

Ambix

The Journal of the Society for the History of Alchemy and Chemistry

CHAIRMAN: Prof. W. H. Brock.

HON. SECRETARY: J. A. Hudson, Applied Sciences, Anglia Polytechnic University, East Road, Cambridge CB1 1PT.

HON. EDITOR: Dr. Gerrylynn K. Roberts, Department of History of Science and Technology, The Open University, Milton Keynes MK7 6AA.

HON. REVIEWS EDITOR: Prof. D. M. Knight.

HON. REVIEWS EDITOR-ELECT: Dr. E. Homburg, Department of History, University of Maastricht, 6200 MD Maastricht, The Netherlands.

HON. TREASURER: Dr. N. G. Coley, 24 Kayemoor Road, Sutton, Surrey SM2 5HT.

ORDINARY MEMBERS OF COUNCIL:

Dr. R. G. W. ANDERSON

Prof. J. H. BROOKE

Prof. A. G. DEBUS

Dr. E. HOMBURG

Prof. D. M. KNIGHT

Dr. P. J. T. MORRIS

Prof. G. REES

Dr. M. A. SUTTON

Dr. KATHERINE D. WATSON

Miss MARIANNE WINDER, M.A.

In *Ambix*, which appears in March, July and November each year (3 parts making a volume), the Society publishes scholarly articles and reviews of books on all aspects of the history of alchemy and chemistry. All correspondence about the contents of *Ambix* should be sent to the Editor, Dr. Gerrylynn K. Roberts. Guidelines for authors may be found on the inside of the back cover. Books for review should be sent to the Reviews Editor-Elect, Dr. E. Homburg. Publishers are asked to notify the prices of books.

Meetings of the Society are held in London, generally twice per year. Information about meetings, which are open to non-members, can be obtained from the Hon. Secretary, J. A. Hudson; or see the Society's website: www.open.ac.uk/arts/HST/SHAC/SHAC.htm

Anyone interested in the history of alchemy or chemistry may become a member of the Society. The annual subscription of £24.00 (US \$42.00) should be sent to the Hon. Treasurer, Dr. N. G. Coley, from whom further information can be obtained. Members receive the current volume of *Ambix* (3 parts) without further payment. Retired members of 10 years standing may pay £17.00 (US \$30.00), full-time post-graduate students on submission of signed confirmation £17.00 (US\$30.00). The Society is registered as a charity. Most back volumes are available at £18.00 (US \$31.50) each.

For non-members, libraries and institutions, the annual subscription to *Ambix* is £50.00 (US \$87.50), and most back volumes are available at £30.00 (US \$52.50). **Orders from non-members should be sent to Black Bear Press Limited, King's Hedges Road, Cambridge CB4 2PQ, England.**

THE COSMOGONIC EXPERIMENTS OF ROBERT FLUDD: A TRANSLATION WITH INTRODUCTION AND COMMENTARY

By D. GRAHAM BURNETT*

Experientia est etiam stultorum magistra, [but] I will stoop a little, for your better instruction, and more clear information, and elucidate and make plain the abstruse subject we have in hand, by some vulgar or occular demonstrations, which may guide them and persuade them to believe that which may otherwise seem incredible. That I may therefore proceed more methodically, I will lay down...the chief platform, on which I propose to build such experimental conclusions, as shall direct the misbelievers...

Robert Fludd,
Mosaicall Philosophy

INTRODUCTION

THE first volume of the *Utriusque cosmi historia* came off the press in Oppenheim at the end of 1617. Its author, Robert Fludd, Esquire and Doctor of Physic, would soon be elected to his first term as Censor of the London College of Physicians. His Fenchurch Street practice as a 'Trismegistian-Platonick-Rosy-crucian Doctor' was so successful that the Oxford-educated Fludd had taken on a French-trained chemist to manage the apothecary. But the thriving practice and the publication of 483 pages of quarto text were not enough to keep Robert Fludd occupied. The close of 1617 saw the publication of two other additions to the Fludd corpus: the *Tractatus apologeticus...* (196 pages) and the *Tractatus theologo-philosophicus...* (126 pages).

Adding up all the bits of Fludd's writings that can be fitted into the grand scheme of *Utriusque cosmi historia* (see Table 1) yields a total of 1661 pages of text and hundreds of copper plate illustrations. In order to keep the excerpts that follow in proper perspective, it helps to bear in mind the scale of the work as a whole: the present translation amounts to six chapters. Each of the thirty-eight 'books' outlined in Table 1 contains as many as *twenty* such chapters. This translation of about twenty-four pages of the original text thus represents only slightly more than *one percent* of the full content of the book. Yet, despite this great, heaving sea of tightly spaced, largely unparagraphed type, *Utriusque cosmi historia* offers itself without resistance to the serendipiter: mysterious illustrations lurk in the leaves, impenetrable but inviting; the day-tripper with enough Latin to read the chapter titles will quickly conceive of the scope and ambition of the work, opening to a first page that reads, 'On infinite nature and the maker of all things.'

If *Utriusque cosmi historia* is about everything—and it is arguably the most encyclopedic text in pre-*Encyclopedie* Europe—where are we to begin, and what

* The Center for Scholars and Writers, The New York Public Library, Fifth Avenue and 42nd Street, New York, New York 10018.

TABLE 1
General Outline*Utriusque Cosmi Maioris scilicet et Minoris Metaphysica, Physica Atque Historia In duo Volumina . . .*

Robert Fludd

Johann Theodore de Bry, Oppenheim & Frankfurt, 1617, 1624

Volume I: THE MACROCOSM

Tractate I: Metaphysics and Cosmic Origins
 Book I: The Origin of the Macrocosm
 Book II: The Structure of the Macrocosm
 Book III: The Music of the Spheres
 Book IV: The Creatures of the Empyrean Heaven
 Book V: The Creatures of the Ethereal Heaven
 Book VI: The Creatures of the Elementary Heaven
 Book VII: The Bodies of Imperfect Mixture
 Tractate II: Arts and Sciences
 Book I: Universal Arithmetic
 Book II: The Temple of Music
 Book III: Geometry or the Art of Measurement
 Book IV: Optics
 Book V: The Pictorial Arts
 Book VI: The Military Arts
 Book VII: Moijon
 Book VIII: Time
 Book IX: Cosmography
 Book X: Astrology
 Book XI: Geomancy

Book VIII: The Soul of the Microcosm Acting in the Body
 Book IX: The Soul of Sensation Acting in the Body
 Book X: The Threefold Soul Seen in the Body
 Book XI: Sap and Generation
 Book XII: The Internal and External Harmony of Man
 Book XIII: The Practice and Composition of Music of the Soul

Section II:
 Book I: Prophecy
 Book II: Geomancy
 Book III: The Art of Memory
 Book IV: Nativities and Genethliology
 Book V: Physiognomy
 Book VI: Chiromancy
 Book VII: The Pyramid

Tractate II:

Section I:
 Portion I: Theosophy, Cabala, Physiology
 Part I: The Character of the Supernatural and Mystical
 Part II: The Character of the Natural, the Elements
 Part II:
 Part I: The Origin of the Archetypal Idea of the

Volume II: THE MICROCOSM

Tractate I:
 Section I:
 Book I: Divine Numbers
 Book II: Divine Harmony
 Book III: The Internal Parts of Man
 Book IV: The Numbers and Harmony of the Interior of Man
 Book V: The External Part of Man
 Book VI: The External Harmony of the Microcosm
 Book VII: The Internal and External Microcosm

Part I: The Origin of the Archetypal Idea of the Microcosm
 Part II: The Origin of the Natural Philosophy of the Microcosm
 Part III: The Principles of the Macrocosm and Microcosm, Meteorology

Portion III: Anatomy
 Appeared as: *Anatomiae Amphitheatrum, 1623*
 Portion IV: Meteorology and Cosmology
 Appeared as: *Philosophia Sacra, 1626*

Sections II & III: Never Appeared
 Tractate III: Never Appeared

thread holds this translation together, a few pages from books I, II and V? In attempting to put together a coherent (and, I believe, significant) set of excerpts, I have been guided by the desire to investigate Fludd's use of an 'experimental method'. All of the material translated below concerns what Fludd referred to as 'experiments' (*experimenta*). As I will discuss the significance of this term in greater detail below, I will for now leave off setting it in quotes, and instead simply remind the reader that the precise and period meaning of the term is, in large part, our subject. These demonstrations, models, and devices are employed throughout the work and serve as significant components of Fludd's wide-ranging arguments. The set of experiments I have selected here all bear on Fludd's account of the generation and operations of the cosmos, and they therefore range from experimental demonstrations aimed at substantiating his particular Neoplatonic-Hermetic interpretation of Genesis, to empirical investigations in dynamics that worked, by Fludd's lights, to refute Copernicanism. A number of annotations follow the translation. It is my hope that the presentation of this material will help students of the period refine their sense of the distinguishing characteristics of the 'experimental philosophy' that became such a distinctive element of seventeenth-century science. On a subject of such importance much might be said. After a brief introduction to Fludd himself, and a review of the specific content of these translated passages, I will turn to these larger questions, and offer a sketch of what I take to be Fludd's significance in the history of experimental investigations of the natural world. By no means complete, I hope that this provisional work stimulates further efforts to understand this interesting phase in what might be called the proto-history of experimentation.

ROBERT FLUDD

In 1616, while still deeply ensconced in the preparation of *Utriusque cosmi historia*, Fludd paused to write quite a public letter of introduction. The setting was the concluding pages of his own brief *Apologia Compendiaria . . .*, a pamphlet directed against the German chemist Andreas Libavius, who had taken up his pen to write an excoriating critique of the Brothers of the Rosy Cross. All who wrote about the Rosicrucians—both for and against—had little to go on, basing their impassioned interventions on whatever could be gleaned concerning the secretive brotherhood from a pair of anonymous tracts that were making the rounds among the learned, to sensational effect. But Fludd certainly caught the bug, as he dreamed of a Rosicrucian fraternity that would be a vast international family of kindred spirits. After defending their impugned virtue (and more broadly the virtue of white magic, Cabalistical learning, and suitably Christian astrological investigations), Fludd turned in the conclusion to the *Apologia Compendiaria* to a plea: Would the brothers, wherever they were, please consider him an eager acolyte and establish some contact with him, so that he might eventually become a member in full standing? The result is a studious

self-portrait of the forty two year old alchemist, doctor, and seeker of ancient wisdom who would eventually be best known for standing firmly on the wrong side of natural-philosophical controversies with such luminaries as Kepler and Mersenne: Fludd offered himself as a scholar and physician, abstemious and without uxorial bonds, celibate and of noble family, well-travelled on the continent, stoic in outlook, committed above all to the pursuit of wisdom—attainable, he thought, only through the light of divine grace.¹

The self-portrait is useful, and poignant as well, as there is every reason to think that Fludd was looking for a set of friends and colleagues who did not, in fact, exist. Which is not to say that Fludd had no circle of like-minded chemical physicians. He surely did. Fludd's fascination with ancient mysteries and powerful texts took root during his years as a student at St. John's College, Oxford, and was only reinforced by his six-year circuit through Spain, France, Italy, and Germany, where he sought out those who shared his omnivorous appetite for recondite learning and the practical dimensions of erudition both ancient and modern. On his return to England, Fludd fit neatly into what A. G. Debus has identified as an Elizabethan compromise between medical practitioners of Paracelsian/chemical leanings and the more conservative cohort of Hippocratic/Galenists: chemical remedies were countenanced, and a largely blind eye was turned on the more extravagant cosmology of mystical sympathies that grounded the new practices.² Fludd's chemical practice was a success, and yet it left him sufficient time to pursue his metaphysical and natural-philosophical interests. In his biography, William Huffman situates Fludd in a network of scholar-antiquaries like William Camden, John Selden, and Sir Robert Bruce Cotton, through whom Fludd would have had access to the great collection of occultist texts amassed by John Dee.³ Moving among these men, Fludd might have crossed paths with Francis Bacon or Ben Jonson. Later in his life, after a carefully-crafted defense of his work (occasioned by public charges of heresy), Fludd would enjoy the patronage of the Stuart monarchs, and he would pass away at the ripe (early-modern) old age of sixty three, a man of considerable means.

If late Renaissance hermeticists were to be grouped as lumpers or splitters, Fludd would have a claim to be king lumper. His distinguishing intellectual proclivity was a confidence that all forms of knowing would fit together, point to the same truths, and ultimately yield the same light. In this sense one could legitimately call him either one of the great synthetic thinkers of the early seventeenth century, or one of the most infuriating philosophical magpies of all times. In the pages of *Utriusque cosmi historia*, Aristotelian element theory gets tricked out to explain the biblical creation story, which is presented in Manichean language, underwritten by gnostic traces of scorn for the earth, and understood to be driven by hermetic forces. Augustine, Orpheus, Hero, Pan, Zoroaster, Demogorgon—all found place as aids to natural-philosophical knowledge. Fludd found his storehouse of ancient wisdom in Ficino's editions of Hermes Trismagistus, Plato, and the Neoplatonists. He read in the Cabala of Reuchlin and the occult philosophy of Agrippa. He called his own

perspective on God, mankind, and nature the 'Mosaicall philosophy'; it was essentially without other adherents.

Unfortunately for Fludd's twentieth-century reputation, he had the misfortune to be 'rediscovered' largely through the writings of enthusiasts for the mysterious and the occult, including most prominently the turn-of-the-century aficionado of the weird and wonderful, A. E. Waite.⁴ This company did little to facilitate serious investigation of Fludd's place in the history of science, nor did his harsh treatment at the hands of the Enlightenment chroniclers of the seventeenth century raise his stock.⁵ In the historiography of the scientific revolution, work on Fludd has been largely circumscribed by accounts of his several public polemics with figures more central to the canon of the seventeenth century, though Frances Yates did much to draw attention to Fludd and the other practitioners of renaissance 'hermetic' science.⁶ Only with the 1988 publication of Huffman's biography did the extent of Fludd's practical success in areas like metallurgy become widely known. Far from being a purely speculative and secret pseudo-magus, Fludd in fact succeeded in winning a royal patent from James I in 1620 for the manufacture of steel, steel said to rival in quality and cost the best imported products.⁷ This—combined with the recognition of Fludd's interesting anatomical investigations, and his later work on both magnetism and the weather-glass—suggests that further investigation of Fludd's empirical work, particularly his interest in experimental approaches to natural philosophy, might cast light on the early phase of important epistemological, sociological, and practical changes in the study of nature.

FLUDD'S EXPERIMENTS

The following translated sections all appear in Tractate I, "Metaphysics and Cosmic Origins," of Volume I, "The Macrocosm," of the whole work, which is usually translated *The History of the Macrocosm and Microcosm*.⁸ The first set of experiments come from Book I, entitled "The Origin of the Macrocosm." Only the end of Chapter VI, "The Universal Essence, with which the Creator of the entire creation shaped matter," has been translated here, and this passage includes three experiments. For Fludd, this "Universal Essence" is light, and all three experiments attempt to show the motive force of light and its familiar, fire. The theme of this section finds best encapsulation in Fludd's own words: 'throughout the universe, light maintains difference.' Working from this concept, he tries to show that the changes wrought by light (and heat, though the distinction is never made explicit)—particularly the power to refine mixed substances and drive off 'crass matter'—are always reversed as soon as the motive force is withdrawn. This notion, that the heavier parts of matter display an antipathy to light, is essential to Fludd's image of the universe arising out of a circular sweep of God's manifest light. At creation, the section of the primordial hyle caught within the compass of this East-to-West circling of divine light underwent a vast process of rapid decoction under the influence of light's decompositional power: the weightier parts of the hyle,

all driven from the celestial periphery, congealed at the center to form the earth.

The action of the light, however, does not simply separate out the earth from the hyle. In fact, each of the five elements—earth, water, air, fire and ether—found their form in that first moment when *Lux* said *Subsisto*. The experimental evidence for this appears in the next translated section, Chapter VX, “What are the elements made of?” drawn from Book II, “The Structure of the Macrocosm.” Here, the fire from ‘diverse rectifications’ is shown to divide wine into five distinct substances that correspond with the known elements.

Combining the motive and divisive forces of light, established in Book I, with the five elements, established through Chapter XV of Book II, yields the interesting experiments translated from Book II, Chapter XVI, which attempt to ‘demonstrate the various configurations arising from the operating of light.’ Fludd depicts and manipulates a series of experimental scenarios in which fire burns around the spherical periphery of a vessel. Through these experiments, which ‘represent the operations [of light] through their effects,’ and through the behavior of the material enclosed in these globes, Fludd claims to substantiate his account of creation and the resulting configuration of the earth, the seas, the air and the heavens.

Having thus established the origin and structure of the Macrocosm, Fludd must explain its motion, and the remaining three chapters, which make up the bulk of this translation (Book V, Chapters XIV, XV and XVI) all address this problem. Through an analogy with fireworks, Fludd explains ‘why the heavens are moved in circles,’ and that this natural motion must proceed from East to West. He must then take on the pressing question of the day: What lies at the center? His systematic rebuttal of Copernicus and William Gilbert makes up the substance of Chapter XV, where two experiments making use of the principle of the lever are used to demonstrate that the heavens must be rotated from without, and that the earth must occupy the most static, or central, place. Chapter XVI, the final excerpt presented here, takes on the difficult issue of epicycles, a celestial phenomenon that would seem to have no place in a universe where all spirit compels bodies to move spherically on a single path. Fludd skirts this problem by identifying a contrary force in all matter, equated with ‘resistance’ in the Aristotelian sense, which he contrasts to the ‘action’ of light. He makes use of experiments to characterize this resistance and demonstrate how the combination of action and resistance generates epicyclic dynamics.

An effort to understand the status of experimentation in the work of Robert Fludd might well begin with a look at what Fludd himself offers about their role in his broader project. In Book V, Chapter XV, Fludd outlines the rhetorical structure that underlies his disputations: ‘We must then undertake to prove this by reasons [*rationibus*] which rely on philosophical speculations and those based on vulgar practice, as well as those drawn from sacred scripture.’ The implication is clear: three modes of investigation co-exist in Fludd’s method, three paths that converge on the truth. The elements of this trinitarian

epistemology correspond to reason, revelation, and sense information.⁹ If the following translated chapters are read with this three-fold method in mind, each full section will easily break down into exactly three corresponding arguments: philosophical speculations arise out of Aristotelian notions of cause and effect, or out of the work of Hero, Plato, or Hermes; revelation occupies the dominant position in the triumvirate and derives primarily from the New and Old Testament (though also, at times, from the Church Fathers); ‘experiment’ names modes of investigation that inform the senses.

What is suggested by an investigative system based on such principles? Two responses come to mind. First, this method is clearly the approach of a systematizer and a synthesizer. It attempts to compass all possible ways of knowing, and press them all into the service of shared truths. Fludd begins to appear like a figure struggling to hold together an increasingly unwieldy brace of commitments: to ancients *and* moderns, Christians *and* pagans, reason *and* revelation.¹⁰ His text confronts the unenviable (and distinctly end-of-the-era) enterprise of performing a miraculous marriage of Platonism, Christianity, Paracelsus, the Black Arts, and late Renaissance mechanics. Second (and stemming from the first), this method is deeply textual. The truth, for Fludd, resides in several large books: one, the book of God; two, the books of the ancient philosophers; three, the book of nature.

To the Neoplatonist, the manifest world could only be the play of shadow on the walls of our communal cave: ideal forms existed outside the realm of human cognition, and human beings were left to try to read truth from the play of its reflected light. Fludd described it this way: ‘in the beginning of the world action drew its origin from the well-spring of the forms, from whose fountains only the least part was able to descend to earth.’ This supreme light manifests itself in three forms: in human reason, in God’s word, and in the certain constant motive light which keeps the universe from returning to the primordial chaos. To the degree that God is present in the physical world—as light—the world becomes a bright repository of clues, a great illuminated text to be read in the language of experiment. More remains to be said about the implications of this very particular ‘experimental philosophy,’ but before I go on, I wish to turn to the historical context for Fludd’s experimental work in greater detail.

FLUDD AND THE HISTORY OF THE EXPERIMENTUM

In his classic 1969 article on the terms ‘experience’ and ‘experiment’ at the opening of the seventeenth century, Charles B. Schmitt wrote, ‘we still lack a comprehensive analytic treatment of the meaning and function of these terms which takes into account the range of uses to which they were put during the period.’¹¹ While the last thirty years has seen a great deal of innovative work on rise of what John Wilkins called (in 1660) the ‘Physico-Mathematicall-Experimentall Learning,’ Schmitt’s call for a detailed study of the late Medieval and Renaissance genealogy of experimentation has not been answered.¹² At the same time, recent scholarship on the Royal Society and

experimental practices in the later seventeenth century has, if anything, underlined the importance of the experiment as one of the most significant components of an emergent natural philosophy that, by the end of the century, would offer European savants techniques of unprecedented power in pursuing knowledge of nature. For this reason, a peep into the cunabula of the experiment remains a significant element of any study of the rise of the new philosophy.

Several lines are usefully highlighted in sketching the background to Fludd's use of the term *experimentum*. First (and most generally) it is necessary to recall that engaging with the natural world—using the experience of one's senses as part of philosophical investigation—hardly began in the seventeenth century. As Daniel Garber puts it, 'people have turned to their senses for information about the world on which to ground their natural philosophy, their medicine and so on as long as there have been such disciplines.'¹³ In this sense, 'experience' in its broadest meaning has always been relevant to the formulation of natural philosophical principles. Continental scholastics found in their Aristotle a category for this aspect of philosophy: *experientia*, a term few authors distinguished rigorously from *experimentum*, which often meant a given instance of *experientia*.¹⁴ In the medieval period this pair of closely related concepts saw considerable amplification: from something like 'sense knowledge' (its meaning for Aristotle, as well as for those of the Empirical school), *experientia* came to signify either knowledge gained through the senses or through any one of a number of different internal illuminations or revelations. This expanded (and, to modern readers, largely unfamiliar) Christian notion of *experientia* is perhaps best understood through a definition of its complement: one needed *experientia* to attain knowledge only in those areas where pure reason itself was inadequate. What logic could work out directly, this defined a field of knowledge that could be attained without reference to *experientia*.

Understanding *experientia* as 'that manner of attaining knowledge where reason itself proves inadequate' sheds some light on the curious connotations that had accumulated around the cognate *experimentum* by the thirteenth century, connotations that stayed with the term right up to the early seventeenth century. For this term (and to some degree *experientia* as well) took on distinctly occult overtones for authors like Roger Bacon. Dijksterhuis cites a number of striking instances: an 'experimental astronomy,' for Bacon, appears to mean explicitly astrological investigations; a contemporary book entitled the *Experimentarius* provides a guide to 'mantic arts'; India receives mention as a land of many 'experimentalists' on the strength of the magical tradition there.¹⁵ At least one aspect of this 'extra-rational' signification of the *experimentum* remained current for renaissance *magoi*, for whom the word could be used to mean 'a recipe or formula of some sort used to bring about a nonnatural change in the course of events.'¹⁶ In investigating Galileo's attitude toward the experiment in his early work *De Motu*, Schmitt even suggests that the Gallilean avoided use of the term *experimentum* precisely

because he associated it with a medieval mysticism, hence his preference for the more archaic (and classical) *periculum*.¹⁷ Embarking on an 'experiment' in 1617, then, had implications that reached beyond the straightforward sensory/empirical investigation of natural phenomenon, and we are safe in assuming that a savant like Fludd, with a keen interest in Bacon as well as all things potent and occult, would have been particularly aware of (and interested in) those implications.¹⁸ In one of his unpublished writings, in fact, Fludd addressed directly the shortcomings of sense knowledge that did not also rely on the keener inner senses. In his estimation one might as well seek enlightenment blindfolded: 'why is dull sense thy only guide, the opinionative imagination the blind and dim lamp which giveth thee light, leaving thy divine essence wholly void of action, in which only consisteth the real vision of God and Verity?'¹⁹

Just as the term 'experiment' carried its curious baggage into Fludd's text, so too did a number of his experimental scenarios themselves. The concept of empirical investigation of nature traces a lineage back through the Greeks (at least), but so also do a number of specific techniques, demonstrations, and devices for the task. If we have followed (in very compressed form) the trajectory of the term *experientia* through philosophical usage, a brief treatment of several instances of early experimental situations will provide additional context for Fludd's efforts. In his 1964 article "Experiment in Early Greek Philosophy and Medicine" G. E. R. Lloyd called for greater detail and specificity in discussing the status of experimentation in Greek investigations of nature.²⁰ Declaring a pox on both interpretive houses then current—on the one hand authors who insisted that the Greeks 'had' the modern experimental method, on the other those who denied that Greek science was 'true' science at all on the grounds that such a method was lacking—Lloyd went on to distinguish among experimental efforts in different areas of natural philosophy. For instance, while there was no experimental tradition in Greek investigations of astronomy or meteorology, Lloyd points to Ptolemy's optics, the work of Philo and Hero in pneumatics, and a number of authors who wrote on acoustics and hydrostatics, as instances of empirical 'tests' of theoretical frameworks. As I work to suggest in the notes that follow this translation, Fludd's knowledge of elements of this Greek tradition was quite significant to his own experimental endeavors, particularly in the instance of the *Pneumatics* of Hero of Alexandria.²¹ Later work by Lloyd himself, as well as by Heinrich von Staden and I. M. Lonie, has refined our understanding of the philosophical status of these sorts of experimental setups within the context of Greek theorizing about nature.²² In particular, it has been argued that—even in the case of sophisticated anatomical experimental interventions (investigating, among other things, heart valves and digestive processes)—Greek 'experiments' were seldom if ever put forward as crucial discriminants among competing interpretations of the natural world. Rather, instances where an investigator elicited and deployed sensory evidence generally served something closer to a rhetorical function, either substantiating the presenter's own

interpretation or undermining that of his opponent. As the experiments frequently called on analogical reasoning, much of what was necessary in order to interpret them favorably had already been presupposed in the structure of the fundamental analogy itself. Much the same thing could be said about a number of Fludd's experiments, and it is safe to assume that he gleaned part of his sense of the *experimentum* as a particular kind of demonstrated analogy from his readings in this Greek tradition.

Given that I have here emphasized Fludd's use of an experimental method in the investigation of cosmogony, it is interesting to note that one of the best instances of early work in this area comes out of the Hippocratic writings (which, of course, Fludd had studied in detail in order to receive his medical qualifications), in particular in the treatise called *On the Nature of the Child*. There, in a section on the fetus, an experimental scenario is invoked: dirt, sand, and lead shavings are mixed in water inside a bladder; allowed to settle, the separation of the distinct substances becomes part of an argument about the formation of body parts. Lloyd suggests that this experiment was likely adopted from an (unrelated) inquiry into the differing gravities of substances in suspension.²³ For Fludd, however, it seems likely that such a scenario suggested a means to test formative moments, in his case not in human gestation, but in the origin of the universe itself. Several of his experiments—the efforts to cull the elements of the universe from a decoction of wine, his attempts to recreate the moments of creation within sealed, spherical vessels—bear more than a passing resemblance to this Hippocratic test. It should be added that similar experimental evidences for the nature of the elements can be found in the writings of a number of the Church Fathers, including Augustine, and Jacob and Job of Edessa.²⁴

These several instances of experimental activities and early uses of the terms *experientia* and *experimentum* suggest a constellation of practices and meanings that must have hung over Fludd's experimental activities in *Utriusque cosmi historia*. By the end of the sixteenth century, empirical Aristotelians like Zabarella could use the term *experientia* to mean something like 'intelligent personal experience,' though there is good evidence that much of what appeared in the writings of scholastics and anti-scholastics alike in the period amounted to hypothetical 'thought-experiences,' rather than actual, hands-on tests of natural phenomena.²⁵ To the degree that such general experiences were invoked as part of natural philosophical debate, they generally served as corroborative and exemplary 'instances,' useful for rendering more evident theories of nature that were themselves put forward as fundamentally theoretical, *a priori* constructions.²⁶ Contemporaneous uses of *experimentum* could have about them the flavor of the occult, as the term signaled extrarational encounters with natural forces.

Called upon to assess the characteristics of these *early* early-modern instances of experimentation—and, in particular, to distinguish this proto-experimental philosophy from the hallmark experimentation of later in the seventeenth century—commentators have focused on the distinctively *non-*

specific nature of the early invocations of experimental evidence. For Schmitt, what made the "Experimentall Philosophy" referred to by Wilkins so different was precisely that the "true" experiment must be planned and set up. The experimentalist must create the experiment, not merely call on familiar instances of common 'experience.' A good example of this latter can be found in the well-known fourteenth century 'experiment' of John Buridan, who objected to any account of terrestrial motion on the grounds that an arrow, shot straight up into the air, came back down in precisely the same location. Here was a common experience with alethic value, but not an 'experiment' in the later and more significant sense, regardless of what it was called in the period. Peter Dear has generalized Schmitt's distinction, arguing that the concept of philosophically-relevant experience underwent a dramatic shift from the scholastic to the early modern period: the move was from 'experience' in the sense of 'general observations of the workings of nature' to 'experiments' as specific instances of nature operating under highly artificial and indeed subverted conditions.²⁷ Here, perhaps, we begin to see one way in which Fludd's experiments stand as an interesting transitional moment in the history of the experimental philosophy. For Fludd certainly invokes Buridan-like 'experiences' in *Utriusque cosmi historia* (for instance, where he notes that, if the earth is spinning, tall towers ought to make a whistling sound, as does a staff when whipped through the air) but, significantly, *he does not called these experiences 'experiments.'* Rather, such common, general experiences are simply discussed in the body of his text as supporting evidence; they are not set off from the text and given the title of *experimentum* as are the fourteen experiments grouped here below in the translation. Fludd clearly conceived of his experiments as discreet, specific events, events that he planned and orchestrated, and that required specialized experimental settings and apparatuses. In this sense, then, Fludd's experiments appear to mark a significant step away from the older form of "experiential" evidence that often went by the same name.

Particular emphasis should be placed, I think, on Fludd's 'experimental instruments,' the custom-designed vessels, fly-wheels, and the like on which his experiments depend. Writing on the history of scientific instruments, W. D. Hackmann has suggested a rough division between 'active' instruments like the air pump or the electrical machine, and 'passive' instruments like clocks, balances, measuring instruments, and even optical devices like the telescope.²⁸ The former could be called 'philosophical,' in that they were used to create new natural phenomena, which in turn called for refined and even novel natural philosophical accounts. The latter, interesting and important as they were, were not seen to cause nature to behave in new ways. Increases in the precision of these passive devices could have large implications for theoretical work, but they never provided the same crucibles for the encounter with natural forces that the active instruments did. Passive instruments showed and recorded; active instruments generated new natural-philosophical events. Useful as these categories might seem at first glance, it is not clear how well

they hold up in reviewing the diversity of seventeenth-century experimentation. In the case of Fludd, the distinction appears to break down altogether. In a number of instances Fludd uses common (and thus seemingly 'passive') instruments to create what he considers 'philosophical' phenomena. Examples would include his use of a balance to illustrate the principle of celestial revolutions, and his experiments with boiling water. All of these are presented as producing 'facts' about nature germane to the creation itself. What counts as a 'philosophical' instrument, not surprisingly, ends up being thoroughly dependent on your philosophy.

While Fludd's experiments may have been *presented* as producing facts about nature—that aspect of seventeenth-century experimentation that Daniel Garber has treated as the most significant innovation of the new experimental philosophy—it is not at all clear that they were successful in doing so in the broadest sense. Fludd may have asserted that he was able to make a good bottle of wine yield sediments homologous to the elements, but this appears not to have come into natural-philosophical discourse in the period as an autonomous and novel 'fact' about nature with which new matter theories would have to contend. Understanding why leads us to consider, for a moment, Fludd's experimental 'community.' The work of Shapin, Schaffer, and others has led to a great deal of emphasis on the sociological dimension of the production of experimental natural knowledge in the period, and it is possible that further work on Fludd would serve as an interesting contrapositive test case.²⁹ Relatively little is currently known about the experimental setting of Fludd's work, but in his writings on experiment Fludd makes little effort to generate a validating social network around his claims. He succeeds in communicating sufficient detail about a number of his trials to buttress his claims that these are actual investigations that he has conducted, but Fludd's taste for the private (and indeed mystical) process of illumination militated strongly against his cultivating the sense of a public witnessing of his experimental work.³⁰ As this became an increasingly important aspect of the production of experimental facts, Fludd's experimental work would have had about it the air of a path abandoned.

In this way and others it would certainly be an exaggeration to put Fludd beside Boyle as a practitioner of the new experimental philosophy. Fludd's experiments manifestly retained a number of the characteristics associated with earlier 'experimental' traditions, and this is consistent with Fludd's studied antiquarian sensibilities. Unlike his contemporary, William Gilbert, Fludd never puts himself forward as rejecting any aspect of classical learning. Another way that Fludd's experiments belong among his late Medieval and Renaissance precursors involves his use of mathematics. To the degree that the 'mathematical way' represents a significant component of later experimental traditions, Fludd's work sits in a different category. At one tantalizing point in this translated material, he seems to suggest that measurements of the experimental vessel in which he has demonstrated the heat-driven separation of the elements could provide ratios of the different forms of matter, ratios that

could, in turn, be used in extrapolating celestial measurements. The mention of these measurements within his experimental system (and their implications for measurements in the world-system) intimates an engagement with quantitative aspects of empirical investigations, but the emphasis on ratios places this unique instance firmly in the context of Fludd's neo-Pythagorean interest in cosmological harmonies. It is worth noting as well that Fludd offers no actual calculations.

Further reflection on this particular moment in *Utriusque cosmi historia* reveals a still more significant way in which Fluddean experimentation must be distinguished from later experimental traditions. For not only does Fludd fail to play out his aside concerning mensuration, he gives no indication that his cosmogonic theory would be vulnerable should measurements be made directly that did not correspond with those predicted by his experimental scenarios. In other words, Fludd offers no indication that his theory is placed at risk by any of his experiments. In this sense Fludd's experiments belong firmly to that tradition identified by Schmitt, common to the classical philosophers, and familiar to both scholastics and anti-scholastics at the turn of the century: 'experiments' could be called on to support one's own (*a priori*) theoretical account, and perhaps and even be employed to critique the theory of an opponent, but there existed little sense of the experiment as a means of placing a theoretical account 'in the balance' of subjecting it to a crucial test by rendering it vulnerable.

Even so, the term 'experiment' must always have conveyed some sense of 'test.' Etymologically, the Latin term shares its root with a charged word like 'peril,' suggesting strongly that an element of risk belongs to the practice of experimental philosophy.³¹ But there are many kinds of risk, and the reader of Fludd's experiments will see that at no time does a Fluddean experiment threaten the integrity of his expansive, synthetic, and ultimately all-encompassing system. Fludd's experiments do not make his theory 'answerable' to the phenomenal world. Rather they are means of helping the phenomenal world speak in favor of his theoretical account. There may be risks, but the risks are not to Fludd's natural philosophy. Here, I think, we are very close indeed to the most significant characteristic of Fludd's un-modern experimental philosophy. Erecting his theory of nature Fludd has much on his mind: classical sources, biblical revelations, hermetic insights. The phenomenal operations of the natural world, while by no means irrelevant, are simply another important field of observations that must be fitted into the totalizing framework of *Utriusque cosmi historia*. The effect of this outlook is not unfamiliar: the theory of nature itself is ineluctably theoretical, but it must, as the saying goes, 'save the phenomena.' Fludd's experiments, seen in this light, represent efforts to demonstrate that the world does not behave in ways inexplicable in his theory. This helps explain how it is that what Fludd calls experiments would often seem to be better called, from our perspective, demonstrations. Intricate as some of the experimental scenarios are, they would perhaps be best understood as efforts to create models of the phenomena of nature—

mechanical 'microcosms' of pedagogical value, metaphors for nature rather than efforts to twist her tail. They would seem more concerned with depicting than with interrogation. The theory itself is never at risk because the experimental scenarios are more concrete illustrations of the theory than they are solicitations of aspects of nature beyond the reach of Fludd's account. To return to the language suggested by Hackmann, Fludd's experiments were designed to 'imitate' nature, not to 'isolate' it.

This conclusion, if correct, should not be taken as a dismissal of Fludd's experimental work. It is easy to forget that demonstration-style experiments—experiments that worked to illustrate or model natural phenomenon—have a long history, one that reaches back before the rise of the Royal Society, and that extends well into the eighteenth and nineteenth centuries. In a sense, this sort of 'experimentation' has always been the most prevalent sort, and merits study in its own right. For Hackmann, however, experimental instruments that were designed to model natural phenomena belong more to the history of science pedagogy and 'public science' than to the history of scientific discovery itself. This might well be right in the later seventeenth century and beyond, but for a natural philosopher like Fludd 'demonstration' experiments were part of a radically different epistemology, one that gave them philosophical importance too easily overlooked from our perspective. To understand what this importance might be, return to the 'analogical' interpretation of Fludd's experiments. According to this view we understand Fludd's experimental scenarios as mechanical, chemical or pneumatic models of the actual natural phenomenon under investigation. Hence, the correct interpretation of each experiment hinges on a 'just as' construal of its meaning. For example, the more rarefied parts of water rise to the periphery of a spherical vessel exposed to heat *just as* the more rarefied parts of the primordial hyle rose to the outermost superficies of the created universe. This, then, would appear to be a straightforward analogy, dependent for its truthseeking value on a more or less elaborate series of one-to-one correspondences between the distinct elements of two distinct realms: the experimental apparatus on the one hand, and the Creation on the other.

Without question, it is in this way that Fludd's experiments have been understood by the majority of those commentators who have discussed his work. For Norma Emerton, writing on Fludd's account of Genesis, his work employs 'myth and alchemy as depictions of creation.'³² Eberhard Knobloch, taking up Fludd's treatment of the musical harmonies of the universe, dismisses his treatment of the echoes between macrocosmic and microcosmic realms as 'pure symbolisms, more poetical and oratorical than philosophical . . .'³³ To these authors and others it is clear that the way that Fludd's work hinges on what appear to be *mere* analogies constitutes *prima facie* evidence that his investigations of nature belong to the category of poetry, symbol, and metaphor: these cannot be accounts of the operations of nature itself; they are better understood as fanciful stories, pictures, and delightful mimetic mechanisms. This interpretation reflects an inability to see that, in the context

of Fludd's principled Christian Neoplatonism, certain analogies, rightly constructed and rightly dramatized, became powerful explanatory instruments. This was not *mere* analogy, analogy as rhetoric, but rather analogy raised to the status of a tool for knowledge of the true nature of things.³⁴

Perhaps one way to begin to understand this is to return to the term *experimentum*, and in particular to its lingering implications of occultism. Here the sense of the 'peril' in *experimental* implied less the risk to a theory placed in the balance, and more the risks associated with tapping and touching the most powerful forces at work in the universe. For Fludd the world could be understood as a living entity, animated by its portion of divine light. This dilapidated sublunary glowed only in light reflected from a Platonic realm of perfect forms. As denizens of the 'cave' we do indeed inhabit a shadow-world, a parallel universe, and in this sense all knowledge must be structured as analogies: things here are as follows, which means that true things, by extrapolation, must be such as this observation would reveal *were we not seeing a dim reflection of the original*. But—and this is the significant point—the flickering light by which we make out the contours of this world, is still *light*, and therefore a luminous link to that realm of divine truth. Fludd says as much himself in discussing one of his experiments: '[This] is clear from the artificial mechanics described above, whose motion, although not naturally made, nevertheless is certain to have a natural explanation' The light that the manifest world shares with the 'well-spring of all forms' is enough to insure that the same forces can be made manifest here as operate in the realm beyond. What this means is that, under the right conditions, the natural philosopher can produce analogies that are more than analogies, analogies that resonate with the presence of the underlying, absolute, and, ultimately, divine truths. Understood in this way, Fludd's experiments are revealed as the potent components of his epistemology that they were, a status that is obscured if they are called either merely models or mysticism. It is more correct, I believe, to understand Fludd's experiments as carefully orchestrated points of contact between the parallel worlds of Christian Neoplatonism; the forms and forces they evidenced were thought to be continuous with their originals.

This was no minor business, nor could any experimentalist thus seeking to dramatize divine forces expect consistently to exercise a great degree of control over the process. There were, needless to say, intangibles at work, and this helps account for Fludd's somewhat guarded, and even elliptical commentaries on his experimental efforts. More was at play, he intimated, than met the eye. He meant it. When he asserted that the plates in his text were 'convenient [*convenientes*]' with the natural world, he wanted it to be clear that his 'representations,' his 'depictions,' had explanatory power, that they went beyond offering one-to-one correspondences between image and reality, that, in fact, in his experimental settings, the edges of truth and image touched.³⁵ The implications are quite striking. Fludd's experimental investigations would appear to reflect a belief in something like the uniformity of nature. If this interpretation of Fludd's experimental philosophy is correct, it offers concrete

evidence that the concept of unity of force—the collapse of scholastic distinctions between sub and super lunar realms (a collapse so critical to the ‘new philosophy’)—may trace its roots to the hermetic Christian Neoplatonist concept of charged ‘conveniences’ in the natural world, and to an understanding of the potent *experimentum* as a means of tapping real, true forces seldom encountered without the skilled creation of an experimental conjunction between analogous world systems.³⁶ Further work on the proto-history of experimentation will allow us to assess the merits of the claim, and will surely yield other surprises as well.

ACKNOWLEDGEMENTS

The author wishes to thank Anthony Grafton, without whose assiduous attentions the present translation would have been impossible. Additional thanks go to Michael S. Mahoney and Karlfried Froehlich. An anonymous referee offered constructive comments on an earlier draft. Daniel Simko and Robert Dumont at The New York Public Library gave invaluable assistance in the preparation of the illustrations.

NOTES AND REFERENCES

1. The episode is recounted in William H. Huffman, *Robert Fludd and the End of the Renaissance* (London: Routledge, 1988) p. 144.
2. Allen G. Debus, *The English Paracelsians* (New York: Franklin Watts, 1972).
3. Huffman, *op. cit.* (1), pp. 31–35.
4. Whose relevant works include: “Robert Fludd: Philosopher and Occultist,” *The Occult Review* (1912) 15: 79–84; *The Real History of the Rosicrucians* (London: Redway, 1887); *The Brotherhood of the Rosy Cross* (New Hyde Park, NY: University Books, 1961); *Hermetic Museum* (New York: Weiser, 1974).
5. For example, see the dismissive treatment of Fludd (and other Neoplatonists) in: Johann Jakob Brucker, *Historia critica philosophiae a mundi incunabulis ad nostram usque aetatem deducta* (Lipsiae: Bem. Christoph Breitkopf, 1742–44). For a similar case, consider John Dee, particularly as discussed in William H. Sherman, *John Dee: The politics of reading and writing in the English Renaissance* (Amherst: University of Massachusetts Press, 1995).
6. In addition to Huffman’s biography, Fludd has been the subject of a monograph: Serge Hutin, *Robert Fludd (1574–1637) Alchimiste et Philosophe Rosicrucien* (Paris: Omnium Litteraire, 1971). Other works include the following: Allen G. Debus, “The chemical debates of the 17th century: The reaction to Robert Fludd and Jean Baptiste van Helmont” in *Reason, Experiments, and Mysticism in the Scientific Revolution* edited by M. L. Bonelli and W. R. Shea (New York: Science History, 1975), pp. 19–47; idem, “Key to Two Worlds: Robert Fludd’s Weather-glass,” *Annali dell’Istituto e Museo di Storia della Scienza di Firenze* (1982) 7(2): 109–44; idem, *Robert Fludd and his Philosophical Key* (New York: Science History, 1979); Joscelyn Godwin, *Robert Fludd: Hermetic Philosopher and Surveyor of Two Worlds* (Boulder, CO: Shambala, 1979).
7. Huffman, *op. cit.* (1), pp. 23–24.
8. Previous English translations of portions of *Utriusque* appear to be limited to the following: Patricia Tahil, trans., *The Origin and Structure of the Cosmos* (Edinburgh: Magnum Opus Hermetic Sourceworks, 1982); and Charles A. Rainsford, trans., *On the Divine Numbers and the Divine Harmony* (Edinburgh: Magnum Opus Hermetic Sourceworks, 1997). The former, published in a limited edition of 250 numbered copies, presents the first two books of Tractate I, thus roughly the first quarter of the present translation can also be found in Tahil’s book. The latter presents a previously unpublished late eighteenth-century translation of portions of Volume II.
9. Note that, in a curious essay on science and something like the ‘collective unconscious,’ the Nobel Laureate Wolfgang Pauli explicitly contrasted what he took to be Fludd’s ‘quaternary’

- attitude to the ‘trinitarian’ outlook of Kepler. My use of the term here is unrelated. See C. G. Jung and W. Pauli, *The Interpretation of Nature and the Psyche* (New York: Bollingen Foundation, 1955) p. 206.
10. Compare the case of Jean Bodin; Ann Blair, *The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton: Princeton University Press, 1997).
 11. Charles B. Schmitt, “Experience and Experiment: a Comparison of Zabarella’s View with Galileo’s in *De Motu*” *Studies in the Renaissance*, XVI, (1969), 80–138, at p. 86. This and his earlier related paper, “Experimental Evidence for and against a Void: The Sixteenth-Century Arguments,” are reprinted in idem, *Studies in Renaissance Philosophy and Science* (London: Variorum, 1981).
 12. The Wilkins quote appears in: Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995) p. 2. The absence of such a synthetic, detailed treatment of ‘experimentation’ in the Renaissance should not be taken to mean that there is not much valuable work in this area. For an introduction to relevant bibliography from the first half of the twentieth century see the references in Schmitt, “Experience and Experiment,” *op. cit.* (11), p. 81, n. 2. In addition to the work of Dear, more recent work includes several collections of relevant essays, see Gabriele Baroncini, ed., *Forme di Esperienza e Rivoluzione Scientifica* (Florence: Olschki, 1992); D. Gooding, T. Pinch, and S. Schaffer, eds., *The Uses of Experiment: Studies in the Natural Sciences* (Cambridge: Cambridge University Press, 1989); D. Batens and J. P. Van Bendegem, eds., *Theory and Experiment: Recent Insights and New Perspectives on their Relation* (Dordrecht: Reidel, 1980).
 13. Daniel Garber, “Experiment, Community, and the Constitution of Nature in the Seventeenth Century” *Perspectives in Science*, 3(2) (1995), 173–205, at p. 175.
 14. Schmitt discusses the confusion among contemporary authors in his “Experience and Experiment,” *op. cit.* (11), pp. 90–92. While some authors worked to maintain some consistent distinctions of usage for the two terms, all treated the terms as closely related.
 15. E. J. Dijksterhuis, (C. Dikshoorn, trans.), *The Mechanization of the World Picture* (Oxford: Oxford University Press, 1961), p. 139.
 16. Schmitt, “Experience and Experiment,” *op. cit.* (11), pp. 86–87. See also the recent article by Ursula Klein, “Experiment, Spiritus und okkulte Qualitäten in der Philosophie Francis Bacon’s,” *Philosophia Naturalis*, 33 (1996) 289–315.
 17. Schmitt “Experience and Experiment,” *op. cit.* (11), p. 135.
 18. Huffman mentions Roger Bacon as one of Fludd’s preferred authors, *op. cit.* (1), p. 33.
 19. A. Debus, *Robert Fludd and His Philosophical Key*, *op. cit.* (6), p. 76. Cited in Huffman, *op. cit.* (1), p. 101.
 20. G. E. R. Lloyd, “Experiment in early Greek philosophy and medicine,” *Proceedings of the Philological Society*, N.S. 10 (1964), 50–72. Reprinted in a revised version (referred to here) in: idem, *Methods and Problems in Greek Science: Selected Papers* (Cambridge: Cambridge University Press, 1991) pp. 74–99.
 21. The classic paper on Hero and Renaissance science remains, Marie Boas, “Hero’s *Pneumatica*: A Study of its Transmission and Influence,” *Isis*, 40 (1949), 38–48.
 22. H. von Staden, “Experiment and experience in Hellenistic medicine,” *Bulletin of the Institute of Classical Studies* 22 (1975), 178–99; I. M. Lonie, “The Hippocratic Treatises ‘On Generation,’ ‘On the Nature of the Child,’ ‘Diseases IV’” *Ars Medica* (Berlin), 11(7), (1981).
 23. Lloyd, *op. cit.* (20), p. 83.
 24. See: Norma E. Emerton, “Creation in the Thought of J. B. Van Helmont and Robert Fludd,” in *Alchemy and Chemistry in the 16th and 17th Centuries*, edited by P. Rattansi and A. Clericuzio (Dordrecht: Kluwer, 1994) pp. 85–101, at p. 91.
 25. Schmitt, “Experience and Experiment,” *op. cit.* (11), p. 105. See also: idem, “Experimental Evidence,” *op. cit.* (11), p. 357, where Schmitt reveals that all the ‘experimental’ disputants on the subject of the void concurred that water contracted on freezing, excellent evidence that no one was freezing water in the sealed containers that were the subject of the controversy.
 26. Schmitt, “Experimental Evidence,” *op. cit.* (11), p. 363.
 27. For instance: Peter Dear, “*Totius in Verba*: Rhetoric and Authority in the Early Royal Society,” *Isis*, 76 (1985), 145–61; idem, “Jesuit Mathematical Science and the Reconstitution of Experience in the Early Seventeenth Century,” *Studies in the History and Philosophy of Science*, 18 (1987), 133–75; idem; “Narratives, Anecdotes, and Experiments: Turning Experience into Science in the Seventeenth Century” in *The Literary Structure of Scientific Argument: Historical Studies*, edited by Peter Dear (Philadelphia: University of Pennsylvania Press, 1985) 135–63.
 28. W. D. Hackmann, “Scientific Instruments: Models of Brass and Aids to Discovery” in *The Uses*

Translation

- of *Experiment: Studies in the Natural Sciences*, edited by D. Gooding, T. Pinch, and S. Schaffer (Cambridge: Cambridge University Press, 1989), pp. 31–65.
29. Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1985). See also: Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).
 30. For an interesting study of the tension between public and private spaces for the production of natural knowledge, see Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis*, 79 (1988), 373–404.
 31. OED, s.v. 'experience.'
 32. Emerton, *op. cit.* (24), p. 99, emphasis mine. It should be noted that elsewhere (p. 92) she suggests that these depictions are thought to have explanatory power.
 33. Eberhard Knobloch, "Harmony and Cosmos: Mathematics Serving a Teleological Understanding of the World," *Physis*, N.S. XXXII(1) (1995), 55–89, at p. 75.
 34. For a perceptive analysis of the status of analogy in the formation of scientific theories, see John D. North, "Science and Analogy," in *On Scientific Discovery*, edited by M. D. Grmek, R. S. Cohen, and G. Cinuno (Dordrecht: D. Reidel, 1980) pp. 115–40.
 35. For a discussion of this sense of 'convenientia,' see M. Foucault, *The Order of Things* (New York Pantheon, 1971), chapter 2.
 36. Hackmann discusses the ancient roots of the 'principle of the uniformity of nature' and links it to concepts of natural 'simplicity' and 'harmony,' *op. cit.* (28), pp. 37–39.

PART I

Tractatus I, Liber I, Caput VI

Chapter VI

Demonstrations by which it is clearly evinced that, by a stopping in the action of the form of light, and by its complete absence, it is necessary that the world and all its matter revert into the first abyss and that dark hyle, following the explanations expressed by us above.

Since all of the light of the sun present is most near and like the light created and perfected the first day—since according to the fathers of theology, the body of the sun was made the fourth day as a reservoir for all rays—for this reason we start our demonstration with a look at its virtue and power, by which we will prove that the presence of light made that original change of form in the hyle. Without this light, the hyle, which was once without form, will return to its original state.

Let there be, then, a ball of lead of sufficient size, such that the thickness of its material should not be at all fragile (so that it should not be broken easily, nor be too porous, lest air pass through it): In the top part of this let there be a hole in which a tube of the same material is fixed. This tube is to be curved and should nearly touch the bottom, in such a way that no air is able to enter or leave the cavity through any other passage, except through the tube.¹ Furthermore, let the other end of this curved tube or pipe be extended almost to the bottom of another bottle filled with water. Let there be, then, a ball A, with a pipe or tube B, and a vessel filled with water C. We conclude that the rays of the sun, heating the ball A, expel the gross and scorched air contained in the ball A, through the passage B, and into the vessel C, toward the bottom of

Caput VI

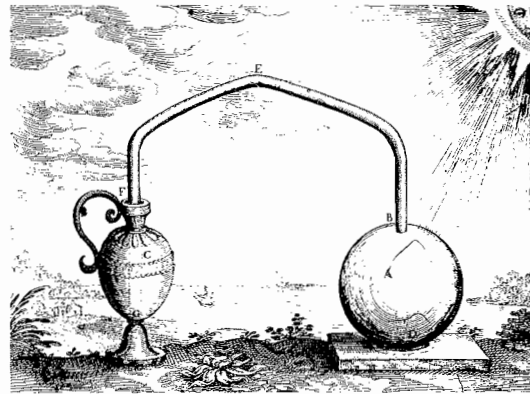
Demonstrationes, quibus manifestum evadit, quod cessante formae lucidae actione, omnimodaque ejus absentia necesse sit mundum ejusque materiam in abyssum primam ac hylem tenebrosam reverti, secundum rationes a nobis supra expressas

Quoniam lucis solaris praesentia omnium propinquissima & similima est lucidae creaturae primo die conditae, siquidem, secundum Theologiae patres, corpus solare factum est quarto die omnium ejusdem radiorum receptaculum; idcirco hanc nostram demonstrationem ab ejus virtute & effectu exordiemur, qua comprobabimus, praesentiam ipsius lucis fecisse hanc formalem in hyle alterationem, ejusque absentiam illam ipsam hylem olim informatam ad pristinum, hoc est, informem statum suum reversuram esse.

Fiat igitur pila ex plumbo, capacitatis satis amplae, ita ut spissitudo materiae ejus nec sit nimis tenuis, ne scilicet cito frangatur, nec nimis etiam porosa, ne aer per eam penetret: In hujus summitate fiat foramen, in quod tuba quaedam recurvata fere ad fundum ejus descendens ex materia eadem infigatur, ea ratione, ut nullus aer queat per aliam viam nisi per canalium istius concavitatem ingredi aut egredi. Altera autem ejusdem canalium seu tubae curvatae extremitas fere ad alium quendam vas aqua repleti fundum extendatur: Sit ergo pila A canalium seu tuba B & vas aqua repletum C. Concludimus igitur, quod solis radii calefacientes pilam A expellent crassum & fuliginosum aerem pilam A contentum, per canalium B in vas C ad fundum aquae illo vase C contentae; qui aer crassus virtute caloris expulsus cum aqua vasis C se permiscebit,

the water contained in that vase C. The gross air, having been expelled, by the virtue of its heat, will mix together with the water of the vase C and make many bubbles, one after another. As soon as the sun sets, or anything be placed between it and the ball (or if this ball is situated in a dark place), then with the absence of the sun (and the cooling of the ball) the original status of the hallowed-out part of the ball will return: that is, the exact amount of gross and dark air which was in it before.

A trial is made thus: because it cannot find air of the same nature in the vase filled with water, it attracts to itself this water, which is still more gross, in place of the air, the natural sympathy [necessitas] of which forces such a proportion to descend into the ball as the rays of the sun expelled earlier, by rarifying and purifying the air. From this trial this may be demonstrated as clearly as may be desired: that every purification in this world and every inequilibrium or change in the thickness or thinness of things comes from the action of this essentializing light; at every point throughout the universe difference is maintained by means of the presence of this light.² Lacking, then, this light, all things will be returned to their original conditions, as is infallibly demonstrated by experimentation. Two such experiments written up below declare the truth even to vulgar eyes, producing their effects by means of the element of fire. We have drawn the demonstration of the first experiment thus.



And going deeper, in order that we may produce another demonstration from the power of our fire—which receives its power at the outset from the sun, and thus indirectly, or

facietque multas bullas, alteram post alteram; Simul ac vero sol recesserit, aut res aliqua alia inter ipsum solem & pilam fuerit interposita, vel ipsa quoque pila in umbra locata, redebit solis absentia pilaeque refrigeratione prior status in concavitatem pilae, nempe eadem aeris crassi & tenebrosi portio, quae fuit inibi antea. Probatio sic fit: cum aerem in eadem natura in vase aqua repleto invenire non potest, ipsam aquam, quae adhuc crassior est, loco aeris sibi attrahit, cujus tantam proportionem in pilam descendere cogit necessitas, quantam ab ea primum radii solares subtiliatione & purificatione aeris expulerunt; quo quidem experimento digito quasi demonstratur, omnem purificationem in hoc mundo & omnem inaequalitatem seu diversitatem in spissitudine aut tenuitate provenire ab actu ipsius lucis essentificae, ejusque praesentia usque ad finem mundi in statu tali differentiam retineri: Deficiente autem luce omnes res ad primum suum statum reversuras esse, infallibiliter hoc ipso experimento convincitur, cujus veritatem etiam oculis vulgaribus declarant, infra scripta duo experimenta effectus suos ab igne elementari depromentia. Demonstrationem autem hujus primi experimenti sic depinximus.

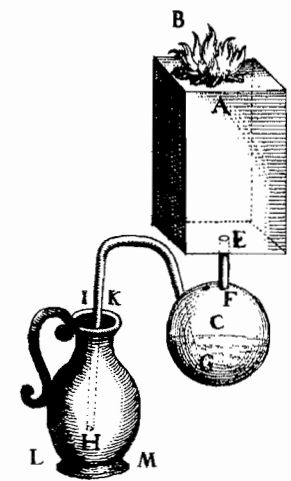
Et imius descendendo jam, ut aliam demonstrationem ab ignis nostri efficacia depromamus, qui a sole in primordio vim suam accipit, & per consequens secundario a fonte

at one remove from the source of light—we produce this demonstration as well, to prove that, in the absence of the natural fire, all things revert to their original conditions; the present experiment is of this variety.

If the form of a small altar-box is made,³ in the middle of the base of which enters one end of a straight tube, the other end of which is placed into a globe beneath the aforesaid box, and if these are made of lead, glass, or any other material such that no air can pass out from the inside of the small altar-box (or out of the globe) except through the tube; and if, following on this, the end of a bent siphon is placed in the globe or sphere, penetrating down to the bottom (with the other extremity in the same way placed in the jar near the globe, that is, down to the bottom in the way that is shown below) then, after all this, if a fire is lit on top of the altar-box, we say that the air contained in the cavity (and rarified by the heat of the fire) seeks a larger space. Whence, through the tube EF, the air rarified in the altar A descends into the sphere C and pushes out the humors contained in the sphere through the siphon GH into the vase or ampule IKLM. When the fire is extinguished, the thinned air recedes and ascends to its original position. Once this has been removed, the water, which was pushed down into the vase, passes out and returns to the sphere. The sphere thus remains in its original state. The figure follows.

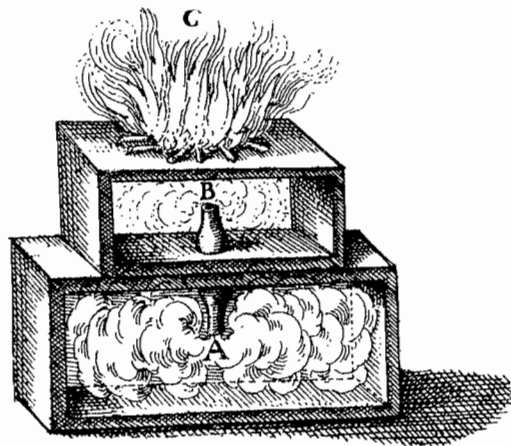
lucido, hoc etiam testimonium afferimus, quo probamus, quod absentia igneae naturae res omnes ad primum revertuntur statum, & hoc experimentum est ejusmodi.

Si forma arulae cujusdam fabricetur, in cujus basis medietate tubae alicujus rectae extremitas una ingrediatur, altera vero in globum sub altari positum, ex plumbo, vitro, vel qua alia materia conflatum, ita ut nullus aer ab arulae ventre aut globi concavitate egredi possit, nisi per hanc tubam: ac si deinde siphonis alcuus reflexi extremitas una in globum seu sphaeram ingrediatur usque ad fundum ejus penetrans, extensâ alterâ ejus extremitate pari modo in ollam juxta globum locatam, fere usque ad ejus fundum, ut infra demonstrabitur, tum si ignis super arulam accendatur, dicimus aerem in ejus concavitate contentum, ignis calore jam rarefactum, ampliorem locum petere: Unde per tubam EF aer rarefactus in arula A descendit in sphaeram C & humorem in sphaera contentum extrudit per siphonem GH in ollam seu ampullam IKLM. Extincto vero igne aer attenuatus recedit, & ascendit in primum suum locum, quo digresso aqua in ollam detrusa revertitur etiam in sphaeram, ac remanet ipsa sphaera in statu suo priori. Demonstratio sequitur.



Similarly, by the following experiment—selected out of Hero’s conclusions concerning pneumatics⁴—the preceding operation of nature is confirmed, for here the dense air initially enclosed in the upper space of the altar-box is rarified by the presence of a fire which is lit above it. In the course of this attenuation the more sooty part is expelled through the hole A into the lowest area, as into the part farthest from the active agent; in such a way that the air of the upper region is brightened and driven on. When the fire is put out, the heavy and burned portion of the air (which left the upper region) returns to its original place and reunites itself with the subtle air, so that its airy spirit may return to the original state of corpulence that it had before the fire was lit.

From this, then, it is clear that all things formed by the eternal light, put on again their unformedness after the kindly face of light and its shaping habit (and the form it has) leave and desert them. And by consequence, when light ceases, all relapses into the original nature and disposition of dark hyle.



Similiter sequenti hoc experimento spiritali ex Heronis conclusionibus desumpto confirmatur praecedens naturae operatio: ubi aer densus in superiori arulae regione inclusus praesentiâ ignis super eam accensi subtiliatur. In qua quidem attenuatione fulginosior ejus pars per foramen A expellitur in regionem infimam, tanquam in partem ab actore remotiorem ita ut aer regionis superioris illuminetur & inactuetur: Extincto vero igne, illa portio aeris fulginosa & spissa, quae egressa est ex regione superiori, revertitur in propriam suam sedem priorem, & cum aere subtili se conjungit, ita ut spiritus ille aereus tum ad pristinum corpulentiae suae statum redeat, in quo fuit ante ignis accessum.

Ex his igitur manifestum est, res omnes a luce essentiali informatas induere iterum in formitates suas, postquam ipsas reliquerit ac deseruerit benevolus lucis aspectus, formalisque ejus habitus, & per consequens, cessante luce omnia esse in pristinam hylae tenebrosae naturam ac dispositionem relapsura.

PART II
Tractatus I, Liber II, Caput XV (pars ultimus)
et XVI

Chapter XV

An experiment concerning wine, out of which it is possible to gather the nature of each of the elements.

We made an experiment—a trial, which points out to us the substances of the elements and the fifth essence, one might say, by the rule of fidelity—out of most excellent wine. Having extracted the spirit out of wine (by means of an operation in no way unusual), I then extracted the oil floating above the spirit from the impurities of the wine, and I brought this to the highest purification by diverse rectifications. After the extraction of the spirit I repeatedly rectified the distilled phlegmatic humor. Finally I cleansed all the dregs of the wine from residual dirt by many washings. Then I poured all this into a round glass of regular proportions, which I sealed Hermetically, as they say, and this bottle rested undisturbed through a whole night. In the morning I discovered five layers: the lowest black and wrapped in darkness; above this abided the portion of the phlegm; continuing in sequence, the oil extracted out of the dregs covered that over; over which in the fourth position the spirit of the wine ascended; and, finally, the oil extracted from it covered over this in the fifth place.

Caput XV

Experimentum de vino, ex quo cujusque elementorum natura colligi potest.

Ex ipso vino praestantiori experimentum fecimus, elementorum & ipsius quintae essentiae substantias, digito & quasi fiducia regula nobis aperte indicans. Namque extracto spiritu ex vino, operatione haud nova, oleum exinde extraxi super spiritu natans deinde ex faecibus vini oleum extraxi, & ad purificationem summam illud rectificatione diversa perduxi. Postea phlegma etiam post spiritus extractionem destillatum saepius rectificavi. Denique faeces totius vini multis ablutionibus a lutosa sua sorde mundificavi: Haec igitur omnia in vitrum rotundum proportione aequali indidi; quod Hermetice, ut vocant sigillavi, & vase hoc per integram noctem quiescente, inveni mane 5 regiones; inferiorem nigram & obscuritate obvelatam; super hac

- . 5 . Æther . 5
- . 4 . Ignis . 4
- . 3 . Aer . 3
- . 2 . Aqua . 2
- . 1 . Terra . 1



phlegmatis portio residebat; deinceps illam cooperiebat oleum ex faecibus extractum, super quod quarto loco spiritus vini ascende-
bat; Oleum vero ex eo extractum ordine quinto ipsum obtegebat.

Chapter XVI

Of certain experiments in the composition of the waters in the aforementioned heavens, demonstrating the various configurations produced out of the operations of light:

It is certain that fire is to be understood under the rubric of light and arises from light, in so far as nowhere in the whole description of the most noble creation of the universe does our divine priest Moses make mention of fire, apart from discussions concerning light.⁵ (This is also discussed more fully in book 6 chapter 8).⁶ No one doubts that the air also and the water belonged to the substance of the mass of the universal waters, since the sacred scripture attests that out of this everything is put together. But now—because (without a doubt) the aforesaid operations seem under suspicion to some, namely those who rely more on sense than on reasoning—it falls to us to represent to the eyes of these disbelievers these operations, which I will do through showing the *effects* arising from these two primary causes, water and light. These folk will then most easily understand all this—even see it all—if they will diligently observe the following experiments.

First experiment, concerning fire and air or subtle water⁷

Light a fire on the top of a concave instrument, excellently well closed, in the base of which, opposite the fire, a hole or certain most fine tube is set up. The air inside, in so far as it approaches the place of the fire, becomes more attenuated. The more gross part of the air thus attenuated, which is more cold, goes toward the deeper position in the chamber, due to the operation of the fire—in as much as it tends most far away from its antithesis. And this is indeed made clearly visible because it is

Chapter XVI

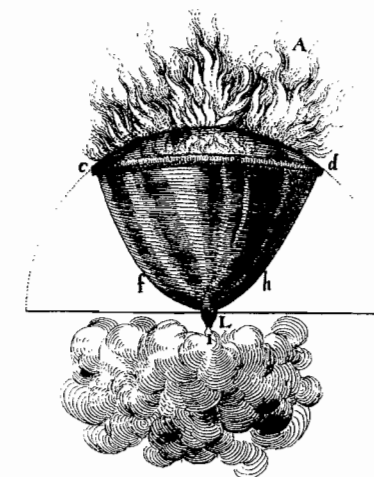
De quibusdam experimentis aquarum in caelorum praedictorum constitutione varias dispositiones, luce operante, demonstrantibus.

Certum est ignem sub lucis nomine comprehendere & ab ipsa luce provenisse; cum nullibi in universali creationis descriptione nobilissimae illius creaturae ignis mentionem fecerit divinus noster Antistes Moyses, praeterquam de luce loquendo: Hoc etiam libro sexto cap. 8 luculentius declaratur. Aerem quoque & aquam fuisse de massae illius, aquarum videlicet universalium substantiae, nemo ambiget, cum ex illa omnia conflare testentur sacrae Scripturae. Jam vero, quia procul dubio praedictae operationes nonnullis sensu magis quam ratione nitentibus in suspitione sunt, restat etiam oculis eorum istas operationes per effectus a duabus illis causis primariis, aqua nempe & luce, derivatis repraesentare, quas quidem facillime visibiliter percipient, si sequentia experimenta diligenter observaverint.

Experimentum primum de igne & aere, seu aqua subtili.

Ignem accenso in superiori instrumenti concavi & optime clausi parte, in cujus fundo igni opposito, foramen seu tuba aliqua minima constituitur, aer intrinsecus, quo magis ad ignis locum accedit, eo magis attenuatur, crassiorque aeris attenuati pars, quae frigidior est, ab igne operante ad imiorem vasis locum, utpote ab inimico suo remotiorem, tendit, quod quidem visibiliter patet, quia in forma vaporis humidi per tubam seu foramen illius regionis egredi sensim percipitur.

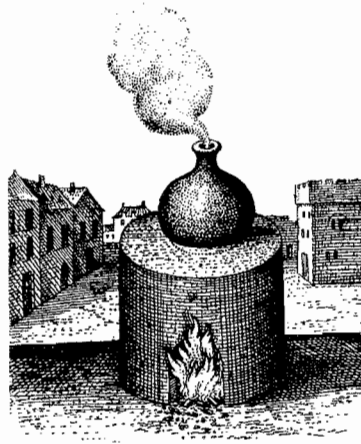
sensibly perceived in the form of humid vapors that escape through the tube or hole of this area.



If BCDEFGH is the vessel made in the form of an altar,⁸ on the upper surface of which the fire A is lit, then inclosed air is thence rarified, and the denser part of it flees the fire and seeks an exit through the tube I, where it is seen to go out through the more exterior hole L and exiting, corresponds to humid vapors. This is fully described in Hero of Alexander's *Pneumatica*, experiment 2.⁹

We draw the movement of the air according to the diameter of a circle, which pertains more to our proposition. In order that I should be able to render this experiment clearer, I took an empty glass flask filled only with air, Hermetically sealed, and I placed it on embers, and with the fire of a torch underneath I heated the glass most gently. This done, the grosser part of the air held in the glass, separated by rarefaction from the finer, fled the fire and, resolving itself into vapor, finally adhered in the form of drops at the top of the vase.¹⁰

BCDEFGH est vas in forma altaris factum in cujus superiori superficie si ignis A accendatur, aer inclusus inde subtiliatur & pars ejus crassior ignem fugiens, per tubam I exitum quaerit, atque per foramen exterius L instar vaporis humidi egredi percipitur. Haec plenius in Heronis Alexandrini *Spiritualibus*, experimento nempe ii demonstratur: Hic vero aeris motum secundum circuli diametrum delineavimus, quia magis ad hoc nostrum propositum pertinet. Ut etiam possim hoc experimentum reddere evidenti, accepi ovum vitrium vacuum, & solo aere repletum, Hermeticeque sigillatum cineribus imposui, ac lampadis igne submisso calefeci suaviter vitrum; quo facto, aeris in vitro inclusi pars crassior rarefactione a tenuiori separata fugiebat ignem, & in vaporem sese resolvens tandem in forma guttarum summitati vasis adhaerebat.



Hence, we conclude then that the thick air, which is fleeing the fire (on account of the cold it contains in itself), tends toward the most distant region from its presence. But the center is the point most distant from the circumference. Consequently, when a powerful heat occupies the surface on any concave globe, then the rarified air or water held and shut in it dispatches its denser part to the center. Indeed, all parts of the air held in the concave globe are progressively more dense precisely to the degree that they lie more distant from the vigor of the fire, as is explained by the following experiment.

Experiment II

Take, then, a globe of glass or copper divided into three regions in such a way that the one surrounds and encloses the concavity of the other.¹¹ These layers may then have holes or tubes sticking out in the way depicted below, and must be girt all around with a most lively fire at the outermost surface of the globe. This done, it will be seen that the outer fire girds the highest layer in its more lively vigor, and that the air contained in it is remarkably attenuated because of the closeness to the life of the fire. It will be noticed too that the other,

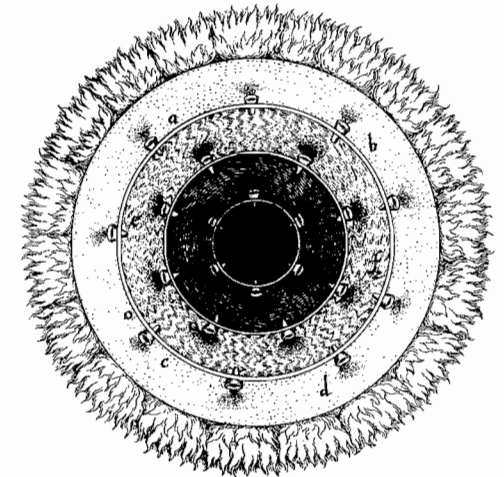
Hinc igitur concludimus, quod aer spissus propter contentam in eo frigiditatem ignem fugiens, ad remotiorem ab ejus presentia regionem tendat; At centrum est locus remotior a circumferentia; Proinde, ubi globi alicujus concavi superficie virtus ignea occupat, ibi retentus & conclusus in ipso aer seu aqua tenuis, grossiores suas partes ad centrum emittet, imo omnes aeris partes in globo concavo comprehensae, tanto sunt gradatim spissiores, quanto ab ignis vigore remotiores existunt, ut hoc explicatur experimento sequenti.

Experimentum II

Fiat igitur globus quidam vitreus vel cupreus, distinctis trebus regionibus, ita ut altera integram alterius concavitatem complectatur; habeantque regiones istae foramina seu tubas quasdam, modo inferius depicto protuberantes, ac cingatur undique igne vivacissimo extima globi superficies; Quo facto ad oculum apparebit ignem illum exteriorem superiori regioni vigorem suum vivaciorem accommodare, aeremque in eâ contentum propter vivi ignis contiguitatem mire attenuari; atque alteram etiam regionem mediam percipere

the middle layer, takes in some heat from the first, but, nevertheless—since the heat is more mild than in the outer one—the air resting in this circle is less subtle and fine, since the fiery force cannot rarify it further. This fiery force lying in the middle layer transmits some strength, although little, into the lower region. From whence the thick air of the higher region (of which there is a great deal), then of the middle region (of which there is less), and then of the lower region (where there is least), tends toward the center, and the preceding proposition (as well as the one that was set out after the end of chapter 7) shows that it amasses in drops.¹² The illustration follows.

quidem a prima vigorem igneum; sed tamen, quoniam ille in ea mitior est, quam in superiori, idcirco existentem in ea aerem minus subtilem esse & tenuem, non valente nimirum vi ignea eum ulterius rarefacere. Ignea denique virtus in media regione delitescens vim quoque aliquam, licet exiguam, in infimam regionem infundet; Unde spissum aerem, tum superioris regionis, cujus major est quantitas, tum illum regionis mediae, cujus est proportio minor, tum denique infimae etiam regionis, qui omnium paucissimus est, ad centrum tendere, & in guttas ibi conglomerari commonstrat propositio praecedens, & illa etiam quae post finem capituli septimi est expressa. Demonstratio sequitur.



The outer sphere, above the surface of which the main fiery force is put in place, is ABCD. The second is EF, the third is IH.¹³ The line measuring the final place of the distance towards which the cold nature is able to move (concealed in the grosser air as it is pushed by the virtue of the fire), is LM, which is the radius of the largest circle. Ooo are holes opened in the convex part through which the thicker part of the air is pushed down to the middle.

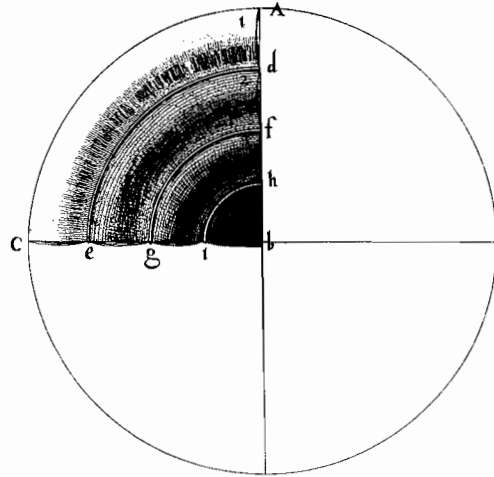
S[ph]aera⁵⁰ superior, super cujus superficiem primaria ignis virtus consistit, est ABCD. Secunda sphaera est EF. Tertia est IH. Linea mensurans ultimum distantiae locum, ad quem movere potest frigida natura, in crasso aere delitescens, ignea virtute impulsae est LM quae est circuli majoris semidiameter. Ooo sunt foramina in convexitate regionis contenta, per quae aeris pars spissior deorsum versus centrum pellitur.

Experiment III

There remains, then, the third experiment, from which demonstration it is shown that the thick air, pushed from the circumference to the center, produces a body that is quite dense and from its density properly called opaque.

Experimentum III

Superest jam experimentum tertium, ex cujus demonstratione patet, necessario aerem crasum, a circumferentia ad centrum depulsum, conflare corpus valde spissum, densum & propter densitatem opacum.



In the beginning, the potential substance of the water in the world was not other than if some part of this artificial globe—divided with sections [transentibus] into different concavities stretching from the center to the circumference (like arc abc in the demonstration given above)—were filled with clear water, or air,¹⁴ where all parts of the water are the same thickness and nature. Moreover, if the fire should touch the surface by the extremity of the vault, the thicker air from the upper region denoted by I, where much more of it is found than with respect to its center (like that of the second and third regions) will be truly gross and compact as it is driven back to the center. This space is able to contain it, for the air—which before was contained in the spaces ACDE, DEFG and FGHI—is compressed, tightly packed, and reduced in size and vapor mass into a very small corner of the arc. It could not, of course, be contained otherwise in a space so

In principio substantia potentialis aquarum in mundo non erat alia, quam si globi alicujus artificialis, in concavitates diversas certis interstitiis ad centrum a circumferentia transeuntibus divisi, pars aliqua, utpote, in demonstratione praemissa arcus abc aquâ limpidâ seu aere repleatur, ubi omnes aquae partes sunt ejusdem spissitudinis & dispositionis: At si ignis tetigerit extremam illius arcus superficiem, aer spissior superioris regionis per I denotatus, qui multo major respectu illius centri esse reperitur, similiter & ille secundae ac tertiae regionis, cum ad centrum reverberatur, erit valde grossus & compactus, neque enim aliter in loco tam angusto, qualis est ille centri contineri posset: namque aer, qui antea in spatiis ACDE & DEFG & FGHI comprehensus erat, in parvulum illum arcus angulum comprimitur, coangustatur & in grossam & vaporosam massam redigitur. Hinc igitur dependet mag-

small. All this, then, is the origin of the great mystery of the ancient mysterious philosophers, in finding the weights and proportions of the elements.¹⁵ And, indeed, the whole universe, on account of this cause, was reduced into spherical form and the Archetype disposed gross bodies toward the center of the machine,¹⁶ in order that—being made always more subtle by rarefaction and attenuation—they would be able, in going up, to select their higher place. For, as was said above, the gross matter needs less space before the process of disassociation, than after rarefaction.¹⁷ By complement of this conception, then, it will not be difficult to measure the volume of the skies, at least with previous knowledge of the size of the earth;¹⁸ nor shall it be laborious to investigate the proportions of the elements in turn, as we are able to judge from their properties the expansion and dilation of each. And, accordingly, it will be clear even to a blind man, that the illustrations in this, our book—which delineate the generated distances and positions of the heavens—will, with careful elucidation, not appear frivolous, but will be seen as convenient with the natural world.¹⁹

Part III**Tractus I, Liber V, Caput XIV, XV, XVI***Chapter XIV*

Why the heavens are moved in circles and further concerning the period of the daily motion, that is, the revolutions of the heavens in the space of 24 hours.

Unless I am mistaken, those who say that the substance of the Empyrean heavens is immobile err in the greatest degree. If indeed we say that the spirit of God is the prime mover in the universe (as we said in chapter 2 of book 2)²⁰—by whose motion, moreover, it is certain that the simple spirit of this place moves—then

num illud antiquorum Philosophorum mysterium, inveniendi pondera atque proportiones elementorum. Et sane totus mundus hanc ob causam in formam sphaericam est redactus corporaque crassiora versus machinae centrum disposuit Archetypus, ut ea rarefactione & attenuatione subtiliora facta semper ascendendo ampliorem sibi locum possent eligere; namque minorem res crassae locum ante resolutionem, quam post subtiliationem requirunt, ut supra dictum est. Hujus igitur cognitionis complemento non erit difficile, coelorum capacitatem metiri, cognitâ saltem prius terrae magitudine; neque etiam elementorum proportiones ad invicem, cum de propria earum extensione ac dilatatione judicare possumus, investigare operosum erit. Proinde quoque & vel caeco, etiam ex illi, nostras in hoc libro ad coelorum distinctiones & positiones delineandas, productas demonstrationes, non frivolas, sed cum ipsa rerum natura convenientes esse, luce clarius apparebit.

Caput XIV

Coeli cur circulariter moveantur, & de du[r]atone⁵¹ motus diurni, hoc est, revolutionis coeli in viginti quator horarum spatio.

In maximum, ni fallor, incurrunt illi errorem, qui dicunt, Coeli Empyrei substantiam immobilem esse: Siquidem Spiritum Domini in illo omnium movere cap. 2. lib. 2 diximus; cujus motu porro Spiritum illius loci simplicissimum movere certum est, non aliter, quam ad ignis inferioris motum, aerem movere-

we see that the air moves no differently than by the motion of the lower fire. By, as it were, the moving presence, and ineffable power of the uncreated spirit—that first creature, most rapid, most lively and opposed to rest—this spirit was created through a flaming forth of that first spirit. All this is as sacred scripture records, for the royal psalmist says: *by the word of God the heavens are made solid and from the spirit of his mouth all the virtues of it are made real.* Therefore light must be first and most distinguished in the heavens and be the universal virtue of the world, in that it necessarily proceeds immediately from the divine and inexplicable spirit. That the spirit of God was born above the waters (or corporal heaven), and that it assigned them their spherical shape by its circular motion, all this is demonstrated to the eyes of reason from the effects. From which it is manifest that the motion of this divine spirit cannot be straight, but circular, so that by its motion it surrounded a mass of the hyle, and separated the universe from the parts of other hyles shut outside, making this enclosed part round and spherical.²¹ Because of its spherically-shaped state, then—in so far as it has no beginning or end—it is made like the creator, and this makes sense, since every effect must have a similitude to its cause.²² Moreover, this form is suitable because it is, of all others, the most noble, ultimate, perfect and commodious, and because it has far more volume than the rest. Immediately after that action of the spirit, the first creature shone forth, coming forth, as it were, from the motion and the shining of the uncreated light. So indeed, it is likely that this creation moves in the same way and by the same rationality of movement, in this way acting in imitation of its first cause.

Further, the effect seems to demonstrate to us the path of this circular motion—which is to say the terminus from which [it comes] and to which [it goes]—to wit, from the East to West, or from the right to the left with respect

percipimus. Praesentiâ autem & virtute ineffabili Spiritus illius increati moventis, primam illam creaturam omnium velocissimam, vivacissimam & quieti contrariam, e[j]usdem⁵² quasi Spiritus fulgore productam esse, sacrae etiam spiriturae referunt: *Nam inquit regius ille Psalmista. Verbo Domini coeli firmati sunt, & Spiritu oris ejus omnis virtus eorum.* Cum igitur lux sit prima & praecipua coelorum & mundi universalis virtus, necesse est, ut immediate ab illo Spiritu divino & inexplicabili procedat. Ferebatur Spiritus Domini in Coelo spirituali super aquis seu coelo corporali, eas terminans, figuramque suo motu sphaericam illis attribuens, quemadmodum ab effectu oculis rationalibus evidenter demonstratur. Ex quibus manifestum est, motum ejusdem Spiritus divini non fuisse rectum, sed circula-rem, ut suo motu illam hyles massam, quam circumsepiebat, & a caeteris hyles partibus, extra mundum exclusis, separabat, rotundam & sphaericam efficeret: tum, quia hujusmodi figura sphaerica, quatenus neque principium neque finem habet, creatori quodammodo assimilatur, cum omnis effectus necessario quandam suae causae similitudinem habere soleat; tum etiam, quia talis figura, aliarum omnium nobilissima, utilissima, perfectissima & commodissima est, quoniam caeteris longe capacior. Immediate igitur post hujus Spiritus actionem prima illa creatura effulgebat, a motu quasi & fulgore lucis increatae proveniens; quam quidem, primae suae causae actus imitando, eâdem viâ, eâdemque motus ratione movisse verisimile est.

Praeterea viam motus hujus circularis, hoc est, terminum a quo ad quem, videtur nobis effectus declarare, videlicet ab ortu fuisse in occasum, seu potius a manu dextra ad sinistram, polum borealem respiciendo; (nam

to the north pole (for Orient [East] and Occident [West] got their titles from the creation of the sun).²³ And this is most certain on account of two main reasons, of which the first is as follows: because human nature (in which the divine light is predominant among all other animals) is accustomed to move its right hand (as if by divine appetite for its light), and to work and to move in every manual operation as if that right one were the most noble and outstanding, through this it is clear that the natural appetites for the heavenly light are moved from the right of heaven. The second reason, which seems to be undeniable, is that the truly violent, imposed and most rapid motion of the sky is perceived to tend from this part toward the West. And as the essential created light, proceeding from this uncreated one, is said to be most noble because nothing is as motile or subtle, according to most philosophers (indeed, including by those most experienced in theology, amongst whom I name Augustine, and his book on the literal interpretation of genesis, where it is called by him *the fundament and supreme principle of natural motion*)²⁴—it is necessary, then, that the more rushing and velocious motions of the sky be totally derived from this source. And as a consequence, the resulting diurnal motion flows from this, by which the universal world is revolved from the East to the West (contrary to the belief of Copernicus) in the sum of twenty-four hours through the virtue of this fountain of brilliant spirit. This also Trismegistus seems to confirm this in words in his first discourse:²⁵ *The mind, indeed the creator, containing together circles with the word and with swift rushing turning turned its spinning machine²⁶ on itself, and ordered it to be turned from the beginning to the end forever.* By beginning he seems to mean East and by end he seems to mean West. So we also see in almost every place in sacred scripture the name East placed before West; in Genesis 13.14,²⁷ Psalm 50,²⁸ and an infinite number of other places. And

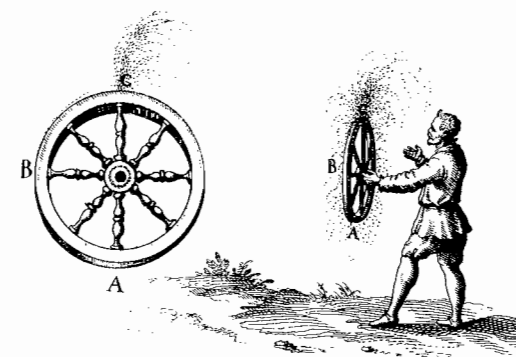
Ortens & Occidens denominationes suas a Solis creatione habuerunt) hocque propter duas praecipuas rationes; quarum prima est, quia natura humana, in qua lux illa divina praecipue inter omnia alia animalia praedominatur, dextram quasi, divino suae lucis appetitu movere, eamque in omni operatione manuali exercere solet, tamquam praestantior & nobilior; per quod, lucis primariae appetitus naturales a parte coeli dextra moveri, manifestum est: Secunda ratio, quae quidem infallibilis esse videtur, est, quoniam raptus & velocissimus coelorum motus, ab illa parte versus occidentem tendere percipitur. At cum lux essentialis creata ab illa increata procedens, secundum plerosque Philosophos, imo & ab ipsis in Theologia peritoribus, inter quos Augustinum super Genesin ad literam nomino, nobilissima dicatur, quia nihil mobilius aut subtilius: atque adeo etiam ab ipso in eodem loco fundamentum & principium supremi motus naturalis appelletur, necesse est, ut rapacior & velocior totius coeli motus ab ejus fonte derivetur; & per consequens motum diurnum, quo universus mundus materialis ab Oriente (contra Copernici sententiam) in Occidentem, viginti quatuor horarum spatio, virtute illius fontis lucidi spiritualis circumvolvitur, ab ipsa profluere; quod videntur etiam Trismegistus in primo suo sermone hisce verbis confirmare. *Mens quidem opifex, una cum Verbo circulos continens, & celeri rapacitate convertens suam ad se machinam flexit, eamque volvi a principio ad finem absque fine praecepit;* per principium ortum, & per finem occasum intelligere videtur. Nonne quoque videmus, sacram Scripturam in omni fere loco nomen Orientis semper praeponere Occidenti, Genes. 13.14 Psal. 50 & infinitis aliis locis. Praeterea in omni adoratione convertunt sese adoratores versus Orientem, ut Ezechiel. 8.16. Matth. ii Luc. 13.29. & multis aliis locis. Similiter stella illa Christi adventum declarans in Oriente apparebat, Atque ita quoque Domini adventus erit ab Oriente

further, in every adoration the worshippers turn themselves toward the East, as in Ezekiel 8.16,²⁹ Luke 13.29,³⁰ and many other places. Similarly, as in Matthew 2,³¹ the star declaring the advent of Christ appeared in the East, and also the second coming of God will be from the East to the West (Matthew 24.27).³² Through all of which it is satisfactorily demonstrated that this uncreated light moves from the East to the West. What indeed is clearer than this? Especially as the effect of this thing may fall upon the senses.

Is it not most sure that a soul is in a man or any other animal, even though it is invisible, so long as we perceive that its body moves hither and thither through its own power? Do we not know that a visible action is enclosed in a plant, when we see it begin to flourish and germinate? Is it not still most certain that the intellectual soul exists above the surface of the corporeal world, since experience attests that this, through itself, forms a sphere and revolves in a natural day? Material of the world could not carry out this motion (since in itself it is incapable of motion), except through the motion of the brilliant fountain, which is in itself the foundation of every natural motion—its well-spring and its origin. And it is by consequence certain that the motion of the first bright creation was circular, and moreover that this motion was from East to West, which was the first motion of all, and that it is more rapid, noble and powerful than the rest, as it is sprung from the fountainhead of universal action. The very way that this spherical material (in itself incapable of motion) is itself moved by this fiery soul placed above the external surface, the following experiment shows: where BCA is a wheel around whose circumference is bound the artificial fire, or so called fuse, A; it follows that the whole wheel is seized very violently by the strength of the burning fuse, perfecting most quickly its circular motion.³³

versus Occidentem Matth. 24.27. Per quae satis demonstratur, Lucem illam increatam ab Oriente versus Occidentem movisse. Quid enim hoc clarius? Maxime, cum etiam illius rei effectus sensum cadat.

Nonne certi sumus, animam in homine seu aliquo alio animali esse, quamvis invisibilem, dum ipsius corpus per se huc atque; illuc movere percipimus. Nonne actum visibilem, in planta cognoscimus includi, dum ipsam vigescere cernimus & germinare? Nonne etiam animam intellectualem supra mundi corporalis superficiem existere certi sumus, dum ipsum per se glomerare, & die naturali circumvolvi experientia testatur? Quem quidem motum materia hujus mundi, cum ad motum per se inefficax sit, nullo modo perficere potuit, nisi per motum fontis lucidi, qui est cujuslibet motus naturalis fundamentum, fons & origo. Et per consequens certum est, primae illius creaturae lucidae motum circularem fuisse, & ab oriente in occidentem, qui omnium erat primarius, reliquisque velocior, nobilior, & potentior, cum ab universalis actionis fonte oriretur. Quomodo autem sphaerica illa materia ad motum per se inepta ab ignea illa anima supra ejus peripherae superficiem posita moveatur, experimento sequenti declaratur; ubi BCA est rota, in cujus circumferentia ignis ille artificialis, A fustum⁵³ dictus, alligatur. Virtute igitur hujus fusi accensi tota rota violenter rapitur, motum suum circularem quarn celerrime perficiens.



We conclude then with the opinion set forth in the third discourse of Trismegistus: namely that the very great circumference is carried in a circle on the air by the harmonizing divine spirit.³⁴ And indeed, taking this further, that from the beginning to the end (by the action of the fire and by the resistance of the humid material) there will be a threefold circular motion in the sky: of which the *first* is that motion from the East to the West (or from right to left), which we have already said is turned about in accordance with the disposition of the bright fountain of the first heaven; the *second*—that is to say the one from the West to the East, or from the left to the right part of the heavens—has its cause from the material part of the bodies of stars and the heavens, as we will shall explain below; and the *third*, arising out of the changes of the form and material, and having its origin in mutual action and passion which we call the “motion of trepidation.” There are also the circles of motion particular to the creatures of heaven—which are stirred up from the action and passion between the material of stars’ substance (tending upward) and its forms (pulling downwards)—of which sort are the motions in epicycles, with which we will deal at length in the part below.

Concludimus igitur cum Trismegisti sententia sermone ejus 3 prolata, ambitum ampliore aereo in circulo, conspirante divino Spiritu vectum esse, & quidem a principio versus finem, ejusque fulgoris actione, ac materiae humidae resistentia triplicem fieri in coelo motum circularem; quorum primus est, hic motus ab Oriente in Occidentem seu a dextra ad sinistram, quem secundum fontis lucidi primi coeli dispositionem jam diximus exagitari. Secundus ex parte materiae corporis stellaris & coelorum causam habet, ut infra declarabimus; ille nempe, qui ab Occidente in Orientem seu a sinistra coeli parte in dextram sit. Tertius ex mutua formae & materiae actione & passione originem suam habet, quem motum tripidationis appellamus. Sunt etiam motus circulares coeli creaturis proprii, qui ab actione & passione inter materiam substantiae stellae sursum tendentis, & formae illius deorsum petentis, concitantur; Cujusmodi sunt ipsorum motus in suis Epicyclis; de quibus infra quoque latius agemus.

*Chapter XV,
Concerning the error of Copernicus and Gilbert,
perceiving the daily revolution of the earth.*

When it comes to the daily revolution, various disputations arise between philosophers, and it is not easy resolving the controversy. Some assert that the universal machine revolves in the space of twenty four hours as a result of the seizing action of the primum mobile, and they insist that the motion is from East to West. This was the general character of the opinions of the peripatetic philosophers, in addition to nearly all those of our present times, with the exception of only a few who hold the contrary opinion. Among these who take exception we find enumerated (by name, in order) from the ancients: Heraclites of Pontus and Ecphantus, both Pythagoreans, Nicetas of Syracuse and Aristarchus of Samos, and some others of that same ilk. Among the more recent ones: Copernicus (that most skillful astronomer), and also our colleague William Gilbert, who has been at work for many years on the study of the power of the magnet. It is the opinion of these that the daily rotation is in no way effected by the primum mobile, nor from the East to the West. They claim instead, that the globe of the earth constantly revolves from West to East [sunset to sunrise] according to the natural motion of the planets in the space of twenty four hours. And certainly the accounts of these men seem, at first (and on the face of things), probable and likely. Nevertheless, if they are inspected more closely and considered diligently, then we shall detect easily that they are clearly nonsense and frivolity. We will then undertake to prove this by reasons, first by those that rely on philosophical speculations and those based on vulgar practice, and then also by others drawn from sacred scripture.³⁵

First, then, it would be miraculous if all the planets of the heavens had a motion in latitude, but the terrestrial sphere, so much

*Caput XV
De Copernici & Gilberti errore, diurnam terrae
revolutionem asseverantium.*

De revolutione diurna, varia oritur inter Philosophos disputatio, & non cito determinanda controversia; dum alii a raptu primi mobilis motu universam machinam viginti quatuor horarum spatio circumvolvi volunt motumque istum ab Oriente in Occidentem fieri autumant; Cujusmodi opinionis sunt peripatetici, & omnes fere nostrae aetatis, paucis solummodo contrariae opinionis exceptis; quorum in ordine ex veteribus; Heraclidem Ponticum, & Ecphantum ambos Pythagoricos, Nicetam Syracusanum & Aristarchum Samium, ac nonnullos alios ejusdem fa[r]inae⁵⁴ ex recentioribus vero Copernicum, Astronomum illum peritissimum, & Gulielmum Gilbertum collegam nostrum in magneticae virtutis perscrutatione a multis annis studiosum, [n]umerari⁵⁵ & nominari invenimus; quorum est sententia, revolutionem diurnam nullo modo a primo mobili, aut ab Oriente in Occidentem fieri; sed ipsum terrae globum ab occasu in ortum secundum naturalem Planetarum progressum, 24. horarum spatio naturaliter circumvolvi constanter affirmant. Atque horum certe rationes, quamvis prima fronte probabiles & verisimiles videantur, attamen si exactius inspiciantur, diligenterque considerentur, eas plane nugosas & frivolas esse facimile deprehendemus: quod quidem rationibus, tum philosophica speculatione & praxi vulgari nitentibus, tum etiam ex Scriptura sacra desumptis, probare conabimur. Primum igitur miraculosum esset, omnes coeli Planetas secundum mundi latitudinem moveri, sphaeram autem terrestrem, iis longe viliorem & ignobiliorem, constanter sub iisdem poli elevationibus cursum suum naturalem quolibet die naturali perficere, atque per consequens ab omnibus caeteris globis motu suo irregularem esse; nam certum est, quod quilibet terrae locus nec

more vile and ignoble than they, constantly completed its natural course each natural day under the same elevation of the poles, meaning that it had a completely different motion from every other sphere. For it is certain that, whatever the position of the earth, it is neither raised up nor depressed down, but rather possesses always the same latitude.³⁶

Secondly, if the circular motion of the earth were completed in the space of twenty four hours, then the earth would move infinitely more quickly than the strongest horse running in a race, faster than a shaft shot most violently from a bow, faster than a shell hurtling forth from the fiery orifice of a canon. Yet the violent galloping of a horse seems, in a certain way—through the compression of air and its resistance—to impede the horse's breathing. Similarly, a staff, drawn through the air by a strong arm, is perceived to give out a sound and to produce no small noise. A globe hurled forth by fiery power from a cannon, as it flies, is proven by the witness of experience to produce a still greater noise through the medium of the air. The motion of all of these, however, would not in any way compare with that which the earth would generate by its daily revolution (if it were ever moved by such a motion). Whence, then, (and as a consequence) from that very swift motion of the earth making its daily rotation, men standing upright on the surface of the earth, large rocks protruding to great heights, tall trees stretching up to the heavens, and excellent palaces and their towers extending up to the clouds, would all produce a far more vehement roaring and loud noise, as a result of the repercussion and resistance of the air.

Since none of these things can be perceived in any way, we see that the earth is in no way moving in such a motion. Nor is it enough to say that the air is moved in accord with the motion of the earth and gives place to it in its motions, since we see that the winds some-

altius elevetur, nec imius deprimatur, sed eandem semper latitudinis sedem possideat. Secundo, si motus terrae circularis spatio 24 horarum absolveretur, citius moveretur terra infinitis gradibus equo vehementissimo cursu deproperante, baculo violenter impulso, globo tormentario ab igneo bombardae officio prodeunte; Atqui violentus equi cursus videtur quodammodo per aeris compressionem ejusque resistentiam impedire equitis respirationem, baculus forti brachio per aerem ductus sonitum edere strepitumque non exiguum ciere percipitur, globusque e bombardae virtute ignea ejectus majorem adhuc strepitum per aeris medium volans inducere experientia teste probatur: Quorum tamen omnium motus cum illo quem terra sua revolutione diurna concitaret, (si tali unquam motu moveretur) nullo modo comparandus esset; Unde consequenter etiam ex velociori isto terrae motu, quo revolutionem suam diurnam conficeret, homines super terrae superficie orthogonaliter stantes, scopuli magni & altissime ab ejus superficie protuberantes, arbores in sublime protensae & palatia superba ac turres eorundem ad nubes usque pertingentes, strepitum atque clangorem longe vehementiorem, per aeris repercussionem ac resistentiam ederent: Quae omnia cum nullo sensu percipi queant, terram tali motu veloci nullo modo moveri censemus. Neque enim sufficit, si respondeatur, ipsum quoque aerem ad motum terrae moveri, eique in suo motu locum dare, cum ventos violenter ab ortu in occasum quandoque flare percipiamus; quorum fane flatus contra terrae motum emissus turbines ac tempestates horrendas probabiliter propter oppositum terrae morum induceret; quae omnia, quia non accidunt, evidenter terram revolutione diurna per se non moveri demonstrant. Tertio, terrae ipsius motum naturalem motui coelorum velocitate nullatenus comparandum esse, probabimus hisce a natura ipsa depromptis experimentis.

times blow violently from East to West. Their blowing—when put out against the motion of the earth—would, in all probability, produce whirlwinds and terrible storms on account of the opposing motion of the earth. All of these things, because they do not happen, clearly show that the earth is not moved by itself in a daily rotation.

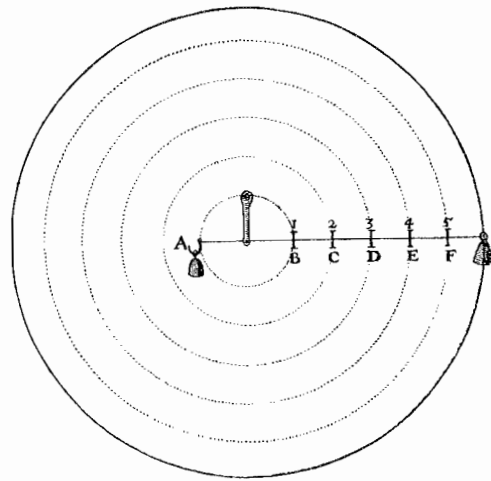
Third, the natural motion of the earth is in no way comparable to the rapid motion of the heavens, as we will prove from the nature of the appended experiments.

Experiment I

By the amount that the circumference of a wheel is distant from its center, by that amount it is moved more easily and quickly (see rule 1 chapter 2 of book 1, concerning motion).³⁷

Experimentum I

Quanto remotior est rotæ circumferentia a suo centro, tanto facillius & velocius movetur. Vide Regul 1 Cap 2 Lib I de motu.



This experiment is shown in book 1 concerning motion, chapter 1 rule 1.

Demonstratur hoc experimentum. Lib I de motu cap 1 & 2 Reg 1.

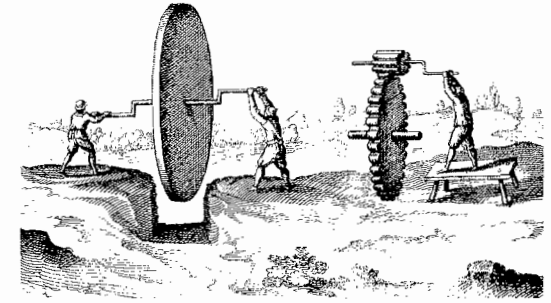
Experiment II

Much greater force is required to produce any motion of a wheel from its center, (known as “motion from the origin” or “from the interior”) than to produce motion from the edge or circumference or outside (a motion which is

Experimentum II

Multo major vis requiritur ad motum alicujus rotæ a centro (quem motum a principio seu ab interiori appellant) quam ad motum a superficie, vel circumferentia, seu ab exteriori, qui motus in fine dicitur.

called “motion at the end”).



This proposition is demonstrated in book 1 concerning motion chapter 2 rule 4 and also by the rules preceding these.

That the earth, then, is the center of the heavens is evident, because the sun and the other stars are seen to have in their natural motions the same distance from the earth as here in our hemisphere; this, to be sure, could not be thus if (as some say in error), the center of everything were at the sun. And then we confirm this further by reasoning as follows: that which is large, heavy, and slow, this is the center of the universe. Indeed, the earth is greater in grossness, which can be demonstrated in this way: that which ascends from the earth is always shown to be more subtle and diaphanous in its substance. Thus, water is more subtle than earth, air than water, fire than air, and the fifth essence (or ethereal matter) than fire, etc. Therefore, we say then that the preceding experiments demonstrate clearly that the external parts of the globe—that is, the parts most toward the circumference—are by nature more apt for moving than the central part, because things are led in rotation by the spirit more easily thus than from the center. And, it was demonstrated, as a consequence, that this earth is naturally very resistant to move, as befits the physical center of the whole macrocosm. Wherefore it is more likely that the daily motion of the machine of the universe stems from the circumference than from the center. This is proved most clearly by two arguments. First (and obviously), the argument can be proved on

Demonstratur haec propositio Libro I de motu cap 2 Reg. 4 & per regulas etiam eam antecedentes.

Quod enim terra sit coelorum centrum, patet; quia Sol & caeterae stellae eandem a terra distantiam in motu suo naturali habere dignoscuntur, quam hic in nostro hemisphaerio; id sane quod fieri non posset, si, ut falso nonnulli autumant, centrum totius esset in Sole. Atque illud etiam ulterius hac ratione confirmamus; quia quod magis grossum & ponderosum est, illud est centrum mundi; Atqui terra est magis grossa quod inde probatur, quia, quo altius a terra ascenditur, eo tenuiora & subtiliora media semper inveniuntur; unde aqua tenuior est terra, aer aqua, ignis aere & quinta essentia seu materia aetherea igne, &c. Ergo. Dicimus igitur, experimenta praecedentia evidenter demonstrare, partes globi exteriores, hoc est, magis versus circumferentiam tendentes, aptiores esse a natura ad movendum, quam partes centrales; quia animâ faciliori circumducuntur, quam illae a centro. Et per consequens ipsam terram tardius naturaliter movere demonstratum est, cum sit totius macrocosmi centrum physicum. Quare verisimilius est, diurnum machinae mundanae motum provenire potius a circumferentia, quam a centro; idque duabus rationibus manifeste comprobatur; scilicet tum, quia centesima pars vigoris proportionaliter centrum moventis, movebit circumferentiam; quem ad modum in machinis illis artificialibus supra descriptis, & vicissim in fine luculenter apparet; quarum motus,

account of the fact that the hundredth part³⁸ of the strength necessary to move the center will move the circumference proportionately—as is clear from the artificial mechanics described above, whose motion, although not naturally made, is nevertheless certain to have a natural explanation.³⁹ Second, the argument can be proved on the grounds that we gave above, namely that, in the beginning of the world, action drew its origin from the well-spring of forms—from whose source only the least part was able to descend to the earth, both because of the distance from the Empyrean heaven (for this center is most distant from the circumference) and on account of the great coldness of the earth (in as much as in it there are four cold quarters and no hot ones, unless heat should come to it as an accident, either from the light included in the shadows by creation or out of the influences of the stars flowing into the viscera of the earth, as we said above). Indeed, out of all this, it is certain that the sky is moved infinitely more quickly than the earth, because the whole appetite of its substance is filled with the vigor and power of the moving soul. And this is nothing other than that most limpid substance of light, ever so invigorating. According to Augustine, nothing is more mobile, nor has faster or more vehement motion at any point. For him, nothing is more subtle than this limpid substance, and on account of this subtlety it is very permeating.⁴⁰ From which it cannot be doubted that, by the greater union of power (as in artificial things), a heavy thing normally moves and revolves lightly and quickly. In this fashion also, this multitude of spirits (which are all found frequently in the heavens in very great numbers and by natural impulse, but, by contrast, are found rarely and only by accident on earth) are among the reasons why the skies are moved infinitely more quickly and smoothly than the earth, seeing that (undoubtedly) the mover is multiplied to infinity and, as a consequence, moves its

quamvis arte confectarum, naturalem tamen habere rationem certum est; tum etiam, quoniam in mundi primordio, actum originem a summa formarum scaturigine provenisse supra declaravimus; a cujus fonte pars minima in terram descendere potuit, tum propter ejus longinquitatem a coelo Empyreo, (centrum enim ab ejus circumferentia longius distat) tum propter immensam terrae frigiditatem; quippe in qua sunt 4 frigiditatis quartae & nihil caliditatis, nisi sit ei accidentaliter adveniens, videlicet aut a luce in creatione tenebris inclusa, aut ex astrorum influentiis in terrae viscera dimanantibus, ut supra diximus. Imo certum est, quod coelum infinitis gradibus velocius moveatur quam terra, quia totus ejus substantiae appetitus animae moventis vigore & virtute expletur; nec quicquam aliud est, quam veluti ipsa lucis actuosissimae substantia limpidissima; quā nihil secundum Augustinum, est mobilius, nihilque ejus motu velocius unquam aut violentius & nihil subtilius, ac ob subtilitatem suam penetrantius. Unde indubitatum est, ut in artificialibus major virium unio, grave quoddam levius ac citius movere & circumvolvere solet, ita etiam horum Spirituum multitudinem, (qui in coelo omnes majori numero & naturali quodam ductu frequentius, in terra autem rarius & per accidens tantum reperiuntur) in causa esse, cur coeli velociter, & infinitis gradibus citius, quam terra, moveantur, quoniam nimirum illic motor in infinitum multiplicatur, & per consequens longe efficacius etiam subjectum suum movet. Unde certe ridiculae sunt Gilberti rationes, impossibile esse credentis, ut queant coeli propter infinitam ipsorum magnitudinem spatio 24 horarum circumduci; namque si exactiori judicio considerasset, tum infinitam agentis naturam, tum etiam patientis dispositionem, facillime invenisset rem longe aliter sese habere, quam ipse existimavit. Etenim, cum sit in regionibus illis agens tam immensum ac potens & materia quoque movenda tam bene disposita ad agentis im-

subject much more efficiently.

Hence it is clear that the arguments of Gilbert are ridiculous. He believes it to be impossible that the heavens should be able to revolve in the space of twenty four hours because of the infinity of their magnitude. If he had considered more accurately *first* the infinite nature of the agent and *then* the disposition of the patient, he would have easily discovered that the matter is very different than he appraised it. And so it is, for there is a great and powerful agent of motion in those regions, and then there is also matter to be moved that is so well-disposed toward accepting the impressions of the agent (such that it is easily turned in either direction by the impulse of the mover). Who, considering this, will suffer himself to be persuaded that the motion of these will take place more slowly in the heavens than in this place, where the agent is weak (and only present by chance), and the material to be moved is badly disposed to tolerating motion. No one has ever doubted, however, that the seat and the throne of the mover is in the heavens, and truly the matter to be moved is of a subtlety of spirit and radiance beyond comprehension, whence it is moved easily back and forth as the disposition of the mover requires. Do we not see that the earth is heavy, and that its weight accords badly with motion, just as a great rock is raised by many hands, which (by virtue of its weight) cannot be supported by the power of a single living soul? But if some part of the earth is dissolved in water, ten parts of that water are equal by weight to one part of earth. Similarly one part of water corresponds by weight to ten parts of air made through rarefaction of the water;⁴¹ and the proportion between air and the substance of fire, and between this substance fire and this substance of the fifth essence will all be the same. From which it is manifest that earth dissolved in water demands a containing space greater by ten times than it occupied before the act of dissolution

pressiones leviter suscipiendas, ita, ut facillime huc atque illuc motoris impulsu vertatur, quis persuaderi sibi patietur motum illic tardius fieri, quam in loco eo, ubi & agens est debilis ac fortuitus, & materia quoque movenda male ad tolerandum motum disposita; Motoris autem sedem & imperium in coelis esse nemo dubitavit; materia vero movenda quoque praeter imaginationem subtilis est, spiritualis & levis; unde facillius huc atque illuc pro motoris dispositione agitur. Nonne videmus terram gravem esse, & motui propter suum pondus male convenientem, lapidemque magnum multis manibus elevari, qui propter gravitatem suam unius animae viventis virtute sustineri non potest? At, si terrae pars aliqua resolvatur in aquam, decem illius aquae partes illam unicam terrae portionem pondere suo exaequabunt. Similiter aquae pars una, respondet pondere suo decem partibus aeris per subtilitatem ex aqua factis; eademque erit proportio inter aeris & ignis substantias, & inter illam ignis & Quintae essentiae. Ex quibus manifestum est, terram in aquam dissolutam decuplo majorem locum continentem requirere, quam ante factam dissolutionem & subtilitatem occupabat; quemadmodum apparet in subtilitacione alicujus mineralis friabilis igne subitaneo facta; nam calore violento in tot Spiritus aereos & aqueos repente solvitur vitriolum aut antimonium, ut Retortae corpus, quod placide antea massam retinebat, non possit ultra materiam istam rarefactam continere; sed maximo cum fragore, ampliorem locum quaerentibus spiritibus illis, disrump[itur].⁵⁶ Dicimus igitur, coeli proportionem in pondere esse aequalem proportioni terrae, corpusque ejus bene dispositum ad motum, quia subtile, tenue, & facile movendum, illud vero terrae male dispositum ad movendum, quia crassum, grave, & quieti proximum tenebrarum receptaculum; quae sunt motui opposita.

Videmus enim, Solem luminis sui actu subtilioris terrae partes sursum quotidie ele-

and rarefaction, just as one finds in the rarefaction of any fragile mineral brought about instantly by the fire. For by the new violent heat the vitriol or antimony is loosened into the many aqueous and airy spirits, in such a way that the body of the retort, which was holding the mass placidly before, is not able to contain the additional rarified material, but with great shattering it is broken by these substances seeking a larger space. We say, then, that a proportion of the heaven by weight is equal to a proportion of the earth, and the body of the former is well arranged for movement because it can be moved easily, subtly, and finely, while that of the earth is badly disposed to movement because it is gross with weight and nearly at rest, the repository of shadows, which are the opposite of motion. We see then that the sun, by the action of its light, raises the subtle parts of the earth upon high every day, but the opposite is true with the more dense parts, as it strikes rocks and other things of the sort in vain and without effecting any sensible motion or rarefaction.

What, finally, is to be said concerning the nature of the earth, which all philosophers claim to be cold? Did not Gilbert himself, well-versed in medicine, confess that cold is the cause of torpor, restfulness, and stupidity, but that heat (which has no dominion on the earth), allots motion, sense, and action to all things. Yet, nevertheless, he was so drawn beside himself by his magnetic force that he was audacious enough to call the whole body of the earth magnetic or a magnet, because he observed that a certain mineral (namely a loadstone) attracts iron to itself and points to the poles of the world, and designated many variations of the poles.⁴² Thus he seems to take the whole for the smallest of its parts. By this method, we could call the sun a small ember because we see it glowing in the night.

We conclude, then, that it is demonstrated above that heaven, with respect to its material

vari; contra vero densiores, saxa videlicet & id genus alia, in vanum & absque ullo motu sensibili aut partium subtiliatione ferire. Quid denique de terrae natura existimandum est, quam omnes Philosophi frigidam esse voluerunt? Nonne confessus est ipse Gilbertus, quatenus in Medicina bene versatus, frigiditatem torporis, quietis, & stupiditatis esse causam; caliditatem vero, quae nullum in terra habet dominium, motum, sensum, & actionem rebus omnibus tribuere? & tamen magnetica sua virtute adeo extra se ductus est, ut totum terrae corpus magnetem aut magneticum appellare ausus sit; quia aliquod ejus minerale, magnetem videlicet ferrum ad se trahere, & ad mundi polos vergere, polorumque variationes designare observavit; & ita totum pro minima ejus parte accipere videtur. Tali etiam modo Solem carbunculum appellare possumus, quia nocte eum splendere videmus. Concludimus igitur coelum, respectu materiae suae & graviditatis ejus, tam facile posse viginti quatuor horarum spatio circumduci, quam terram; cum sit pondere suo terrae proportionale; at respectu praeparationis suae, melius & facilius moveri quam terram, supra demonstratum est.

and its weight, can be more easily turned in the space of twenty four hours than the earth, because (as far as weight is concerned) heaven is proportional to the earth, and, with respect to its readiness, it is, in fact, more easily and better moved.

If the reading of all this is not sufficient as proof, then we call on the sacred testimony of the truth of scripture in this matter, for Christians acknowledge that to call scripture false is very impious and profane. It is found then in the book of Joshua, chapter 10: *the sun and the moon stood still in the heavens and hastened not to the west for a whole day*. Nor is it permissible to respond to this that this passage in Joshua is to be interpreted as referring to the natural motion of the sun: for he speaks concerning the day and the diurnal motion, and admits that the author of it is the sun, in as much as, without its standing still, the day could not be drawn out. But if we want even more manifest testimony, the Bible records in second Kings 20⁴³ that God made the sun go in reverse, for the shadow of the sundial went back through 10 degrees. Similarly, this diurnal motion is excellently declared by the greatest psalmist in Psalm 19.5, where he describes *the sun going out of its tabernacle moving from the east to the west*. Is it not clear, then, that our divine Matthew agrees with our efforts here, when he says in chapter 24.27 that *the fiery light comes from the East to the West*, and that, in a similar way, when he says that from that direction to the West shall come the final day of the Lord? Surely a distinct enough account can be given concerning all this: these are the motions of an uncreated essence, of which one example is the son who will come on the last day (from East to West), and another is the Holy Spirit of the Lord which moved above the waters on the first day in the same way. And hence also the name of the East—as it were, the terminus, in all sacred literature, as we said before—is always placed before the West, just as also prayer is made in

Quod si neque haec omnia etiam legenti sufficiunt, sacram denique Scripturam in hac re veritatis testem appellamus, quam falsam dicere valde impium & scelerarum esse, agnoscunt Christiani: Invenitur igitur in libro Josuae cap 10 *Solem & Lunam constitisse in medio coeli nec deproperasse ad occasum spatio unius diei*; neque enim illic respondere licet, accipiendum esse illum Josuae locum de motu Solis naturali: loquitur enim de die & motu diurno; cujus autorem esse Solem fateatur, utpote sine cujus statione seu consistentia dies continuari non potuit. Sed si manifestius adhuc testimonium desideramus, commemoratur. 2 Reg. 20. Deum fecisse, Solem retrogredi; nam umbra horologii per 10. gradus est retroacta. Similiter motus hic diurnus a Psalmista optime declaratur Psalm 19.5 *ubi Solem e tabernaculo suo egredientem moveri ab ortu in occasum luculentur* expressit. Nonne etiam cum intentione nostra convenit Divus Matthaeus cap 24.27. dicens *fulgur venire ab Oriente in Occidentem*, & quod simili quoque modo, ab illa parte ad occasum, venturus sit die ultimo ipse Dominus? quippe in quibus diserte satis docetur, motus increatae essentiae, cujusmodi est filius ultimo die venturus ab Oriente ad Occidentem, & spiritus Domini sanctus primo die super aquas eadem viâ movens. Atque hinc etiam nomen Orientis, tanquam terminus a quo semper in sacris literis, uti antea diximus, pr[a]eponitur⁵⁷ Occidenti; quemadmodum & adoratio sit versus illam partem, & templa quoque nostra eam respiciunt. Terram denique nullo modo movere declarat nobis Psalmista suo Psalm 104 vers 5 cujus haec sunt verba: *Posuit Dominus terram super fundamenta sua ita ut nunquam movere possit*. Ex quibus omnibus manifestum est, coelum universum

this direction and our temples look that way. Finally, that the earth in no way moves is declared to us by the psalmist in his psalm 104 verse 5, whose words are: *the lord placed the earth over its foundations that it should not be moved forever*. All of which makes it most clear that the universal heavens are moved from East to West by this motion of the sun, and that the hours of the day are in no way as the aforementioned authors hold (through the movement of the mass of the earth).

Chapter XVI

Concerning an explanation of the natural motion of the planets, which is from West to East, and against those who say that the stars move with respect to the motion of their orbs, whence an observation of the Astronomers concerning motion of the epicycle.

The motion of the heavens of the middle region is not called their natural motion but rather a violent and *raptus* motion, (though in its nature—that is, with respect to the Empyrean heaven from whose bright fount it is derived—it too takes place naturally). For the natural motion of the bodies is not to follow the motion of their source, but of that mass in which the motion takes place. And here a great mystery must be observed, namely that, as the motion of the heavenly bodies is distinguished from the inferior ones on account of the excellence and perfection of its essence (having a motion entirely contrary to it which is circular and which fits all the perfect parts of the universe), thus also between the heavens of the more perfect parts of the world *contrary motions arise*. For, though there is no difference between each of the superior heavens (both the spiritual and the corporeal) as far as the order and figure of their motion is concerned, nonetheless, at their *termini a quo* there is the greatest contrariety, since the first (that is, the spiritual) is borne from the East, and the last (that is, the material) is borne from the opposite point of

ab Oriente in Occidentem moveri, & per hunc ipsum Solis, nec ullatenus, secundum praedictorum autorum sententiam, per terrestri massae motum, diei horas constitui.

Caput XVI

De ratione motus naturalis Planetarum, hoc est, ab occasu in ortum, & contra ipsos, qui dicunt, stellas movere ad motum suorum orbitum, unde Astrologorum de Epicycli motu observatio.

Motus coelorum mediae regionis ab Oriente in Occidentem, non ipsorum motus naturalis dicitur, sed violentus & raptus (quamvis in sua natura, hoc est respectu coeli Empyrei a cujus fonte lucido derivatur, naturaliter etiam fiat). Motus namque corporum naturalis est, non fontis sui, sed molis illius, in qua fit motio, motum sequi. Atque hic quidem mysterium observandum magnum in hoc scilicet, quod, ut motus coelestis ab inferioribus distinguitur propter excellentiam & perfectionem suae essentiae, & motum habet iis omni modo contrarium, nempe circularem, qui omnibus mundi partibus perfectioribus convenit; Sic etiam inter coelos partis mundi perfectioris magna oritur motus contrarietas: Quamvis enim utriusque coeli superioris tam spiritualis quam corporalis, in sui motus ordine & figura, nulla sit differentia; attamen in ipsorum terminis a quo summa est contrarietas; cum prior ab ortu, spiritualis nempe, & ultimus a puncto ejusdem hemisphaerii opposito feratur, videlicet materialis; quae quidem motus circularis oppositio a differentia illa derivatur, qua est inter materiam & formam; quarum cujuslibet est naturaliter, propter separationem unius ab

the same hemisphere. This opposition of the circular motion is derived from the difference that exists between the matter and the form (to each of which it naturally belongs, on account of their separation one from another) which gives rise to contrary motions. Whence heavy things, from their material part, are accustomed to move downwards in the chaos of darkness (as was said), and the light things are normally moved upwards, in accordance with the natural place of light, as we sufficiently explained in the fiery disposition and production of the sun.

But truly where the proportion is perfect—in the encircling of the upward tending and agitated material and the descending form—there the bright and radiant form is not sufficient to drive downward the ascent of the vaporous material. Nor is the material going higher strong enough to ascend, as it is impeded by the rays that are descending proportionately. Hence a double circular motion is induced in this same body on account of the diverse dispositions of things that go into making it up, to wit, the form and the matter. It is necessarily thus, in order that ethereal bodies be moved circularly, because the equal proportions of their parts prevents a universal movement upwards or downwards. In what way the prior motion (which we call the *raptus*) is brought about, we described above.

But here we will say a little concerning the motion opposed to this—that from West to East—which we call the proper motion of the bodies of the stars. For, although it is the duty of form to attribute to the body to which it belongs both name and being, nevertheless, that whole which is moved we call ‘body’ or ‘a mobile thing.’ If, however, it is moved through itself by an active, intrinsic principle we call this ‘natural motion’—that is, the motion by which a body is moved according to the appetite of its nature. But if it should have motion from some external principle, such as

alio, motus contrarios efficere; Unde gravia, ex parte materiae, deorsum, ut in tenebrarum congerie dictum est, levia sursum secundum naturalem lucis sedem movere solent, ut in ignea dispositione & Solis productione satis declaravimus; At vero ubi optima est proportio, in materiae agitatae & ascendentis, formaeque descenditis amplexu, ibi forma lucida & radiosa non est sufficiens, ad propulsandos inferius materiae vaporosae ascensus; neque vero materia ascendens altius valet ascendere, cum a radiis proportionaliter descenditibus impediatur; hinc fit, ut duplex etiam motus inducatur circularis in eodem corpore, propter diversas dispositiones rerum ad ejus compositionem concurrentium, nempe, materiae & formae; Necesse enim est, ut corpora aetherea circulariter moveantur, propter aequalem partium suarum proportionem, motum universalem sursum vel deorsum impediendum. Quo a[u]tem modo motus prior, quem raptum appellavimus, inducatur, supra descripsimus. Hic vero de motu ei opposito, ab occasu scilicet in ortum, quem proprium corporum stellarium motum appellavimus, paucis dicemus. Quamvis formae illud sit officium, corpori, cui in est, nomen, & esse tribuere, totum tamen illud quod movetur, corpus, & mobile appellamus; si autem per se movetur, a principio illo activo intrinseco movetur, quem motum naturalem diximus, hoc est, quo corpus quodlibet secundum suae naturae appetitum movetur; Sin a principio externo motum habet, cujusmodi est raptus ille, eo casu non naturalis, sed motus per accidens nominatur. Ex his igitur certum est, motum illum Planetarum, qui partim ab agitatione materiae, & partim a principio interno & centrali sit motum ejus naturalem esse; per quem ab Occidente in Orientem fertur; quippe cum ejus dispositio magis corpori conveniat. Tardior enim est, illo formali, eique in progressu suo contrarius. Atque hic etiam observandum est, quod, quo magis materia crassior in corpore Plaetario

the *raptus*, in that case the motion is named not natural, but 'accidental.'

From this, then, it is certain that the motion of that planet is its natural motion which arises partly from an internal and central principle and partly from the agitation of the matter through which it is borne from West to East, in as much as this disposition best suits the body. (For it is slower than the formal one and contrary to it in its progression). And it is also to be remembered that, in so far as the thicker matter abounds in the body of the planet, by this amount its natural motion shall be more violent—as is very clear in the planets configured from the sun towards the earth and especially, it is clear, in the moon. Similarly, this is the motion through which the stars produce vital, sensible, substantive, and multiplicative effects in the inferiors, which do not in any way happen to bodies from the rapid motion of the heavens.⁴⁴ But philosophers were not able to render a natural explanation of this motion of the stars, wherefore they ascribe it to a metaphysical cause, that is, intelligences.⁴⁵ Since we have tried to refute their opinions above, we will explain its natural motion in this place in accord with our abilities.

It is certain and established that there is action and resistance in every mobile body: action from the intrinsic moving principle and passion and resistance from the moving subject. Thus, that body of the planets, snatched by the violent motion of the heavens, in its resistance, seems to undergo retrogradation, no differently than, in the firing of a cannon loaded with gunpowder, a great charge of matter is seen to move against the motion of the fiery spirit, and (on account of its resistance against the fiery nature of the powder) it is perceived to move backward.⁴⁶ And similarly, then, balls thrown against walls are discerned to move in opposition and to rebound. Through which the great discrepancy between the movement of the matter and that of the form is clearly seen.

abundat, eo violentior sit motus ejus naturalis, ut in Planetis a Sole versus terram constitutis, & praecipue in luna liquido apparet. Similiter hic motus est ille, per quem stellae vitales, vegetabiles & multiplicativos effectus in inferioribus producant, qui a raptu coelorum motu nullo modo corporibus obveniunt; Hujus autem stellarum motus rationem naturalem reddere Philosophi certe minime poterunt; quare causae metaphysicae, scilicet intelligentiis eum ascripserunt; quorum opiniones quoniam superius refutare conatus sumus, rationem ejusdem naturalem hoc in loco pro posse nostro explicabimus. Certum & comprobatum est, in omni corpore mobili esse actionem & resistantiam; actionem a principio movente intrinseco; at passionem & resistantiam a subjecto mobili: Sic corpus illud Planetarum raptu coelorum motu agitatum resistendo videtur retrogredi; non aliter quam in bombardae pulvere tormentario oneratae executione; magnum materiae pondus contra Spiritus igniti motum movere cernitur, & propter resistantiam ejus contra igneam pulveris naturam retrogredi percipitur; Atque similiter etiam pilae contra parietem jactae resilire, & in contrarium movere dignoscuntur; per quod magna inter motum materiae & formae discrepantia haud obscure cernitur.

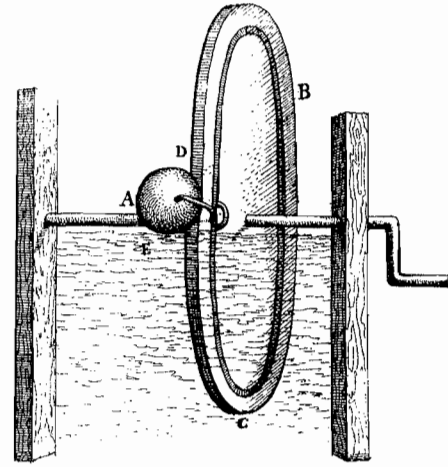
Three things, moreover are to be observed concerning the resistance of the material of this kind. First, *the substance of the resistor is crassa matter*—to which alone it belongs to be moved against the rapid motion, because it is the disposition of its nature to rest.

Ad hujusmodi autem materiae resistantiam tria sunt observanda; nempe *crassa materiae resistantis substantia*; cujus solius est, contra raptum motum ferri; quia naturalis ejus dispositio est quiescere;



Thus we see that if a little water, oil, or a stone is placed above the surface edge of a wheel, and the wheel is turned violently from the East to West (as is demonstrated here), [Figure] the parts of the water or the oil or the stone are bourn against the circumrevolution of the wheel toward the East. So too, if a little water is placed is placed above a square, and that is turned violently with the hands from East to West, this watery body will be moved from the West to the East above the square.⁴⁷ The second thing is *the medium resisting and repelling the thing moved*, for the body of the planets, having been driven from their place by the original and universal motion of the universe toward the West, is resisted by the substance of the ether (to which it belongs no less to resist and slowly move back the denser material than the water in the following experiment acts against the wooden globe, in as much as the water is the medium in which the wheel moves). For as the grossness of the planet is in relation to the tenuousness of the ether in which are borne the planet bodies, so the substance of the wood is in relation to the water, in as much as, we devise the larger part of it to be water and air, whence it floats even in water.

Sic videmus, quod si super rotae alcujus superficiem perifericam pauxillum aquae vel olei, seu etiam lapis ponatur, rotaque ab Orientem in Occidentem violenter volvatur, ut hoc in loco demonstratum est, partes aquae vel olei seu lapidis versus Orientem contra rotae circumvolutionem ferantur. Sic si aquae parum supra quadram ponatur, illâ manibus ab Orientem versus occasum violenter versâ, corpus illud aqueum ab occasu versus ortum super quadram movebitur. Secundum est *medium resistens & repellens rem motam*: nam corpus Planetarium originali & universali mundi motu versus occasum ab ortu pulsum reprimitur a substantia aetheris; cujus non minus est resistere & lente retromovere densiorem planetae materiam, quam aqua in sequenti experimento retroagit globulum ligneum; quippe quae aqua est medium, in quo rota movetur; nam, ut crassities Planetae se habet ad tenuitatem aetheris, in quo corpora Planetaria quasi natant; sic se habet ligni substantia ad aquam, ut pote cujus partem majorem, aquam & aerem esse invenimus; unde & in aqua supernatat.



On the wheel BCD let there be a globe of wood that can move back and forth outside the circumference of the wheel by means of small wheels moving on the two sides. In other words, let there be A—the small wooden globe on the wheel BCD—included on the edge of the wheel in such a way that it is able to move easily back and forth. We say then that if the wheel is moved from East to West in a certain watery medium, the resistance of the water to the violent motion of the mover restrains A, which is pushed a little bit to the East. This occurs on account of the disposition of the material, which is most drawn to rest. Whence it is moved imperceptibly and slowly in contrary directions by resisting the cause that acts from without.

The third thing is *the nature of the eternal light*, for which it is natural to move toward the appetite of its body, without which faculty the body would not be able to move or exist. Thus we see that the animal moves hither and thither in accord with its body's appetite, by virtue of its central essence. And Trismegistus calls this *natural motion* of the planet in his second discourse, and he calls the other, by which the stars are turned from the East, not *motion* but *resistance*, for he says that opposition contains the reverberations of the moving thing and claims that repercussion is the

In rota BCD sit globulus ligneus, huc atque illuc super rotae circumferentiam decurrens, virtute parvularum rotarum in duobus lateribus moventium: Similiter sit A in rota BCD parvulus globulus ligneus, ita peripheria rotae inclusus, ut huc atque illuc moveri facile queat: Dicimus igitur, quod, si in medio quodam aequo rota illa moveatur ab ortu in occasum, resistentia aquae violento motoris motui renitentis globulos A & A paulatim versus orientem impellat; Quod fit propter materiae dispositionem, quae quieti amicissima est, unde resistendo causae extrinsecus agenti via contraria sensim & tarde movetur. Tertium est *lucis internae natura*, cujus est naturaliter movere ad corporis sui appetitum, sine quo corpus neque existere neque movere posset: Sic videmus animal ad corporis sui appetitum huc atque illuc movere virtute suae essentiae centralis: Atque hunc motum Planetarum naturalem vocat Trismegistus sermone suo secundo; alterum vero illum, quo stellae rotantur ab ortu, proprie non motum sed resistentiam vocat; nam oppositionem, reverberationem motionis continere dicit, repercussionemque stationis agitationem esse voluit. Ex his igitur elici potest, non esse difficile corpora Planetaria contra primi coeli motum movere; Quatenus enim sunt corporea, eatenus actionibus contrariis resistunt; & per

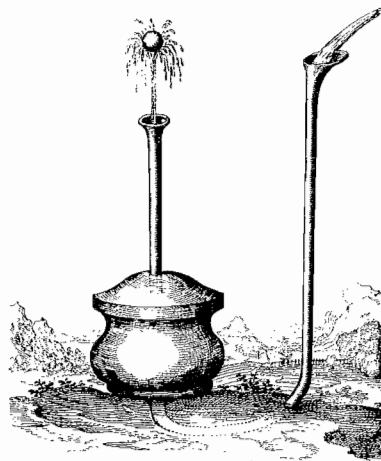
agitation of the stable thing.⁴⁸ From this, then, it is possible to infer that it is not difficult for the planetary bodies to move against the motion of the first heaven. Since, indeed, these are bodies to that extent that they resist the contrary action, and through this resistance they are able to bring about motion to the contrary, but slower. Moreover, the light enclosed in planets, which naturally seeks after its proper place (but is held back by the matter, which does not permit it to ascend on account of its appetite), seems perhaps to seek the first origin of the violent snatching in a circular motion, from whose center at first it is derived, and to which, as to a most perfect place, it similarly desires to move; whence also the body in which it exists must also be moved by its motion. Or rather, because this first mover was accustomed to send forth its effects from East to West, thence perhaps it may be that it tends toward that part always quickly or slowly but without pause, according to the magnitude of the matter or the greater or lesser portion of the bright form. Does not that divine contemplator among men normally investigate more and more God, and His habitat, by such motion of his form, and strive for the probable path, through which the great effect of his power is perceived to descend?

It is thence plain that the celestial bodies move slowly against the action of the first heaven, both with respect to their essential imprisoned forms and also on account of the disposition of the dense matter of their bodies, of which it is the innate property to resist the action of the light—just as some river flowing, descending from its origin, streaming towards the sea, is violently repelled and rebounded by the contrary tide of the sea driving back. And nonetheless, it is perceived to move slowly against the motion of the sea in the flood tide by its own natural motion. In this, then, certainly, the sea, both with respect to its magnitude and the impetus of its

hanc suam resistentiam motum contrarium, etsi tardiozem, efficere possunt. Praeterea lux in Planetis inclusa, cujus est naturaliter proprium suum locum petere, cum a materia retineatur, quae propter suum appetitum illam altius ascendere non permittit circulari motu suum rapti illius motus originem fortasse quaerere videtur, a cujus centro ipsa primum derivata est, & ad quod tanquam locum perfectiorem tendere appetit: unde etiam suo motu corpus, in quo existit, moveri necesse est; Aut, quia motor ille primus suos effectus ab Oriente versus Occidentem emitere solebat, inde fortassis fit, ut versus illam partem, semper citius aut tardius absque intermissione tendat, secundum materiae magnitudinem aut formae lucidae portionem majorem vel minorem. Nonne solet divinus ille inter homines contemplator magis magisque DEUM DEIque habitaculum tali suae formae motu percutare, & per viam probabiliorum tendere illam nempe per quam majores potestatis ejus effectus descendere percipiuntur?

Manifestum igitur est, corpora coelestia, tum respectu suarum formarum essentialium incarceratarum, tum etiam propter materiae densae suorum corporum dispositionem, quorum est, lucis actionibus resistere, contra primi coeli actionem lente movere; non aliter, quam flumen aliquod a sua origine descendens, & versus mare decurrens, contrario ei maris refluxu violenter reverberatur & repellitur, atque ipsum tamen lente in tumido illo fluxu, etiam contra maris motum, naturali suo motu movere percipitur. In quo certe motu contrario mare tum magnitudine, tum motu sui impetu, coelo Empyreo comparandum, & naturalis fluminis motus, illi cor-

motion, must be compared to the Empyrean heaven, and the motion of the natural flow, struggling against the motion of the river, must be compared to the motion of the planetary body that resists the motion of the sea. We conclude, then, that the fires, those sparkling heavens, are drawn spherically and precisely revolved on account of the movement upwards of the matters of the heaven, and [the movement] of their rays tending downwards. For the first light also turns the bright globe of the planet with all matter of the heaven from East to West, by raising it up in such a way that it restores liberty to the held and captive light, but the heavier and more resistant organization of its matter, by tending downwards, forces the planet to strive in a contrary path. Thus also we see that, by the motion of water, a ball of wood or a fruit jumps in the air and is borne greatly up and down as is shown in the following experiment⁴⁹.



Hence, therefore, those motions of the planets—which the Astronomers call direct, stationary and retrograde, and described by them in the Epicycle—exist on account of unequal proportions between light and spirit in the body of all the except the sun. For the sun we say does not have Epicycles but always observes the same distance in its motion, since it is made out of a similar and equal proportion of the condensed spiritual matter and of this light. Which is why, among all of the aforementioned bodies, it is the more perfect, being stable, strong and regular in its motion.

poris Planetarii contra maris motum enitentis. Concludimus igitur ignes, illos rutilos coelestes sphaerice circumduci & assidue circumvolvi, propter coeli materiam sursum movementem, & eorum radios deorsum tendentes: Lux enim primaria globum lucidum Planetæ cum universa coeli materia ab Oriente in Occidentem vertit, illum quodammodo elevando, ut luci inclusæ & captivatae libertatem restituat; Sed gravior & tenacior materiae ejus dispositio deorsum tendendo Planetam cogit viâ contrariâ eniti; Sic etiam aquae motu pillam aliquam ligneam vel pomum aere saltare, magisque sursum ac deorsum vehi videmus, ut experimento sequenti declaratur.

Hinc igitur illi Planetarum motus ab Astrologis in Epicyclo describuntur, quos directum, stationarium, & retrogradum vocant, propter inaequalitatem proportionis, inter lucem & Spiritum corpora Planetaria omnia, praeter Solem, constantis; Nam ideo Solem nullum habere Epicyclum dicimus, sed eandem semper distantiam in suo motu observare, quoniam ex aequali & simili proportione materiae spiritualis condensatae, & illius lucis componitur. Quare omnibus praedictis corporibus perfectior, stabilior, & in suo motu regularior existit.

NOTES AND REFERENCES

1. It seems likely that Fludd drew this apparatus, though not his interpretation, from a twelfth or thirteenth-century manuscript of Philo of Byzantium's treatise *De Ingendis Spiritualibus* that belonged to Thomas Allen, Fludd's contemporary. The manuscript can now be found in the Bodleian. In *Integrum Morborum Mysterium* (p. 9) Fludd claims to have discovered the device in a very ancient document. He was clearly fond of the demonstration, reproducing it in his *Philosophia Sacra* . . . of 1626, and *Medicina Catholica* . . . of 1631. For a full discussion see: Sherwood Taylor, 'The Origin of the Thermometer,' *Annals of Science*, 5 (1942). There is a parallel between this device and the 'fountain which trickles by the action of the sun's rays,' demonstration #47 in Hero of Alexandria's *Pneumatics*. (Fig. a) Fludd presumably had access to the 1575 Latin edition of the text, from which Figure a, and those that follow, are drawn. For an English edition, see B. Woodcroft, ed., and J. G. Greenwood, trans., *The Pneumatics* (London: Taylor, Walton, and Maberly, 1851).

What strikes Fludd as important about this demonstration is not simply that the light rays from the sun have the power to force a certain *arem crassum & fuliginosum* from the vessel. He will return to this power later, in Book II, Chapter XVI, assigning to it the universal generative impetus (see Experiment III in that section). Here, because he is seeking to support his claim that 'throughout the universe, difference is maintained by the presence of light' (see the introduction, and n. 2 below), he wants the reader to witness that when the apparatus is moved into the shade, the active process *reverses* itself, and, though the burned air has escaped, the cooling inside the sphere draws up the crassest matter it can find, in this case the water. Note that Fludd (at the end of this paragraph) claims that the system will draw up water in an amount corresponding to the amount of air lost. The proportions that can be established between the elements will come up again in Book II, Chapter XVI, and Book V, Chapter XV. He clearly believes that such relationships can be measured, although he offers no account of doing so.

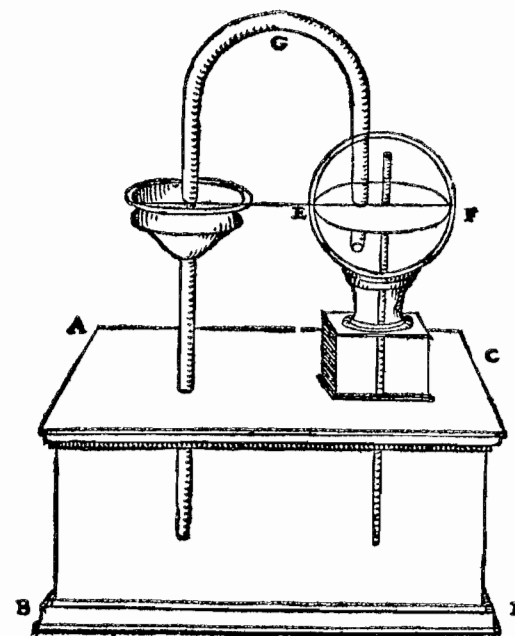


Fig. a

2. This line, among the most intriguing of the translated text, stands as the theme of this chapter and is essential to an understanding of the work that follows. Following the Neoplatonic notion of light as the active principle, and darkness (or 'opacity' or, at times, 'matter') as static, Fludd constructs his explanations of the creation and motion of the universe. (See Book V,

Chapters XV and XVI for explanations of motion and resistance, the natural motion of spirit from East to West and of body from West to East, see also the argument on the mechanics of the epicycle). Visible light, in its formative and sustaining virtues, cannot be separated from the light of grace.

3. This apparatus corresponds to the working parts of the device presented in demonstration #37 of Hero's *Pneumatics* (Fig. b), 'temple doors opened by fire on an altar.' (See Tractate II, Part VII, Book III, where Fludd copies Hero's whole door-opening system, credits him, and then appends the very same illustration of this experiment as a diagram of the mechanism's inner workings). This provenance explains the somewhat strange use of *arula*, or altar, to describe the firebox. Note that here and elsewhere Fludd builds his experimental scenario out of the 'engine' of a classical mechanism but omits the 'device,' the door opener or wine dispenser.

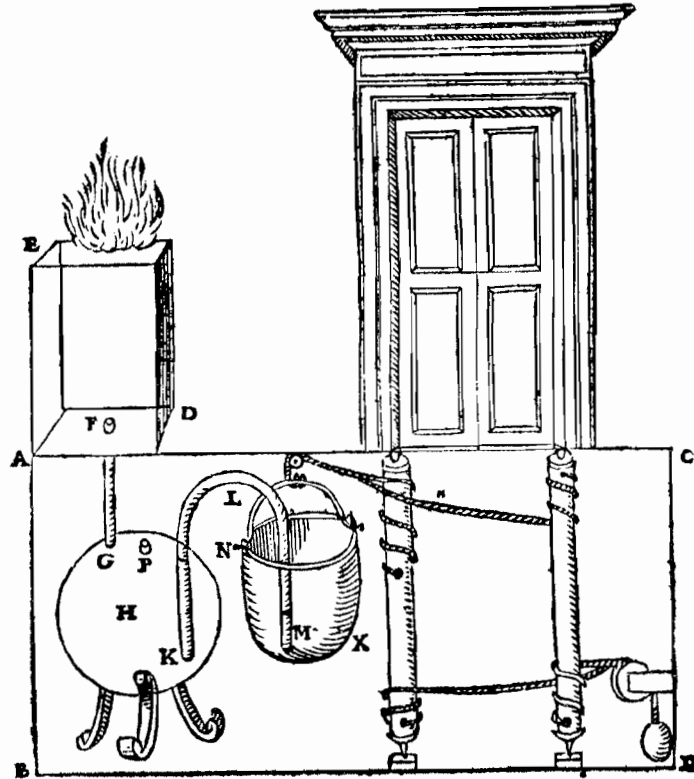


Fig. b

4. Again, nothing as useless as two boxes with a fire on top appears anywhere in Hero. However, if we understand the reference to mean that Fludd has borrowed the *active principle* from the *Pneumatics*, then the best parallel seems to be #11, "libations at an altar produced by fire" (Fig. c).
5. The citation here of Moses carries a great deal of weight. Not only does scripture form one of the three pillars of Fludd's method (Book V, Chapter XV, end of first paragraph; see also introduction), but Moses was a possible source for the Hermetic opus. Recall that Fludd took Moses as the namesake of his philosophical system *Mosaicall Philosophy: Grounded upon the Essential Truth or Eternal Sapience* (London: Moseley, 1659 [in English]).
6. Chapter VIII of Book VI begins: 'Quod ignis hic noster inferior, quem communem & artificialem vocamus, a luce illa coelesti originem suam duxerit, tum veterum Philosophorum rationibus, tum etiam ipsorum exemplis satis comprobatur . . .' The arguments made draw from Pliny, Pythagoras, Bartholomew and Pseudo-Dionysus.

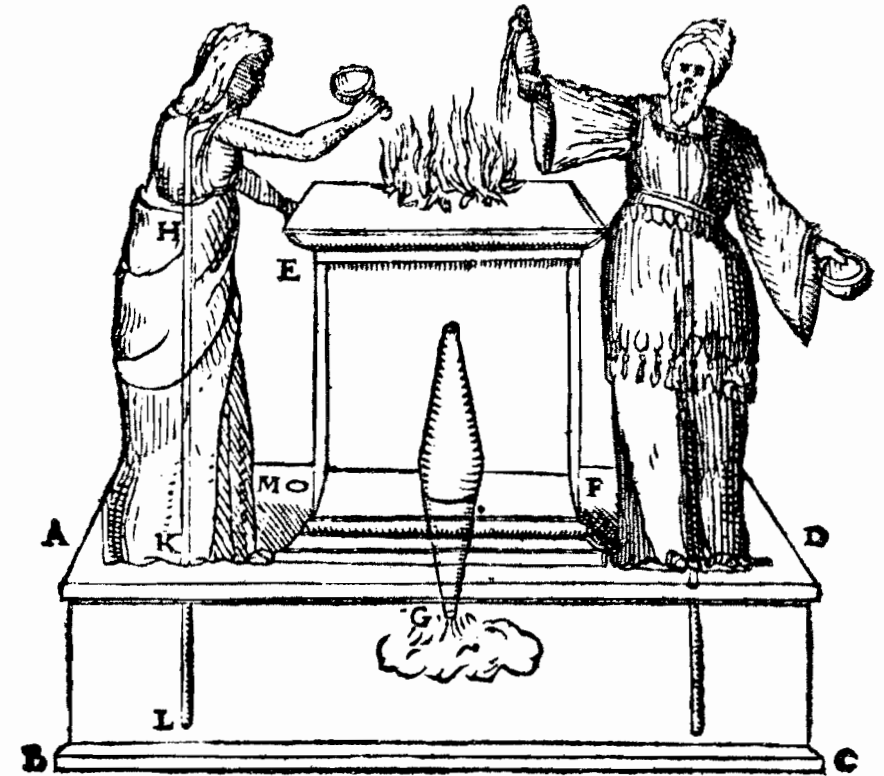


Fig. c

7. I read here, as in the beginning of the second paragraph of experiment III in the same section (see note 14), that in the construction *igne & aere, seu aqua subtili*, 'seu' implies an appositive, meaning that subtle water (water vapor) is, in fact, air. Fludd accepted the notion of the transmutation of the elements. Water could be considered rarified earth, as outlined by Hero, who suggested that when water, left for several weeks, became slime it was beginning a natural transformation back into earth. All of this is of some importance in the experiments II and III below, where a dynamic model of the creation will be constructed. Note that the fire on the outside of the copper globe drives water droplets to its center. For Fludd this would have been enough to suggest that given longer time and greater heat earth would form at the center of the heated cavity. This is the cosmogony he outlines in Book I.
8. Note the construction of the 'altar' with a surface that corresponds to a spherical curve. In this way the reader is being prepared for the following experiments, which will extend the fire around the entire spherical periphery. As we have already seen in the experiments in Book I Chapter VI, the flow of crass matter away from the fire is not dependent on the fire conforming to a circle, but Fludd shapes this experiment in such a way as to model the dynamics of creation. As he writes several lines down, 'we draw the movement of the air according to the diameter of a circle, which pertains more to our proposition.'
9. This 'experiment 2' does not correspond to the numbering system employed by Woodcroft. The closest approximation to this apparatus is probably # 11 (Fig. c) above.
10. There is a sense in which Fludd could be portrayed here as substantiating the previous experiment by means of a 'control': this sub-experiment demonstrates that *the water vapor is a product of the air itself*, and not somehow introduced from the outside (as one might have argued in response to the previous demonstration, where the nozzle afforded communication between the vessel and the surroundings. Note that this is one of the very few places in *Utriusque* where the plate does not seem to correspond with the text (see also n. 13): Fludd

states explicitly that his flask was *Hermeteice sigillatum*, while the illustration shows billows of water vapor emerging from the neck of the vial. Hutin claims that all the illustrations, cut under the auspices of Johann de Bry, were reviewed by the author.

11. This and the following demonstrations are particularly interesting, representing dynamic models for the creation and structure of the universe. This experiment uses concentric spheres and the following one apparently uses radial partitions, 'stretching from the center to the circumference.' (See experiment three below). While this would seem to be a fairly substantial difference in the configurations, the experiments themselves seem identical in procedure and conclusions. In each of the systems, fire placed against the external shell of the globe causes the 'grosser matter' to migrate to the center, where, presumably, it can be seen in the form of droplets of water. Exactly how the condition of the central sphere can be viewed through the fire and concentric vaults is never explained. Judging from what we know of the sustaining virtue of light (Book I, Chapter IV), the moment the fire was extinguished to inspect the central sphere for residue, the whole system would return to its original state. The similarity of the diagrammed experiment and the creation illustrations from Book II is striking. (See following note).
12. Chapter VII of Book II concludes: 'Hinc igitur est, quod perennis illa lucis scaturigo, primo die in superiori mundi regione creata ejusdem materiam occultatam mox patefaciens, eamque in actum reducens, tenuem & subtilissimam partem secundum sui ipsius dispositionem efformavit, crassiorem ejus portionem deorsum versus centrum in mediam regionem detrudendo, ut sine impedimento ullo simplicissimam spiritus substantiam, quam quasi in formam universalem reduxit, gubernare, & secum per omnes mundi latebras transferre posset. Atque hinc est, quod dimidia hujus regionis informatae corporalitas, in mediam repercussa, mediam magis corpoream reddit, quam supremam.' Compare the following illustration (Fig. d) from Chapter VII with the illustrations for Experiments I, II and III

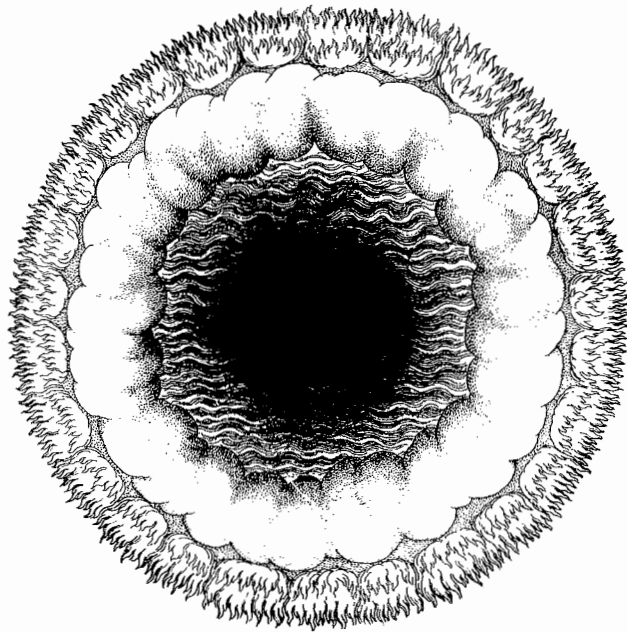


Fig. d

13. Note that IH and LM are illegible on the plate.
 14. Again reading 'seu' as an appositive.
 15. Alchemical transformations hinged on this knowledge of elemental 'sympathies' reflected in their harmonies and proportions.
 16. See reference to 'universal machine' in citation of Hermes. (Book V, Chapter XIV)

17. As this seems to be precisely the opposite of what Fludd has said above, there is a temptation to assume that '*minorem*' ought to read '*majorem*.'
18. This passage proves to be among the most interesting encountered in this translation. The experiment making use of concentric spheres provides a way to 'investigate the proportions of the elements in turn, by judging from their properties the expansion and dilation of each.' Through inspections of the proportions of the elements configured in the device, then, it ought to be possible to discover the 'weightiness and proportions of the elements' in the universe. The experimental model would thus appear to possess both 'substantial' and 'formal' analogical validity. As I suggest in the introduction, the experiment here serves as the intersection of parallel worlds.
19. Note the use of the word *convenientes* to designate the character of the similitude between Fludd's illustrations and the natural world. In the tradition of mystical Neoplatonism, Fludd here hints that the diagrams and illustrations in *Utriusque* may be more than just pictures. Their configurations include more than meets the eye. This is consistent with the reading I have suggested for Fludd's powerful 'experimental philosophy': these are charged scenes where divine forces are being made manifest. On Fludd's images, see Herbert Berry, "Dr. Fludd's Engravings and their Beholders," *Shakespeare Studies* 3: (1967), 11-21.
20. Book II, Chapter II opens with the memorable image of creation (see n. 21) proceeding from the "fiat," in the form of a ring of light guided by a dove, representing the Holy Spirit. The chapter concerns: "How God shone only on himself before the creation of the universe: as well as the gift of love that God gave the section of Hyle comprising the world. Why the world is shaped like a sphere."
- 21.

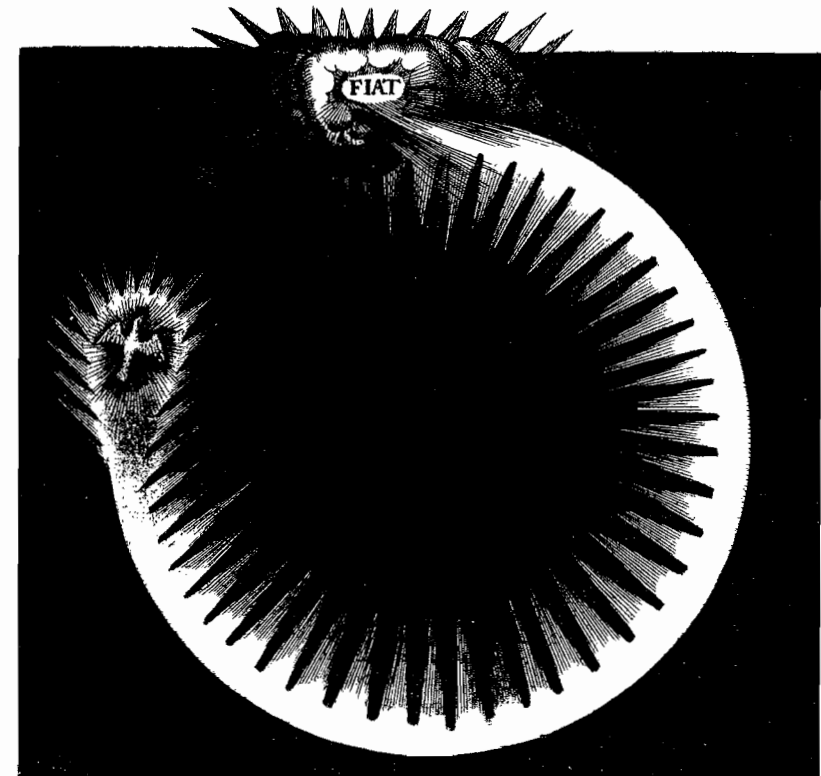


Fig. e

22. Here the Aristotelian relationship of cause and effect is expanded to imply shared forms. This seems to be another instance of Fludd's suggesting correspondences between different realms: causes imply 'conveniences.'

23. The words *Orientis* and *Ortus* are used interchangeably by Fludd to mean East and West. Similarly *Occidentis* or *Occasus* are used to mean West. This is the only place in the text where I have translated 'Orient,' and 'Occident,' because the reference is to the etymology of the Latin terms.
24. This is one of two references made to Augustine in this translated text, the other appearing in the middle of the following chapter, see n. 40. Only this citation directly refers to an Augustinian text, *De Genesi ad litteram*, begun in 401. Fludd's (mis)reading of Augustine deserves closer attention. In *De Genesi*, Augustine (following the Neoplatonic readings of the likes of Origen and Philo of Alexandria) identifies two creations of light, which correspond to the formations of the ideal and the manifest forms. The first, the creation of the divine and ideal *Lux*, corresponds with Genesis 1:3, 'and God said, Let there be light, and there was light.' The second, manifest *Lumen*, is identified with verse 16, 'and God made two great lights; the greater to rule the day, and the lesser to rule the night: He made the stars also.' A similar interpretive technique was used by these commentators, (notably Philo) to explain the two references made to the creation of man.

Interestingly, Fludd appears to conflate these two creations of light in order to place the motive force of light at the very inception of the universe. For Augustine, the making of light at Verse 3 of Chapter 1 represents the 'illumination of rational creatures' (Book I, Chapter 17). Thus: 'Light was made and by this we understand that rational creatures were formed by eternal light... Thus, the created work was, in a sense, first made in the angelic nature' (Book I, Chapter 8). And again: 'If it was spiritual light that was made when God said *Let there be light*, it must not be interpreted as the true Light which is co-eternal with the Father, through which all things were made and which enlightens every man [the Holy Spirit], but rather as that light of which Scripture could say, *Wisdom has been created before all things*' (Book I, Chapter 17). And again: 'And if the light spoken of first of all in the words, *Let there be light, and light was made* must be supposed to have a primacy in creation, it is nothing other than intellectual life, which must be in a formless and chaotic state unless it is turned to its creator and illuminated' (Book I, Chapter 9).

Nowhere in any of the relevant passages concerning this light does Augustine speak of it as 'motile' or 'penetrating' or 'the fundament and supreme principle of natural motion.' Rather, the interpretation of light as wisdom or intellection suggests a static and contemplative virtue and not at all an active or moving power. The explicit reference to Augustine's calling light the 'principle of natural motion' (by which Fludd presumably means the East to West rotation of the heavens, the primary subject of this chapter), seems particularly inappropriate in light of Augustine's equally explicit dismissal of the question of celestial motion presented in Book II, Chapter 10: 'With regard to the motion of heaven, certain Christian writers have enquired whether it is in reality stationary or moving. . . [and some] present the picture of heaven turning either like a sphere, if we suppose another axis not visible to us extending from another pivotal point, or like a disk, if there is no other axis. My reply is that there is a great deal of subtle and learned enquiry into these questions for the purpose of arriving at a true view of the matter; but I have no further time to go into these questions and discuss them, *nor should they have time whom I wish to see instructed for their own salvation. . .*' (emphasis mine).

This would seem as firm a rebuff of the Fluddian agenda as Chapter 17 of the same book, 'against astrologers,' where all divination is said to be the work of communing with evil spirits, and all power is denied to the influences of celestial bodies. (see n. 44). In the passage that serves as commentary on the creation of the heavenly lights, Augustine limits his discussion to questions concerning the relative brightness of the celestial bodies and suggestions that the sun may play some limited role in the motion of the planets, but he insists that the powers of the celestial bodies have been exaggerated by previous thinkers.

How did Fludd read his Augustine? The question calls for a more complete study, but provisionally, I think it could be argued that, wanting to hold up the power of the 'subtle fluid' of light as the formative and motive virtue in the universe, Fludd must have wrung the idea out of Augustine by equating Augustine's *Lux* (the light of reason, which created the angels) with Fludd's own definition of *Lumen*, the manifest light in the world. Even if this is not the case, it can hardly be denied that Fludd is projecting a preoccupation with motion onto the author of *De Genesi*.

All of which brings us to ask how Fludd knew the text of the work. Could he have been using an unusual version of text, perhaps a manuscript copy? It seems unlikely, but according to J. H. Taylor, from whose translation the above citations have been taken (*St. Augustine The Literal Meaning of Genesis* [New York: Newman Press, 1982]), there are 43 manuscript copies of *De*

Genesi in Great Britain and Ireland, more than in any other country, with the exception of Italy. More likely, Fludd is at work on one of his own (rather unique) exegeses, using a standard text. Among the printed editions to which Fludd would have had access are the following: Amerbach, 1506, as part of the collected works; Erasmus, 1528; the Louvain Editors, 1576. Huffman (p. 230) notes that Fludd gave a French translation of *The City of God* (G. Hervet, 1585) to the Jesus College (Oxford) library.

25. What could explain Fludd's mis-citation of this quotation? It is found at the beginning of Book I, sermon i, not ii. I include the translation from the Greek by Louis Ménard in *Hermès Trismégiste* (Paris: Trédaniel, 1977): 'La Pensée créatrice, unie à la raison, enveloppant les cercles et leur imprimant une rotation rapide, ramena ses créations sur elle-même et les fit tourner de leur principe à leur fin comme entre deux limites inaccessibles, car là où tout finit, tout commence éternellement.'

There appears no obvious justification for Fludd's assertion that 'by beginning he seems to mean East.' Could Fludd here be relying on his reader being unfamiliar with the Hermetic corpus? If Fludd had full access to Book III of Hermes, it is strange that he did not call on the following passage from sermon ii to support his assertion concerning the motion from the East: 'L'orient, mon fils Hôros, est sans cesse troublé et échauffé par le lever du soleil, comme l'occident par son coucher . . .'

26. See n. 16 *supra* on the 'mechanical universe.'
27. Genesis 13:14 (this and following biblical citations from the King James edition [1611]): 'And the Lord said to Abram, after that Lot was separated from him, Lift up now thine eyes, and look from the place thou art northward, and southward, and eastward, and westward.'
28. Psalm 50:1: 'The mighty God, even the Lord, hath spoken, and called the earth from the rising of the sun [in Vulgate: *ortu*] unto the going down thereof [in Vulgate: *occasum*].' It is interesting that this phrase from the rising of the sun to its setting can be interpreted either to denote a duration of time or an extent of space.
29. Ezekiel 8:16: 'And he brought me into the inner court of the Lord's house, and, behold, at the door of the temple of the Lord, between the porch and the altar, were about five and twenty men, with their backs toward the temple of the lord, and their faces toward the east; and they worshipped the sun toward the east.'
30. Luke 13:29: 'And they shall come from the east and from the west, and from the north, and from the south, and shall sit down in the kingdom of God.'
31. Matthew 2:9: 'When they had heard the king, they departed; and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was.'
32. Matthew 24:27: 'For as lightning cometh out of the east, and shineth even unto the west; so shall also the coming of the Son of man be.'
33. Fludd may well have drawn the curious design of this demonstration from his knowledge of fireworks. Fludd spent time in Italy, and he would certainly have encountered Vannoccio Biringuccio's *Pirotecnica* (1540). In Book X Chapter X, Vannoccio describes the 'Method of Preparing Fireworks called *Girandoles*, Which Were Once Customarily Used in Some Tuscan Cities'. These devices (Fig. f) spin by the action of the fireworks at their peripheries. Firework wheels less grand than these would likely have been seen in Italian cities on feast days during the period of Fludd's voyage.
34. *Hermès Trismégiste*, (Ménard, trans.), Book I, sermon iii: 'Et l'air enveloppa le cercle extérieur, porté dans son cours circulaire par l'esprit divin.'
35. I discuss this passage as a statement of Fludd's general method in the introduction. Note that this three-pillared structure underlies the argument of every chapter. For example, in Book V, Chapter XIV, concerning 'why the heavens are moved in circles': 1) philosophical arguments based on Aristotelian concepts of cause and effect; 2) biblical citations, a reference to Augustine and a quote from Hermes; 3) practical demonstration based on pyrotechnics.
36. Joscelyn Godwin translates part of this passage as a caption to one of the plates reproduced in *Robert Fludd: Hermetic Philosopher and Surveyor of Two Worlds* (Boulder, CO: Shambala, 1979). His translation reads: 'Besides, it would be remarkable if the Earth alone were to move steadily upon its axis, while all the other planets varied in latitude.' A question must be raised here as to whether Fludd is specifically addressing his argument to Copernicus' terrestrial *revolution* or Gilbert's terrestrial *rotation*. I am inclined to think that Godwin does not do justice to the phrase *constanter sub iisdem poli elevationibus cursum suum naturalem quolibet die naturali perficere*. I am not convinced that this 'constant elevation of the poles' necessarily means 'steadily upon its axis,' for an object can revolve around a central point and have either a variable or constant polar elevation. Furthermore, while Godwin's interpretation points Fludd's criticism at



Fig. f

Gilbert, it is difficult to see how we are to understand the second half of the phrase: 'while all the other planets varied in latitude.' A discussion of the latitude of other planets would seem to have no place if all that Fludd is arguing is that it would be odd if the earth rotated while all other heavenly bodies revolved.

Perhaps this confusion can be resolved by interpreting the passage as refutation of Copernican revolutions. The argument could then be interpreted this way: it would be exceedingly unlikely for the earth to rotate around the sun, staying always in the same plane with respect to the fixed stars, while all the other planets orbiting the sun have measurable elevations and declensions with respect to the ecliptic. In this way, 'constant elevation of the poles' means that the earth is never 'elevated or depressed, but possesses always the same latitude' with respect to the sphere of the fixed stars. Understood in this way the discussion of the 'latitude' or variable elevation of the other planets becomes germane to the general argument.

37. The following citations are taken from Chapter II of Book VII of Tractate II of Volume I and they refer to this and the following experiment: "Regula I: Omnis rota volubilis axe suo, quanto est major, tanto facilius movetur, cum in superficie tangitur, aut agens & motum causans illi applicatur." (An illustration corresponding to that of Experiment I follows). "Regula IV: Quo altior est rota, & minoris axis, eo facilius movetur, si motus ei accidat in extremitate, hos est, si in illam agatur a superficie: Sed de rotis a centro moventibus contrarium est sentiendum." (An illustration of two toothed wheels—in a configuration corresponding to that of Experiment II—follows). See the brief discussion of these experiments in: R. Westman, *Hermeticism and the Scientific Revolution* (Berkeley: University of California, 1977) pp. 61–64.
38. I assume here that Fludd means *centesima pars* loosely; he would certainly have been familiar (as is even illustrated by experiment I in this section) with the principle of the lever at the core of this problem.
39. As I suggest in the introduction, this short passage is a remarkably concise statement of Fludd's experimental philosophy: experimental phenomena are subject to the same fundamental natural principles and parameters as natural celestial phenomena. Thus the logic of Fludd's experiments goes beyond analogy: his models are not simply depictions of the operations of the natural world, but are microcosms that illustrate the very same principles. To sharpen the distinction, compare Fludd's model-like experiments with similar experimental demonstrations by Descartes. Both *Le Monde* and *La Dioptrique* contain demonstrations which seem to be analogous to those of Fludd. In one the propagation of light is illustrated by means of a vat of grapes, and in another vision is likened to a blind man feeling his way with a stick. Both offer metaphorical ways of understanding the phenomena they represent. Descartes would not have claimed, however, that the same physical forces were at work in his model systems. They are, in fact, models, whereas the 'models' of Fludd serve as tools by which celestial forces can be scrutinized.
40. See n. 24 *supra*.

41. Unsubstantiated assertions like this were the characteristics of Fludd's work that contemporaries like Kepler found exasperating. Why no measurements were made from the experiment concerning the division of wine (Book II, Chapter XV), is difficult to explain, particularly in view of Fludd's apparent willingness to expose his dynamic models to empirical and even quantitative analysis (see introduction).
42. This *variationes* probably refers to Gilbert's four magnetic phenomena appended to the simple action of attraction: direction, declination, dip and rotation.
43. 2 Kings 20:9-11: 'And Isaiah said, This sign shalt thou have of the Lord, that the Lord will do the thing he hath spoken: shall the shadow go forward ten degrees or go back ten degrees? And Hezekiah answered, It is a light thing for the shadow to go down ten degrees: nay, but let the shadow return back ten degrees. And Isaiah the prophet cried unto the Lord: and he brought the shadow by ten degrees backward, by which it had gone down in the dial of Ahaz'
44. Fludd is here providing an explanation for the astrological powers of the heavens, which arise from the third form of motion outlined by Fludd, one which is unique to Fludd: the *motion of trepidation*. While the parts of *Utriusque* concerned with this motion are not among those translated here, the motion of trepidation refers to a vibration, that of music and the celestial harmonies. It arises out of the Aristotelian action and reaction and is used here to explain the powers of the stars over terrestrial bodies.
45. Read as 'all angelic powers,' which Fludd arranged hierarchically as follows (*Utriusque*, Volume II, p. 219): 1) Seraphim; 2) Cherubim; 3) Dominations; 4) Thrones; 5) Powers; 6) Principals; 7) Virtues; 8) Archangels; 9) Angels.
46. Are we to understand the 'backward motion' of the analogy to refer to the recoil of the cannon itself, or some 'backspin' on the cannonball? There is some ambiguity here.
47. As in the construction of the boiler in the form of a sphere (Book II, Chapter IV, first demonstration) Fludd here configures the experiment in such a way as to 'model' his argument: if the wheel (or the square) were to be rotated from west to east, the particle on it would still move the other way. Note that this is the only experiment of the fourteen to be included in this section that is not explicitly called an *experimentum* in the text.
48. *Hermès Trismégiste*, (Ménard, trans.), Book I, sermon ii: '*Hermès*: Tout ce qui est mu se meut non dans le mobile, mais dans le stable. Le moteur est stable, car il ne peut partager le mouvement du mobile. *Asclèpios*: Comment donc, ô Trismégiste, voyons-vous ici le mouvement des mobiles partagé par leur moteur? Car tu disais que les sphères errantes étaient mues par la sphère fixe. *Hermès*: Ce n'est pas là un mouvement partagé, ô Asclèpios, mais un contre-mouvement. Ces sphères ne se meuvent pas dans le même sens, mais en sens contraire. Cette opposition offre au mouvement une résistance fixe; car la réaction des mouvements est l'immobilité; les sphères errantes étant mues en sens contraire de la sphère fixe, leur mouvement inverse est produit par la résistance qu'elles s'opposent entre elle, et il n'en peut être autrement.'
49. Despite the different sources of propulsion (steam versus water), this experiment appears to be a modification to Hero's article #45, 'a jet of steam supporting a sphere' (Fig. g). Note that

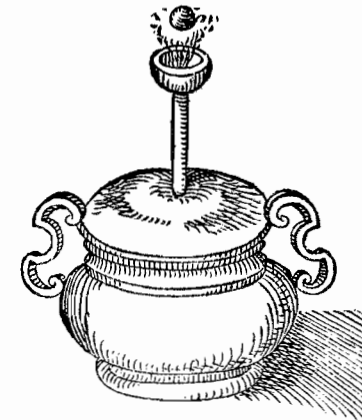


Fig. g

above Fludd has referred to the Empyrean heavens as a 'sea,' and here he uses water to demonstrate the character of its action. (Fig. g)

50. 1617 edition printed with 'p' missing; 1624 edition corrected.
51. 1617 edition omits the 'r' in *duratiōne*; 1624 edition omits the entire word, shifting *motus* from a genitive to a nominative.
52. In 1617 edition the 'j' is inverted, reading like an 's'; 1624 edition corrected.
53. *Fusum* is an anglicism. In classical Latin *fusus* is a second declension masculine substantive meaning 'spindle,' unrelated here. Moreover, one would be hard pressed to read *fusum* here as an accusative. Fludd intends *fusum* to be a second declension neuter noun meaning "fuse."
54. 1617 edition printed with a 't' in the place of the 'r' 1624 edition corrected.
55. 1617 edition printed with 'n' upside down; 1624 edition corrected.
56. 1617 text reads *disrumpatur*; 1624 text reads *disrumpitur*.
57. 1617 text omits 'a'; 1624 text corrected.