110</sup>

Averse to any sort of "imperfect guesses," Hooke carefully answered in the second part of the tract his own objections to the instrumental procedures of his opponents. Bruno Latour and Françoise Bastide have described the modern counterpart of such circumstantial narratives—the "material and methods" section of modern scientific articles—as an implicit dialogue with potential contradictors.<sup>111</sup> Hooke made explicit the dialogue with former astronomers.

### Hooke's Point and Archimedes's Lever

In order to avoid the mistakes of his predecessors, Hooke started by defining the point of observation: the zenith of Gresham College. This was one crucial episode of the experimental narrative in which the question of refraction was solved. For this protocol avoided both refraction and the variability of instrumental measures:

Having therefore examined the wayes and Instruments for all manner of Astronomical observations hitherto made use of, and considered of the inconveniencies and imperfections of them; and having also duly weighed the great accurateness and certainty that this observation necessarily required: I did next contrive a way of making observations that might be free from all the former inconveniencies and exceptions, and as near as might be, fortified against any other that could be invented or raised against it. This way then was to observe by the passing of some considerable Star near the Zenith of Gresham Colledge, whether it did not at one time of the year pass nearer to

it, and at another further from it: for if the Earth did move in an Orb about the Sun, and that this Orb had any sensible Parallax amongst the fixt Stars; this must necessarily happen, especially to those fixt Stars which were nearest the Pole of the Ecliptick.<sup>112</sup>

The definition of a series of fixed points was the condition for demonstrating the motion of the Earth. The definition of the fixed point of the Pole is what reveals the circular motion of the “Zenith point” of Gresham College, that is, of the Earth. The relationship between the observing point (the Zenith point) and the observed point (the star) was the core of the *experimentum crucis*. This relationship was also reflected in the general structure of the text, which set out from the observer’s position at Gresham College toward the remote point of a star.<sup>113</sup> Interestingly, this literary structure was already implemented in *Micrographia*. Both texts, in fact, endeavored to build a world from a point. In *Micrographia*, the observer starts from the point of a needle and finally reaches the minute points of the fixed stars (both being represented by a point surrounded by a circle). The parallelism between Hooke’s two texts can be traced further. If chemistry was for Tycho a “terrestrial astronomy,”<sup>114</sup> astronomy may well have been for Hooke a kind of “celestial microscopy,” and as such, an enterprise akin to the “experimental method” he had set forth in the preface to *Micrographia*. The essential continuity between microscopical and astronomical endeavors is already manifest in the literary structure of *Micrographia*, and is further reinforced if one considers the similarity of the methodological claims of both *Micrographia*’s preface and the *Attempt*. In many respects, the *Attempt* follows the same line of argument as *Micrographia*; it attempts to transfer visual demonstration from microscopy to astronomy. In that sense, the *Attempt* coheres with the natural philosophical agenda set out in *Micrographia*, in terms of the role that instruments are to play. If Kepler and Tycho used to some extent perspectival and naturalistic representational techniques, it was only to depict their instruments.<sup>115</sup> The other astronomers who used telescopes before Hooke were preoccupied with the vast agenda of mapping the Moon: this was exploration rather than demonstration.<sup>116</sup> In this context, Hooke’s endeavor appears as a pioneering gesture. What he offered was a new perspectival vision of the heavens, in which the point of view of the astronomer, as the Earth rotated around the Sun, became the basis of the demonstration. This was the completion of the project of a “transmigration into heavens, even whilst we remain here upon Earth in the flesh,”<sup>117</sup> as it was formulated in *Micrographia* observation 58.

The point is a crucial element in Hooke's method because it is the basis for an Archimedean use of instruments: "It was therefore my next inquiry where I might fix this Archimedean Engine that was to move the Earth."<sup>118</sup> The roof telescope fixed on the Zenith point literally permitted Hooke to move the Earth. His protocol assembled the elements that, as Bruno Latour has shown, give power to laboratories: change of scale, reversal of forces,<sup>119</sup> inscriptions through instruments. Hooke's Gresham rooms constituted an experimental space where the forces were reversed. In Latour's words,

[laboratories are] technological devices to invert the hierarchy of forces. Thanks to a chain of displacements—both of the laboratory and of the objects—the scale of what people want to talk about is modified so as to reach this best of all possible scales: the inscription on a flat surface written in simple forms and letters. Then everything they have to talk about is not only visible, but also readable and can be easily pointed at by a few people who by doing this dominate. This is as simple and as sufficient as Archimedes's point about moving the Earth and making the weakest the strongest.<sup>120</sup>

Thus, technical observation and reformed astronomical iconography were both to solve the problem of astronomical certitude and to reverse the existing hierarchy of disciplines. Metaphysical and mathematical problems alike would be solved by machines. As Bennett has shown, this was one of Hooke's crucial mottos, and indeed a recurrent plea of his texts. In the realm of astronomy, this was a particularly bold claim, and a way to pronounce the triumph of technicians over traditional astronomer-mathematicians.<sup>121</sup> That Hooke saw his observational method as radically new is clear when he lists an impressive genealogy of astronomers from whom he both followed on and stood out: "I am apt to believe we should make another distribution of their magnitudes [of the fixed stars], then what is already made by Ptolemy, Tycho, Kepler, Bayer, Clavius, Grienbergerus, Piff, Hevelius and others."<sup>122</sup> The reference to a lineage reaching back as far as Ptolemy indicates that Hooke was gesturing toward the tradition of astronomer-mathematicians while asserting the novelty and efficiency of his approach. Central to Hooke's observing method were not just telescopes but telescopic sights, thirty-six feet long (object glass focal length) and micrometer scales, neither of which Tycho or Kepler possessed. If one were to look for a complete physically grounded model of the cosmos, as Tycho and Kepler affirmed they did, then new technological innovation would prove necessary. Hooke finally made his point in a short paragraph at the end of the experimental narrative:

'Tis manifest then by the observations of July the Sixth and Ninth: and that of the One and twentieth of October [1669], that there is a sensible parallax of the Earths Orb to the fixt Star in the head of Draco, and consequently a confirmation of the Copernican System against the Ptolomaick and Tichonick.<sup>123</sup>

### Instruments of Proof

The limitations of Tycho Brahe's instruments, Hooke argued, called for a thorough rebuilding and meliorating of existing instrumentation. The focus on instruments is clear from the engravings accompanying the text of the *Attempt*. The plate combines accurate engravings of the micrometers that permit a measurement of less than a minute and a cross-section of Hooke's observatory. As in the detailed descriptions of microscopes in the preface to *Micrographia*, this drawing makes the telescope an instrument of proof. The large "tubeless" telescope mounted through the roof of Gresham College and made of various glasses composed a complex chain, a vertical "laboratory" pointed at the sky. Thanks to this powerful apparatus, the experimentalist was no longer lost in the infinity of the heavens, but was capable of following the path of the star that was projected onto the limited and controlled space he had equipped with graduation marks.<sup>124</sup>

As Martin Kemp has pointed out, "the appearance of the heavens only becomes eloquent to the enquirer after structure when coupled with systematic measurements in which the eye serves as just one component in an instrumental system of controlled recording over a period of time."<sup>125</sup> This last sentence describes very precisely what Hooke had devised: a way to apply an accurate scale onto the controlled image of the star. As we have seen, the Curator was not content with the traditional astronomical measurements obtained through open sight observations. His procedures, instruments, drawings, and textual descriptions all aimed at "seeing" and showing the star itself, not only its abstract path. Such was the aim of Hooke's undertaking: to make visible through instruments the formerly invisible parallax and to transport into his "laboratory" the inaccessible star. Capturing the image of the star on his observatory table, Hooke could almost scrutinize it as he would have done with a microscope. A double process of projection and magnification allowed the microscopist-astronomer to measure what had hitherto remained invisible. The procedure permitted the transformation, as it were, from *in vivo* to *in vitro*, by capturing and controlling the otherwise fugitive image.

The transfer of mechanistic principles, instrumental procedures, and experimental demonstration from the realm of natural philosophy to the realm of astronomy aimed at “the true perfection of Astronomy.”<sup>126</sup> Hooke’s “System of the World,” then, could be construed in this perspective: “I shall explain a System of the World differing in many particulars from any yet known, answering in all things to the common Rules of Mechanical Motions.”<sup>127</sup> The “System of the World” was the logical outcome of a spectacular demonstration of the power of instruments in the realm of astronomy. Instruments, Hooke argued, could ultimately answer the question of the mechanical cause of the movements of planets. Hooke’s *Attempt* was an important step toward what Bennett calls “the thoroughgoing dissolution of the customary distinction between mathematical science and natural philosophy.”<sup>128</sup> The plate accompanying the *Attempt* is a striking illustration of such dissolution (that was Newton’s *Principia*) and an early example of Hooke’s ambition to establish mechanics as the basis of natural philosophy.<sup>129</sup>

#### POETICS OF PROOF

The title *Attempt* seemed to announce the modest rhetoric of the experimental essay as defined by Robert Boyle. According to Steven Shapin:

One of the most straightforward ways of displaying modesty was the use of the form of the experimental essay. The essay, that is, the piecemeal reporting of experimental trials, was explicitly contrasted to the natural philosophical system. Those who wrote entire systems were identified as “confident” individuals, whose ambition extended beyond what was proper or possible. By contrast, those who wrote experimental essays were “sober and modest men,” “diligent and judicious” philosophers, who did not “assert more than they can prove.”<sup>130</sup>

It is now clear, however, that Hooke was aiming at an experimental proof. The phrase *An Attempt to prove the Motion of the Earth by Observations* seems an oxymoron between the tentative style of the Boylian essay and the proof that was aimed at. Here as often, Hooke was playing with the meaning of words: his “attempt” was less a tentative essay than a new experiment, indeed an *assay*.<sup>131</sup> In fact, as Simon Schaffer has made clear, the word “essay” was then used in the senses of both the literary essay inherited from Montaigne through Bacon, and the experimental essay developed by Boyle. The displacement from “essay” to “attempt” was akin to the move from Bacon’s *instantia crucis* to Hooke’s *experimentum crucis*: both signified an essential

shift toward a new and determining role given to experiments and instruments.

After this analysis of the texts and methods by which Hooke gains access to microscopical and astronomical distances, we may sketch an overview of their singular poetics. It is probable that the strong symmetry that we have noted between the astronomical and microscopical enterprises is reflected in common poetic questions.

Access to distances poses in a sharp way the issue of accreditation. In the poetics of the new experimental science, public experiments replace the *auctoritas* of texts. Steven Shapin has stressed the importance of multiple testimonies in the establishment of proof<sup>132</sup>—the *matter of fact* described by Simon Schaffer.<sup>133</sup> Peter Dear<sup>134</sup> has shown how the experimental narrative constituted a new genre of scientific writing, whose various “literary technologies” have been explored by Shapin and Schaffer: the public experiment and “virtual witnessing” guaranteed the accreditation of the experimental fact. Witnessing by a single man was *not* proof, even within the experimental framework—but this was the precise characteristic of observations made by means of a microscope or a telescope. When the authority of the report could not be founded on the presence of several persons worthy of faith to witness the event (the experiment or observation), then the process of accreditation found itself gravely compromised. Robert Hooke brings an original resolution to the problem posed by microscopic and telescopic observation by relying (even more than did his colleagues at the Royal Society) upon available literary techniques—at the cost of a profound transformation in them.

Thomas Sprat’s *History of the Royal Society* (1667) is usually considered the birth of modern scientific writing stripped of the flourishes of Scholastic rhetoric. This text has long been interpreted as carrying the banner for a radically anti-rhetorical “scientific style” that later influenced the style of the whole of English literature at the end of the seventeenth century.<sup>135</sup> But the work of Peter Dear and Brian Vickers<sup>136</sup> has amended this thesis by interpreting the text in the context of the polemic over the utility and legitimacy of natural philosophy. Vickers shows that Sprat was not taking aim at rhetoric in itself, but at excessive use of it. Itself strongly rhetorical, Sprat’s anti-rhetorical gesture is an effort to make scientific discourse and practice autonomous. Sprat, after Hooke, advocates a new rhetoric founded on images of nature itself rather than on traditional tropes and old mythological *exempla*. The natural figures of this new rhetoric would be “solid and strong.”

“masculine and durable” to the extent that they would come from “images that anyone can observe, and visible things familiar to the mind of man.”<sup>137</sup>

We can now reread Sprat in the light of the poetics of proof established in 1665 by Hooke:

But besides this, the very way of *disputing* itself, and inferring one thing from another alone, is not at all proper for the spreading of knowledge. It serves admirably well indeed, in those Arts, where the connexion between the propositions is necessary, as in the *Mathematicks*, in which a long train of *Demonstrations*, may be truly collected, from the certainty of the first foundation: But in things of probability onely, it seldom or never happens, that after some little progress, the main subject is not left, and the contenders fall not into other matters, that are nothing to the purpose: For if but one link in the whole chain be loose, they wander farr away, and seldom, or never recover their first ground again. In brief, *disputing* is a very good instrument, to sharpen mens wits, and to make them versatil, and wary defenders of the Principles, which they already know: but it can never much augment the *solid substance* of *Science* itself: And me thinks compar'd to *Experimenting*, it is like *Exercise* to the Body in comparison of *Meat*: For running, walking, wrestling, shooting, and other such active sports, will keep men in health, and breath, and a vigorous temper: but it must be a supply of new food that must make them grow: so it is in this case, much contention, and strife of argument, will serve well to explain obscure things, and strengthen the weak, and give a good, sound, masculine colour, to the whole masse of knowledge: But it must be a continued addition of observations, which must nourish, and increase, and give new Blood, and flesh, to the *Arts* themselves.<sup>138</sup>

We find here the organic comparison by which Hooke had explained the vigor of the experimental “chain.” Again, it is observation that “nourishes” reflection, just as meat—in its earlier sense of nourishment<sup>139</sup>—is necessary to a body taking exercise. In this very muscular conception of thought, deductive reasoning (unfolding its arguments starting from certain principles) suits only mathematics and its “long train of Demonstrations.” Here we see again the extent to which experimental philosophy belongs not to Descartes and his long chains of reasons; the deductive method, Sprat underlines, is suitable only to mathematics. By adopting (like Hooke) the Cartesian metaphor of reason chains, Sprat turns it into an anti-Cartesian argument. The deductive chain, when used outside the domain of mathematics and applied to knowledge of nature, always risks breaking. In the wake of Hooke, Sprat uses the

metaphor of the weak link to signify the fragility of the deductive chain and therefore the necessity of the experimental method.

#### CONCLUSION: INSTRUMENTS AND IMAGES

The journey from insects to stars sheds light on the grand coherence of Hooke's project. Access to the remote is given by means of optical instruments that let us see and then report the distant image. Thanks to the precision of instruments guaranteeing the exactitude of measurements, the experimentalist can apply a *computus* to the real<sup>140</sup> (the letters of the engravings of *Micrographia*, the gradations to follow the path of the Dragon's star) and he thus maps the space of new worlds. The equivalence between seeing and drawing, then between drawing and knowing, which Constantijn Huygens wished for, seems here to be achieved in a particularly spectacular and effective way.<sup>141</sup>

Contrasting two founding texts of 1543, *Fabrica* by Vesalius and *De Revolutionibus* by Copernicus, Martin Kemp found an essential heterogeneity of modes of anatomical and astronomical representation.<sup>142</sup> If we pursue questioning in the seventeenth century, the case of Hooke is particularly revealing, since the Curator practices both types of investigation and both types of illustration. As we have seen, microscopical iconography and astronomical iconography remain very distinct, with the former testifying to an aesthetic concern for naturalist detail that the latter does not attain. But with Hooke the two types of illustration are combined in a common mechanistic register, which constructs continuity between the small machines of nature and the machines created by humans, and from these machines to the human body itself. The Renaissance analogy between fabricating the world<sup>143</sup> and fabricating the body is thus not only confirmed but also reinforced by the essential commensurability between the object observed, the observer, and the instrument thanks to which he observes.

The diversity and complex status of images included in the cosmological texts (diagrams, engravings, naturalist drawings, instrumental iconography, sketches, celestial maps) recall their multiple origins: mathematics, cosmography, collections of curiosities, and books of marvels. From their ancient status as mathematicians, seventeenth-century astronomers retained their confidence in the demonstrative power of the diagram; from travelers they learned the art of anecdotes in order to give flesh and movement to two-dimensional images; like cosmographers, they had the ambition to draw maps of newly discovered worlds; from the painters, they took a repertoire

of techniques in order to paint these worlds in their finest details. Because they mark the transition from approximative drawings to naturalist and scientific drawings, from celestial maps to selenographic (and chorographic) maps, from a poetics of the probable to a poetics of proof, cosmological texts constitute a fascinating point of convergence and amalgam of old means to grasp something new.

To reach distant places, to make visible what was not—this is the goal of experimental science in the seventeenth century. The construction of knowledge takes place through the exploration of an enlarged territory of investigation, including previously invisible worlds. Such an expansion implies defining precisely the means of access to these new worlds, then the means of transporting the accumulated data, and finally the means of communicating and lending credence to this data. In order to authorize its new régime of visibility, experimental philosophy turned to suitable enunciative techniques, progressively distinct from the techniques of accreditation issuing from rhetoric. However, our analysis has shed light on the permanence of the rhetorical functioning of accreditation. So it would be misleading to interpret these transformations of the image (from figuration to inscription) as a radical breaking away by scientific discourse from literary discourse. Far from creating a discourse of science *ex nihilo*, Hooke adopts one by one the available poetic figures, techniques, and strategies. Figures are hollow and empty, he says, when they serve abstract arguments; figures are rich and powerful, on the other hand, when they are “nourished,” in Sprat’s phrase, by figures found in nature.

The old poetic and pictorial repertoire is indeed there, but recast, re-framed, limited, and placed at the service of a poetics of proof. With *Power*, the image of the flea dragging a golden chain was gradually transformed into a poetic and mythic vision of the flea harnessed to a golden chariot. This freedom of poetic invention and extended metaphor is closely controlled in *Micrographia*, where the drawn image defines the conceptual framework in which imagination can evolve. The imagination is not made redundant by the development of techniques and instruments that enable making visible what was invisible; rather it is disciplined by the image. The marvels discovered thanks to optical voyages are no longer told in marvelous tales but in pictorial achievements where the magnification is the hyperbolic register of proof.

## Margaret Cavendish

### *The Battle of Instruments*

Then came the Lice-men, and endeavored to measure all things to a hairs-breadth, and weigh them to an Atom; but their weights would seldom agree, especially in the weighing of Air, which they found a task impossible to be done; at which the Empress began to be displeas'd, and told them, that there was neither Truth nor Justice in their Profession; and so dissolved their society.<sup>1</sup>

Among the many hybrid species she invented for her new world, Margaret Cavendish, the Duchess of Newcastle, chose lice-men to represent the members of the Royal Society. It is easy to recognize members such as Robert Hooke—"the man who measured London," in the words of Lisa Jardine<sup>2</sup>—and Robert Boyle, the inventor of the air pump. The choice of lice is obviously ironical and satirical, and also refers to one of the most famous engravings in Hooke's *Micrographia*: the monstrous louse attached to a human hair. The Empress is the heroine of Margaret Cavendish's novel, and her violent reaction reflects the Duchess's opposition to the Royal Society. Since it was not within her power to eliminate the society that she disliked so much, Cavendish opted instead for meticulous deconstruction by building a rival and little-known monument, her *Observations upon Experimental Philosophy: to which is added, The Description of a New Blazing World*. This work consisted of two parts; the philosophical *Observations* and the fictional *Blazing World*, published together in 1666, openly attacked Hooke's *Micrographia*, which had been published a year earlier.

By targeting Hooke's treatise, Cavendish was in fact questioning the entire new philosophy:

I am as ambitious of finding out the Truth of Nature, as an honorable Dueller is of gaining fame and repute; for, as he will fight with none but an honorable and valiant opposite, so am I resolv'd to argue with none but

those which have the renown of being famous and subtil Philosophers; and therefore as I have had the courage to argue heretofore with some famous and eminent Writers in Speculative Philosophy; so have I taken upon me in this present work, to make some reflections also upon some of our Modern Experimental and Dioptrical Writers.<sup>3</sup>

Her enemies are named from the outset: experimental philosophers, particularly those who use optical instruments. Her work is therefore explicitly presented as a response to Hooke, who represents experimental philosophy and whose *Micrographia* was seen as the banner of the Royal Society and its method. Against the conception of natural philosophy as experimental, Margaret Cavendish strongly opposed the use of instruments for the observation of nature. She not the measurements, but the mere endeavor of measuring; she did not scrutinize the instruments but the implications of their use.

#### “A HIGH HEEL TO A SHORT LEG”

Margaret Cavendish formulated her own observation as follows:

I observe, experimental philosophers do first cry up several of their artificial instruments, then make doubts of them, and at last disprove them; so that there is no trust nor truth in them, to be relied on: For, it is not an age since weather glasses were held the only divulgers of heat and cold, or change of weather; and now some do doubt, they are not such infallible informers of those truths. By which it is evident, that experimental philosophy has but a brittle, inconstant, and uncertain ground. And these artificial instruments, microscopes, telescopes, and the like, which are now so highly applauded, who knows but they may within a short time have the same fate; and upon a better and more rational enquiry, be found deluders, rather than true informers.<sup>4</sup>

This was a particularly pertinent and cunning argument against mechanical philosophy, as it pinpointed the paradoxical nature of an enterprise that grounded its certainty upon instruments while denouncing them as unreliable and deceptive. Cavendish of course never read the *Attempt*, published one year after she died. An attentive reader of *Micrographia*, however, she noticed the symmetry of Hooke's microscopical and telescopical endeavors, and opposed both. The *Observations* and *The Blazing World* set forth a radical critique of Hooke's astronomical project and undermine the underlying experimental method of both *Micrographia* and the *Attempt*. In opposing mechanical philosophy, Margaret Cavendish was in agreement with many

of her contemporaries, in particular Hobbes and Henry More. Yet her disapproval was distinctive in that it repeatedly focused on one specific aspect of the new science: the “dioptrical inspections”<sup>5</sup> by means of a prosthetic use of instruments that Hooke championed. However, Cavendish not only criticized Hooke but also formulated her own alternative method:

Wherefore there are these following conditions required to the optic perception of an exterior object: First, the object must not be too subtle, rare, or little, but of a certain degree of magnitude; Next, it must not be too far distant, or without the reach of our sight; then, the medium must not be obstructed, so as to hinder our perception; And lastly, our optick “sensorium” must be perfect, and the sensitive motions regular.<sup>6</sup>

Obviously, these methodological constraints precluded any microscopical or astronomical inquiry whatsoever. Her attack combined defiance against instruments and a traditional critique of the weakness of the senses. Following Hooke in his critique of our senses as deceptive, Cavendish explained that the magnifying action of instruments could only increase, and not correct, the weakness of our senses. This criticism was illustrated by a striking image that repeated and caricatured the experimentalists’ perception of themselves. Cavendish turned the image of a prosthetic instrument—the eye prolonged by a telescope or a microscope—into a ridiculous picture: “In short, Magnifying Glasses are like a high Heel to a short Leg, which if it be made too high, it is apt to make the wearer fall.”<sup>7</sup> The metaphor explores the themes of imperfection and artifice and uses them to highlight the deceptive nature of instruments. Hooke showed that the accuracy of Tychonian measuring instruments was ineffectual without the telescope-aided eye. Cavendish went one level farther when she suggested that the magnifying power of optical instruments was ineffectual if the senses themselves were weak and deceptive. The weakness of our postlapsarian senses was not reversible, and to magnify them would only exacerbate their deceptive effect. Far from bringing us closer to the essence of things, experimental observation only doubled the remoteness of the truth:

Magnifying, multiplying, and the like optic glasses, may, and do oftentimes present falsely the picture of an exterior object; I say, the picture, because it is not the real body of the object which the glass presents, but the glass only figures or patterns out the picture presented in and by the glass, and there mistakes may easily be committed in taking copies from copies.<sup>8</sup>

The strength of the Hobbesian line of argument, as it is repeated and developed in the *Observations*, lies in its insistence on the essential difference between constructed objects and nature itself.<sup>9</sup> In Hooke's mechanistic epistemology, both the observed objects and the tools of observation stemmed from a deeply mechanistic conception of nature that broke through the division between art and nature.<sup>10</sup> By contrast, Hobbes and Cavendish insisted upon the distinction. "Art, which is but a particular Creature, cannot inform us of the Truth of the Infinite parts of Nature, being but finite itself."<sup>11</sup> She denounced a crucial disparity between the scales and natures of man's creations and of God's Creation—a disparity that signaled the impossibility of using the former to understand the latter. In this respect, her position was irreconcilable with Hooke's mechanical philosophy, in which, as Jim Bennett as shown, the natural and the artificial "are fully commensurate,"<sup>12</sup> inasmuch as nature is itself construed as a machine. Unlike Hobbes, however—whose attacks were directed against experimentalists but not astronomers—Cavendish focused on the "Diopticians," recognizing that Hooke's optical agenda served his broader experimental program. Cavendish's critique was particularly lucid when she condemned experimental method and optical instruments as part of the same enterprise.

The use of instruments was not only misleading but dangerous, inasmuch as it entailed political instability. At the end of *The Blazing World*, this led to a radical decision:

I would advise your Majesty to dissolve all their societies; for 'tis better to be without their intelligences, than to have an unquiet and disorderly government. . . . The truth is, said she, wheresoever is learning, there is most commonly also controversy and quarrelling.<sup>13</sup>

Observations and experiments could not produce consensus but only dissension and debate, and sow the seeds of potential violence. Throughout all her writings, Cavendish set the new philosophy side by side with the civil wars' destructions.<sup>14</sup> In this analogy, experimental philosophers were described as rebels and compared to the instigators of civil wars, "which endeavor to pull down the hereditary mansions of noblemen and gentlemen, to build a cottage of their own."<sup>15</sup> In Cavendish's attack on Hooke, there was, as Katie Whitaker<sup>16</sup> has shown, a defense of aristocratic standards of politeness. In her previous work on natural philosophy, Cavendish had praised Robert Boyle, "a very civil, eloquent and rational writer; the truth is, his style is a gentleman's style."<sup>17</sup> By contrast, Hooke's preface to *Micrographia* had explic-

itly presented his “Reform in Philosophy” as an attempt to supersede and discipline elevated ideas:

Talking and contention of Arguments would be turn'd into labours; all the fine dreams of Opinions, and universal metaphysical natures, which the luxury of subtil Brains has devis'd, would quickly vanish, and give place to solid Histories, Experiments and Works.<sup>18</sup>

In this light, the outrage of the Duchess is no longer surprising. Returned from exile to a chaotic though newly restored England, she clearly sensed herself under attack. In many respects, Hooke embodied the reformative spirit. He therefore became her main target. By rejecting the “new order” of Hooke’s method, Cavendish was stating her attachment to a vanished political order and to aristocratic values that were threatened by the mechanistic philosophy. What irritated Margaret Cavendish above all, as Anna Battigelli has shown,<sup>19</sup> was the mechanistic portrait of the natural philosopher repeatedly sketched by Hooke.<sup>20</sup> She responded by reasserting a strict and conservative social and epistemic hierarchy: “Experimental and mechanic philosophy cannot be above the speculative part, by reason most experiments have their rise from the speculative, so that the artist or mechanic is but a servant to the student.”<sup>21</sup> Cavendish’s disdain for instruments could therefore be understood in the context of the European court culture to which she belonged. Her contempt for machines was supplemented by a refusal of bookish knowledge;<sup>22</sup> knowledge was not something to be gained through laborious contrivances or long hours of learning, but rather with the courtier’s effortless facility. “I will not deceive the world . . . by being a mountebank in learning, but will rather prove naturally wise than artificially foolish,”<sup>23</sup> she declared. Advocating a philosophy of “works” and “hands,” Hooke was menacing her conception of natural philosophy as a noble enterprise.

In *The Blazing World*, this rhetoric of debasement was extended through the satirical fiction by literalizing the transformation from aristocratic reason to worker-bee craft. The experimentalists were turned into hybrids (licemen, bear-men, fish-men, etc.) and reduced to their mission. They became servants entirely devoted to the task allotted to them by their physiological characteristics. Experimentalists were, in other words, monsters.

#### A TERATOLOGY OF KNOWLEDGE

Samuel Pepys’s famous reaction to *Micrographia* was one of admiration for “the most ingenious book that ever I read in my life.”<sup>24</sup> But Margaret Cav-

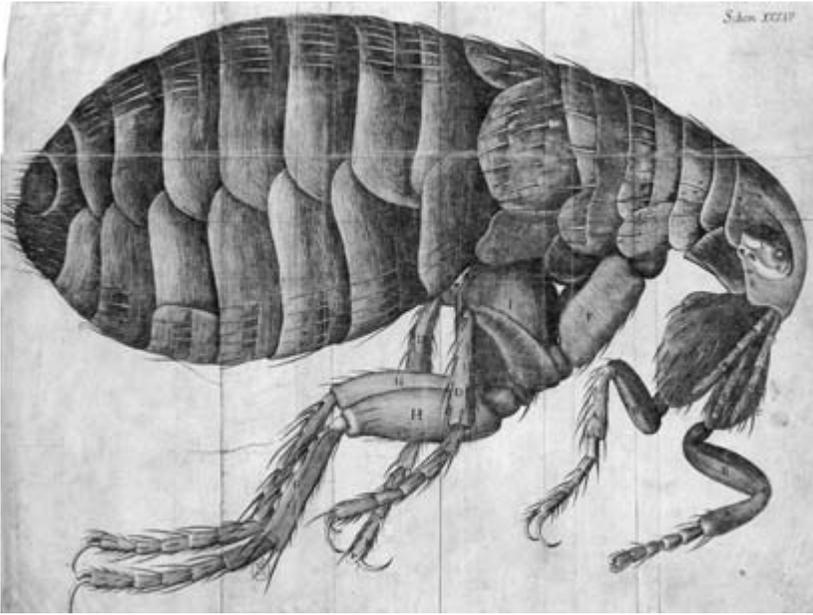


FIGURE 6 \* Hooke, *Micrographia*, scheme 34.

endish was apparently less impressed by its ingenuity than by the terrifying nature of the immense, detailed engravings of insects that revealed the repulsive details of their anatomy (Fig. 6). The heroine of the *Blazing World* reacts accordingly: “Lastly, They shewed the Empress a Flea, and a Lowse; which Creatures through the Microscope appear’d so terrible to her sight, that they had almost put her into a swoon.”<sup>25</sup> But Cavendish chooses to fight rather than to faint. Magnification is but a distortion, and she explains that “the more the Figure by Art is magnified, the more it appears mis-shapen from the Natural, in so much as each joint will appear as a diseased, swell’d and tumid Body, ready and ripe for Incision.”<sup>26</sup> Evoking organic detail and the dissection of sick bodies, the Duchess equates *Micrographia*’s illustrations with medical and teratological iconography.

#### Wonders and Monsters under the Microscope

Hooke’s rhetorical strategy, both in his pictures and in his text, is to highlight the spectacular nature of the world revealed by the microscope. But Cavendish turns the monstrosity of his drawings against him, debasing his rhetoric of wonder into a science of monstrosity.

Cavendish's first defense against the rhetorical construction of *Micrographia* is to reject the wonder that pervades Hooke's text. Many of her observations begin by stating obviousness or denying amazement. "I cannot wonder with those, who admire. . .," "I cannot admire, as some do . . ."27: these expressions inaugurate most of her observations in the "treatise," which are numbered and juxtaposed exactly like Hooke's observations. The so-called "wonders of these Glasses" become merely "superficial wonders"28; the serious "fellows" of the Royal Society are thrown off their pedestal, portrayed as unruly "Boys that play with wat'ry Bubbles, or fling Dust into each others Eyes, or make a Hobby-horse of Snow."29 The prefaces—always polemical spaces—provide the two discourses on method with their main battlefield. Margaret Cavendish dramatically inverts Hooke's rhetorical amplification, for she repeats, word for word, the final sentence of *Micrographia's* preface, and cancels out its effect. Each species is returned to its proper scale, and she reinstalls the hierarchy of beings and sizes in order to devalorize experimental philosophy: "Art is so far from altering Infinite Nature, that it is no more in comparison to it, than a little Flie to an Elephant."30 The rest of the treatise becomes a rhetorical battle through which Cavendish systematically attempts to reverse every Hookian formula and to undermine the instrumental basis of his method. The microscope becomes a "False Informer,"31 and its wonders are reduced to monsters.

Whereas Hooke's entire rhetorical construction tries to show that nature's wonders are not to be found in its monsters but its most commonplace creatures, Cavendish defends the opposite opinion—that his creatures are not wonders, but monsters. Reversing Hooke's visual rhetoric, which relies on the magnified insects' monstrous appearance, she gives new meanings to his pictures. Hooke shifts teratological iconography into the region of philosophical wonder, but Cavendish takes *Micrographia* at face value and denounces its so-called wonders of nature as unnatural monsters.32 Her rhetorical strategy is in fact a chiasmus that structures the book as a whole: *Micrographia's* wonders become monsters in the *Observations*, and enter the realm of fiction in the *New Blazing World*.

#### "Hermaphroditical Science"

The Duchess was not only offended by the debasement implied by the use of machines, she was also profoundly horrified by the products of experimental philosophy:

If the picture of a young beautiful lady should be drawn according to the representation of the microscope, or according to the various refraction and reflexion of light through such like glasses; it would be so far from being like her, as it would not be like a human face, but rather a monster, than a picture of nature.<sup>33</sup>

These were the outcomes of Hooke's experimental method—the disfigured lady that Swift would describe with further horror<sup>34</sup>—optical aberrations produced by excessively deforming and enlarging instruments. Here the Duchess was in fact only digressing on Hooke's own statement at the beginning of *Micrographia* (which concerned only artificial productions): “the more we see of their shape, the less appearance will there be of their beauty.”<sup>35</sup> Building upon this notion of ugliness, she turned it into repulsiveness and made it the core of her argument: using instruments amounted to studying monstrous and exceptional things, and therefore to distorting our vision and understanding of nature. Here we reach yet another level of Cavendish's attack, and maybe its most original aspect.

It is to be observed, that art, for the most part, makes hermaphroditical, that is, mixt figures, partly artificial, and partly natural; . . . In the like manner, may artificial glasses present objects, partly natural, and partly artificial.<sup>36</sup>

Not only was Hooke's mechanical philosophy doomed to produce disproportioned and irregular shapes—monsters—but these were in fact the worst type of monsters: hermaphrodites.<sup>37</sup> Cavendish chose a sexual anomaly to name what we would today call a cyborg. Hooke's astronomical and microscopical observations equated to hermaphrodites inasmuch as they shockingly united, by monstrous hybridization, nature (man's eye) and artifice (the telescope). Offspring of monsters were not viable, the fiction seemed to demonstrate. In the *Blazing World*, telescopic observation resulted in the fiercest controversies:

But these telescopes caused more differences and divisions amongst them, than ever they had before; some said, they perceived that the Sun stood still, and the Earth did move about it; others were of opinions, that they both did move; and others said again, that the Earth stood still, and the Sun did move; some counted more Stars than others; some discovered new Stars never seen before.<sup>38</sup>

Here the telescopes do not help to decide between the competing cosmological hypotheses; instead, they cause the multiplication of monstrous

theories: the simultaneous motions of the Earth and the Sun, the proliferation of stars—this was a direct reference to *Micrographia's* observation 58.<sup>39</sup> While Cavendish fiercely condemned these aberrant productions, she also underlined how they could be a source of pleasure-in-disorder for the experimentalists. At the end of the same episode, they request the conservation of their instruments, arguing that

we take more delight in Artificial delusions, than in Natural truth. . . . We shall want Employments for our Senses, and Subjects for Arguments; for, were there nothing but truth, and no falsehood, there would be no occasion to dispute, and by this means we should want the aim and pleasure of our endeavors in confuting and contradicting each other; neither would one man be thought wiser than another, but all would either be alike knowing and wise, or all would be fools; wherefore we most humbly beseech your Imperial Majesty to spare our Glasses, which are our only delight, and as dear as our lives.<sup>40</sup>

This was a burlesque reversal of the search for certainty through instruments, as the product was not knowledge but dispute. Here Cavendish denounced not only a propensity but a taste for discord residing at the heart of experimental practice. She denounced the instruments simultaneously as the main source of disputes and the main source of pleasure for experimental philosophers, in a critique of hermaphroditic science where moral and epistemological condemnations merged.

Yet hermaphroditism often bore a positive valence in the writings of the duchess. As Kate Lilley has shown, hermaphrodite characters are frequent in Cavendish's works.<sup>41</sup> She would even playfully present herself as a hermaphrodite figure in a masculine outfit, as described by Pepys,

with her velvet cap, her hair about her ears; many black patches, because of pimples about her mouth; naked-necked, without any thing about it, and a black just-au-corps.<sup>42</sup>

Though she was protesting against hermaphroditic experimental science on the grounds of social and epistemological disorder, the Duchess was also clearly sensitive to its aesthetic and indeed sexual seduction. Cavendish's accusation of hermaphroditism thus combined horror and pleasure—and in fact covertly also referred to herself.<sup>43</sup>

On 30 May 1667, the year after the publication of the *Observations*, Margaret Cavendish visited the Royal Society upon her own request. Very little is known of the visit, except that the fellows were not particularly impressed

by this strange woman with her extravagant outfit: "I do not like her at all," Pepys wrote in his diary, "nor did I hear her say any thing that was worth hearing, but that she was full of admiration, all admiration . . . After they had shown her many experiments, and she cried still she was full of admiration, she departed."<sup>44</sup> Hooke was in charge of entertaining her by various experiments,<sup>45</sup> but no record remains of their encounter.

#### THE EMPIRE OF FICTION

Recent analyses of *The Blazing World* have correctly insisted on the retreat of the authorial figure in the world of fiction.<sup>46</sup> Yet reading *Observations* and *The Blazing World* concurrently, it appears that this retreat is also an appropriation: far from abandoning their techniques and instruments to experimentalists, Cavendish appropriates them for the benefit of fiction—just when she is objecting to use of fiction in natural philosophy. What had been criticized and expelled from the investigation of nature as illegitimate and deceptive is placed at the service of the Empress: instruments, techniques, artifices, and monsters find a new place and a surprising legitimacy when they obey her wishes and assist her pleasure.

A fictional response by natural philosophy to the Royal Society's reforming enterprise, *The Blazing World* dramatizes the failure and destruction of experimental philosophy. After many long exposés offered by the animal-men, the experimentalists, the expected entertainment turns to boredom and disappointment. Discontented, the Empress dismisses most societies and considers them useless if not harmful. The return to the old order is dramatized in the fiction by the sudden abandon of the world constructed by the Empress in favor of the immediate return to a previous state that is perfectly conserved and immutable. If this turn of events at first appears disappointing, in fact it gives the death blow to experimental philosophy by demonstrating the ultimate failure of any reform. Thus, fiction serves to dramatize the return to the old order. In this sense, the use Cavendish makes of fiction runs counter to how experimental philosophers use it. Rather than allow a virtual projection into a world that does not yet exist, the fiction of *Blazing World* reestablishes a state that has disappeared. Of course, the world constructed by the duchess cannot be reduced to a fictional reiteration of England before the Civil War (even if the similarities are evident). But what the fiction achieves through the narration is a regressive temporal evolution capable of abolishing change—a perfect example of what Michael McKeon called "conservative narratives."<sup>47</sup>

## Instruments of Power

By affirming the necessity of absolutism as the foundation of epistemological certitude—and not the inverse, as the experimentalists claimed—the Duchess reaffirms the priority of civil power. Fiction dramatizes the endangerment of the civil order and its reestablishment when the Empress imposes philosophical assent. In the last part of the novel, the Empress undertakes not only to reform the Blazing World of fiction but “*the world from which it issued . . . plunged into a terrible war.*” This intervention of the fictional world into the English civil war signals the omnipotence of fiction—rather than a solipsist retreat—and proposes a Restoration much more radical than the one that actually took place. That this must occur through the bloody deployment of military power is only the consequence of a temporary and unfortunate weakening of civil power, which was caused by the ambition of the experimentalists. The end of the novel describes an incredible unleashing of violence aiming to ensure the economic, military, and political domination of England over all nations of the world. This domination is guaranteed by the all-powerful speech of the Empress, whose hyperbolic orders set the rhythm for the end of the book:

The Empress sent them word, that in case they did not submit to him [the King of England, Scotland, France, and Ireland], she intended to fire all their towns and cities, and reduce them by force, to what they would not yield with a good will. . . . The Empress commanded the bear-men to view through their telescopes what towns and cities those were that would not submit . . . , she sent to all the princes and sovereigns of those nations, to let them know that she would give them a proof of her power, and check their obstinacies by burning some of their smaller towns; and if they continued still in their obstinate resolutions, that she would convert their smaller loss into a total ruin. . . . At last a rain came, and upon a sudden all their houses appeared of a flaming fire, and the more water there was poured in them, the more they did flame and burn; which struck such a fright and terror into all the neighboring cities, nations and kingdoms, that for fear the like should happen to them, they and all the rest of the parts of that world granted the Empress’s desire, and submitted to the monarch and sovereign of her native country, the King of ESFI. . . . Thus the Empress did not only save her native country, but made it the absolute monarchy of all that world.<sup>48</sup>

The Empress destroys all the ships that refuse to bend and pay tribute to the king of their country of origin; she threatens to destroy the cities of nations that have commerce by means of land.<sup>49</sup> It should be stressed that such

violence relies on instruments that had been banished in the first part of the novel. The whole ending tends to show that instruments and machines can be useful, hence legitimate, on condition they serve political and military power. The novel dramatizes the instrumentalization of instruments—and of experimentalists. The old members of scholarly societies are transformed into redoubtable war machines. Converted into military instruments, telescopes are reintroduced into *The Blazing World*, for they can detect enemy ships before being discovered. “Art” thus finds its legitimacy and utility when it comes to celebrating and affirming civil power.<sup>50</sup> If instruments are capable of demonstrating anything, it is solely her power.

Artifice, ferociously denounced throughout *Observations*, seems to preside over the construction of a fictional world. When it is presented as such, artifice is very acceptable. Cavendish stigmatizes only the scandal of artifice utilized to see and speak the truth. On the contrary, fiction, the very realm of artifice, seems the only legitimate site of allegory, symbolism, invention, and fabrication. It is in fiction that mechanical inventiveness can legitimately be deployed. It is in fiction (not in a philosophical treatise) that Cavendish explores the “contrivances” so dear to her century: the fountain of fire, the theater of machines, the submarine of war, etc. This radical divergence of interpretation of artifice is explained yet again by the fact that Cavendish and Hooke do not assign instruments the same function. For Hooke, the perfect optical instrument is like a window on nature: the mystique of transparence (which we have already mentioned)<sup>51</sup> culminates in the dream of a fusion of the observer with the object he observes. On the other hand, for Cavendish nature does not require any invention to be observed, and it does not contain any marvel. It is solely in the domain of literary invention that meaning and figures can be deployed.

### Politics of Genres

Cavendish’s project is to reestablish a world founded on harmony and equilibrium and constructed around a single, central, and luminous figure of absolute authority. Accordingly, her text is a philosophical as well as political utopia. The link between fictional construction and philosophical construction is much more than a simple analogy or a playful reversal. A good government, explains Cavendish, implies a good practice of natural philosophy, and vice versa. This is why the materials used to construct her fictional world borrow elements recognized as perfect by the philosophers of her day: the hexagonal form of the alveoli of beehives, a universal and perfect language.

The inseparability of natural philosophy and political philosophy is affirmed several times. Thus *Further Observations* starts with a defense of the Ancients against the experimentalists, who call themselves “modern” when the state of the world has deteriorated rather than improved.<sup>52</sup> Cavendish makes the good health of the government the criterion for evaluating philosophy, giving the example of the link between scientific and political perfections among the Ancients:

As for example; How well was the world governed, and how did it flourish in Augustus’ time? How many proud and stately buildings and palaces could ancient Rome show of the world, when she was in her flower? The cedars, gold, and many other curiosities which Solomon used in the structure of that magnificent temple, (the like whereof our age cannot show) were as safely fetched and brought to him out of foreign places, as those commodities which we have out of other countries either by sea or land: Besides, I doubt not but they had as profitable and useful arts and knowledges, and as skilful and ingenious artists as our age can boast of; if not the very same, yet the like, and perhaps better, which by the injury of time have been lost, to our great disadvantage; it may be they had no microscopes nor telescopes, but I think they were the happier for the want of them, employing their time in more profitable studies.<sup>53</sup>

As Peter Dear notes, the Temple of Solomon was (according to Joseph Glanvill) the “Romantick model”<sup>54</sup> of the Royal Society, the direct heir of Bacon’s *New Atlantis*. In her *Blazing World*, Cavendish is inspired by the Baconian utopia—but she upends it, offering a world in which authority is founded on political power rather than on the experimental work of the scientific community. Here utopia is less scientific than political, and the establishment of a science is annulled in favor of the restoration of the monarchy.

Moreover, fiction functions as a mechanism of redemption and compensation, as much at the personnel level (expressed by the dream of reestablishing the lost fortune of her husband, restoring the world as it was before the Civil War, and obtaining personal recognition) as at the historical and philosophical level. However, the utopian genre does not in itself circumscribe or describe how *Blazing World* works in the course of the narration.

Tale of an imaginary voyage, utopia, philosophical novel, and allegory: the text’s genre changes as the novel develops. Starting from the traditional poetics of the travel narrative that leads to a politico-scientific utopia (thus mixing Bacon and More, two major intertexts in the first part of the novel), Cavendish shows the destabilization of this utopia at the end of part 1; the

last part reaffirms the legitimate and monarchical power (allegorized by the figure of the omnipotent Empress), inverting what had been constructed in the first place. Utopia can be considered as the ideal “witness” state, on the basis of which any modification can be evaluated and judged. We can interpret the shift from utopia to the philosophical novel, and then to dystopia, as a series of generic transformations resulting from the epistemic and political destabilization of the fictional world. Hence restoration occurs through the total restoration of monarchical power, as well as of the first utopia. The shift from one genre to another within the same text becomes the symptom of the threat to the perfect government, a utopia that is in fact a uchronia: nostalgia for a time that is irreparably lost.

That fiction functions in two time frames means this text cannot be reduced to a satire. In effect, the genres of satire and utopia do not contradict but rather articulate each other: satire is merely the first movement in a wider process of deconstruction and reconstruction. A dynamic tool, fiction amplifies and aggravates the motif of scientific controversy in order to produce a tension that is resolved in the reestablishment of the preceding order. This mechanism of fiction is applied in a systematic way in *Blazing World*, to the point that we can draw up a table of these successive transformations, aggravations, and reestablishments covering all the controversial points; the most important of these are listed in the table (following page).

Accordingly, the fiction of *The Blazing World* may be interpreted as an aggravation of the figures furnished by science itself. The originality of the satire in *The Blazing World* is to draw all its arguments from the discourse and practice that it criticizes, to the point of borrowing its very method: optical enlargement and inversion. To construct an alternative and competing universe by rigorously borrowing the same materials used by the institution in order to bring it down is to carry to a pitch the procedures of polemic reversal. It is also to affirm loudly the omnipotence of fiction, capable not only of creating everything from nothing, but a Blazing World on the basis of an outmoded institution.

Indeed it is because all powers are ascribed to fiction that it can function as a prism and reestablish what has been transformed. Cavendish’s fiction functions like a closed world in which all the elements are known, controlled, and organized according to the wishes of the author. However, it should be stressed that the closure is not total. If the Blazing World is inaccessible to the exterior, Cavendish manages a shift toward the real, authorizing the intervention of the dreamt-of world in the real world. It is true that this intervention remains within the universe of the fiction. But the Duchess sketches thereby

<i>Micrographia</i>	<i>Observations</i>	<i>Blazing World</i>	
<b>Defense of experimental philosophy</b>	<b>Counter-method (Treatise)</b>	<b>Amplification and Aggravation (Satire)</b>	<b>Overthrow and reestablishment of the old order (Return to the first utopia)</b>
Imperfection of artificial objects	Prosthetic instruments, themselves artificial, which can only produce fallacious results	Instruments that create discord	Instruments at the service of absolute monarchy
Beauty of creatures unveiled by the microscope	The disfigured girl and the frightened flea	The microscope and telescope, creators of monsters	Dramatization of the spectacle of power by the appropriation of machines
Association of art and nature: marvels of the microscope	Denunciation of the hermaphrodite productions of experimental science	Experimentalists as hybrids adapted to their task	Instrumentalization of experimentalists
Preface: Hooke on the new hierarchy of faculties	Denunciation of the ambitions of experimental science and reaffirmation of the old hierarchy	Dramatization of the consequences of chaos and anarchy	Reestablishment of the hierarchy of power

a new topography of worlds real and fictional. Linked by their pole, the two contiguous worlds are juxtaposed as image and reflection in a distorting—or rather reforming—mirror. The world restored in the fiction constitutes a refuge, permits a withdrawal, but does not prevent a return to the real, or even an intervention, even if fantastic, into reality.

By making the closed and protected world of her fiction the site of her total authority, Cavendish reestablishes a hierarchy of force that asserts the omnipotence of the sovereign, reiterated and reflected in the authority of the author.<sup>55</sup> She inaugurates the autonomy of literary fiction that will not cease being asserted, with the corollary of the difficult issue of the cognitive value of a discourse that wants to be freed of both reality and truth. What Margaret Cavendish is designing is a territory proper to fiction, both closed and yet in interaction with reality. A territory of the marvelous that is invented

rather than discovered, it privileges the creative imagination over investigative exploration.

## CONCLUSION

Cavendish's titles were playful puns. Her *Observations* meant radical "objections," while her *Blazing World* was in fact "proclaiming" the end—albeit fictional—of the Royal Society. Her fiction, an explicit rewriting of Bacon's *New Atlantis*, did not call for a Great Instauration but rather for a complete Restoration of the past order. For all her eccentricities, the Duchess was in fact one of the fiercest advocates of epistemic, political, and social order—an order that would carefully distinguish between natural and mechanical philosophy, nature and art, gentlemen and workers. Hooke's project of intertwining these categories could only yield monstrous results and hermaphroditic science. While she haughtily claimed her sense of disgust, she also registered and to some extent shared the seduction of such an enterprise. Cavendish's withering prose thus helps to embrace the scope of the experimental reform and astronomical ambition that Hooke started with *Micrographia* and systematized in the *Attempt*. She castigated in a particularly lucid way the disruptive aspect of the prosthetic use of instruments that was at the center of the experimental program.

By an ironic twist of fate, both Cavendish and her work were later considered to be monstrous, "as if some giant cucumber had spread itself over all the roses and carnations in the garden and chocked them to death."<sup>56</sup> Virginia Woolf drew a grotesque portrait of the Duchess, condemning her lack of structural balance and the heterogeneous genres she relied on. This judgment may seem severe, but it reflects the unclassifiable and "hermaphroditic" nature of her work. Combining men and animals, science and literature, verse and prose, male and female, Cavendish's work is not easily categorized. By constructing textual hybrids and turning them into fictional themes, she constantly, repeatedly, and obsessively broke the boundaries.

In the new poetics of fiction in which Cavendish participates, fiction is the site of the author's free interpretation and inventiveness. Domain of *au-toritas*, it permits constructing worlds based on reason and then juxtaposing them with our imperfect world. Far from being a realm of solipsistic creation, fiction as it is used in *Blazing World* is constructed from the materials it is criticizing. The characteristic of Cavendish's fiction is to amplify the motifs it finds among its enemies in order to undermine them. It amplifies optical motifs that become instruments of satire and the pretext for a fictional recon-

struction that wants to be a Restoration much more radical than what took place historically. The distanced optics of fiction attempts to be utopian, condemnatory, and compensatory in turn, so that there can be a return from disorder to order, from monsters to marvels, from defeat to victory, from decadence to glory. This is a “modern” definition of fiction, we might say, which conceives of it as the invention of a radically new world.

The analogy with new worlds here deploys all its polemical potential. If for a century natural philosophy was able to exploit the idea of a discovery, an exploration, and then a cartography of a terra incognita, fiction conceived as a new world itself, offers new possibilities of interaction with reality: new worlds of fiction, rather than possible worlds. To the *modal* logic by which relations between the fictional and the real are usually explained, I propose to add the hypothesis of an optical logic—distanciation and distortion—which involves the metaphor of new worlds. Beyond the radical rejection of instruments implied by Cavendish’s epistemology, our analysis has revealed a recuperation of these same instruments at two levels: they serve the Empress and participate in the construction of a novel about absolutism; and (ironically) they furnish the model for a poetics of fiction founded on the exaggeration and enlargement of the figures of scientific discourse. This recuperation of optical instruments into its own game is an astonishing episode in the history of fiction. Far from providing a definitive interpretation, a fixing of meanings, optical instruments become the means for a liberation of literary fiction by the affirmation of its power to endlessly distort reality.

## Conclusion

“I have just returned from the Country of Saturn,”<sup>1</sup> Huygens wrote to Chaplain when he finished writing *Systema Saturnium*. In all the texts we have encountered, the writing is indeed an adventure just as much as an investigation of nature. In our turn we have to look back at the space through which we have ventured and recall the principal stages of the journey. The reader will perhaps have found that I have led him or her on a somewhat erratic voyage, from astronomy to microscopy, from optics to cosmology. However, it was those meanderings that have enabled me to sketch an itinerary that is more logical than chronological, permitting me to envisage successively different technical means of reaching across astronomic and microscopic distances, as well as the different poetics being used: fictional poetics (the imaginary voyage), the poetics of the conjectural probable (the theoretical voyage), and the poetics of experimental proof (the optical voyage). These three stages are by no means independent and closed poetics; on the contrary, I have tried to detail degrees that lead from one to another, to situate the texts according to these degrees (and not within tight categories), and to describe the many interactions between these three postulations that have been essential in the formulation of the unknown.

Is there a remedy for the incertitude inherent in cosmological discourse? My enquiry has offered an analysis of various poetic responses that in the course of the seventeenth century were adopted to accredit a discourse with a fragile epistemological and ontological status. I started with the realization of the recurrence of the narrative form, which is explained only by a conception of the discovery of the unknown as a voyage; this was a methodological and practical borrowing (rather than a simply metaphorical one) from the Great Discoveries, and especially a poetic borrowing, since the voyage of the revived astronomy also implied a type of writing: the tale of the voyage. Such an approach, both methodological and discursive, characterized all of our

texts, permitting definition of a discursive modality common to the ensemble of the corpus under consideration—beyond its generic heterogeneity, from lunar fictions to astronomical treatises—of a back-and-forth as well as a de-centering of the gaze. With the narrative turning point demanded by Kepler at the start of *Astronomia Nova*, the tale becomes not only the fundamental textual form of astronomy, but also a principle of investigation that respects the intellectual order of discoveries and sketches the trajectory of coming and going between the known and the unknown, thus grasping the novelty of the objects of the “new astronomy.” After Kepler, to this narrative form was added recourse to fiction. The fictional tale of the *Dream* combines the structure of the travel tale and the fiction of an optical trip to the Moon in a striking demonstration achieved by visualizing the Copernican theses—a thought-experiment that is also a hypotyposis of the Copernican hypothesis. Thereafter throughout the century, the cosmological journey constituted a formidable polemical means in the debate over Copernicanism, exploiting and systematically appropriating the strategies of accreditation used in the travel genre. We have seen, for example, how Godwin, by superimposing a scholarly discourse over a fictional discourse, put the strategies of accreditation of the one at the service of the other, thus restoring lunar fiction to the category of the possible—but also weakening the discourse of astronomical knowledge. The crumbling away of separate categories of fiction and knowledge was confirmed in the use Wilkins made of them, then in Fontenelle’s rapprochement of astronomical conjectures and literary fictions. But Fontenelle rejected the implausible lunar journey and situated himself at an equal distance, as it were, from a fictional poetics and a probabilist poetics. Against the patent implausibility of the lunar journey, Huygens and Fontenelle privileged the category (both poetic and epistemological) of the plausible, reactivating an old poetic category and placing it at the heart of a poetics able to express the epistemic specificity of cosmological discourse. But whereas Huygens conceived the plausible as a valid tool in the construction of stable conjectural edifices, Fontenelle used it to affirm a playful skepticism capable of unmaking the worlds he had just imagined. It was against the probabilism, in which most of the century’s astronomers remained, due to the inaccessibility of celestial objects, that Robert Hooke fought when he imported the methods of experimental demonstration into the domain of astronomy. With Hooke, the passage from a poetics of the plausible to a poetics of proof took place on several levels: first, the microscopic level by the transformation of the epidictic discourse of the *enargeia* into an apodictic discourse founded on new techniques of visualization; then on the astronomical level by the

establishment of an *experimentum crucis* that transforms the instruments of observation into instruments of demonstration.

The poetic traits that are characteristic of cosmological discourse of the seventeenth century include (1) the new importance conferred on narrative as a mode of enunciation essential to scholarly discourse and (2) new scale of “veracity” stretching from the fictional to the probable, then from the probable to proof, in a series of fine gradations that efface epistemological boundaries. After Hooke, the poetic tools common to scientific discourse and literary discourse challenged the pertinence of the dichotomies by which people sometimes tried to distinguish the two: imagination vs. reason, fiction vs. nonfiction, figurative vs. literal. Upon analysis, it seems that such dichotomies obscure the mechanisms common to both discourses without showing the specificity of either. Once these dichotomies are set aside, we must not confuse texts arising from literary fiction and those arising from scientific discourse: Dyrcona’s flight in *Cyrano* does not have the same status as Duracotus’s flight in Kepler, nor as the *theoros*’s voyage in Huygens. In conclusion, one must try to characterize the specificity in other terms.

#### Fictionalizing Narratives and Factualizing Narratives

Because the thematic line of the cosmological voyage crosses the ontological frontier between fiction and nonfiction, we have been able to follow it from Kepler to Huygens via Godwin and Wilkins. The common point in these voyages is the presence of figures: neither the thought experiment of *The Dream* nor the analogical reasoning of *Cosmotheoros* could do without delegates, the “conceptual personae” that take the optical trip. Thus the symmetrical analysis of literary and scientific texts reveals the inadequacy of one of the criteria that are sometimes offered to distinguish factual tales from fictional ones: the literalness of the former, and the figurative nature of the latter. However, if there is indeed a constant trait in cosmological texts, it is the presence of figures; the difference between fictional and scholarly discourse resides in the way the figures are used and deployed in the text. The shift is not from the figural to the literal, but from free figures to disciplined figures that are controlled by the semiotic arrangements of theoretical texts. Thus in Kepler’s *Dream*, it is the footnotes and successive shifts that situate the fiction of the lunar voyage, and make the Daemon of Levania the spokesman of the new astronomy. The hyperbolically strange and foreign discourse of the scholar-demon is nevertheless solidly tied to the authorial voice: it is that connection that constructs Keplerian selenography as a referential rather

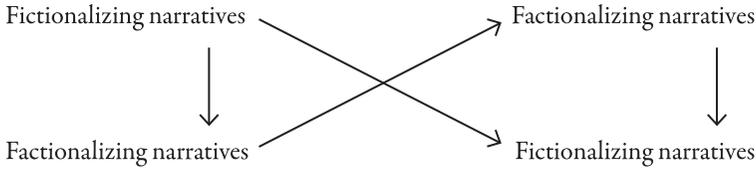
than a fictional discourse. By contrast, fictional voyages do not allow for such a “return” of the referential, because they do not frame the fictional discourse within a control mechanism of the sort.

To put it another way, the circulation of information and knowledge, and its control at each textual level is what characterizes theoretical texts in relation to fictional ones. The movement described by Hooke and Sprat, for whom the metaphor of the circulation of the blood designates another circulation, that of information coming from perception and passing from one sense to another, from one faculty to another, guarantees the permanence of *matters of fact* in an uninterrupted chain.

This means that it is the ways such shifts are linked that differentiate and signal certain texts as essentially fictional and others as essentially theoretical. When a fictional and theoretical text shifts from one plane of reference to another—from Europe to the Moon and then China in Godwin, from the dream to the book and then to the demon’s discourse in Kepler, from the macroscopic to the microscopic scale in Hooke—it is the nature of these shifts that varies. There are loose chains in fictional texts that jump from one enunciative level to another without requiring a return to the plane of the first enunciation; and there are sustained and disciplined chains in theoretical texts, guaranteeing the preservation of information from one enunciative level to another. In Godwin, for example, no overarching discourse comes to underwrite and to reframe the fictional narrative voice. The scholarly discourse is integrated into the fictional tale, but nothing enables it to be situated in relation to an enunciative plane of reference. In Huygens, on the other hand, the scholarly discourse is prime, and an authorial voice guarantees the preservation of data from one plane of reference to another. If fiction intervenes, it is only occasionally, as a support for reflection and as figuration of the process of delegation in the “conceptual character” who is the *theoros*, both space voyager and delegate, both fiction and function. In Kepler, continuity from one plane of reference to another is assured on the one hand by the footnotes that bind the fictional discourse to the scholarly discourse, and on the other hand, by the framing arrangement that sharply circumscribes the fiction. Ultimately, therefore, it is both the sites of fiction and its enunciation (the types of shifting that frame it or leave it free to act) that enable us to situate our texts according to their fictional or factual tendencies.

To show that this is a matter of tendencies and not an impassable barrier, I propose to use the term *fictionalizing narratives* for texts moving toward fiction (without renouncing any cognitive ambition) and the term *factualizing narratives* for texts that endeavor to construct facts (without renouncing

occasional recourse to fiction). The advantage of this formulation is that it grasps the gradations between fictionality and factuality, rather than fixing them in tight categories (see diagram).



If we follow the diagonal linking fictionalizing narratives, we go toward works that in our period were becoming more and more fictional and recognizable as such; this is the birth of a poetics specific to the novel. If we follow factualizing narratives in the other diagonal, we go toward works that constantly attenuate figuration and present themselves as tales that mimic raw facts; this is the poetics of the experimental account that we saw at work in Hooke. But it is in the two vertical columns that we can situate most of our texts, for they borrow from both registers. The vertical line on the left represents the case of fictionalizing narratives that learned from factualizing ones how to re-purpose themselves for new effects: Cavendish integrated the optical distortions of instruments into her fiction; *Cyrano* used philosophical polemics as a dynamic fictional principle; Godwin transformed the impossible lunar fable into a fable of the possible by the intervention of flying machines. The vertical on the right shows the inverse case of factualizing narratives that used fictionalizing ones to re-purpose them: Kepler, Fontenelle, Huygens, and Hooke adopted the structure of the lunar journey but de-figured and de-fictionalized it. However, most often literary and scientific texts are organized along the two diagonals, and are easily recognizable as essentially fictionalizing or factualizing. It is the specificity of the chosen corpus, uniting texts situated in zones of interchange of the two discourses, that enabled us to study their interactions.

Such an analysis moves beyond the bifurcation between literary discourse (supposed to have a monopoly on fiction and the imagination) and scientific discourse (considered a simple literal recording of reality). However, if one accepts such a bifurcation of figuration and literalness, of imagination and reason, then literary fiction loses its legitimacy for saying something about the world; in other words, it loses any cognitive and epistemological capacity. And from this perspective, scientific discourse is deprived of the resources of the imagination and of literary techniques without which it could never be deployed.<sup>2</sup> The interest of the cosmological texts that we have analyzed is

to abolish this false division of labor between literature and science, and to show how much the two retain modes of parallel truthfulness, even if they do not fuse with each other.

### Fiction and Hypothesis

Hence the differentiating factor between scientific texts and literary texts is not between nonfiction and fiction, but rather in the role and place granted to fiction. In scientific discourse, fiction is localized, situated, signaled by markers that frame and control it; for example, fiction is elucidated by the footnotes in the *Dream*. But things change when fiction evolves in an explicitly literary framework: no index permits it to be situated, especially in relation to the scholarly discourse that characterizes the lunar fictions of the seventeenth century. The credibility of this scholarly discourse is then indexed by the fictional discourse within which it is integrated. From this come the many games that undermine what is known (if not radically relativizing and destabilizing it) that we have encountered in Godwin, Cyrano, and Cavendish.

If the texts studied are not all “fictions,” they all take the question of fiction very seriously, whether to make use of it or else to warn about its dangers. One frequently encountered phenomenon has been the recharacterization of fiction as a discourse of the *possible*: we looked at the case of the lunar fable that was epistemologically reinvested when it moved from the impossible to the possible thanks to the mechanization of the trip to the Moon in Godwin, Wilkins, and Cyrano. Symmetrically, ancient cosmological (non-Copernican) theories were disqualified as “fictions.” This use of the term “fiction” was more a rhetorical weapon against opposing theories than a stable discursive category. Whether ally or enemy of scholarly discourse, fiction constantly changed field. Diachronically we have been able to observe that each generation characterized previous or opposing theories as “fictions.” Thus the term *fiction* became a weapon and a rhetorical strategy to remove credibility. Hence the need to carefully distinguish this rhetorical usage of the *term* itself—Kepler denounces Osiander’s “fable,” Huygens the “fictions” of Descartes, Kepler, and Fontenelle—from the usage of the fictional *mode* in the texts that we have examined. In order to distinguish these two usages, I have reserved the term “fictive” for fiction in the sense of falsehood, error, or illusion, and “fictional” for heuristic fiction.

In this heuristic usage, fiction rejoins hypothesis along a zone of interchange that we have traveled from Kepler to Huygens. It is also a zone of

turbulence, in which fiction learned to play on its ontological ambivalence, and the notion of hypothesis was itself redefined. In effect, with Kepler a new practice of hypothesis was born: the astronomical hypothesis acquired a physical meaning and was distinguished from the mathematical fictions of previous astronomers. But this new “astronomical hypothesis,” as Kepler defined it, retained a strong link with fiction conceived not as falsehood or as unreal, but as a heuristic faculty of the human imagination. Just as Kepler had distinguished between “astronomical hypotheses” and “geometrical hypotheses,” so I have distinguished between “fictional” and “heuristic” fictions, on the one hand, works capable of saying something about the world, and on the other hand, “fictive” fictions, in the sense of illusion or falsehood.

Understood in this first sense, fiction in science can become the support for heuristic activities: the gesture of abduction<sup>3</sup> in the creation of hypotheses, thought-experiments, and “conceptual personae” all arise integrally from scientific invention. In literature, fiction gives up none of its cognitive prerogatives, while profiting from its particular epistemological status for its impunity and freedom. For example, Fontenelle offered conjectures that constantly verged on fiction, for which he was reproached by Huygens, partisan of a controlled use of conjecture and figuration. With Cyrano and Cavendish, we witnessed the development of a fictional discourse inherited by the novel, which in Barbara Cassin’s words is “a *pseudos* that knows it is a *pseudos*, and offers itself as such in an illusion that is freely agreed, a discourse that renounces any ontological equivalence to follow its own demiurge.” She explains that we recognize that discourse as “novelistic fiction (*plasma*)”<sup>4</sup> — the plasticity (not falsehood) of a fictional discourse that is capable of integrating knowledge without depending on the same criteria of validation and accreditation as that knowledge.

### Optics of Fiction

The fictional mode, as distinct from the fictive as lying, then becomes the exocentric way of looking at the world. From Kepler’s fictional description of the Moon in the *Dream* to Fontenelle’s “visions,” the permanence of fiction is definitively explained by its optical properties and its capacity to produce images. Optical decentering by fiction constitutes the trait common to the texts studied because it could arouse strong images: anti-Aristotelian with Kepler, iconoclastic and anti-religious with Cyrano, anti-reformist with Cavendish. The fiction of Cyrano and Cavendish lent itself to distanciation that was both cosmic and comic, appropriating the optical games of micro-

scopes and telescopes and turning them against (in Cavendish's case) those who had developed them. More generally, we saw that optical techniques were at work in all the cosmological texts that made a voyage the fictional actualization of the lens's effects. Among the principal aspects of optics we encountered, there was bringing closer (seeing a close-up of what is inaccessible), magnification (seeing the detail of the imperceptible), and reversal (seeing an inverted image of what we know). In these three optical effects, we recognize certain traditional mechanisms and motifs of literary fiction: the imaginary voyage, satiric enlargement, and the inverted world. It seems as if these mechanisms were being reactivated by their instrumental actualization: the first by the telescope, the second by the microscope, and the third by the *camera obscura*.

But the instrumentalization of these optical effects also involves a modification of their meaning. In his distant travels, the explorer of the Renaissance—or at least his gaze—remained the same; the “I saw” of “autopsy” remained constant—it was even what ensured his credibility. Everything changed with the introduction of optical instruments that engaged in a modification of the gaze and of what was gazed at. The “equipped eye” of Robert Hooke radically transformed what he observed: the dragon star, deprived of its rays, appeared much smaller than it had seemed; the sharpest razor was now just a blunt blade; the vilest insect revealed extraordinary refinements. The equipped eye must now absorb these transformations in order to accede to microscopical and astronomical distant horizons. This was indeed the immense upheaval introduced by optical instruments: experimentalists discovered that to report faithfully objects at astronomical distances, optical deformation was necessary. While Renaissance travelers sought to bring back objects in their integrity (but Jean de Lery's parrot was eaten), the astronomers and microscopists were bringing back from distant worlds images that were transformed—and reliable precisely because they were transformed. From one level of reference to another, the considerable distortion to which the microscope and telescope submitted objects (as we saw with Margaret Cavendish) is the very condition of their transport and circulation. Enlarged, schematized, and simplified, the images of astronomical and microscopic distances made sense and “made science,” in the phrase of Isabelle Stengers, due to their successive transformations.

While the new optics were sometimes used in literature for satiric purposes in a very conventional process of the magnification and exaggeration of traits, writers retained from the century's optical revolution another essential element: the need to transform in order to see correctly. For this reason,

it seems to me, optics played a particular role in the new poetics of fiction. It is not only the effects of optical distortion that are exploited for the comic game of satire, but also the idea of a necessary correction of the gaze: because they compensate, correct, and reveal, the various aspects of optics mentioned above (see far, see in detail, see inverted) are not so much deforming what they show to sight than making it possible to see what was previously opaque. We can perceive the fecundity in literature of such an optical conception of fiction. It helps rethink the articulation of fiction and the real, less in terms of ontological opposition (we saw the ineffectiveness of such an approach) than in terms of accessibility and readability: by this interpretation, fiction would be one of the means for making the world visible and readable thanks to its redescription.

The novel learned from optics that sometimes you have to magnify in order to see better, to exaggerate in order to be exact, to select in order to describe well. This path is worth exploring further, for example in relation to the fictions of the eighteenth century. The cosmological journey becomes a favorite narrative form of the philosophical tale: one thinks of the “point of view of Sirius” in Voltaire’s *Micromégas*, which inherits something from the overarching philosophical gaze of Antiquity, but adds optical effects that were refined in seventeenth century texts. By circulating from ancient philosophy to the new astronomy and to literature in the seventeenth century, then again from literature to philosophy in the following century, the motif is enriched but remains above all a means of grasping (by decentering the gaze) our own world. Fiction then becomes one of the available tools for seeing, by redescribing (according to various optics) what surrounds us. This could be showing the invisible or the inaccessible, but much more often it allowed things to be seen differently (as by Hooke’s microscope), things that were already available to be seen but eluded us. Between defamiliarization by the far-away journey and the rediscovery of what one thought one knew, between telescopic vision and microscopic vision, literary fiction found in optics new paths for exploring the world.

For ten years now, important research on the theory of fiction has dethroned a definition of fiction as “noncognitive” discourse. From Thomas Pavel’s “thought of the novel” to the theory of possible worlds, from the pragmatic analysis of Jean-Marie Schaeffer to the “philosophical fictions” studied by Neil Kenny, Frank Lestringant, and Terence Cave, we have seen a complex articulation of fiction and knowledge. Analysis of the corpus of cosmological texts of the seventeenth century confirms these conclusions and casts a new light on certain differences in the ways theoretical and fictional texts

function. By the study of texts on the frontier between the literary and the scientific, I hope to contribute to the “generalized poetics” that François Rastier called for and toward which Michel Serres, Fernand Hallyn, and Gillian Beer, among others, have opened the way. It is indeed a question of better understanding the interactions between literature and science (even if one wants to challenge one or the other, or the one by means of the other) as distinct domains of the same culture, sharing the same interrogation of (and fascination with) what makes up our world.

### Copernican Poetics

It is on purpose, and without claiming to embrace all the cosmological and astronomical discourse of the seventeenth century, that I have limited my enquiry to texts that defended heliocentrism and the “new science.” This has enabled me to study the adoption and transformation of thematic motifs, textual strategies, and more generally, cosmopoetic figures appropriate to Copernican arguments—paradox, reversal, and optical displacement. These figures, according to whether they are used in fictionalizing or actualizing texts, either extend into fictional stories or else develop into lines of argument.

But the unity of this Copernican filiation helps to nuance its various textual actualizations according to the periods being considered. Between the years of the composition of Kepler’s *Dream* and those of Huygens’s *Cosmotheoros*, the stakes changed. It would be naïve to postulate the unity of a Copernican poetics across the century, as the defense of heliocentrism became hackneyed. Instead, what this enquiry has permitted me to emphasize is the variety of what was involved in this line of argument.

Thus one can speak of Copernican poetics in both of the senses that have been given to this expression: textual strategies *at the service of* the Copernican hypothesis, on the one hand, but also its uses as a powerful poetic and argumentative *tool* on the other. In its first meaning, “Copernican poetics” refers back to Kepler, and to a certain extent, to Godwin—even if the Copernican line of argument is already just a point of departure more than a goal. Kepler made Copernicanism the basis for a renewal of astronomy; Godwin used it to extend the picaresque tale to the cosmic scale. In the second half of the century, the defense of the Copernican system was no longer a burning issue; the cause had been won and so the stakes changed. The power of the reversal and upheaval effected by this argument was conserved as a lever in the new debates. It seemed as if astronomers and writers were continuing to use

Copernican arguments, but for other purposes. Cyrano made it the means of a radical epistemological destabilization; Hooke employed it to demonstrate the superiority of his measuring instruments and more generally the demonstrative power of experimental philosophy; Fontenelle put the Copernican cosmology at the center of a vast enterprise to translate scholarly discourse for the benefit of the general public; Huygens made his cosmology the base for his political, anthropological, and philosophical credo. Each used the immense lever of the Copernican change of perspective. And Kant would do the same, at the cost of an overthrow of the Copernican overthrow.<sup>5</sup>

In the final analysis, this is how I propose to interpret the permanence of textual motifs and figures across very different historical and epistemological contexts: Copernican cosmopoetic figures participated in the making of the new worlds of fiction and science; they furnished new matrices of invention because they were above all figures of movement. By fictional, conjectural, or instrumental optical movement, these texts actualized the Copernican paradox by exploiting its polemical and fictional potentialities and its philosophical implications. Zeno's paradox demonstrated the impossibility of movement. The paradox of the new astronomy was to demonstrate that, without moving, we nonetheless move. In a vertiginous voyage, imperceptible but reckless, across the cosmos, or in Robert Hooke's terms, in a "transmigration into heaven, even whilst we remain here upon Earth in the flesh."<sup>6</sup>



## NOTES

### INTRODUCTION

1. Kepler, *The six-cornered snowflake*.
2. The term *cosmopoetics* was used by Proclus commenting on Plato's *Timaeus*.
3. Koyré, *La Révolution astronomique*. See also Lindberg and Westman, *Reappraisals of the scientific revolution*, and Shapin, *The scientific revolution*.
4. Whitehead, *Science and the modern world*, 55.
5. Serres, *Hermès V: Le Passage du Nord-Ouest*.
6. Serres, *Feux*, 14.
7. Serres, *Feux*, 12–13.
8. See notably Jordanova and Williams, *Languages of nature*; Levine, *One culture*; Christie and Shuttleworth, *Nature transfigured*; Marchitello, *Narrative and meaning*; Mazzotta, *Cosmopoiesis*; Spiller, *science, reading, and Renaissance literature*; Saiber, *Giordano Bruno and the geometry of language*; Turner, *The English Renaissance stage*; Fletcher, *Time, space, and motion in the age of Shakespeare*.
9. Nicolson, *A world in the Moon*; idem, "Kepler, the *Somnium*, and John Donne"; idem, *Science and Imagination*; idem, *Voyages to the Moon*.
10. Lovejoy, *The great chain of being*.
11. Davis, *Factual fictions*; McKeon, *The origins of the English novel*; Pavel, *Univers de la fiction*; Pageaux, *Naissances du roman*; Troiano, *New physics and the modern French novel*; Mayer, *History and the early English novel*; Garavini, *La Maison des jeux*; Pavel, *La Pensée du roman*.
12. Moss, *Novelties in the heavens*; Fahnestock, *Rhetorical figures in science*.
13. Schaffer and Shapin, *Leviathan and the air-pump*.
14. Blair, *Theatre of nature*; Steczowicz, "The Defence of Contraries"; Paradis, "Montaigne, Boyle, and the essay of experience."
15. Dear, *The literary structure of scientific argument*; Westman, "Proof, poetics, and patronage: Copernicus's preface to *De Revolutionibus*"; Licoppe, *La formation de la pratique scientifique*.
16. Schaffer and Shapin, *Leviathan and the air-pump*; Shapin, *A social history of truth*; Dear, *Discipline and experience*.

17. Latour, "La rhétorique scientifique: qu'est-ce que la force d'un argument?"; idem, *Science in Action*; Latour and Bastide, "L'opéra du rein — mise en scène, mise en fait."
18. Viala, *Naissance de l'écrivain*.
19. Chartier, *Histoire de la lecture*; Rosellini, "Lecture et 'Connaissance des bons livres': Charles Sorel et la formation du lecteur."
20. Eisenstein, *The printing revolution*; Frasca-Spada and Jardine, *Books and the sciences in history*.
21. Bridenne, *La littérature française d'imagination scientifique*; Jones, *Studies in the history of English thought and literature*.
22. Beer, *Open fields*, 177.
23. See Jones, "Science and English prose style"; idem, *The seventeenth century: studies in the history of English thought and literature from Bacon to Pope*; idem, *Ancients and moderns: A study of the rise of the scientific movement in seventeenth-century England*; but see also Vickers, "The Royal Society and English prose style: a reassessment."
24. Galison, *Image and logic*.
25. Greenblatt, *Marvelous possessions*, 23.
26. Holton, *Scientific imagination*; idem, *Thematic origins of scientific thought*.
27. Pavel, *Univers*, 170.
28. For a similar approach, see Campbell, *Wonder & science*; Turner, *The English Renaissance stage*; Wolfe, *Humanism, machinery, and Renaissance literature*; Sawday, *Engines of the imagination*.
29. Spink, "Literature and the sciences in the age of Molière."
30. For instance de Verville, *Le Cabinet de Minerve*; and Domayron, *Histoire du siège des Muses*.
31. Fatouville, *Arlequin, empereur de la Lune*; Behn, *The Emperor of the Moon*; D'Urfey, *Wonders in the Sun*; Settle, *The World in the Moon*.
32. For Britain, see for instance Llasera, *Représentations scientifiques et images poétiques*. For France, see Chomety, *Philosopher en langage des dieux*.
33. See Moss, *Novelties in the heavens*; Stengers, "Les affaires Galilée"; and Biagioli, *Galileo courtier*.
34. See notably Campbell, *Wonder & science*; Bezzola Lambert, *Imagining the unimaginable*.

## CHAPTER ONE

1. See notably Kenny, *Philosophical fictions and the Renaissance*; idem, *The palace of secrets*; Guerrier, *Fictions du savoir à la Renaissance*.
2. Jardine, "The significance of the Copernican orbs."
3. Gingerich, "From Copernicus to Kepler: heliocentrism as model and as reality"; idem, "Circles of the gods: Copernicus, Kepler, and the ellipse."
4. Koyré, *La Révolution astronomique*.
5. Blair, "Tycho Brahe's critique of Copernicus and the Copernican system."

6. Dobrzycki, *Reception of Copernicus' heliocentric theory*; Taton and Wilson, *Planetary astronomy*.
7. See notably Holton, "Johannes Kepler's universe," in *The scientific imagination*; Stephenson, *Kepler's physical astronomy*; Hallyn, *La structure poétique du monde*; Field, *Kepler's geometrical cosmology*; Voelkel, *The composition of Kepler's Astronomia Nova*.
8. Jardine, *The birth of history*.
9. Kepler, *Dream*, 38 n 7. This is what Robert Westman called "the Wittenberg interpretation": a partial adoption of *De Revolutionibus*. Westman, "The Melanchthon circle, Rheticus, and the Wittenberg interpretation of the Copernican theory."
10. Kepler, *Dream*, 38 n 7.
11. Hallyn, *La structure poétique du monde*, 275; Romm, "Lucian and Plutarch as sources for Kepler's *Somnium*," 100.
12. Kepler, *Dream*, 36 n 4.
13. Kepler, *Dream*, 30 n 2.
14. Ballestra-Puech, "Le Songe allégorique de Cicéron à Lesage," 24.
15. Forestier, "Le rêve littéraire du baroque au classicisme," 218.
16. Kepler, *Dream*, 32 n 2.
17. Lucian, *True History*, §4, 204.
18. Cassin, "Du faux ou du mensonge à la fiction."
19. Kepler, *Dream*, 33 n 2.
20. Robinson, *Lucian and his influence in Europe*; Lauvergnat-Gagnière, *Lucien de Samosate et le lucianisme en France au XVIe siècle*.
21. Jardine, *The birth of history and the philosophy of science*; Gingerich and Voelkel, "Tycho and Kepler."
22. Hallyn, *La structure poétique du monde*, chap. 9.
23. Lafond, "Burlesque et Spoudogeloion dans les Etats et Empires de la Lune"; Bury, "Ménippe dans la Lune."
24. Kepler, *Dream*, 58 n 48.
25. "From that very city and house there emanated malicious gossip about me." Kepler, *Dream*, 40 n 8.
26. Kepler, *Tertius interveniens*, 126, in *Gesammelte Werke*, IV, 245–247.
27. Kepler, *Dream*, 63 n 55.
28. Kepler, *Dream*, 64 n 56.
29. Kepler, *Dream*, 37 n 6.
30. Grafton, "Kepler as a reader."
31. Kepler, "Geographical or, if you prefer, Selenographical Appendix, To the Very Reverend Father Paul Guldin, priest of the Society of Jesus," in *Dream*.
32. Kepler, *Dream*, 150.
33. Kepler, *Dream*, 151.
34. Kepler, *Dream*, 166 n XXXIV.
35. Kepler, *Dream*, 151.
36. Kepler, *Dream*, 152.

37. Maestlin, A2r, quoted by Barker and Goldstein, "Realism and instrumentalism," 249.
38. Dear, *Discipline and experience*, 124–126; Sorensen, *Thought experiments*; Swirski, *Cognitive sciences and literary knowledge*.
39. Blair, "Tycho Brahe's critique," 362.
40. Kepler, *Dream*, 15–16.
41. Kepler, *Dream*, 71 n 65.
42. Kepler, *Dream*, 15.
43. Kepler, *Dream*, 65 n 59.
44. Kepler, *Dream*, 65 n 60. See Maus de Rolley, "Voler avec le diable."
45. Clark, *Thinking with demons*, 162.
46. Kepler, *Dream*, 71 n 64.
47. Kepler, *Dream*, 64 n 57.
48. Kepler, *Dream*, 72 n 72.
49. Kepler, *Dream*, 73 n 75.
50. Holton, "Kepler's universe," 54.
51. Stephenson, *Kepler's physical astronomy*.
52. Holton, "Kepler's universe," 48.
53. Kepler, *Dream*, 14.
54. Kepler, *Dream*, 62 n 52.
55. Van Helden, "The invention of the telescope."
56. Kepler, *Dream*, 128 n 208.
57. Kepler, *Dream*, 125 n 207.
58. Kepler, *Dream*, 57 n 47.
59. Chen-Morris, "Shadows of instruction."
60. Kepler, *Dream*, 17.
61. Kepler, *Dream*, 78 n 89.
62. Kepler, *Dream*, 23.
63. Kepler, *Dream*, 101 n 135.
64. Copernicus, *On the Revolutions of Heavenly Spheres*, I, 8, p. 36.
65. Kepler, *Dream*, 87 n 110.
66. Kepler, *Dream*, 87 n 110.
67. Dick, *Plurality of worlds*, 70 ff.
68. Kepler, *Dream*, 27.
69. See chapters 3 and 4.
70. "None of this will be unbelievable to anybody who has read about Cola, the Sicilian manfish." Kepler, *Dream*, 130.
71. Kepler, *Dream*, 133.
72. Kepler, *Dream*, 134.
73. Kepler, *Dream*, 28.
74. Kepler, *Dream*, 27.

75. Dick, *Plurality of worlds*, 86.

76. Kepler, *Dream*, 89 n 116.

77. Duhem, *Sozein ta phainomena*; Westman, “Kepler’s theory of hypothesis and the ‘realist dilemma’”; Westman, “The Melanchthon circle”; Lloyd, “Saving the appearances”; Jardine, “The forging of modern realism”; Barker and Goldstein, “Realism and instrumentalism.” According to the recent interpretation by Barker and Goldstein, the astronomers of the Renaissance were not “instrumentalists” or “fictionalists” (they refuse these denominations because of their anachronism) but “realists” who were always dissatisfied. This historiographic and philosophical debate interests us in that it reflects the unstable ontological and epistemic status of astronomical hypotheses until Kepler.

78. Kepler, *Dream*, 41 n 8. Kepler’s mother was prosecuted as a witch. See Nicolson, “Kepler, the *Somnium*, and John Donne”; Koestler, *The watershed: a biography of Johannes Kepler*.

79. Westman, “The astronomer’s role in the XVIth century.”

80. See note 87 and Hallyn, *La structure poétique du monde*, 52–55.

81. “To the reader on the hypotheses in this work,” unsigned preface by Andreas Osiander to *Copernicus: On the revolutions of the heavenly spheres* (1543), trans. A. M. Duncan (1976), 22–23.

82. Quoted by Kepler, *Astronomia Nova*, verso of the title page, citing Pierre de la Ramée, *Leçons de Mathématiques*, book II, p. 50.

83. Kepler, *New astronomy*, 28.

84. Gingerich, “From Copernicus to Kepler,” 522; Blair, “Tycho Brahe’s critique of Copernicus,” 368.

85. Martens, *Kepler’s philosophy and the new astronomy*, 60.

86. In various texts and languages, one encounters the terms *fabula* (in Kepler in the positive sense of heuristic fiction in note 2 of *the Dream*, and in the negative sense of falsehood in the address to Ramus at the start of *Astronomia Nova* quoted above), *fable* (in Hooke in both senses as we will see in chapter 5), and *fiction* (in Huygens, Wilkins, and Godwin, again in both senses of the term; in Cavendish in its positive sense). Fontenelle uses both *fable* and *fiction*, generally in a positive sense. It is therefore impossible to discern a clear distribution of positive and negative senses of the two terms. But the permanence of the two terms characterizes the period—and the permanence of their positive and negative valences.

87. Greimas and Courtés, *Semiotics and language: analytical dictionary*.

88. Kepler, *Dream*, 14.

89. For an analysis of contemporary scientific texts, see Latour and Bastide, “Writing science: fact and fiction”; Latour, “A relativistic account of Einstein’s relativity.” I am grateful to Bruno Latour, who gave me a copy of the unpublished works of Françoise Bastide.

90. Hallyn, *La structure poétique du monde*, 275–279.

91. Kepler, *Dream*, 28–29.

1. See next chapter.
2. Burton, *The Anatomy of Melancoly*, 48.
3. Mersenne, *Questions inouïes*, 11.
4. The two first editions of this text had different titles: *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* (printed by E. G. for Michael Sparke and Edward Forrest, London, 1638); and *A discourse concerning a new world & another planet in 2 bookes* (printed [by John Norton and R. Hearne] for John Maynard, & are to be sold at the George, in Fleetstreet neare St. Dunstans Church, London, 1640). I am using the edition of 1640 because it includes a chapter on the lunar flight and a reference to Godwin. Henceforth referred to as *Discourse*.
5. Francis Godwin, *The Man in the Moone, or a Discourse of a voyage thither, by Domingo Gonsales*, 1638. The references come from the bilingual edition by Annie Amartin-Serin (Nancy, 1984). But I have also drawn from the abundantly annotated edition by William Poole that appeared in 2009. I thank Poole for making it available to me before its publication, as well as for his articles on Godwin.
6. See especially Hutton, “*The Man in the Moone* and the new astronomy: Godwin, Gilbert, Kepler”; and Poole, “The origins of Francis Godwin’s *The Man in the Moone* (1638).”
7. Godwin, *The Man in the Moone*, 52–53.
8. Godwin, *The Man in the Moone*, 50–51.
9. Godwin, *The Man in the Moone*, 58–59.
10. Godwin, *The Man in the Moone*, 62–63. Poole notes that the allusion to a non-existent second book imitates the last sentence of Lucian’s *True History*.
11. Godwin, *The Man in the Moone*, 46–47.
12. Godwin, *The Man in the Moone*, 8–9.
13. Godwin, *The Man in the Moone*, 57–59.
14. Godwin, *The Man in the Moone*, 52–53.
15. Godwin, *The Man in the Moone*, 52–53.
16. Godwin, *The Man in the Moone*, 54–55.
17. For a discussion of Godwin’s sources, see the aforementioned articles by Poole and Hutton, as well as Janssen, *Francis Godwin’s “The Man in the Moone”*; Philmus, *Into the unknown*; and Butler, introduction to his edition of *The Man in the Moone*, 47–51.
18. There are seven occurrences of “mine eyes” in the passage on lunar flight. In the *Address to the reader*, Domingo is presented as a “little eye-witness.”
19. Godwin, *The Man in the Moone*, 54–55.
20. This is the case for Gilbert and Burton, whom Godwin uses as his main astronomical sources. See Poole, introduction to his edition of *The Man in the Moone*, 20.
21. Godwin, *The Man in the Moone*, 54–55.
22. Godwin, *The Man in the Moone*, 54–55.

23. Lestringant, *Écrire le monde à la Renaissance*; idem, "Le Récit de voyage," 49–64.
24. Godwin, *The Man in the Moone*, 8–9.
25. Godwin, *The Man in the Moone*, 8–9.
26. Godwin, *The Man in the Moone*, 44–45.
27. Godwin, *The Man in the Moone*, 44–45.
28. Wilkins, *Discourse*, 240.
29. Wilkins, *Discourse*, 185.
30. Wilkins, *Discourse*, 203.
31. Wilkins, *Discourse*, 141.
32. See Ian Maclean: "For Aristotle and for his medieval and Renaissance commentators knowledge is hierarchical: there are different degrees of certainty (*gradus certitudinis*) in different sorts of knowledge. The most certain (*apodictic*, scientific) knowledge belongs to metaphysics and mathematics; physics (natural philosophy) is a step below; lower still are found ethics, politics, "economics" (domestic management). For all practical purposes this distinction is reduced to a dichotomy between the certain on the one hand and the endoxical or the 'probable' (that which is accepted by the most trustworthy authorities in any domain) on the other." Maclean, "Foucault's Renaissance episteme reassessed," 161.
33. Shapiro, *Probability and certainty in seventeenth-century England*, 15–43.
34. Wilkins, *To the Reader*.
35. Wilkins, *To the Reader*.
36. Wilkins, *Discourse*, 86.
37. Wilkins, *Discourse*, 60.
38. Wilkins, *Discourse*, 59.
39. Lestringant, *L'atelier du cosmographe*, 13–15.
40. Virgil, *Aeneid*, IX, 641.
41. Wilkins, *Discourse*, 238.
42. Hankins and Silverman, *Instruments and the imagination*.
43. Mersenne, *Questions inouyes*, 11.
44. Wilkins, *Mathematical Magick*, 199–210.
45. Wilkins, *Mathematical Magick*, 202–203.
46. Wilkins, *Discourse*, 77.
47. Wilkins, *Discourse*, 83.
48. Wilkins, *Discourse*, 142.
49. Wilkins, *Discourse*, 88.
50. Walter Raleigh, *The Discoverie of the Larga, Rich, and Beautifull Empire of Guiana*, in Richard Hakluyt, *The Principal Navigations, Voyages, Traffiques and Discoveries of the English Nation*, 12 vols., J. MacLehose & Sons, Glasgow, 1903–1905, vol. 10, 406, quoted by Greenblatt, *Marvelous possessions*, 22.
51. Godwin, *The Man in the Moone*, 57–59.
52. Cyrano de Bergerac, Savinien, *Oeuvres complètes*, 75–76.

53. For a recent bibliography see Darmon, *Le songe libertin*, and the special issue of *Littératures classiques*, 53, 2004, 173–208.

54. Alcover, *La pensée philosophique et scientifique de Cyrano de Bergerac*; Bloch, “Cyrano de Bergerac et la philosophie”; Darmon, *Philosophie épicurienne et littérature au XVIIe siècle en France*; idem, *Le songe libertin*. See also Moreau, “Guérir du sot.” *Les stratégies d’écriture des libertins à l’âge classique*.

55. Pioffet, “Godwin et Cyrano: deux conceptions du voyage”; Darmon, “Rhétorique du songe, fictions heuristiques et politique de la ‘grimace.’”

56. Cyrano de Bergerac, *L’Autre Monde ou les Etats et Empires de la Lune et du Soleil*. The first novel, *Les Etats et Empires de la Lune*, will be hereafter referred to as *Moon*; the second, *Les Etats et Empires du Soleil*, will be referred to as *Sun*. *Moon*, 6.

57. *Moon*, 15.

58. *Moon*, 16.

59. *Moon*, 5–9.

60. *Moon*, 7.

61. See especially Darmon, “L’imagination de l’espace entre argumentation philosophique et fiction,” and Moreau, “Guérir du sot.”

62. Moreau, “Les héritages polémiques de l’Autre Monde,” 41.

63. Darmon, “Rhétorique du songe,” 186.

64. Requemora, “Machines volantes, machine du monde et machinations.”

65. *Moon*, 41.

66. Parmentier, “Imagination et fiction dans *Les États et Empires* de Cyrano de Bergerac,” 228.

67. Kepler places an octahedron between the orbits of Mercury and Venus, an icosahedron between Venus and Earth, a dodecahedron between Earth and Mars, a tetrahedron between Mars and Jupiter, and a cube between Jupiter and Saturn. See Hallyn, *La structure poétique du monde*, 195–198.

68. *Moon*, 28–29.

69. *Sun*, 217.

70. On the relationship between Cyrano and Lucian, see Darmon, *Le songe libertin*, 176–177, and Bury, “Ménippe dans la lune: Cyrano à l’école de Lucien.”

71. *Moon*, 30.

72. *Moon*, 36–37.

73. Poulouin, “Cyrano iconoclaste,” 24; Moureau, “Dyrcona exégète.”

74. For the transformations of religious iconography, especially Marian, after Galileo’s telescopic discoveries, see the fine analysis by Eileen Reeves, *Painting the heavens: art and science in the age of Galileo*, ch. 4. She describes the representation of “weight” of the Virgin’s body in *The Assumption of the Virgin* by Nicolas Poussin (1650).

75. *Sun*, 227.

76. *Sun*, 217.

77. Darmon, *Philosophie épicurienne et littérature*.

78. *Sun*, 330.

79. Moon, 135.

80. Steczowicz, "The Defence of Contraries"; Maclean "Foucault's Renaissance episteme reassessed: an Aristotelian counterblast," 163–164; Alcover, *La pensée philosophique et scientifique de Cyrano de Bergerac*, 135.

81. The Man in the Moon ("Jean de la Lune") was a popular myth very common in Elizabethan England; for example, he appears in Shakespeare's *Midsummer Night's Dream*, with lantern and broom. See Poole, introduction to his edition of *The Man in the Moone*.

82. In the *General Scholium* of the third edition of the *Principia*, Newton declares: "I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction." Isaac Newton, *Philosophiæ Naturalis Principia Mathematica, General Scholium*, 943.

83. Cavendish, *The Blazing World*, "To his grace the Duke of Newcastle."

### CHAPTER THREE

1. Dijksterhuis, *The mechanization of the world picture*.

2. Cusa, *De Docta Ignorantia*, II, 12, Herder, I, 396: "Unde erit machina mundi quasi habens undique centrum et nullibi circumferentiam, quoniam eius circumferentia et centrum est Deus, qui est undique et nullibi." "The machine of the world will have its center everywhere, so to speak, and its circumference nowhere, because its circumference and its centre are God, who is everywhere and nowhere." On this metaphor see G. Baroncini, "Note sulla formazione del lessico della metafora 'machina mundi,'" and Beugnot, "La Notion de 'monde' au XVIIIe siècle."

3. Copernicus, *On the Revolutions of the Heavenly Bodies*, 3–5. On the notion of *opifex*, see Hallyn, *La structure poétique du monde*, 62, and Jardine, "The places of astronomy."

4. Hallyn, *La structure poétique*, 86–92.

5. *Institutionum astronomicarum libri duo* (Groningue, Saffius, 1616), 14–15, quoted by Hallyn, *La structure poétique*, 165.

6. See Jardine: "The true astronomer is no mere technician, but, like God, an *artifex*. In constructing his cosmology he follows nature, not in copying it but in imitation of the divine creative powers. Just as such a conception of the production of works of art as emulation of God's creative act lies at the heart of Mannerist artistic theory." Jardine, "The places of astronomy," 54.

7. Schaffer, "The devices of iconoclasm," 498.

8. This aspect of Cartesian cosmology has been well studied, notably by Jean-Pierre Cavallé and Fernand Hallyn, and we need not linger over it, although Descartes will re-

main a recurrent reference point in the chapter and the following one. See Cavaillé, *Descartes. La fable du Monde*, and Hallyn, *Les structures rhétoriques de la science*, chap. 4.

9. Fontenelle, *Conversations*, 8.

10. Fontenelle, *Conversations*, 8.

11. *Bienséance* was one of the rules of classical poetics obeyed in seventeenth-century French theatre and forbade any overly direct reference to the body so as not to offend the audience's taste and sensibility.

12. Fontenelle, *Conversations*, 9.

13. Fontenelle, *Conversations*, 10.

14. Fontenelle, *Conversations*, 10.

15. Fontenelle, *Conversations*, 10.

16. Fontenelle, *Conversations*, 11.

17. For instance, Descartes, *Traité des passions*, art. 73, in *Œuvres*, vol. 11.

18. Fontenelle, *Conversations*, 10.

19. Cavaillé, *Descartes. La fable du monde*, 41.

20. See especially Blair, *Theatre of nature*, 153–179.

21. Fontenelle, *Conversations*, 11.

22. Fontenelle, *Conversations*, preface, xiii.

23. Fontenelle, *Conversations*, 13.

24. Fontenelle, *Conversations*, 27.

25. Fontenelle, *Conversations*, 37.

26. Fontenelle, *Conversations*, 74.

27. Fontenelle, *Conversations*, 70.

28. Fontenelle, *Conversations*, 74.

29. Fontenelle, *Conversations*, 117.

30. Fontenelle, *De l'origine des fables*, 275.

31. "Intelligence about invisible things is acquired by means of those that one does see, and about the unknown by means of those that one does know." Belon, letter to the Cardinal of Chastillon, in *La nature et diversité des poissons*.

32. "We see therefore in the infancy of learning, and in rude times, when these conceits which are now old and trivial were new and unheard of, that the world was full of parables and similitudes. . . . For it is a rule in the arts of transmission, that all knowledge which is not agreeable to anticipation or presuppositions must seek assistance from similitudes and comparisons." Bacon, *De augmentis*, 6.2, in *Works*, vol. 4, 452.

33. Fontenelle, *Conversations*, 115.

34. Galison, "Descartes's comparisons," 323.

35. Fontenelle, *Conversations*, preface, xiv.

36. Hallyn, introduction, *Metaphor and analogy in the sciences*.

37. Shea, "Looking at the Moon as another Earth."

38. *Conversations*, 22. Christophe Martin in his notes suggests seeing here an allusion to Lucian's tale where the hero, shipwrecked on an island, discovers Greek charac-

ters. We may also detect an allusion to a story told by Cicero in *De Republica* v.28 9 and Vitruvius viii, or a reference to a geometry lesson in Plato's *Menon*.

39. Schaffer, "Natural philosophy as public spectacle"; idem, "Public experiments."

40. Leonard Marsak has shown it is a mistake to speak of Fontenelle's Cartesianism, since he keeps Descartes's cosmology and not his metaphysics. Similarly, we see how he constructs his analogical method by freely making use of Descartes's. Marsak, "Cartesianism in Fontenelle."

41. See Blanco, *Les rhétoriques de la pointe*.

42. See Parker, "'Concept' and 'conceit.'"

43. Fontenelle, *Conversations*, 80–81.

44. The English language supplies two terms that designate on the one hand the imagination conceived as a faculty ("imagination") and on the other hand the imagination conceived as an unlimited power of invention ("fancy"). These two terms are synonymous at the start of the seventeenth century. The question of the invisible seems to lead to a gradual separation of these two terms. For some historians of ideas, this distinction between "imagination" and "fantasy" parallels the distinction in Greek between *eikasia* and *phantasia*. At least that is the opinion of M. W. Bundy (*The theory of imagination in classical and medieval thought*), which was then challenged by J. M. Cocking (*Imagination: a study in the history of ideas*), 13. This distinction, peculiar to the English language, plays an essential role in the conception of fiction as invention issuing from "the fancy" and not from the imagination conceived as a deceptive faculty.

45. Fontenelle, *Conversations*, 46.

46. Lestringant, *Écrire le monde à la Renaissance*, 10 et sq.

47. Fontenelle, *Conversations*, 79.

48. Fontenelle, *Conversations*, 63.

49. Fontenelle, *Conversations*, 62.

50. See for instance: "Let us suppose in addition that God truly divides it into many such parts, some larger and some smaller, some of one shape and some of another, *as it pleases us to imagine them*"; "And my plan is not to set out (as they do) the things that are in fact in the true world, but only to make up *as I please* from [this matter] a [world] in which there is nothing that the densest minds are not capable of conceiving." Descartes, *Le Monde ou Traité de la Lumière*, chap. 6, in *Œuvres*, vol. 11.

51. "Yet, in order that this infinity not impede us and not embarrass us, let us not try to go all the way to the end; let us enter in only so far that we can lose from view all the creatures that God made five or six thousand years ago and, after having stopped there in some fixed place, let us suppose that God creates from anew so much matter all about us that, in whatever direction our imagination can extend itself, it no longer perceives any place that is empty." Descartes, *Le Monde ou Traité de la Lumière*, chap. 6, in *Œuvres*, vol. 11.

52. Descartes, *Le Monde ou Traité de la Lumière*, chap. 6, in *Œuvres*, vol. 11.

53. Fontenelle, *Conversations*, 130.

54. Fontenelle, *Conversations*, 61.
55. Fontenelle, *Conversations*, 60.
56. Fontenelle, *Conversations*, 58.
57. Fontenelle, *Conversations*, 141.
58. Fontenelle, *Conversations*, 7.
59. See Hallyn, *Les structures rhétoriques de la science*, chap. 4.
60. Fontenelle, *Conversations*, 65.
61. Fontenelle, *Conversations*, 131.

#### CHAPTER FOUR

1. Huygens, *Cosmotheoros*, 10–11.
2. Huygens to Chapelain, 27 March 1659, n° 602, 379.
3. Chapelain to Huygens, 15 October 1659, n° 675, 495.
4. Chapelain to Huygens, 18 December 1659, n° 695, 529.
5. Jardine, “The places of astronomy,” 49.
6. Huygens, *Cosmotheoros*, 3–4.
7. Hahn, “Huygens and France.”
8. *Nouveau traité de la pluralité des mondes, où l'on prouve par des raisons philosophiques que toutes les planètes sont habitées et cultivées comme notre Terre. Ouvrage composé par feu Monsr. Huygens, ci-devant de l'Académie Royale des Sciences*, Paris, 1702.
9. *De la pluralité des mondes* [ . . . ], traduit du latin de feu Mr. Cretien Huygens, de l'Académie Royale des Sciences, à La Haye, chez Jean Neaulme, 1724.
10. Huygens, *Cosmotheoros*, 2–3.
11. Huygens, *Cosmotheoros*, 5–6.
12. Huygens, *Cosmotheoros*, 4–5.
13. Licoppe, *La formation de la pratique scientifique*, 90.
14. Huygens, *Systema Saturnium*, in *OC*, vol. 15, 298.
15. Lestringant, *L'atelier du cosmographe*, 46–48.
16. Licoppe, *La formation de la pratique scientifique*.
17. Van Helden, *Huygens's ring*, 17.
18. Seidengart, “Les théories cosmologiques de Huygens,” 215.
19. Power, *Experimental Philosophy*, preface.
20. Huygens to Chapelain, July 1656, n° 323, 472.
21. Huygens, *Cosmotheoros*, 9.
22. The different value accorded to the two notions clearly appears in most of the texts I consulted that had the double occurrence. For example, there is the letter of Wren to Neile of 11 October 1661: “Though I might have taken occasion together with this old paper to have sent some new Hypotheses, yet considering they would as yet be but mere conjectures, I have let alone those thoughts.” Quoted in *Œuvres Complètes (OC) de Huygens*, vol. 3, 417. The two terms correspond, in short, to two distinct degrees on the scale of certitude mentioned earlier.

23. Huygens, *Cosmotheoros*, appendix 3, 824.
24. Fontenelle, *Conversations*, 8.
25. Huygens, *Cosmotheoros*, 101.
26. Westman, "Huygens and the problem of Cartesianism," 97–98. See also Huygens, "De probatione ex verisimili," *OC*, vol. 21, 541.
27. Huygens, *Cosmotheoros*, 9–10.
28. Huygens, *Cosmotheoros*, 20.
29. Huygens, *Cosmotheoros*, 43.
30. Kremer, "Vraisemblance et reconnaissance de la fiction."
31. Huygens, *Cosmotheoros*, 17–18.
32. Huygens, *Cosmotheoros*, 2.
33. Mandelbaum, *Philosophy, science, and sense perception*, chap. 2.
34. Huygens, *Cosmotheoros*, 7–8.
35. Huygens, *Cosmotheoros*, 37–38.
36. Huygens, *Cosmotheoros*, 17–18.
37. Huygens, *Cosmotheoros*, 58.
38. Huygens, *Cosmotheoros*, 63.
39. Huygens, *Cosmotheoros*, 62.
40. Huygens, *Cosmotheoros*, 62.
41. Huygens, *Cosmotheoros*, 62.
42. Huygens, *Cosmotheoros*, 29.
43. See Hallyn, *La structure poétique*, 104–105; Kemp, "Temples of the body and temples of the cosmos."
44. Huygens, *Cosmotheoros*, 117.
45. Sutton, *Science for a polite society*, 162.
46. Huygens, *Cosmotheoros*, 150–151.
47. Huygens, *Cosmotheoros*, 86.
48. Van Helden, "Huygens and the astronomers," 156.
49. Cocking, *Imagination*.
50. Huygens, *Cosmotheoros*, 33.
51. Huygens, *Cosmotheoros*, 32.
52. Huygens, *Cosmotheoros*, 34–35.
53. Huygens, *Cosmotheoros*, 35.
54. Huygens, *Cosmotheoros*, 77.
55. Huygens, *Cosmotheoros*, 99–100.
56. Huygens, *Cosmotheoros*, 15.
57. Huygens, *Cosmotheoros*, 4.
58. Van Helden, *Huygens's ring*, 23.
59. See Elzinga, *On a research program*; idem, "Christiaan Huygens' theory of research"; and Westman, "Huygens and the problem of Cartesianism."
60. Huygens, *Vie de Baillet*, *OC*, vol. 10, 403.
61. Huygens, *Systema Saturnium*, 300.

62. Huygens, *Cosmotheoros*, 159–160.

63. See for instance Bernier, *Abrégé de la Philosophie de Gassendi*, 133.

64. Huygens, *Cosmotheoros*, 160.

65. Huygens, *Cosmotheoros*, 4.

66. Holton, *Scientific imagination*, 48.

67. “For astronomers in the Renaissance, the fundamental processes of representation do not seem to have been essentially different from those of Ptolemy or his Islamic successors. The visual qualities of the illustrations bore only schematic relationship to the visualization demanded of the astronomer. Scientific instruments come closer to the hypothetical mental models, but only with respect to the gross characteristic of the arrangement of the basis armature of the celestial machines. Where more specifically Renaissance modelling can be discerned is in the humanist metaphors and analogies used to characterize form and function, relying upon beauty, economy, and decorum (intellectual, visual, social).” Kemp, “Temples of the body and temples of the cosmos,” 82.

68. Jardine, “The places of astronomy.”

69. See Peter Galison, on Wheeler’s mathematical machines: “Every machine account is a story like this one, a kind of picaresque novel, with a bundle of energy as hero. The shell moves, if it is upright it passes, if it is reversed it hits the protrusion and is flipped, then it falls out the shoot. . . . As in a story, the spotlight of our attention follows a thing or motion as it traverses obstacles, undergoes transformation over time, and emerges different than it was at the outset. Complex machines are assemblies of such stories.” Galison, “Structure of crystal, bucket of dust.”

70. Huygens, *Cosmotheoros*, 11.

71. Huygens, *Cosmotheoros*, 138.

72. Huygens, *Cosmotheoros*, 125.

73. Jardine, “The places of astronomy,” 50. It is this type of model that Priestley denounces as fiction in the epigraph to part 2.

74. Huygens, *Cosmotheoros*, 130–132.

75. Huygens, *Cosmotheoros*, 135.

76. “Conceptual personae are not mythical personifications or historical persons or literary or novelistic heroes. . . . This does not mean that the two entities do not often pass into each other in a becoming that sweeps them both up in an intensity which co-determines them. . . . It is as if, between them, not only alliances but also branchings and substitutions take place.” Deleuze and Guattari, *What is philosophy?*, 65–66.

77. Huygens, *Cosmotheoros*, 63.

78. Holton, *Scientific imagination*.

79. On conceptual personae in scientific texts, see Hammad, “Le bonhomme d’Ampère”; Latour, “A relativistic account of Einstein’s relativity”; Hallyn, *Les structures rhétoriques de la science*, 259–283.

80. See notably Poole, “*Nuncius inanimatus*: seventeenth-century telegraphy.”

81. Latour, “A relativistic account of Einstein’s relativity.”

82. Koyré, *Du monde clos à l'univers infini*; Randles, *The unmaking of the medieval Christian cosmos*.

83. Priestley to his students at the Warrington Academy in 1761, quoted by Schaffer, "Natural philosophy as public spectacle," 1.

84. Shapin and Schaffer, *Leviathan and the air-pump*.

#### CHAPTER FIVE

1. Robert Hooke, *Micrographia*, preface. See Hunter and Schaffer, *Robert Hooke: new studies*, 36–37.

2. Bennett, "Robert Hooke as mechanic and natural philosopher"; "Hooke's instruments for astronomy and navigation"; "Hooke's instruments"; "Instruments and ingenuity."

3. The first was John Evelyn's *Sylva* in 1664.

4. Mandelbaum, *Philosophy, science, and sense perception*, 88–112. Mandelbaum credits Boyle with proposing a solution to the problem: knowledge that is confirmed at the level of observation, that is found to apply to all matter whatsoever, and is scale invariant can be assumed to apply to atoms also. See also Shapin and Schaffer, *Leviathan and the air-pump*, 37 n. 26.

5. Henry Power, *Experimental Philosophy, in Three Books, Containing New Experiments, Microscopical, Mercurial, Magnetical with Some Deductions and Probable Hypotheses, Raised from Them, in Avouchment and Illustration of the now famous Atomical Hypothesis*, Preface to the Ingenious Reader.

6. Hooke, *Micrographia*, preface.

7. Hamou, *La mutation du visible*.

8. Power, *Experimental Philosophy*, preface.

9. Horace, *First Epistle*, trans. Rushton Fairclough, epigraph of *Micrographia*.

10. Galileo, *Sidereus Nuncius*, 36.

11. Hooke, *Micrographia*, 2.

12. Gilman, *The curious perspective: literary and pictorial wit in the 17th century*.

13. William Shea explains: "The mountains in the Moon are equally invisible to the eye that looks at them through a telescope. Their presence can only be inferred from variations in the light and dark areas of the lunar surface interpreted by someone with a knowledge of perspective. Most astronomers in Galileo's day were trained as mathematicians but he had also received instruction in the theory and practice of perspective, and he had distinguished himself as an amateur painter." Shea, "Looking at the Moon as another Earth: terrestrial analogies, and seventeenth-century telescopes," 87.

14. Hooke, *Micrographia*, "Observ. LX. Of the Moon," 242.

15. Harwood, "Rhetoric and graphics in *Micrographia*," 138.

16. As Steven Dick explains, the study of atoms is a case in point, explaining how matter is made of moving atoms while also putting forth a theory of the formation of cosmic bodies. Dick, *Plurality of worlds*, 7.

17. Dennis, "Graphic understanding," 332.
18. Hooke's aim is "the knowledge of the efficient and concurrent causes of all these curious Geometrical Figures [ . . . ] which has made the Philosophers hitherto to conclude nature in these things to play the Geometrician. [ . . . ] and here we meet with nothing less than the Mathematicks of nature, having every day a new Figure to contemplate, or a variation of the same in another body." Hooke, *Micrographia*, 87.
19. Hooke, *Micrographia*, 154.
20. See M. M. Slaughter, *Universal languages and scientific taxonomy*.
21. Hooke, *Micrographia*, 1.
22. Alpers, *The art of describing*, chap. 4.
23. Hallyn, "Atoms and letters," 62.
24. Hamou, *La mutation du visible*, 142.
25. See Dear, "Totius in Verba," and Zakin. "Inside books of the worlds."
26. Hooke, *Micrographia*, 85.
27. Hooke, *Micrographia*, 93.
28. Daston and Park, *Wonders and the order of nature*, chap. 8.
29. "A compilation, or particular natural history, must be made of . . . every thing, in short, which is new, rare, and unusual in nature." Bacon, *Novum Organum*, 138.
30. 'Espinasse, *Robert Hooke*, 43.
31. Cooper and Hunter, *Robert Hooke: tercentennial studies*, introduction, xvii.
32. "Yet what I think Hooke did inherit from the 'natural magical' tradition was its tantalizing premise to be able to achieve the ostensibly impossible. It is almost as if Hooke had effected the transition from magician to a certain kind of modern theoretical physicist, in the way in which he played on the partial revelation of amazing truths about nature to which he claimed that he was privy. In other words, Hooke was a 'scientist' in a full, modern sense, yet this was not exclusive of his being something of a 'wonder-monger.'" Hunter, "Robert Hooke: the natural philosopher," 149.
33. There have been many studies of these "wonder books" or "books of secrets," including Céard, *La nature et les prodiges*, and Daston and Park, "Unnatural conceptions: the study of monsters in sixteenth- and seventeenth-century France and England," 35–38.
34. Lestringant, *Écrire le monde à la Renaissance*, 31.
35. Hooke, *Micrographia*, preface.
36. For an analysis of the naturalization of wonder, see Daston and Park, "Unnatural conceptions," 35.
37. "So vast is the variety of Objects which will come under their Inspections, so many different ways there are of handling them, so great is the satisfaction of finding out new things, that I dare compare the contentment which they will enjoy, not only to that of contemplation, but even to that which most men prefer of the very Senses themselves." Hooke, *Micrographia*, preface.
38. Hooke, *Micrographia*, 174.
39. "And as amongst Stones some are call'd precious from their excellency, so also

are there Sands which deserve the same Epithite for their beauty; for viewing a small parcel of *East-India* Sand (which was given me by my highly honoured friend, Mr. *Daniel Colwall*) and, since that, another parcel, much of the same kind, I found several of them, both very transparent like precious Stones, and regularly figur'd like Crystal, *Cornish* Diamants, some Rubies, &c. and also ting'd with very lively and deep colours, like *Rubys*, *Saphyrs*, *Emeralds*, &c. These kinds of granuls I have often found also in *English* Sand. And 'tis easie to make such a counterfeit Sand with deeply ting'd Glass, Enamels and Painters colours." Hooke, *Micrographia*, 80.

40. Hooke, *Micrographia*, 152.

41. This emphasis on the sensual nature of microscopic vision is directly opposed to Boyle's imperative of total abstraction. For Boyle, the experimental philosopher only finds pleasure "in abstracted truths; . . . such truths as do not at all, or do but very little, gratify men's ambition, sensuality, or other inferior passions and appetites." Quoted by Shapin, "Who was Robert Hooke?" 270.

42. Daston and Park have noted that Paré had to remove a section on lesbianism that contained a description of female genitalia before he was allowed to include *Des Monstres et prodiges* in later editions of his complete works.

43. This interpretation of *Micrographia*'s graphic precision was suggested by Campbell, *Wonder & science*, 183.

44. Hooke, *Micrographia*, 175–176.

45. While the text recalls the aesthetics of miniatures, the engraving of the reflection in the facets of the eye remind us of the reflections in the soap bubbles of Dutch still lives. The curved reflections of a window in soap bubbles are typical of David Bailly's still life paintings and vanitas symbols (see for instance *Still life with portrait of the artist*, 1651, Stedelijk Museum, Leiden, and *Vanitas still life with portrait*, ca. 1650, Herbert F. Johnson Museum of Art; the first is reproduced in Alpers, *The art of describing*, p. 85 and front cover).

46. See Schaffer, "Natural philosophy as public spectacle"; idem, "Making certain"; Dear, "Jesuit mathematical science and the reconstitution of experience in the early 17th century"; idem, "Miracles, experiments, and the ordinary course of nature."

47. Thomas Muffet (or Mouffet, Moffett, Muffett), *Insectorum sive Minimorum Animalium Theatrum*. This work was posthumously published and written jointly with Edward Wotton, Conrad Gesner, and Thomas Penny.

48. Hooke himself underlined the change when he referred to Power's work at the end of the preface to his *Micrographia*: Power's "design was only to print Observations without Pictures."

49. Montgomery, *The Moon and the Western imagination*, 104.

50. John Harwood compares Hooke's drawings to the vivid presence of *enargeia* with good reason. See John Harwood, "Rhetoric and graphics in *Micrographia*." The various comments Hooke made about the risk of seductive images were indeed in line with the Renaissance commentaries of Cicero and Quintilian. However, the fact that the effect of *enargeia* was sought through a new *vehicle*—not through texts (*ekphrasis*)

but through drawings (visualization)—has not been explored in its full scope. Drawing upon Harwood's illuminating analysis, I shall understand *enargeia* in the strict rhetorical and textual sense it bore at the time in order to focus on the shift from the textual to the visual mode of representation.

51. See Galand-Hallyn, *Les Yeux De L'éloquence*, 99–100.

52. Quintilian, *Institutio Oratoria*, book VIII: iii, 62.

53. Observation 1, The Flea: "his head, body, and limbs also, be all of blackish armour-work, shining and polished with jemma's, most excellently contrived for the nimble motion of all the parts: nature having armed him this Cap-a-pe like a Curiazer in war, that he might not be hurt by the great leaps he takes." Power, *Experimental Philosophy*, 2–3.

54. Power, *Experimental Philosophy*, 2–3.

55. 'Espinasse, *Robert Hooke*.

56. "I indeavoured first to discover the true appearance, and next to make a plain representation of it. . . . And therefore I never began to make any draught before by many examinations in several lights, and in several positions to those lights, I had discovered the true form." Hooke, *Micrographia*, preface.

57. Alpers, *The art of describing*.

58. The expression of this confidence in the expansion of the universe of the visible toward the universe of the invisible is to be found in the preface. Our instruments, explains Hooke, will one day be sufficiently powerful to see both the atoms and the inhabitants of the other planets: "'Tis not unlikely, but that there may be yet invented several other helps for the eye, as much exceeding those already found, as those do the bare eye, such as by which we may perhaps be able to discover living Creatures in the Moon, or other Planets, the figures, of the compounding Particles of matter, and the particular Schematisms and Textures of Bodies." Hooke, *Micrographia*, preface.

59. Hooke, *Micrographia*, preface.

60. See Wilson, *The invisible world*. I would like to thank Catherine Wilson for allowing me to see her unpublished article, "Aesthetic appreciation of nature in early modern science."

61. Power, *Experimental Philosophy*, 83.

62. Hamou, *La mutation du visible*, 138.

63. Galison, "Descartes's comparisons: from the invisible to the visible."

64. On the history and meaning of the *Kunstammer*, see Bredekamp, *The lure of Antiquity and the cult of machine*. For a description of Quiccheberg's theory, see especially 28–30.

65. Power, *Experimental Philosophy*, 36.

66. Panofsky, *Perspective as symbolic form*; Kemp, *The science of art*; Arasse, *L'annonciation italienne. Une histoire de perspective*; Hamou, *La vision perspective (1435–1740)*.

67. Kepler had already noticed the symmetrical pattern of the snowflake, a beautiful example of the geometric quality of the fabric of the world, from the minute forms to

the celestial harmonies. See Johannes Kepler, *The six-cornered snowflake*. Modern crystallography had confirmed the different forms of symmetry—2-fold, 5-fold, rotational, plane, etc.—which appear more and more pronounced the more one “zooms in.”

68. Kemp, *Temples*, 54.

69. Worp, “Fragment eener Autobiographie van Constantijn Huygens,” in *Bijdragen en Mededeelingen van het historisch Genootschap*, Utrecht, 1897, 120, quoted by Alpers, *The art of describing*, 7.

70. “Inscription: a general term that refers to all the types of transformations through which an entity becomes materialized into a sign, an archive, a document, a piece of paper, a trace. Usually but not always inscriptions are two-dimensional, superimposable, and combinable. They are always mobile, that is, they allow new translations and articulations while keeping some types of relations intact. Hence they are also called ‘immutable mobiles,’ a term that focuses on the movement of displacement and the contradictory requirements of the task. When immutable mobiles are cleverly aligned they produce the circulating reference.” Latour, *Pandora’s hope*, glossary, 306–7. See also Latour, “Les ‘Vues’ de l’esprit” and *Science in action*.

71. Harwood, “Rhetoric and graphics in *Micrographia*,” 143, and Dennis, “Graphic understanding,” 324.

72. Harwood, “Rhetoric and graphics in *Micrographia*,” 135.

73. Hooke, *Micrographia*, preface. Hooke’s description of the circulation of information through the different faculties can be seen as an early formulation of the circulation of reference.

74. Westman, “Proof, poetics, and patronage”; Kemp, “Temples of the body and temples of the cosmos.”

75. Harvey, *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus*.

76. Latour, *Science in action*.

77. See next chapter.

78. “Nec miremur tam tarde erui quae tam alte iacent.” Seneca, *Quaestiones Naturales*, book 7, chap. 30, 2 (Hooke’s reference is misleading: book 1, chap. 30).

79. Robert Hooke, *An Attempt to Prove the Motion of the Earth*. See also Keynes, *A bibliography of Dr. Robert Hooke*, 30.

80. The pun was already in Seneca, who discussed comets in book 7 of *Quaestiones Naturales*.

81. The last page of the *Attempt* is frequently alluded to, as it formulates the famous “System of the World” that Newton read and completed. Since W. W. Rouse Ball’s pioneering study of 1893 and rediscovery of the letters exchanged between Hooke and Newton in 1679–1680, the role of Hooke in Newton’s development toward the inverse square law of gravitation has been much discussed in an extensive secondary literature. Hooke’s “System of the World” at the end of the *Attempt* has played an important role in this ongoing discussion. See for instance Koyré, “An unpublished letter of Robert Hooke to Isaac Newton”; Pugliese, “Robert Hooke and the dynamics of motion in a curved path.” Recent studies include Gal, “Meanest foundations and nobler superstruc-

tures,” and Hunter, “Robert Hooke: the natural philosopher.” With the exception of Jim Bennett (especially in Bennett, “Hooke’s instruments for astronomy and navigation,” and idem, “Hooke’s instruments,” quoted below), however, few commentators have taken the whole text into consideration.

82. Specific methods of astronomical observation were possible by 1669 that were impossible in, for example, 1640. An example is the pioneering work on object glass manufacture by Huygens and Campani in the 1650s, making possible the  $3\frac{1}{2}$  inch diameter, 36 foot focus lens by Richard Reeves, which Hooke used. In addition, the revolution in the micrometric measurement of small angles after Gascoigne’s methods, described in private letters of circa 1640, became more widely known after publication and commentary by Hooke in 1667. Without these technological developments, Hooke’s context-related investigations would not have been feasible. See Bennett, “Hooke’s instruments for astronomy and navigation”; idem, “Hooke’s instruments”; idem, “Instruments and ingenuity.”

83. Van Helden, “Telescopes and authority from Galileo to Cassini,” 10.

84. Hooke, *Attempt*, 1.

85. Hooke, *Attempt*, 4.

86. Hooke, *Attempt*, 2.

87. Hooke, *Attempt*, 3.

88. On the Baconian aspect of Hooke’s denunciation of human errors, as exposed in the *General Scheme* but already perceptible in the *Attempt*, see Hunter, “Robert Hooke: the natural philosopher,” 117–120.

89. Hooke, *Attempt*, 3.

90. See, for instance, one of the first reactions to *De Revolutionibus* in Rheticus’s *Narratio prima*: “With regard to the apparent motions of the Sun and Moon, it is perhaps possible to deny what is said about the motion of the Earth. . . . But if anyone desires to look either to the principal end of astronomy and the order and harmony of the system of the spheres or to ease and elegance and a complete explanation of the causes of the phenomena, by no other hypotheses will he demonstrate more neatly and correctly the apparent motions of the remaining planets.” (tr. slightly modified from E. Rosen by O. Gingerich), *Three Copernican treatises*, 165, 192, as quoted in Gingerich, “From Copernicus to Kepler,” 514.

91. Hooke, *Attempt*, 4.

92. Hooke, *Attempt*, 2–3.

93. Hooke, *Attempt*, 3.

94. Hooke, *Attempt*, 3.

95. Hooke, *Attempt*, 4.

96. Hooke, *Attempt*, 5.

97. “And therefore we may hence learn, upon what sure grounds all the Astronomers hitherto have built, who have calculated the distance of the Planets from the Horizontal Parallax; for since the Refraction and Parallax are so nearly ally’d, that the one can-

not be known without the other, especially by any wayes that have been yet attempted, how uncertain must the Parallax be, when the Refraction is unknown? And how easie is it for Astronomers to assign what distance they please to the Planets, and defend them, when they have such a curious subterfuge as that of Refraction, wherein a very little variation will allow them liberty enough to place the Celestial Bodies at what distance they please." Hooke, *Micrographia*, 236. This criticism is repeated in the *Attempt*: "Now if we are uncertain what part of the observed Angle is to be ascribed to refraction, we are uncertain of the whole observation as far as the possible uncertainty of refraction. Let me have but the liberty of supposing the refraction what I please, and of fixing the proportional decrease thereof according to the various elevation of the Rayes above the Horizon; I will with ease make out all the visible Phenomena of the Universe, Sun, Moon, and Stars, and yet not suppose them above a Diameter of the Earth distant." Hooke, *Attempt*, 15.

98. Shapin and Schaffer, *Leviathan and the air-pump*, chap. 2.

99. Hooke, *Attempt*, 8.

100. "And thirdly, the common way of Division is also lyable to many inconveniencies: And 'tis hardly possible to ascertain all the subdivisions of Degrees into minutes for the whole Quadrant, though that be not altogether impossible." Hooke, *Attempt*, 8.

101. Hooke, *Attempt*, 4.

102. Hooke, *Attempt*, 2.

103. On the transformation and attribution of the phrase *experimentum crucis*, see Vickers, "Francis Bacon and the progress of knowledge," 511. According to Vickers, the coinage was made by Robert Boyle, in his *Defence of the Doctrine touching the Spring and Weight of the Air* (1662), referring to Pascal's experiment on the Puy-de-Dôme as "an *experimentum crucis* (to speak with our illustrious Verulam)," in Boyle, *Works*, vol. 1, 151.

104. Hooke, *Attempt*, 8–9.

105. Bennett, "Hooke's instruments for astronomy and navigation," 25.

106. Hooke, *Attempt*, 9.

107. "For though *Ticho*, a man of unquestionable truth in his assertions, affirm it possible to observe with large Instruments, conveniently mounted and furnished with sights contrived by himself (and now the common one is for Astronomical Instruments) to the accurateness of ten Seconds; and though Riccioli and his ingenious and accurate Companion Grimaldi affirm it possible to make observations by their way, with the naked eye to the accurateness of five Seconds; Yet Kepler did affirm, and that justly, that 'twas impossible to be sure to a less Angle then 12 Seconds: And I from my own experience do find it exceeding difficult by any of the common sights yet used to be sure to a minute." Hooke, *Attempt*, 8.

108. Hooke, *Attempt*, 9.

109. Glanville, *The Vanity of Dogmatizing*, sigs. B2v5–B4v and 5–9.

110. Glanvill, *Scepsis scientifica*, 'To the Royal Society', sig b4v, as quoted in Shapin and Schaffer, *Leviathan and the air-pump*, 37.

111. Latour and Bastide, "L'opéra Du Rein," 93.

112. Hooke, *Attempt*, 11.

113. "By this observation of the Star in the day time when the Sun shined, with my 36 foot Glass I found the body of the Star so very small, that it was but some few thirds in Diameter, all the spurious rayes that do beard it in the night being cleerly shaved away, and the naked body thereof left a very small white point." Hooke, *Attempt*, 26.

114. Tycho Brahe, *Opera omnia*, vol. 6, 145.

115. Kemp, "Temples of the body and temples of the cosmos," 71.

116. See for instance Wren's critique of Hevelius: the telescope, when properly used, allows one "not only [to] draw Pictures of the Moon, as Hevelius has done, but Survey her & give exact maps of her, & discover exactly her various Inclinations, and herein Hevelius's Errors." As quoted in Bennett, "Hooke's instruments," 21. Such correction was precisely what Hooke undertook in the last observation of *Micrographia* (*Of the Moon*, 242–246).

117. Hooke, *Micrographia*, 234.

118. Hooke, *Attempt*, 10.

119. The reversal of forces by way of optical instruments is in fact a recurrent figure of Hooke's rhetoric. See for instance the last sentence of the preface of *Micrographia*, as quoted above: "my little Objects are to be compar'd to the greater and more beautiful Works of Nature, a Flea, a Mite, a Gnat, to an Horse, an Elephant, or a Lyon."

120. Latour, "Give me a laboratory and I shall move the world," 164.

121. Shapin, "Who was Robert Hooke?"

122. Hooke, *Attempt*, 6.

123. Hooke, *Attempt*, 25.

124. Hooke's device was perfectly in keeping with the perspective machines and optical devices used by painters and natural philosophers alike since the Renaissance. See Kemp, *The science of art*, chap. 4.

125. Kemp, "Temples of the body and temples of the cosmos," 43–44.

126. Hooke, *Attempt*, 28.

127. Hooke, *Attempt*, 27.

128. Bennett, "Hooke's instruments for astronomy and navigation," 32. See also Bennett, "Hooke's instruments," 80–83.

129. "We see therefore the necessity of the conjunction of Physical and Philosophical with Mechanical and Experimental Knowledge," Hooke *Attempt*, 16.

130. Shapin, "Pump and circumstance," 494.

131. "In the early seventeenth century, impressed by Michel de Montaigne's *Essais*, Francis Bacon composed a set of similarly titled, briefly tentative moral reflections. Robert Boyle soon adapted this kind of literary technology to his experimental 'essays'. Since then the English language has somewhat distinguished between essay and assay, between literary work in library or study and the messy labours of workshops, mines or

mins. Other languages make the distinction fuzzier, as the paired terms *essai*/experience and *Versuch*/Probe indicate." Schaffer, "Public experiments," 299–300.

132. "Boyle insisted that witnessing was to be a collective enterprise. In natural philosophy, as in criminal law, the reliability of testimony depended crucially upon its multiplicity." Shapin, "Pump and circumstance," 487.

133. Schaffer, "Making certain."

134. Dear, "*Totius in Verba*."

135. Jones, *Ancients and moderns*; idem, "Science and English prose style."

136. Dear, "*Totius in Verba*"; Vickers, "The Royal Society and English prose style."

137. Sprat, *History of the Royal Society*, 414–415.

138. Sprat, *History of the Royal Society*, I.

139. According to the OED, *meat* meant "solid food, as opposed to drink."

140. This phrase has been coined by Claude Imbert, "L'épisode formaliste, avant et après," Colloque de Cerisy, 12–19 July 2006, organised by Bruno Latour and Philippe Descola, "L'anthropologie historique de la raison scientifique."

141. Alpers, *The art of describing*, 8.

142. Kemp, *Temples*.

143. "Divina haec Opt. Max. fabrica." Copernicus, *De Revolutionibus*, I, x, 10.

## CHAPTER SIX

1. Cavendish, *The Blazing World*, 56.

2. Jardine, *The curious life of Robert Hooke*.

3. Cavendish, *Observations*, 10.

4. Cavendish, *Observations*, 98–99.

5. Cavendish, *Observations*, 4.

6. Cavendish, *Observations*, 82.

7. Cavendish, *Observations*, 12.

8. Cavendish, *Observations*, 50–51.

9. For a treatment of Cavendish's natural philosophy in relation to Hobbes, see Hutton, "In dialogue with Thomas Hobbes: Margaret Cavendish's natural philosophy," and Cottegnies, "Blazing Leviathan: les beautés de la raison dans *Le Monde Glorieux* de Margaret Cavendish."

10. "It may be argued that what is crucial about the mechanical philosophy is not so much a ban on active matter and occult causes, but rather a mechanical approach to nature: the use of machines as metaphors for natural principles, and the insistence on the role of mechanical aids in their empirical investigation. Hooke espoused a highly sophisticated and influential programme aimed at breaking the old division of art and nature and making a coherent new ontology for natural philosophy and a workable position for the natural philosopher on this basis." Hunter and Schaffer, *Robert Hooke: new studies*, introduction, 17.

11. Cavendish, *Observations*, 5.

12. Bennett, "Hooke's instruments," 67.
13. Cavendish, *The Blazing World*, 202.
14. Whitaker, *Mad Madge*, 281.
15. Cavendish, *Observations*, preface. M. A. Dennis has pointed out that Hooke's "reformation in Philosophy," though it promised peace, contained the possibility of social disorder and a potential violence that could be compared to the Protestant Reformation. Dennis, "Graphic understanding," 312.
16. Whitaker, *Mad Madge*, 279.
17. Cavendish, *Philosophical Letters*, 495–496.
18. Hooke, *Micrographia*, preface.
19. Battigelli, *Margaret Cavendish and the exiles of the mind*, 92.
20. Bennett, "Robert Hooke as mechanic and natural philosopher."
21. Cavendish, *Observations*, 49.
22. See for instance the gloss of the frontispiece of her *Philosophical and Physical Opinions* (1655):
 

Studious She is and all Alone  
 Most visitants, when She has none,  
 Her Library on which She look's  
 It is her Head, her Thoughts her Books.  
 Scorning dead Ashes without fire  
 For her owne Flames doe her Inspire.
23. Cavendish, *Observations*, "To the Reader," 12.
24. Pepys, *Diary* 6:18, 23 January 1665: "Before I went to bed, I sat up till 2 a-clock in my chamber, reading of MR. Hookes Microscopicall Observations, the most ingenious book that ever I read in my life."
25. Cavendish, *The Blazing World*, 31.
26. Cavendish, *Observations*, 9.
27. Cavendish, *Observations*, 36, 78.
28. "But though there be numerous Books written of the wonders of these Glasses, yet I cannot perceive any such, and at best, they are but superficial wonders, as I may call them." Cavendish, *Observations*, 10.
29. Cavendish, *Observations*, 11.
30. Cavendish, *Observations*, 13.
31. Cavendish, *Observations*, 27.
32. This use of "monsters" is purely rhetorical. As for nature's recognized monsters, Cavendish treats them according to the usual opinion of the time—as nature's irregularities. See for example her *Philosophical Letters*, 229.
33. Cavendish, *Observations*, 51.
34. See, for instance, after the description of a monstrous breast, the reference to magnifying glasses: "This made me reflect upon the fair skins of our English ladies, who appear so beautiful to us, only because they are of our own size, and their defects not to be seen but through a magnifying glass; where we find by experiment that the

smoothest and whitest skins look rough, and coarse, and ill-colored." Swift, *Gulliver's Travels*, 130.

35. Hooke, *Micrographia*, 2.

36. Cavendish, *Observations*, 50.

37. Daston and Park, *Wonders and the order of nature*, 200.

38. Cavendish, *The Blazing World*, 140.

39. Hooke, *Micrographia*, 218.

40. Cavendish, *The Blazing World*, 142.

41. Lilley, introduction to Cavendish, *The Blazing World*, xxix.

42. Pepys, *Diary*, 26 April 1667.

43. This ambivalence toward hermaphroditism was in fact not unique. As explained by Lorraine Daston and Katherine Park, the oscillation between pleasure and horror, wonder and repugnance, was an important feature of the early modern reaction to monsters, and especially to hermaphrodites. Daston and Park, *Wonders and the order of nature*, 190–214. As Arnold Davidson points out, before the eighteenth century hermaphrodites could actually choose their sex when they reached adulthood (but then they could not change their mind again). Davidson, "Sex and the emergence of sexuality," 19.vf

44. Pepys, *Diary*, 30 May 1667.

45. Battigelli, *Margaret Cavendish and the exiles of the mind*, 113.

46. Battigelli, *Margaret Cavendish and the exiles of the mind*; Campbell, *Wonder & science*, chap. 6; Cottagnies and Weitz, *Authorial conquests*.

47. McKeon, *The origins of the English novel*, 230–231.

48. Cavendish, *The Blazing World*, 212–214, 225–231.

49. Cavendish, *The Blazing World*, 213.

50. "The Duchess told them [the shipwrights and architects] how some in her own world had been so ingenious, and contrived ships that could swim under water, and asked whether they could do the like?" Cavendish, *The Blazing World*, 213. Cavendish seems to have been particularly fascinated by the "contrivances" and "inventions" of Cornelius Drebbel, as witnessed by the reference to the submarine that so impressed the court of James I. Cornelius Drebbel built the first submarine in 1620, and after having tested several models, presented to King James in 1624 a submarine capable of transporting sixteen passengers. And of remaining at a depth of four meters for three hours, and making trips between Westminster and Greenwich. However, it was never used for military purposes.

51. See chapter 5.

52. "In many things, they [the Ancients] come nearer to truth than many of our moderns; for surely the ancients had as good and regular rational and sensitive perceptions, and as profitable arts and sciences as we have; and the world was governed as well, and they lived as happily in ancient times, as we do now, nay more." Cavendish, *Further Observations*, in *Observations*, "I. Ancient Learning Ought Not to be Exploded, nor the Experimental Part of Philosophy Preferred Before the Speculative," 195.

- 53. Cavendish, *Further Observations*, 195–196.
- 54. Glanvill, “An Address to the Royal Society,” in *Scep̄sis Scientifica*, Londres, 1665, cited by Dear, “*Totius in Verba*,” 147.
- 55. Cottegnies and Weitz, *Authorial conquests*.
- 56. Woolf, *A room of one’s own*, 59–60.

## CONCLUSION

- 1. Huygens to Chapelain, 27 March 1659, n° 602, *OC*, vol. 2, 379.
- 2. Bruno Latour has especially stressed the crucial role of walk-on parts in scientific discourse: “Without the extras, no science is possible—who would go inhabit distant places if one could not delegate figurines, these partial observers?” Bruno Latour, *Résumé d’une enquête sur les modes d’existence, ou Bref éloge de la civilisation qui vient* (*Summary of an enquiry into Modes of Existence, or Brief Elogy of the Coming Civilization*) text for the Cerisy Colloquium, “Exercises in empirical metaphysics,” 23–30 June 2007, chapter 12: “Having enough solicitude for the beings of fiction,” 176.
- 3. This is what Fernand Hallyn calls, following Peirce, the specific process of invention of hypotheses. Hallyn, *La structure poétique du monde* (*The poetic structure of the world*), 9.
- 4. Cassin, “Du faux ou du mensonge à la fiction (de *pseudos* à *plasma*),” in *Le Plaisir de parler. Etudes de sophistique comparée*, 25.
- 5. Blumenberg, *The genesis of the Copernican world*.
- 6. Hooke, *Micrographia*, 234.

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## INDEX

- Alberti, Leon Battista, 155
- Alpers, Svetlana, 140, 156
- Archimedes, 165, 167
- Aristotle, 2, 18, 21, 30–31, 34–35, 54, 62, 71, 74, 86, 117, 128, 136, 161, 197, 209 n 32
- Bacon, Francis, 2, 9, 59, 87, 134, 140, 143, 149, 151, 157, 161, 164, 169, 186, 189, 212 n 32, 218 n 29, 224 n 131
- Bailly, David, 219 n 45
- Ballestra-Puech, Sylvie, 21
- Barker, Peter, 207 n 77
- Battigelli, Anna, 178
- Beer, Gillian, 5, 200
- Behn, Aphra, 8
- Bennett, Jim, 167, 169, 177
- Boyle, Robert, 149, 157, 164, 169, 174, 177, 217 n 4, 219 n 41, 223 n 103, 224 n 131
- Brahe, Tycho, 18, 23, 27, 38, 119, 139, 154, 160, 163, 168
- Burton, Robert, 45, 46, 208 n 20
- Cardano, Gerolamo (Cardan), 65
- Cassin, Barbara, 197
- Cassini, Giovanni Domenico, 97
- Cavendish, Margaret, 9, 12, 74–75, 174–83, 185–90, 195–98, 207 n 86, 225 n 9, 226 n 22, 226 n 28, 226 n 32, 227 n 50, 227 n 52
- Chapelain, Jean, 95–96, 191
- Cicero, 20–21, 27, 72, 98, 213 n 38, 219 n 50
- Clark, Stuart, 29
- Copernicus, Nicolaus, 2, 11, 18, 33, 34, 38–39, 47, 50, 51, 59, 65, 73, 79, 101, 118, 158, 160, 172, 222 n 90
- Cyrano de Bergerac, Savinien, 9, 11, 45, 47, 49, 51, 53, 55, 57, 59–61, 63–73, 75, 80, 82, 86, 88–89, 122, 127, 193, 195–97, 201
- Darmon, Jean-Charles, 66
- Daston, Lorraine, 142, 219 n 42, 227 n 43
- Dear, Peter, 170, 182, 186
- De Gheyn, Jacob, II, 156–57
- Della Porta, Giambattista, 32
- Descartes, René, 9, 18, 64, 70, 74, 81, 83, 87–89, 91–93, 97, 103, 114, 116–17, 126, 149, 152, 154–55, 171, 196, 213 n 40, 213 nn 50–51
- Deleuze, Gilles, 124, 216 n 76
- Dick, Steven, 217 n 16
- Drebbel, Cornelius, 156, 227 n 50
- Einstein, Albert, 125
- Epicurus, 65
- Evelyn, John, 217 n 3
- Fontenelle, Bernard le Bovier de, 9, 11, 12, 35, 45, 75, 79, 81–102, 104, 106, 108–13,

- Fontenelle, Bernard le Bovier de (*continued*)  
 125–27, 129, 133, 192, 195–97, 201,  
 207 n 86, 213 n 40
- Galilei, Galileo, 2, 8–9, 19, 27, 32, 37, 46,  
 54, 59, 61, 63, 114–15, 125, 136, 137
- Galison, Peter, 6, 77, 216 n 69
- Gassendi, Pierre, 56, 64
- Gilbert, William, 30, 48, 55, 208 n 20
- Glanvill, Joseph, 165, 186
- Godwin, Francis, 9, 11, 45–57, 59–67,  
 69–75, 80, 82, 86, 122, 124–25, 127,  
 192, 194–96, 200, 207 n 86, 208 n 10,  
 208 n 17, 208 n 20
- Greenblatt, Stephen, 6
- Hallyn, Fernand, 3, 43, 88, 141, 200,  
 228 n 3
- Hamou, Philippe, 141, 220
- Harriot, Thomas, 28, 41, 154
- Harvey, William, 306
- Hévelius, Johannes, 137, 159, 163–64, 167,  
 224 n 116
- Hobbes, Thomas, 176–77, 225 n 9
- Holton, Gerald, 6, 30–31, 125
- Homer, 154
- Hooke, Robert, 9, 12, 46, 129, 131, 133–81,  
 183, 185, 188–89, 192–202, , 207 n 86,  
 218 n 18, 218 n 32, 218 n 37, 218 n 39,  
 219 n 48, 219 n 50, 220 n 56, 220 n 59,  
 221 n 73, 221 n 81, 222 n 82, 222 n 97,  
 223 n 100, 223 n 107, 224 n 113,  
 224 n 116, 224 n 119, 224 n 124,  
 224 n 129, 225 n 9, 226 n 15, 226 n 24
- Horace, 136
- Huygens, Christiaan, 9, 11–12, 35, 45,  
 74–75, 81, 93–113, 115–29, 133, 191–97,  
 200–201, 207 n 86, 222 n 82
- Huygens, Constantijn, 156, 172
- Kemp, Martin, 119, 154, 168, 172, 216 n 67
- Kepler, Johannes, 1–3, 9, 11, 17–48, 51–53,  
 55, 59–68, 70–74, 79–80, 82, 86, 93,  
 96, 98, 108, 110, 112, 114, 115, 118–19,  
 122–25, 127, 143, 166–67, 192–97, 200,  
 207 n 86, 210 n 67, 220 n 67, 223 n 107
- Kircher, Athanasius, 97, 104
- Koyré, Alexandre, 2, 18
- La Fontaine, Jean de, 8
- Latour, Bruno, 77, 125, 157, 165, 167,  
 221 n 70, 228 n 2
- Lery, Jean de, 198
- Lucian, 9, 11, 18, 20, 22–23, 27, 45–46,  
 55, 68, 72, 74–75, 87, 98, 117, 126,  
 208 n 10
- Lyly, John, 71
- Maestlin, Michael, 26, 27, 29, 32
- Mandelbaum, Maurice, 134, 217 n 4
- Maxwell, James Clerk, 125
- McKeon, Michael, 183
- Mersenne, Marin, 46
- Milton, John, 8
- Molière, 8
- Montaigne, Michel de, 3, 169, 224 n 131
- Montesquieu, 3
- Montmor, Henri Louis Habert de, 100
- Newton, Isaac, 3, 9, 73, 169, 211 n 82,  
 221 n 81
- Nicolson, Marjorie, 3
- Oldenburg, Henry, 159
- Osiander, Andreas, 38–39, 196
- Paré, Ambroise, 146, 219 n 42
- Park, Katherine, 142, 219 n 42, 227 n 43
- Pascal, Blaise, 3, 223 n 103
- Pavel, Thomas, 6, 199
- Pepys, Samuel, 178, 182–83, 226 n 24
- Plato, 20–21, 23, 67, 73, 79, 98, 117, 120,  
 213 n 38
- Plutarch, 20–23, 27, 63

- Power, Henry, 9, 103, 134–35, 149–52,  
154–55, 157, 173, 219 n 48, 220 n 53
- Priestley, Joseph, 77, 80, 128–29, 216 n 73
- Ptolemy, 2, 18, 30, 71, 74, 79, 90, 119, 128,  
167, 216 n 67
- Pythagoras, 19, 58, 65
- Quiccheberg, Samuel, 154, 220 n 64
- Quintilian, 219 n 50
- Raleigh, Walter, 61
- Ramus, Petrus, 39, 73, 207 n 86
- Reinhold, Erasmus, 128
- Rheticus, Georg Joachim, 222 n 90
- Riccioli, Giovanni Battista, 160, 162–63,  
223 n 107
- Scaliger, Julius Casear, 35
- Schaffer, Simon, 77, 80, 163, 169, 170
- Seneca, 131, 158
- Serres, Michel, 2–3, 141, 200
- Shadwell, Thomas, 15, 17
- Shapin, Steven, 163, 165, 169–70,  
225 n 132
- Shapiro, Barbara, 57
- Sorel, Charles, 71
- Sprat, Thomas, 170–71, 173, 194
- Sutton, Geoffrey, 110
- Swift, Jonathan, 146, 181, 226 n 34
- Van Helden, Albert, 112, 115, 159
- Vesalius, Andreas, 154–56, 172
- Vickers, Brian, 170
- Virgil, 33, 59, 154
- Vitruvius, 109, 213 n 38
- Whitehead, Alfred North, 2
- Wilkins, John, 9, 11, 29, 45–47, 49, 51, 53,  
55–65, 67–69, 71, 73, 75, 80, 82, 86, 98,  
140, 192–93, 196, 207 n 86
- Wren, Christopher, 151, 214 n 22,  
224 n 116

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