CHAPTER 1

The discarded image

In Book 8 of *Paradise Lost*, Raphael opens his response to Adam's questions about astronomy with these words:

> "To ask or search I blame thee not; for heav'n
> Is as the book of God before thee set,
> Wherein to read his wondrous works, and learn
> His seasons, hours, or days, or months, or years:
> This to attain, whether heav'n move or Earth,
> Imports not, if thou reckon right; the rest
> From man or angel the great Architect
> Did wisely to conceal, and not divulge
> His secrets to be scanned by them who ought
> Rather admire; or if they list to try
> Conjecture, he his fabric of the heav'ns
> Hath left to their disputes, perhaps to move
> His laughter at their quaint opinions wide
> Hereafter, when they come to model heav'n
> And calculate the stars, how they will wield
> The mighty frame, how build, unbuild, contrive
> To save appearances, how gird the sphere
> With centric and eccentric scribbled o'er,
> Cycle and epicycle, orb in orb."
>
> (8.66–84)

Raphael begins this speech with an important biblical and Christian commonplace that underpinned the serious study of the world for centuries (and in some quarters still does): that the world is a kind of book – not only a thing in itself but, in a manner analogous to speech or writing, a vehicle for communicating the power and divinity of its Creator. "The heavens declare the glory of God," exclaimed the Psalmist (Ps. 19:1); "the invisible things of [God] from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead," wrote St. Paul (Rom. 1:20); "the whole

world is a shadow, a way, a trace; a book with writing front and back," reechoed St. Bonaventure in the thirteenth century.[1] Milton himself, in the invocation to Book 3 of the epic, has already lamented his own loss of visual access to that book:

> . . . for the book of knowledge fair
> Presented with a universal blank
> Of Nature's works to me expunged and razed,
> And wisdom at one entrance quite shut out.
> (3.47–50)

This fundamental analogy justified astronomical study and, Milton would assume, transcended virtually all controversy as far as his poem's fit audience was concerned. For, as John Calvin wrote in his *Commentary on Genesis*, astronomy "is not onely pleasant to be knowen but also verie profitable. It cannot be denied but that the same Arte doth set forth the wonderfull wisedome of God" – even if, regrettably, "certeine phrentike persons . . . boldly reject whatsoever is to them unknowen."[2]

A second relatively noncontroversial claim Raphael makes in this part of his response concerns one of the main practical uses of astronomy – the formation and regulation of the calendar: "seasons, hours, or days, or months, or years." Reform of the calendar had been a pressing ecclesiastical theme in the sixteenth century because of the urgency of reestablishing a proper date for Easter. Pope Gregory XIII had established a calendar reform commission, which eventuated in the papal bull of 1582, *Inter Gravissimas*, and in the calendar known to this day as the Gregorian.[3] Moreover, although astronomers were essential contributors to calendar reform, Raphael is perfectly correct to state that the regulation of the calendar ("This to attain . . .") is unaffected by claims for or against Earth's movement. Raphael does *not* declare astronomy is general unimportant. Rather, it merely "imports not" when it comes to our "learn[ing] . . . seasons, hours, or days, or months, or years." What is critical in this regard is "reckon[ing] right." For fathoming the practical, calendrical dimensions of time is more a task for mathematics than for physics or cosmology.

[1] *Collationes in Hexameron* 12.14; in *The Works of Bonaventure*, trans. José de Vinck (Paterson, NJ: St. Anthony Guild Press, 1970). For more on the "two books" theme, see the excellent contribution by Kenneth Howell, *God's Two Books: Copernican Cosmology and Biblical Interpretation in Early Modern Science* (South Bend, IN: University of Notre Dame Press, 2002).

[2] John Calvin, *A Commentarie of John Calvine, Upon the First Booke of Moses Called Genesis*, trans. Thomas Tymme (London, 1578), sig. C.iii.[r].

[3] See, among numerous other accounts, James M. Lattis, *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolemaic Cosmology* (Chicago: University of Chicago Press, 1994), pp. 20–1.

Raphael's next point, about the great Architect's policy of concealment, presents a greater challenge to interpretation. Perhaps Milton (via Raphael) is merely echoing (and Christianizing) the Presocratic philosopher Heraclitus: "Nature loves to hide" (φύσις κρύπτεσθαι φιλεῖ). As for the reference to God as "Architect," Copernicus had similarly spoken of the Creator of the Universe as *Opifex* (maker, framer, artist, or artisan). Behind these lines may lurk the double meaning of "mystery" familiar to students of the late medieval mystery cycles, in which artisans, protectors of trade secrets, nonetheless play a role in bringing to light the secrets of divine revelation. In any case, the Architect's policy of concealment is nondiscriminatory: The workings of the Universe are divulged to neither humans nor angels. What follows in this speech as well as in subsequent ones, however, implies that the concealment is no permanent or complete ban on astronomical understanding. Instead, Raphael's language indicates the need for effort and reverence in the process of acquiring knowledge. God does not "divulge" his secrets – etymologically "make them public" (literally, "vulgarize" them) – to be "scanned by them who ought / Rather admire." The latter word reemphasizes the normative wonder evoked earlier (line 68), while "scanned" carries a strong sense, contrary to the piety one ought to exercise in beholding the heavens, of standing in criticism or judgment of a particular work of art (OED, 2.a.&b.). The now-familiar meaning of "scan" as involving mere visual, neutral, and possibly hurried examination does not appear in the English language until more than a century after Milton. Thus, Raphael is emphatically *not* saying "Don't look," and Milton is not merely engaging in the "scientific obscurantism" that Grant McColley identifies as the last refuge of literalists who (he thinks) oppose enlightened enquirers' reading "the open book of the world."[4]

Indeed, the "or" of line 75 implies a large measure of permission: "or if they list to try / Conjecture, he his fabric of the heav'ns / Hath left to their disputes, perhaps to move / His laughter." Given Raphael's opening metaphor of "the book of God," one naturally expects readers to attempt conjecture or interpretation. Such hermeneutical activity is practicable and permissible within the prescribed bounds of reverence. And although within this text it is hard to tell whether God's imagined laughter is derisive or merely amused, what is clear is that the practice of cosmological interpretation will result in disputes, will prove controversial, and will include

[4] Grant McColley, "The Ross-Wilkins Controversy," *Annals of Science* 8.2 (April 15, 1938): 153–89 (p. 187).

the danger of creaturely pride – in particular, forgetfulness regarding who actually made and governs the "fabric" or edifice of the world.

Scientifically, the key (and still useful) term in these lines is "model," which Milton concisely employs as a verb. What astronomers do is to make models of the heavens in order to "save appearances." More will be said about the latter phrase farther on in this chapter and elsewhere. But it is perhaps wise here to belabor the point that as long as one is consciously making a model, one is aware that one's proposals are subservient to a larger reality.[5] If one forgets that subservience, however, then impiety or scientific category mistakes can arise. For example, in 1541, Reformer Philipp Melanchthon complained in a letter about various "absurdities" plaguing churches and schools – a complaint he illustrated by reference to "that Polish astronomer who moves the Earth and immobilizes the Sun."[6] Having heard only distant reports of the new cosmology of Copernicus, whose work had not yet been published, Melanchthon suspected the new teaching of a *lack* of the kind of subservience to reality just referred to, hence the word *absurdity* and his clearly ironic description about the astronomer moving Earth. Such irony, however – along with an awareness of the distinction between models and reality – is often in rather short supply, even today. Journalistic and Internet summaries of science history still repeatedly talk about how Copernicus "removed Earth" from the center of the Universe. Actually, he did not: It was never there in the first place. What he did, quite piously and consciously, was to propose an alternative model that he considered superior to – more faithful to reality than – the one taught by his predecessors and contemporaries.

Thus, to return to Raphael's words, astronomers should piously recognize that what they "wield" (or "govern," OED, 1.a.) is their models rather than the "mighty frame" itself. That right balance will require them to acknowledge who truly holds the pen when it comes to authoring the "book of God." But again, as with "scan[ning]" earlier in the excerpt, the temptation will be to play the role of the self-important literary critic and to "scribble" over the substance of that text. Apparently, Milton and Raphael – and, as we shall see, Copernicus and others – found many of the scribblings of astronomers themselves to be inelegant and potentially risible.

[5] A helpful introduction to models can be found in Ian G. Barbour, *Myths, Models, and Paradigms: A Comparative Study in Science and Religion* (New York: Harper & Row, 1974); see for example p. 69.

[6] Melanchthon to Mithobius, 16 Oct. 1541; in *Corpus Reformatorum, Philippi Melanchthonis Opera*, eds. C. G. Bretschneider and H. E. Bindsell, 28 vols. (Halle: Schwetschke, 1834–60), vol. 4, col. 679, letter #2391: *ille Sarmaticus Astronomus, qui movet terram et figit Solem*.

The technical astronomical terms that Raphael mentions in his first response to Adam – "centric and eccentric . . . Cycle and epicycle" – apply mainly, although not exclusively, to what is sometimes collectively called *Aristotelian/Ptolemaic astronomy*. In Whiggish narratives of science history, this set of beliefs and explanations is often passed over dismissively. For any student of the history of thought, however, that system and its cultural, philosophical, and religious fabric are fascinating and essential for an understanding of Renaissance and early modern literature. Perhaps the most sympathetic account is that offered by C. S. Lewis's study *The Discarded Image*, a title I here borrow as a convenient name for the broadly Aristotelian/Ptolemaic model. As with any disused artifact seen only (if at all) in a book or a museum, its power and usefulness may initially be hard for present-day observers to grasp. But the magnitude of the scientific achievement of Copernicus and his heirs in the sixteenth and seventeenth centuries is most fully appreciated by those who glimpse the greatness as well as the flaws of the cosmology that was eventually and by circuitous paths superseded. For that "image" was a thing of considerable beauty and aspects of it had been delighting human beings for almost 2,000 years.

Although the phrase "Aristotelian/Ptolemaic" suggests an equal yoking of Aristotle (384–322 BC) with Ptolemy (ca. 90–168 AD), it is best to emphasize (with some oversimplification) that the former was a physicist and philosopher and the latter an astronomer and mathematician. In fact, in the sixteenth century and earlier, "mathematician" and "astronomer" were virtually interchangeable terms, while physicists studied a quite distinct subject matter.

Most of us have much more practical experience with physics than with astronomy. Although we notice when it is winter and when it is summer, when the Sun rises and sets, and perhaps whether the Moon is waxing or waning, we generally leave the actual details and meaning of those things to specialists – professional astronomers, calendar-makers, meteorologists. In contrast, everyone is continuously at work doing physics: estimating the weight of objects, determining which ones we had better not drop on our toes, judging the speed of vehicles so as to avoid getting knocked down in the street, measuring the temperature of the air outside our doors or of the heating elements under our frying pans. Most sports that people watch or play are complex, skillful explorations of practical physics, although almost none are connected in any direct way to astronomy. In short, there are very few real astronomers. But in myriad practical ways, everyone is a physicist.

Such elementary observations offer some insight into why Aristotle, the first thinker to formulate a systematic physics, was so influential for so long. From his teacher Plato, Aristotle learned an abiding respect for order, for precision of ideas, and for mathematical truths – especially those of geometry – even if these could never be fully embodied in this world in physical "reality." Plato had tried, by means of the exercise of philosophical reason, to see beyond this imperfect physical world: to discern Justice with a capital "J" and to comprehend the perfections of geometry that Euclid would later systematize. For Plato, it was these unchanging and incorruptible "forms" and mathematical verities that properly constituted reality. This is why quotation marks appear in the phrase physical "reality" – because real reality, for Plato, is not physical at all.

Aristotle by no means rejected all his master's teachings, but he is striking for his this-worldly, hard-nosed, commonsense application of the love of order, perfection, and unity he inherited from Plato. The poet Goethe said that whereas Plato is like a pointed flame striving heavenward, Aristotle assembles materials from far and wide and step by step upon an earthly foundation erects his edifice, also rising heavenward, but like a pyramid.[7] This picture conveys Plato's hard-to-systematize upward striving as well as its contrast with Aristotle's clear, well-proportioned solidity firmly rooted to this Earth.

What kind of world did Aristotle "construct"? One commentator has called it a "two storey" Universe.[8] Before the time of Plato and Aristotle, there were opposite tendencies in Greek thought, typified by Heraclitus and Parmenides.[9] Parmenides declared that all things are one and unchanging and that change itself is merely illusory. Heraclitus, by contrast, asserted that "everything flows and nothing abides; everything gives way and nothing stays fixed."[10] Strife is the very nature of reality. However, Aristotle established a peaceful coexistence between these two contrary philosophical temperaments by assigning them "separate territories" in his

[7] Paraphrase of Johann Wolfgang Goethe, *Geschichte der Farbenlehre*, in *Goethes Werke*, vol. 14 (Hamburg: Christian Wegner Verlag, 1960), p. 54: "[Aristoteles] umzieht einen ungeheuren Grundkreis für sein Gebäude, schafft Materialien von allen Seiten her, ordnet sie, schichtet sie auf und steigt so in regelmäßiger Form pyramidenartig in die Höhe, wenn Plato, einem Obelisken, ja einer spitzen Flamme gleich, den Himmel sucht."

[8] Arthur Koestler, *The Sleepwalkers: A History of Man's Changing View of the Universe* (1959; Harmondsworth, UK: Penguin, 1982), pp. 61–5.

[9] For more on the history of the contrary Heraclitean and Parmenidean tendencies, see Hélène Tuzet, "Cosmic Images," *Dictionary of the History of Ideas*, ed. Philip P. Wiener (New York: Scribner's, 1968), 1:513–23.

[10] *The Presocratics*, ed. Philip Wheelwright (New York: Odyssey Press, 1966), p. 70. The next quotation is from p. 71.

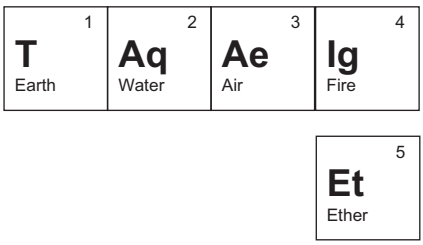

Figure 1.1 Aristotelian Periodic Table of the Elements

two-storey Universe. The upper storey – the world beyond the Moon – is where no change takes place. There, the spheres of the stars move in perfect regularity and harmony and nothing comes into being or passes away. But below the Moon, within the "sublunary" sphere, is the domain of time and mutability. Here, everything changes and, as Heraclitus said, "you cannot step twice into the same river."

For Aristotle, these two domains are made of qualitatively different kinds of stuff. He accepted the teaching of Empedocles that there are four "elements": earth, water, air, and fire (from heaviest to lightest). But, Aristotle added, beyond the Moon, everything is ethereal – literally made of ether, also known as the fifth element ("quintessence"). This system is illustrated by the rather lighthearted "periodic table of the elements" that appears in Figure 1.1.

The primitive appearance of this "periodic table" should not, however, hide the practical, commonsense basis of Aristotle's system. By "earth," Aristotle referred not merely to soil but more generally to that which is solid, including, of course, virtually everything other than water that constitutes Earth. Based on observation, one knows that whatever is made of earth – a rock, for example – will when released from one's hand drop straight down through the air and through any water it meets until it rests upon Earth's solid surface. Water will also fall down through the air but will stop at or in some body of water, such as a sea or a lake, that rests in turn upon solid earth. In the same way, air that is trapped beneath the surface of a lake will bubble up when released and rejoin the air that rests upon the surface of the water. Similarly, fire, as everyone can observe, strives upward through the air just as air rises through water.

Aristotle's theory of the four elements thus harmonizes with what he calls "natural place." In modern physics, to express it in rough Newtonian

terms, stones or raindrops fall toward Earth because Earth, as a massive body, gravitationally attracts other things that have mass – including stones, raindrops, and also air. However, air is less dense than water – it has less mass per unit of volume – just as water is in turn less dense than rocks. This is why water displaces air and rocks displace air and water. But for Aristotle, it is *place*, not body or mass, that exerts the attractive influence. When a rock falls, it is seeking or being drawn to its proper place. Likewise, when a bubble rises, it is not so much that the water is *dis*placing the air as that the air is seeking what was its natural place to start with. Such are Aristotle's influential ideas about what he calls "the potency of place."[11]

That concept of place is intimately related to Aristotle's concept of motion. *Natural* motion, he asserts, is of two different kinds, in accordance with which "storey" of the Universe it occurs in. In the upper storey – in the heavens – what is natural is uniform circular motion about a center. But down here, where humans live, in the lower storey, natural motion is straight-line motion toward or away from the center. In the earlier examples of the stone and the bubbles, the stone naturally falls straight downward toward the center of the Universe (where Earth's center, on account of Earth's heaviness, also happens to be). And the bubble rises heavenward, following a vertical, rectilinear trajectory away from the center of the Universe.

As one observes daily, however, not all objects follow this straight-down or straight-up trajectory. Tennis balls, for example, do not spend most of their travel time going straight up or straight down, for there is also such a thing as unnatural or "violent" motion. When a player tosses a ball straight up in the air, that is violent motion. But nature gradually takes over and reverses the ball's course so it falls back to Earth. Even when a player hits the ball over the net with a rising stroke, one can see how nature starts to take over – to mitigate the violence done to the tennis ball – and to pull its trajectory toward one that is vertical and centripetal.

Finally, the distinction between natural and violent motion is one that applies only in the lower storey of the Universe. In the heavens, not only is all motion circular, but all motion is natural. One might object that meteors and comets do not appear to display circular motion about a center. This, however, is one of the reasons why Aristotle and most other astronomers for almost 2,000 years presumed that meteors and comets pursued their courses within the sublunary sphere – high up, to be sure, but still within the lower storey of the Universe.

[11] Aristotle, *Physics*, in *The Works of Aristotle*, ed. W. D. Ross (Oxford: Clarendon Press, 1930), vol. 2, 208b–209a.

As one moves from the lower storey of the Universe to the upper storey, one moves from physics to astronomy and also to what Aristotle dubbed *metaphysics* – "that which is beyond physics." It is worth repeating that the upper storey of the Universe, according to this model, is, properly speaking, not physical but ethereal – made of different stuff and characterized by different laws of motion. This motion, as already observed, is for Aristotle uniform and circular. In fact, the assumption concerning the incorruptibility of the heavens and the uniform circularity of the spheres persisted, astonishingly, even beyond the time of Copernicus, who did not challenge it. In Chapters 3 to 5 and elsewhere, we shall see how Milton engaged controversies concerning this powerful and persistent binary: perfection up there; imperfection down here.

In its most schematic form, Aristotle's astronomy is nicely illustrated by a picture (Figure 1.2) published in 1539 and again many times through the sixteenth century in Peter Apian's *Cosmographia*. The picture is, of course, a Christianized view of Aristotle's Universe, although much Islamic and Jewish thought of the Middle Ages was also deeply Aristotelian.

Examining the picture from inside out, one sees the four sublunary domains corresponding to the four elements – earth and water together in the inmost sphere, with air and then fire above them – followed by the first planetary sphere: that of the Moon. Then come the rest of the planetary spheres: of Mercury, Venus, the Sun, Mars, Jupiter (or Jove), and Saturn. Other items today included in the category of planets – Uranus, Neptune, and (some people still think) Pluto, none of which had yet been discovered – are no part of Aristotle's Universe, whereas for him and his followers, the Moon and the Sun are indeed two of the seven planets.

One observes, furthermore, that the planets are pictured *between* the circles inscribed in this graphic. This might be surprising, for the modern concept of an orbit – depicted as a circle (or ellipse) marking a planet's trajectory – tends to be read anachronistically back into such schematic models. Modern depictions naturally show planets *on* the lines rather than between them. However, this is not how Aristotle or the Middle Ages understood planetary locomotion. Each planet was thought to be carried by an ethereal sphere. The thickness of the shell of each sphere, as in this picture, is at least as great as the planet's diameter. Moreover, also perhaps surprisingly, there is absolutely no space between the spheres, for that would imply a vacuum, which Nature abhors. The "orbs" are all tightly nested one within the other, like the firm, perfectly spherical, and translucent layers of a cosmic onion. Of course, they all turn at different speeds, but the "friction" thus created produces not dissonance but

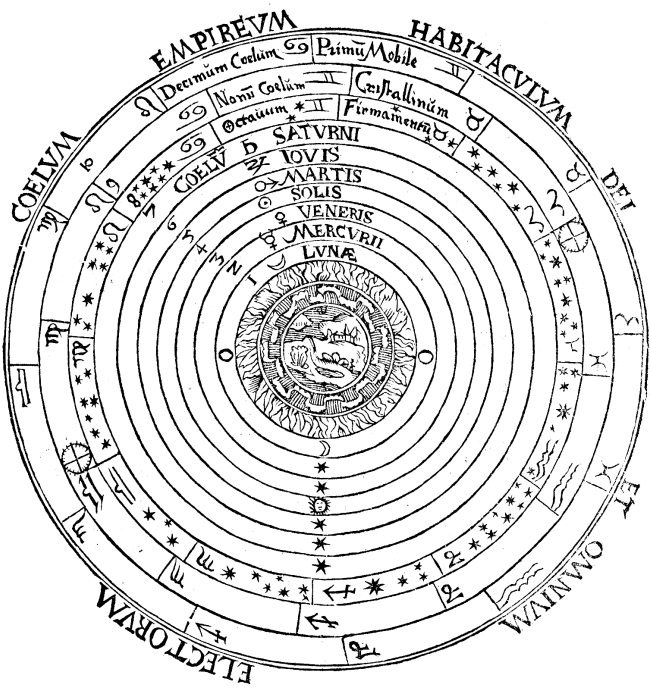

Figure 1.2 Aristotle's universe as illustrated in Apian's *Cosmographia* (1539)

(some thought) music: the harmony of the spheres – although this idea originated not with Aristotle but with the Pythagoreans.

Beyond the final planetary sphere (of Saturn) comes that which is labeled *Firmamentum* – the term for the heavens that appears in the Vulgate version of the biblical creation account of Genesis 1 – and more commonly known as the sphere of the fixed stars. The next or ninth sphere is apparently empty but not in the sense of forming a vacuum; rather, it is also crystalline (*Cristallinum*) – here marked out with the signs of the Zodiac. Finally, at the extremity of the world is the *Primum Mobile*, the prime mover, the sphere that encompasses and governs the movement of all the other spheres. Thus far, the Universe. But, of course, literally above and beyond it, in this Christianized version – indicated although not depicted – is the "empyreal" Heaven, the dwelling place of God and all the elect (saints and angels): *coelum empireum, habitaculum dei et ominium electorum*.