
SARA ELIZABETH BOOTH and ALBERT VAN HELDEN

The Virgin and the Telescope: The Moons of Cigoli and Galileo

The Argument

In 1612, Lodovico Cigoli completed a fresco in the Pauline chapel of the Basilica of Santa Maria Maggiore in Rome depicting Apocalypse 12: “A woman clothed with the sun, and the moon under her feet.” He showed the crescent Moon with spots, as his friend Galileo had observed with the newly invented telescope. Considerations of the orthodox view of the perfect Moon as held by philosophers have led historians to ask why this clearly imperfect Moon in a religious painting raised no eyebrows. We argue that when considered in the context of biblical interpretation and the rhetoric of the Counter-Reformation, the imperfect Moon under the woman’s feet was entirely consistent with traditional interpretations of Apocalypse 12.

In 1610, after competing with several artists, Lodovico Cardi da Cigoli (1559–1613) received the commission to paint the dome of the new Pauline Chapel of the Basilica of Santa Maria Maggiore in Rome. This basilica was no ordinary structure. It was the most important shrine in Marian worship in Western Christianity, founded in the fourth century when, according to “The Miracle of the Snow,” the Virgin appeared one summer night in a vision to Pope Liberius (352–366) and a wealthy patrician and told them to build a church on the spot on the Esquiline Hill where they would find snow. The following morning they did indeed find a spot on the hill outlined in snow, and as the Virgin of their vision had instructed they erected a basilica on this spot.

Richly endowed and adorned by popes over the centuries, the basilica housed many relics, the most important of which were the *Presepio*, or the Manger of Christ, the body of St. Jerome, and the Icon of the Virgin and Child painted by St. Luke (Ostrow 1996a, 1–3, 25, 120–32). During Galileo’s lifetime, two large chapels were added to the basilica: the Sistine Chapel (1585–1590) built by Pope Sixtus V to house the *Presepio* and the body of St. Jerome, as well as his own tomb and that of his predecessor, Pius V; and the Pauline Chapel (1605–1610) built by Pope Paul V to house the icon of the Virgin and Child, and his own tomb and that of his predecessor, Clement VIII.

Ostrow has analyzed Cigoli’s lunar representation in the Pauline Chapel of

Santa Maria Maggiore in Rome in the context of Counter-Reformation rhetoric, and he, Marina Warner, and Eileen Reeves have documented and extensively discussed lunar symbolism in the various representations of the Virgin Mary: as the Woman of the Apocalypse, in depictions of the Assumption, the Immaculate Conception, and the Queen of Heaven (Warner 1976; Ostrow 1996a, 210–240; 1996b; Reeves 1997, 138–72). Although Cigoli's depiction of the Virgin in the dome of the Pauline Chapel has frequently been referred to as the *Immaculata* (Ostrow, 1996a, 236–40; 1996b; Reeves 1997, 138–48) and, less frequently, the *Assumption* (Edgerton 1990, 253), it is important to note that his charge was as follows:

In the cupola is to be painted the Vision of the Apocalypse, chapter 12, that is, a Woman clothed with the Sun, and the Moon under her feet, and around her head a crown of twelve stars, opposite St. Michael the Archangel in the figure of a combatant, and [also] facing the three hierarchies, each divided into three orders. Below her is to emerge a *serpent with its head crushed as in chapter 3 of Genesis*, around [her] the twelve Apostles. (Matteoli 1980, 246; emphasis added)

Cigoli painted the Woman of the Apocalypse (fig. 1) as she was described in the instructions drawn up by the Oratorian Fathers, Tommaso and Francesco Bozio (Ostrow 1996a, 186–90), but with an interesting twist that has piqued the interest of historians of art and science alike: “the Moon under her feet” bears a remarkable likeness to one of the copper-plate engravings in Galileo's *Sidereus Nuncius* (fig. 2), and, as such, as Ostrow so aptly notes, it has been viewed as something of an “iconographic curiosity” (Ostrow 1996b, 223). It is an “astronomical moon” (hereafter referred to as a Galilean moon), clearly maculate, as opposed to a “religio-artistic moon,” a perfectly smooth body without a spot. In the context of the rhetoric of the Counter-Reformation, Cigoli's painting of the Galilean moon beneath the feet of an obviously Marian figure would seem to be a serious infraction against the highly prescriptive artistic programs of the Church in which the Virgin was inevitably depicted as standing on an immaculate moon. The question we hope to resolve here is how the Moon under the Woman's feet in Cigoli's fresco functions symbolically. A related question we will also explore is why this apparent alliance between religious art and science occurred. We hope to demonstrate that the Galilean moon is not as unorthodox as it may seem, but rather a fitting part of the iconographic assemblage comprising the fresco. In short, we will argue Cigoli painted the Woman of the Apocalypse, not the *Immaculate Conception* or the *Assumption*.

Central to any discussion of Cigoli's painting is, of course, the close relationship between Galileo and Cigoli. But an exploration of other topics will also be necessary in order to arrive at a satisfactory answer to the questions posed by Cigoli's Moon: the role of *disegno* in observations and depictions of the Moon; the Moon in natural philosophy and as a subject of telescopic inquiry; its role as sign in



Fig. 1. Lodovico Cigoli, *The Woman of the Apocalypse*, 1612. Rome, Santa Maria Maggiore. Courtesy of Foto Vasari.

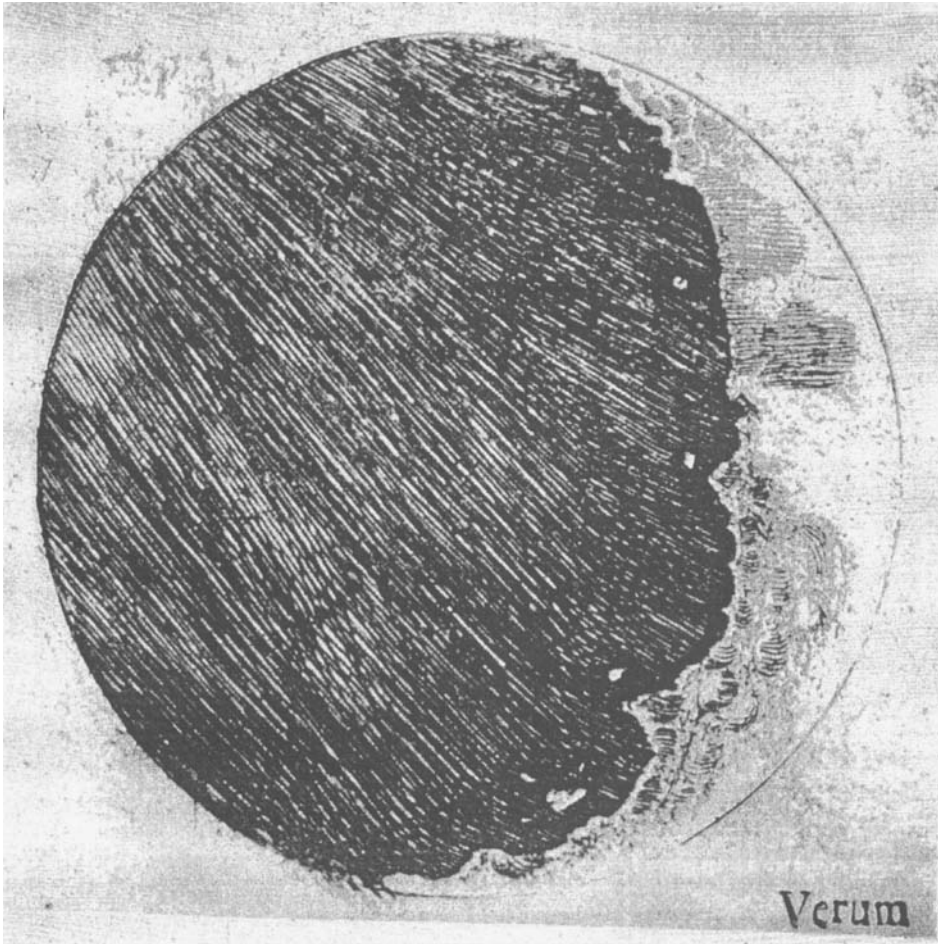


Fig. 2. Galileo Galilei, four-day old Moon. In *Sidereus Nuncius*, 1610. Courtesy of Wellesley College.

the Christian hermeneutic, or allegorical, tradition that allied Marian and lunar representations in art; and the role played by the Marian figure and the Moon in the political and artistic context in which Cigoli carried out his commission.

The Art of *Disegno* and Galileo's Moon

In his *Sidereus Nuncius* (1610), Galileo made a strong claim that, instead of being a perfectly smooth sphere, the Moon had a rough surface much like the Earth's. Although the argument was carried in the text, the four copper-plate engravings, based on Galileo's telescopic observations, provided important support for his

argument. Over the past several decades, historians have proposed various theories to account for the nature of Galileo's lunar representations.

Terrie Bloom and Samuel Edgerton theorize that Galileo's training in *disegno*, which included drawing, composition, perspective, and chiaroscuro, enabled him to correctly interpret what he observed on the Moon through the telescope as relief on the lunar surface and accurately represent his observations. According to Bloom and Edgerton, the English scientist Thomas Harriot, who actually preceded Galileo in observing the Moon through a telescope, initially *could not* see this relief because Renaissance artistic conventions of perspective and chiaroscuro had not yet become common in England. However, after Harriot read Galileo's *Sidereus Nuncius* and observed the copper engravings, he could see relief and thus represent it in his own depictions of the Moon (Bloom 1978; Edgerton 1984; 1990, 235–37, 250–51). Scott Montgomery has argued that the representational conventions used by sixteenth-century map-makers, such as scalloped coastlines or shaded mountains, with which Galileo must have been familiar, helped him to *see* relief on the Moon (Montgomery 1996, 224–29),¹ whereas Mary Winkler and Albert Van Helden have argued that beginning with Galileo and Harriot, astronomers slowly developed a visual language of their own, culminating in Johannes Hevelius' *Selenographia* of 1647 (Winkler and Van Helden 1992, 1994).

However, Eileen Reeves's important book *Painting the Heavens: Art and Science in the Age of Galileo* (1997) puts Galileo's relationship with, and influence on, artists from Cigoli to Velasquez in a much wider context. She argues that, several years before the telescope Galileo, already a Copernican, looked at the Moon with the eye of an artist and realized that the "ashen" light of the Moon, i.e., the muted light seen before and after conjunction on the dark part of the Moon, was analogous to the muted light observed on objects illuminated by indirect light, the representation of which was a technique that all young artists had to learn. This realization enormously strengthened Galileo's belief in the Copernican theory in which the Earth was a planet, just like the reflecting Moon (Reeves 1997, 23–56, 91–137).

The Moon in Natural Philosophy

Although in Aristotelian natural philosophy the heavens are perfect and immutable and therefore the Moon is a perfectly spherical body, no one could argue that to the naked eye the Moon *looks like* a perfect body. It has spots. The nature of the Moon, then, had been the subject of speculation since Greek Antiquity. Among the pre-Socratic philosophers, Anaxagoras thought all heavenly bodies were fiery

¹ Amir Alexander, on the other hand, argues that Harriot's many lunar drawings reveal that his representations were conditioned by his practice of coastal mapping, which he had begun in the New World in the retinue of Sir Walter Raleigh (Alexander 1998).

stones. Diogenes of Apollonia thought that the planets, fixed stars, Sun and Moon consisted of red-hot pumice stone through the pores of which came rays of aether. Democritus thought that originally the Sun and Moon were not fiery, being made of the same kind of atoms as the Earth, but that later, in the process that led to the enlarging of the Sun's circle, fire came to predominate in them. He believed that both the Sun and Moon were made up of round atoms. Both Anaxagoras and Democritus believed that the Moon had mountains, valleys, and plains, much like the Earth (Dicks 1970, 59, 78, 82). It is also reported the Pythagorean philosopher Philolaus of Croton (ca. 410 BC) thought the Moon was like the Earth but had animals fifteen times larger than those of Earth because its day was fifteen times longer (Dicks 1970, 74).

However, Aristotle brushed aside the speculations of the pre-Socratics and insisted on a rigid distinction in kind between the heavens and the earthly realm. Up above, phenomena repeated themselves with perfect regularity; here below things changed: The heavens were perfect and immutable, whereas the region below the Moon was the seat of change and corruption. He argued this perfection in two ways, however: in Book I of *De Caelo* he related a heavenly body's degree of perfection to its distance from the Earth, whereas in Book II he related the degree of a body's perfection to simplicity of motion by which the sphere of the fixed stars, whose diurnal rotation was the simplest of all heavenly bodies, was most perfect (Aristotle 1930, 268.a–281.a; Grant 1985). In neither context did he discuss the Moon and its spots of which he was of course aware, because he stated that the Moon always keeps the same face turned toward the Earth (Aristotle 1930, 290.a.26). Finally, the Stoics thought that, although heavenly bodies were made up of very pure fiber or aether that pervades the entire upper region of space, the Moon was a mixture of air and gentle fire; and therefore not earthlike (Plutarch 1918, 922.d–923.e, 264–266).

Most of what we know about this subject comes from Plutarch's essay *On the Face that Appears on the Orb of the Moon*. Philosophers who believed the Moon was perfectly smooth and spherical, as befits a heavenly body, had put forward an ingenious argument to explain its spots: The Moon acts as a mirror, reflecting the ocean surrounding the earthly land mass. But Plutarch pointed out a reflection of the ocean would appear uniform without differences in shading, whereas the face of the Moon consists of lighter and darker areas (ibid., 920.f–921.d, 260–61). In addition, if the Moon were a perfect mirror of sunlight, then light would be reflected from her surface to us from one point only (ibid., 929.d–930.e, 278–80). We find this argument and its refutation again in Galileo's *Dialogue* of 1632, where Plutarch is not cited. Galileo's demonstration by means of mirrors calls to mind the eye of the artist (Galileo 1962, 69–80).

Plutarch also argued the Moon could not be composed of glass or crystal, for then the Sun's light would pass through it and solar eclipses would not be possible. On the contrary, the manner in which the Sun's light is, in fact, reflected from the lunar surface shows that its surface is like the Earth's:

Let us not then think that we offend in holding that [the Moon] is an earth, and that this her visible face, just like our earth with its great gulfs, is folded back into great depths and clefts containing water or murky air, which the light of the sun fails to penetrate or touch, but is obscured, and sends back its reflection here in shattered fragments. (Plutarch 1918, 935.c, 289)

Thus, both the Stoic notion that the Moon is a mixture of air and gentle fire, and the Aristotelian notion that it is made up of aether or the fifth element, are wrong. Plutarch puts it as follows:

It comes to this . . . Look on her as earth, and she appears a very beautiful object, venerable and highly adorned; but as star, or light, or any divine or heavenly body, I fear she may be found wanting in shapeliness and grace, and do no credit to her beautiful name, if out of all the multitude in heaven she alone goes round begging light of others. (Ibid., 929.a, 276–77)

The problem for Aristotle's followers was to reconcile several propositions. First, the Moon must be a perfectly smooth and spherical body; second, the Moon shines with light borrowed from the Sun; and third, the Moon shows dark spots. Because a perfectly smooth body, like a spherical mirror, would reflect the Sun's light from only one small area, one might conclude the lunar surface must be rough, like a wall reflecting sunlight. But because its surface *could not* be rough, the conclusion had to be that the Moon, although she shines with light borrowed from the Sun, does not reflect it. Rather the parts illuminated by the Sun absorb the light and then become self-luminous. The spots could then be explained by positing differences in what we might call optical density, whereby some parts absorb the Sun's light better than others. The parts that absorb less sunlight would thus radiate less light and appear darker to the viewer (Ariew 1984). This ingenious explanation is first recorded in the works of Alhazen (965–c. 1040), from whom it passed to Averroës (1126–1198). The influence of Averroës' ideas about the spots in the Moon can be traced from the thirteenth to the seventeenth century (Ariew 1984, 220–23), and it would therefore be an error to assume that the issue of the Moon's light and its spots was first raised in reaction to Galileo's discoveries.

The various problems of the Moon's appearance must not be underestimated. A comprehensive theory of its nature had to explain the following phenomena: the "ancient spots" visible to the naked eye; the "ashen light" before and after conjunction; the total blackness of the Moon during solar eclipses; and the reddish and sometimes grayish light during lunar eclipses. Kepler treated these problems in his *Astronomiae Pars Optica* of 1604. The arguments against the earthlike nature of the Moon, and their refutations, were all contained in Plutarch's tract, which was well known around the turn of the seventeenth century, and, indeed, Kepler appended a Latin edition of *On the Face that Appears on the Orb of the Moon* to his *Somnium*, which appeared posthumously in 1630 (Kepler 1630). What was new in Kepler's discussion was his explanation of the "ashen" light of the Moon. If

this light was caused by the Moon's translucence, as Witelo had argued, or to the Moon's own light, as Erasmus Reinhold had argued, then how did one explain why the Moon appears totally dark during a solar eclipse? But in order to rule out translucence and proper light, Kepler had to explain both the "ashen light" and the reddish light during lunar eclipses. He attributed the former to reflection from the Earth and the latter to light refracted by the Earth's atmosphere into the Earth's shadow cone (Kepler 1604, 216–27, 234–47). Having disposed of these problems, Kepler could support Plutarch's argument that the Moon's surface was like the Earth's and had seas and continents, mountains and valleys.

Galileo's telescopic discoveries about the Moon (and to a lesser extent the phases of Venus) reopened the old scientific question of the nature of the Moon's surface. Galileo refuted the argument of Alhazen and Averroës by simply stating that his observations demonstrated the Moon's surface is not smooth but rough (Galileo 1989, 40–53) and that the light of the Sun is reflected from this rough surface as sunlight is from a brick wall; that is, if the Sun's light is reflected by the Moon, the lunar surface must be rough (Galileo 1962, 72–83). Of course, as Kepler's 1604 discussion shows, one hardly needed the telescope to make that argument. But for adherents to the Aristotelian cosmology who wished to preserve the perfection of the heavens, the arguments of Galileo (and Kepler) were not conclusive. All Galileo had shown was that the dark outlines of the new small spots revealed in the brighter part of the Moon changed over time as the angle of illumination from the Sun changed. If one accepted these observations, did it necessarily mean that the lunar surface is rough and uneven and that there are mountains on the Moon? Could not these new phenomena be explained by citing the old argument of "rarity and density?" (Ariew 1984, 223–25).

Galileo's own utterings in *Sidereus Nuncius* posed a question to the skeptical and suggested openings for attack. If there were mountains on the Moon, why then did its periphery appear perfectly circular? Galileo gave two reasons. First, the limb is seen tangentially across a number of mountain ranges so we see only the tops of the ridges, not the valleys; these tops merge with each other to form a periphery very close to exactly circular. Second, there was perhaps an atmosphere around the Moon, and when we observe the Moon's limb we are looking obliquely through this atmosphere, which tends to absorb light as our atmosphere does on Earth (Galileo 1989, 48–51). This last argument was subsequently dropped by Galileo when he could find no other evidence of a lunar atmosphere (Galileo 1962, 100).

Of all Galileo's initial discoveries, the earthlike nature of the Moon raised the most difficult questions. The letter of 24 March 1611 from the mathematicians of the Collegio Romano to Cardinal Bellarmine concerning Galileo's telescopic discoveries gives us some insight into how the problem of the Moon was regarded by Church mathematicians. Fathers Clavius, Grienberger, van Maelcote, and Lembo were asked for their opinions about these discoveries and replied in some detail. Regarding the Moon, they wrote:

The great inequality of the Moon cannot be denied. But it appears to Father Clavius more probable that the surface is not uneven, but rather that the lunar body has denser and rarer parts, as are the ordinary spots seen with the natural sight. Others think that the surface is indeed uneven, but thus far we are not certain enough about this to confirm it indubitably. (Galileo 1890–1909, XI: 93, idem 1989, 111)

The three younger mathematicians apparently agreed with Galileo; however, the aged Father Clavius (1537–1612), who had initially been skeptical of Galileo's discoveries, wished to preserve the traditional interpretation. Clavius had been the touchstone of astronomical orthodoxy in the Jesuit order for several generations, arguing against the homocentric spheres of Fracastoro, the Copernican theory, and the notion of a fluid heaven in which the planets moved "like birds in the air or fish in the sea" (in Lattis 1994, 94–102). Now Galileo's discoveries posed new problems. In the last edition of his enormously influential *Commentary on the Sphere of Sacrobosco*, Clavius added a brief passage about these new celestial discoveries in which he called Galileo's *Sidereus Nuncius* a "very reliable little book." About the Moon, Clavius wrote: "And when the moon is a crescent or half full, it appears so remarkably fractured and rough that I cannot marvel enough that there is such unevenness in the lunar body." And he ended the passage as follows: "Since things are thus, astronomers ought to consider how the celestial orbs may be arranged in order to save these appearances" (Clavius 1612, 3:75; in Lattis 1994, 198). Until the very end, Clavius was careful to speak as a "mathematician" only.

In the meantime, all the philosophers could do was rehearse variations of the old explanation of the Moon's spots. Father Clavius' explanation that the Moon had "denser and rarer parts" had been entirely qualitative, but Galileo's calculation of the heights of lunar mountains added a quantitative dimension to the problem. The traditional explanation now had to account for mountains four miles high, and moreover mountains covered by a transparent, perfectly spherical layer.

The alternative explanation of the naked-eye spots of the Moon — that the Moon's surface is rough like the Earth's — was revived by artists and scientists in the Renaissance. But it was Leonardo da Vinci who bridged the worlds of art and science. In the case of the Moon, he was familiar with, and rejected, the standard arguments of the philosophers to explain its spotted appearance. He argued instead that the Moon is not self-luminous; rather, it must act as a spherical mirror that reflects the Sun's light to the Earth. However, this mirror was not smooth; otherwise, sunlight would be reflected to us from only one point on its surface. Instead, the Moon's surface was made up of areas of land and seas, and the water of the seas was disturbed by waves:

The skin or surface of the water which comprises the sea of the moon . . . is always ruffled, little or much, more or less, and this roughness is the cause of the proliferation of the innumerable images of the sun which are reflected in

the ridges and concavities and sides and fronts of the innumerable waves. (In Kemp 1981, 324)²

Thus, because the Moon shines with borrowed light, its surface must be rough. Leonardo compared this rough lunar surface with that of the Earth, arguing that the Earth's surface, too, reflected the Sun's light. The "ashen light" of the Moon was therefore reflected light from the Earth, and the Earth was in this respect no different from the planets (in Kemp 1981, 324–5).

Leonardo's arguments can be found again in Kepler's *Optics* of 1604 (Kepler 1604, 202, 223–24) and Galileo's *Dialogue* of 1632 (Galileo 1962, 67–73). Reeves has pointed out that copies of Leonardo's notebook on painting circulated in northern Italy in the late sixteenth century and it is not unreasonable to suppose that Galileo may have been familiar with Leonardo's argument from another notebook (Reeves 1997, 29–31, 114–118). Reeves also argues that the explanation of the Moon's "ashen light" was rather obvious to anyone who was thoroughly familiar, as Galileo was, with artistic techniques used to depict reflected light. Some astronomers, such as Kepler and Maestlin,³ arrived at the explanation of the "ashen light" by *reasoning* from the Copernican assumption that the Earth was a planet and could therefore reflect light as the Moon did. Some artists, such as Leonardo (and perhaps Cigoli), started from their own *experience* in representing reflected light and on the basis of this experience concluded that the "ashen light" of the Moon was reflected "earth-shine," an indication that the Earth was like the planets. However, because of his training in both art and science, Galileo could make the argument starting from either side, and, as Reeves states, the artistic approach to the problem strengthened his Copernican convictions (Reeves 1997, 138–183).

Cigoli (1559–1613) and Galileo (1564–1642) had been friends since their youth, when they both took lessons in mathematics and perspective from Ostilio Ricci (Galileo 1890–1909, XIX: 604; Matteoli 1980, 21) and they remained in close contact throughout their lives. Unfortunately, most of the letters from Galileo to Cigoli are lost, but many of Cigoli's letters to Galileo have survived. It is clear from these that Cigoli was vitally interested in Galileo's science, and especially his astronomy. Reeves has argued that in his *Annunciation* of 1607, Cigoli showed the "ashen light" of the Moon at about the time Galileo arrived at his explanation (Reeves 1997, 91–137). But Cigoli was not a learned man in the traditional sense, although he wrote an excellent treatise on perspective, *Trattato di Prospettiva Prattica*, which has been published at last (Cigoli 1992). In October 1610, he wrote to Galileo that he had not yet seen *Sidereus Nuncius*, and that if he had seen it he

² Original text: British Library, MSS Arundel 263, 94v.

³ In his *Astronomia pars Optica*, Kepler quotes from a (now lost) *Disputation on Eclipses* published by Maestlin in 1596, in which Maestlin explains the "ashen" light of the Moon as reflected light from the Earth (Kepler 1604, 223–24).

would not have understood it because it was in Latin.⁴ He therefore urged Galileo to issue an Italian version (Galileo 1890–1909, X: 442). However, Cigoli did have a view of the relationships between “mathematics” and art. In the summer of 1611, he read a copy of the letter of the mathematicians of the Collegio Romano in which they stated their official judgment on Galileo’s lunar observations (see above) and he wrote to Galileo about Father Clavius’ thoughts about the Moon:

I was most astonished by the opinion of Father Clavius about the Moon: that he doubts its unevenness because it appears to him more probable that it is not of uniform density. Now, I have thought and thought about this, and I find nothing to say in his defense except that, be he as great as he wants, a mathematician without *disegno* is not only a mediocre mathematician, but also a man without eyes. (Ibid., XI: 168)

According to Cigoli, then, one had to know drawing, or *disegno*, to be a complete mathematician. In this judgment, Galileo surely would have agreed with him. *Disegno* went together with the study of geometry and perspective, as Galileo and Cigoli had experienced it under Ostilio Ricci. Only those who did not combine these skills could be foolish enough to try to explain away the evidence of their senses by postulating invisible substances.

Cigoli, then, was intimately familiar with Galileo’s argument concerning the lunar surface and the engravings of the Moon in *Sidereus Nuncius*. We may assume that before he eventually obtained his own telescope in 1612 (Galileo 1890–1909, XI: 287) he looked through the telescopes of others. And he incorporated Galileo’s lunar discoveries into his own work, when, in 1610, he was commissioned to decorate the cupola of the Pauline (or Borghese) Chapel in the Basilica of Santa Maria Maggiore in Rome.

The Moon and the Allegorical Tradition

As Winkler and Van Helden have pointed out, the paucity of realistic representations of the Moon⁵ before the telescope is somewhat of a puzzle (Winkler and Van Helden 1992). In the past several decades, a few pre-telescopic realistic lunar representations have been brought into the mainstream of scholarship in the history of science: In 1965, Sister Suzanne Kelly reprinted Gilbert’s *De Mundo nostro Sublunari* written around 1600 (but not printed until 1651) which contains a naked-eye lunar map (Kelly 1965, 2:172–3); in 1987, Gibson Reaves and Carlo Pedretti called attention to three Leonardo drawings, one of which is a particularly realistic representation of the half-Moon (Reaves and Pedretti 1987);⁶ and in 1994

⁴ In his biography of his uncle (1628), Giovanni Battista Cardi wrote that Cigoli had been introduced to the Latin language but showed no interest in it (Matteoli 1980, 19).

⁵ We are ignoring the various diagrams of the Moon in astronomical texts.

⁶ The drawings are in *Codex Atalanticus*, ff. 310r and 674v, and *Codex Leicester*, f. 2r.

Scott Montgomery added the striking (if small) renderings of the Moon by Jan van Eyck (Montgomery 1994; idem 1996, 202–6). Artists had, however, painted the Moon in various non-naturalistic guises for centuries before the telescope. The most important was in the context of depictions of the Virgin Mary, a relationship derived from the exegetical interpretations, or glosses, of the Old and New Testaments. The prescriptive programs of Christian art and architecture derive from this view of Christian oratory, whose primary function was to interpret and preach the holy word.

In the Christian allegorical tradition, the Old and New Testaments were regarded as a harmonious whole; hence, the figures and events of the Old Law (Old Testament: the letter or “figura”) prefigured those in the New Law (the New Testament: the spirit or “fulfillment”). In other words, the Old Testament was to be read not only as history (literally) but also as a series of signs, or predictions, of what was to be fulfilled in the New (allegorically) (Mâle 1972, 133–34).⁷ For example, Jerusalem is literally the city, the “figura,” in the Old Testament that prefigures the New Jerusalem, the “fulfillment,” in John’s vision of the Apocalypse in the New Testament. Augustine points out, however, that figurative signs are polysemic, that what they stand for can change according to the scriptural passages — the context — in which they occur. The variation of the figure can take two forms: it can be used in “a good sense, *in bono*,” or “in an evil sense, *in malo*.” Consequently the figurative sign “lion” is to be understood *in bono* in “the lion of the tribe of Judah . . . has prevailed” (*Apocalypse* 5.5), but *in malo*, as a sign of the Devil, in “your adversary the devil, as a roaring lion, goeth about seeking whom he may devour” (1 *Peter* 5.8; *On Christian Doctrine* III. XXV, 35–37). Thus, the Moon as sign of the Virgin’s purity would signify the Moon *in bono*, whereas the Moon as sign of sublunary corruption, for example, of the infidel, or of the heresy of the Reformation, is the Moon *in malo*. As will become apparent below, this distinction is crucial to an analysis of Cigoli’s Moon (see also Ostrow 1996b).

One traditional depiction of the Virgin and the Moon — The Woman of the Apocalypse — is based on various glosses of chapter 12 of the book of *Revelations*, or *Apocalypse*. The Woman of the Apocalypse, according to exegetes, is the “fulfillment” of the prophecy in the Old Testament, the “figura,” in *Genesis* 3. 15: “I will put *enmities* between thee and the woman [Eve], and thy seed and her seed: she shall crush thy head, and thou shalt lie in wait for her heel” (in Reeves 1997, 142; emphasis added). The first four verses of the Twelfth Chapter of the *Apocalypse* (taken here from the Douai Bible) are as follows:

1. And a great sign appeared in heaven: A woman clothed with the sun, and the moon under her feet, and on her head a crown of twelve stars:
2. And being with child, she cried travailling in birth, and was in pain to be delivered.

⁷ Umberto Eco notes Aquinas’s statement that the authors of the Old Testament were not aware they were writing prophecy as they labored under divine inspiration (Eco, 155).

3. And there was seen another sign in heaven: and behold a great red dragon, having seven heads, and ten horns: and on his heads seven diadems:
4. And his tail drew the third part of the stars of heaven, and cast them to the earth: and the dragon stood before the woman who was ready to be delivered; that, when she should be delivered, he might devour her son. (*Douai Bible*, 288)

This passage was glossed in a number of ways. Methodius of Philippi (third century CE) in *The Symposium of the Ten Virgins* interpreted the woman as the Mother Church. The Sun in which she was clothed was Christ and His light illuminated the Church and the Moon, whose reflected light symbolized the mediating power of the Church and through its continuing cycle of waxing and waning the cycle of life. In this interpretation the Moon is thus seen as a sign *in bono*. Other exegetes identified the Woman as the Virgin Mary who crushed beneath her feet the imperfect (maculate) Moon which at various times throughout the history of Christianity signified the excessive materialism of the Church itself, the crescent of the infidel Saracens, or during the Counter-Reformation the Protestant heresy (Ostrow 1996a, 243 ff.; Reeves 1997, 139–40). In this case, then, the Moon was to be seen *in malo*. (Figures 3 and 4 show medieval miniatures of



Fig. 3. *The Woman of the Apocalypse*. From a French manuscript, c. 1320. New York: Cloisters MSS 68, f. 20. With permission.



Fig. 4. *The Woman of the Apocalypse*. From an English manuscript, c. 1250. New York: Pierpont Morgan Library, MSS 524, 7E5, 8v. With permission.

what came to be called “The Virgin of the Apocalypse,” faithfully representing the *Apocalypse* 12:1–4, in which the Moon signifies the Infidel.)⁸

In the seventeenth century the doctrine of the Immaculate Conception was especially strong in Spain, where a canon for representing the Virgin as such was worked out by Francisco Pacheco, Diego Velázquez, Bartolomé Murillo, and others, whose prescription was a melding of several traditions in which the Virgin, clothed in the Sun, was to be standing on the Moon. However, the dragon was to be omitted and eventually the Virgin’s crown of twelve stars was omitted as well (Warner 1976, 246–48). Finally, there is the depiction of Mary in paintings of the Assumption. The notion that Mary, who did not suffer corruption by union of the flesh and therefore could not suffer dissolution of the body developed in the West into the notion that the Virgin’s body ascended to heaven, and the feast of the Assumption became a major religious festival in the late Middle Ages.⁹

All the aforementioned images of the Moon allied with the Virgin were present at the beginning of the seventeenth century and have presented problems for historians who have dealt with how the spotted Moon in Cigoli’s painting in Santa Maria Maggiore is to be interpreted. We will propose a solution below.

In many seventeenth-century representations of the *Immaculata*, the Virgin Mary is depicted as a young, beautiful maiden, arms folded across her breast. Her hands are usually pressed together in prayer, her eyes modestly cast down. Her feet, if they are visible at all, are dainty and point downward (fig. 5). In depictions of the Assumption, the Virgin Mary, her expression rapt, is represented as a lovely woman being borne aloft on a luminous cloud, sometimes by winged angels (fig. 6). But note, in Cigoli’s fresco the Virgin is depicted as a mature woman. One hand gathers up her gown, while in her other hand she holds a blossoming scepter, the symbol of Jesus’ power that he himself has given to her (Mâle 1949, 81).¹⁰ There is nothing dainty or light about her feet: they are heavy and solid, as is her body, and they are planted firmly on the maculate Moon, beneath which lies the coiled Serpent. Note also the expression on her face: it is one of supplication, not ecstasy, as is often seen in depictions of the Assumption. Here, she is not only the Church Militant but Mediatrix, who “pray[s] for us now and at the hour of our death.”

Given the contrast between the three Marian representations discussed above, how can we arrive at a satisfactory interpretation of the iconographic weight carried by Cigoli’s Moon? First, as Arthur Danto has argued: “A [painting’s] title

⁸ The Woman on the Moon could also be seen as the Immaculate Conception. This doctrine has a very long history, beginning in the Middle Ages and culminating in Pope Pius IX’s Bull, *Ineffabilis Deus* (1854), which declared as Church dogma that Mary was untainted by original sin, i.e., immaculately conceived (Warner 1976, 236–38).

⁹ In 1950 the Assumption was proclaimed an article of faith by Pope Pius XII (Warner 1976, 81–102). The key text in the mass for the celebration of the Assumption, however, was Chapter 12 of the *Apocalypse* (Warner 1976, 93).

¹⁰ Mâle makes this identification in his description of “The Coronation of the Virgin,” a thirteenth-century tympanum in Notre Dame, Paris. The flowering staff can also represent the rod of Jesse: “And there shall come forth a rod out of the root of Jesse, and a flower shall rise up out of his root” (*Isaiah* 11:1).



Fig. 5. Diego Velasquez, *The Immaculate Conception*, c. 1619.
Courtesy of the National Gallery, London.



Fig. 6. Peter Paul Rubens, *The Assumption*, 1626. Courtesy of Cathedral of Our Lady, Antwerp.

is more than a name or a label; it is a *direction* for interpretation” (Danto 1981, 117). By using the very instructive example of Breugel’s *Landscape with the Fall of Icarus*, he points out that a viewer who does not know the title of the painting would not understand that the legs in the painting “are the focus of the whole work . . . in the sense that the whole structure of the painting is a function of these being Icarus’ legs” (Danto 1981, 118). Given that the title of a painting directs the viewer’s interpretation, we must exercise caution in accepting the titles, *The Immaculate Conception* (Reeves 1997, *passim*; Chappell 1975, 93, and 1992; Kemp 1990, 94; Matteoli 1980, 245) or *The Assumption* (Panofsky 1954, 5 and 1956, 3–4; Edgerton 1991, 253). If we do not, we may, like the naive viewer of Breugel’s *Landscape with the Fall of Icarus*, not understand that the structure of Cigoli’s painting is a function of the Galilean Moon. Furthermore, in the interpretation of scriptural passages on which paintings of the Immaculate Conception and the Assumption are based, the Virgin is compared to the Moon because both are “spotless,” whereas the Moon in the Woman of the Apocalypse is compared to the mutability and evil of the sublunary world.

This is an important distinction in terms of how the Virgin and the Moon would

be apprehended. In depictions of the Virgin as Immaculata or in the Assumption, for example, Mary is *like* the Moon, “as beautiful as the Moon” (Song of Songs 6:10; Reeves 1997, 142), as pure and perfect as the Moon. The two function together as what Eco in his discussion of Thomistic aesthetics refers to as a “pictorial simile.” It would be difficult to imagine how Cigoli’s maculate Moon and the Woman could function as a pictorial simile of either the Immaculate Conception or the Assumption. In addition, as Victor Lasareff notes, it is necessary to attend to the ideas expressed by the form, i.e., the entire iconographic program.

Clearly, the ideas expressed by the form, the iconographic program of Cigoli’s fresco, are at odds with those expressed by representations of the Virgin as Immaculata and in the Assumption. The latter expresses the ideal nature of the Virgin, the former the fate of whatever is anathema to the Church and, therefore, to God. Heresy, like the serpent under the Woman’s foot, will be crushed. Hence, Cigoli’s Moon, as part of what Lasareff terms “a complete iconographic scheme” (Lasareff 1938, 26–28), here that of the Woman of the Apocalypse, is quite an orthodox piece of the scheme. That is to say, its Galilean character is clearly fitting within the program in which it appears.

Note also that in their charge to Cigoli (see above) the brothers Bozio refer specifically to *Genesis* chapter three, in which, according to traditional exegetical readings, Eve prefigures the Woman of the Apocalypse. Immediately after specifying Cigoli’s task, they designated how the fresco was to be read, clearly referring to the Woman’s prefigurement in *Genesis* chapter three, citing her own “genealogy,” if you will, citing both *figura* and fulfillment:

As Andrea Cesariense and St. Methodio have it, such a Woman signifies the Church; and according to St. Bernard and many other Latin writers, the Madonna literally signifies the Church no less than the Madonna who, from the beginning of the World, manifested with the Angels through the Incarnation, fights until the end of the World, triumphing in Heaven. And thus the first prophesy uttered in the creation of the World, against the Serpent who signifies the devil, “and she shall crush thy head” [*Gen.* 3:15], pertains to her (in Ostrow 1996a, 280).

Cigoli’s fresco cannot be regarded as the “*tota pulchra*” type described in Reeves (Reeves 1997, 142). The Woman is clearly not depicted as “beautiful as the Moon” (Song of Songs 6:10, in Reeves 1997, 142). Nor is this a depiction of the Virgin in the fullness of her life being bodily, and peacefully, assumed into heaven. This is the Virgin as Church militant, crushing evil under her feet. We must, therefore, call this fresco, as did the Oratorian fathers, the *Woman of the Apocalypse* and read the Moon as evil and corrupt.

There is little doubt that in the Counter-Reformation climate, for Paul V and his scholars, the Moon and Serpent in this fresco depicting the Apocalypse symbolized the Protestant heretics, those who denied and ridiculed the cult of the Virgin. Cigoli’s Moon may thus be viewed as a coincidental interface between his intentions

to paint a Galilean Moon, and the Church's intention to depict a frightening scene. The rhetoric of the Counter-Reformation was not only designed to demonstrate the errors of the ways of the (Protestant) heretics but also to portray the fate of those who did not adhere to doctrine. The Apocalyptic Woman is, after all, part of the Last Judgment. Such pictorial programs have always been used by the Church, not only to teach, but to manipulate the faithful to act according to received doctrine. As Ostrow has demonstrated, the frescoes of the Sistine and Pauline chapels of Santa Maria Maggiore must be read in the context of the Counter-Reformation (Ostrow 1996a). In importing Galileo's spotted Moon into this religious theme, Cigoli successfully put the new astronomical Moon in the service of an apocalyptic Counter-Reformation program.

This, however, raises the question as to why no artist after Cigoli painted the Moon as he did. In the history of representations of the Virgin Mary, his depiction of a maculate Moon is unique. Indeed, lunar iconography in this context tended to disappear in Italian art, and only in Spain was it pursued through the seventeenth century. In the succession of Marian representations there, we can see how the different traditions discussed above merged into a vision of the Immaculate Conception, which jettisoned some, but also retained other symbols associated with the Woman of the Apocalypse (Reeves 1997, 184–212). Thus Giambattista Tiepolo's paintings of the Immaculate Conception (fig. 7) for Italian patrons differ radically in this respect from his one Spanish commission (Levey 1986, 274–83) in that he closely follows Francisco Pacheco's prescription for such depictions of the Virgin, who must be shown "in the flower of her age, between twelve and thirteen years old, very beautiful, with lovely and solemn eyes, a perfect nose and mouth, rosy cheeks, and with hair as close to gold as the paintbrush will allow," and with her feet on the Moon (Reeves 1997, 194). Reeves has argued that this artistic vision of the Moon in the Spanish tradition is related to the efforts by scholars such as Giulio Cesare Lagalla and the Jesuits Christoph Scheiner and François d'Aguillon, to save the perfection of the Moon (Reeves 1997, 196–212). If eventually Catholic mathematicians and philosophers had to abandon lunar perfection, their thoughts lived on, frozen as it were, in the Moons of the Immaculate Conceptions painted by the artists.

Cigoli observed the Moon through a telescope and joined a new astronomical vision of a Moon with a rough surface full of mountains and valleys to a long artistic tradition of the Virgin Mary on the Moon, just as the cult of the Immaculate Conception was becoming ever more powerful in the Counter-Reformation. At about the same time that Cigoli began painting the dome of the Pauline Chapel, Adam Elsheimer painted the *Flight into Egypt*, in which he showed an unmarked full Moon in the heavens while its reflection in the water was covered with spots (Byard 1988). But in this respect Cigoli and Elsheimer were the exceptions among artists. The maculate Moon did not become part of any artistic tradition, and even among astronomers it was some time before lunar representation was taken up seriously. Galileo's proposal to the Medici Court, in 1610, to depict and publish



Fig. 7. Giovanni Battista Tiepolo, *The Immaculate Conception*, c. 1735.
Courtesy of the Prado Museum, Madrid.

every phase of the telescopic Moon, for which he needed financial support from the Grand Duke, was never executed (Galileo 1890–1909, X: 300).

Conclusion

Galileo's Moon renewed an age-old problem about the nature of the Moon. Philosophers and astronomers committed to the Aristotelian cosmology searched for explanations of Galileo's celestial discoveries within that paradigm. Clavius and others postulated a completely transparent, that is invisible, layer of celestial material that covered Galileo's lunar mountains. But this was an inferior argument, and almost all scholars realized it. In the Christian-Aristotelian cosmology, the centrality of the Earth was supported by biblical passages. But one could not derive Aristotle's cosmology from Scripture, which said nothing about the perfection of the heavens or the Aristotelian spheres. Cardinal Bellarmine himself had, earlier in his life, constructed a cosmology entirely based on Scripture, and it looked nothing like Aristotle's universe (e.g., Baldini 1984). The question of the Moon's perfection must, therefore, not be too closely tied in our minds to the question of Copernicanism. In a biblical context the Moon could be interpreted either as a sign of purity and immaculateness or of corruption and maculateness. In the context of the interpretation of *Apocalypse* 12, the latter was the case. Regardless of whether Cigoli himself believed the maculate Moon was evidence for a heliocentric universe, the fact is that it fit in admirably with the charge written by the Brothers Bozio. Thus, his moon cannot be viewed as an "iconographic curiosity." Nor was he attempting to surreptitiously import the Galilean moon into the basilica. On the contrary, his rendition of the Woman of the Apocalypse so pleased the Pope that in 1613, just before the artist's untimely death, he had Cigoli made a member of the Order of the Knights of Malta (Matteoli 1980, 34–35).

Acknowledgments

Samuel Y. Edgerton, Jr., Steven F. Ostrow, and Eileen Reeves read a previous version of this paper. We thank them for their generous help. They are not responsible for any errors we may have made. We also thank Jet M. Prendeville, Head Librarian of the Alice Pratt Brown Library at Rice University for her help.

References

- Alexander, Amir. 1998. "Lunar Maps and Coastal Outlines: Thomas Harriot's Mapping of the Moon." *Studies in History and Philosophy of Science* 29:345–68.
- Alhazen. 1924–25. "Über das Licht des Mondes," translated by Karl Kohl. *Sitzungsbericht der Physikalisch-medizinischen Societät in Erlangen* 56–57:305–98.
- . 1925. *Über die Natur der Spuren [Flecken], die man auf der Oberfläche des Mondes sieht*, translated by Carl Schoy. Hannover: Heinz Lafaire.
- Ariew, Roger. 1984. "Galileo's Lunar Observations in the Context of Medieval Lunar Theory." *Studies in History and Philosophy of Science* 15:213–26.
- Aristotle. 1930. *De Caelo*, translated by J. L. Stocks. In *The Works of Aristotle*, vol. 2, edited by W. D. Ross. Oxford: Clarendon Press.
- Augustine. 1958. *On Christian Doctrine*, translated by D. W. Robertson, Jr. New York: Macmillan.
- Baldini, Ugo. 1984 [1983]. "L'astronomia del Cardinale Bellarmino." In *Novità Celesti e Crisi del Sapere: Atti del Convegno Internazionale di Studi Galileiana*, edited by Paolo Galluzzi. Monograph 7, *Annali dell'Istituto e Museo di Storia della Scienza*. Florence.
- Bible. 1899. *The Holy Bible translated from the Latin Vulgate diligently compared with the Hebrew, Greek, and other editions in diverse languages. The Old Testament first published by the English College at Douay, A. D. 1609 and The New Testament first published by the English College at Rheims, A. D. 1582*. Baltimore and New York: John Murphy.
- Bloom, Terrie F. 1978. "Borrowed Perceptions: Harriot's Maps of the Moon." *Journal for the History of Astronomy* 9:117–22.
- Byard, Margaret M. 1988. "Galileo and the Artists." *History Today* 38 (Feb. 1988):30–38.
- Chappell, Miles. 1975. "Cigoli, Galileo, and *Invidia*." *Art Bulletin* 57:91–98.
- . 1992. "Prefazione," in Marco Chiarini, Serena Padovani, and Angelo Tartuferi, *Lodovico Cigoli, 1559–1613: tra Mannerismo e Barocco*, 11–19. Catalog of an exhibit in the Palazzo Pitti, 19 July to 18 October. Florence: Amalthea.
- Cigoli, Lodovico Cardi da. 1992. *Trattato pratico di prospettiva di Ludovico Cardi detto il Cigoli: manoscritto Ms 2660A del Gabinetto dei disegni e delle stampe degli Uffizi a cura di Rodolfo Profumo*. Rome: Bonsignori.
- Clavius, Christopher. 1612. *Commentarius in Sphaeram Ioannis de Sacrobosco*, vol. 3. In *Opera Mathematica*, 5 vols. Mainz.
- Danto, Arthur C. 1981. *The Transfiguration of the Commonplace*. Cambridge: Harvard University Press.
- Dicks, D. R. 1970. *Early Greek Astronomy to Aristotle*. London: Thames and Hudson.
- Duhem, Pierre. 1913–59. *Le Système du monde: Histoire des doctrines cosmologiques de Platon à Copernic*, 10 vols. Paris: Hermann.

- 1985. *Medieval Cosmology: Theories of Infinity, Place, Time, Void, and the Plurality of Worlds*, translated and edited by Roger Ariew. Chicago: University of Chicago Press.
- Eco, Umberto. 1988. *The Aesthetics of Thomas Aquinas*, translated by Hugh Bredin. Cambridge: Harvard University Press.
- Edgerton, Samuel Y., Jr. 1984. "Galileo, Florentine Disegno, and the 'Strange Spottedness' of the Moon." *Art Journal* 44:225–33.
- . 1990. *The Heritage of Giotto's Geometry: Science and Art on the Eve of the Scientific Revolution*. Ithaca: Cornell University Press.
- Galilei, Galileo. 1962. *Dialogue Concerning the Two Chief Systems of the World, Ptolemaic and Copernican*, translated by Stillman Drake. Berkeley: University of California Press.
- . 1890–1909. *Le Opere di Galileo Galilei*, edited by Antonio Favaro. Florence: Barbèra.
- . 1989. *Sidereus Nuncius or The Sidereal Messenger*, translated by Albert Van Helden. Chicago: University of Chicago Press.
- Grant, Edward. 1985. "Celestial Perfection from the Middle Ages to the Late Seventeenth Century." In *Religion, Science, and Worldview: Essays in Honor of Richard S. Westfall*, edited by M. J. Osler and P. L. Farber, 137–62. Cambridge: Cambridge University Press.
- Hevelius, Johannes. 1647. *Selenographia sive Lunae Descriptio*. Gdansk.
- Kelly, Sister Suzanne, O.S.B. 1965. *The De Mundo of William Gilbert*, 2 vols. Amsterdam: Menno Hertzberger.
- Kemp, Martin. 1981. *Leonardo da Vinci: The Marvellous Works of Nature and Man*. Cambridge, Harvard University Press.
- . 1990. *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat*. New Haven: Yale University Press.
- Kepler, Johannes. 1604. *Ad Vitellionem Paralipomena, quibus Astronomiae Pars Optica Traditur*. In *Johannes Kepler Gesammelte Werke*, vol. 2. Munich: C. H. Beck (1937–).
- . 1630. *Somnium seu Astronomia Lunari*. In *Gesammelte Werke*, vol. 11, part 2. Munich: C. H. Beck.
- Lasareff, Victor. 1938. "Studies in the Iconography of the Virgin." *Art Bulletin* 20:26–65.
- Lattis, James M. 1994. *Between Copernicus and Galileo: Christoph Clavius and the Collapse of the Ptolemaic System*. Chicago: University of Chicago Press.
- Levey, Michael. 1986. *Giambattista Tiepolo: His Life and Art*. New Haven: Yale University Press.
- Mâle, Émile. 1949. *Religious Art from the Twelfth to the Eighteenth Century*. New York: Pantheon.
- . 1972. *The Gothic Image: Religious Art in France of the Thirteenth Century*, translated by Dora Nussey. New York: Harper and Row.
- Matteoli, Anna. 1980. *Lodovico Cardi-Cigoli. Pittore e Architetto*. Pisa: Giardini.

- Montgomery, Scott L. 1994. "The First Naturalistic Drawings of the Moon: Jan Van Eyck and the Art of Observation." *Journal for the History of Astronomy* 25:317–20.
- . 1996. *The Scientific Voice*. New York: Guilford Press.
- Ostrow, Steven F. 1996a. *Art and Spirituality in Counter-Reformation Rome*. Cambridge: Cambridge University Press.
- . 1996b. "Cigoli's *Immacolata* and Galileo's Moon: Astronomy and the Virgin in the Early Seicento." *Art Bulletin* 78:219–35.
- Panofsky, Erwin. 1954. *Galileo as a Critic of the Arts: Aesthetic Attitude and Scientific Thought*. The Hague: Martinus Nijhoff.
- . 1956. "Galileo as a Critic of the Arts: Aesthetic Attitude and Scientific Thought." *Isis* 47:3–15.
- Plutarch. 1918. *On the Face that Appears on the Orb of the Moon*. In *Selected Essays of Plutarch*, translated by A. O. Prickard, 2:246–312. Oxford: Clarendon Press.
- Reaves, Gibson and Carlo Pedretti. 1987. "Leonardo da Vinci's Drawings of the Surface Features of the Moon." *Journal for the History of Astronomy* 18:55–58.
- Reeves, Eileen. 1997. *Painting the Heavens: Art and Science in the Age of Galileo*. Princeton: Princeton University Press.
- Trabucco, Agostino. 1957. "La 'Donna ravvolta di sole' (Apoc. 12) L'interpretazione ecclesiologica degli esegeti cattolici dal 1563 alla prima metà del secolo XIX." *Marianum* 19:1–58.
- Van Helden, Albert, and Mary G. Winkler, see Winkler, Mary G. and Albert Van Helden.
- Warner, Marina. 1976. *Alone of All Her Sex: The Myth and the Cult of the Virgin*. New York: Knopf.
- Winkler, Mary G. and Albert Van Helden. 1992. "Representing the Heavens: Galileo and Visual Astronomy." *Isis* 83:195–217.
- . 1994. "Johannes Hevelius and the Visual Language of Astronomy." In *Renaissance and Revolution: Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe*, edited by J. V. Field and Frank A. J. L. James. Cambridge: Cambridge University Press.

University of Houston and Rice University