Galileo's World Reprise
Art and Astronomy Walking Tour

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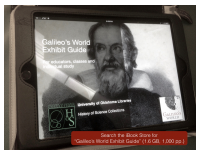
What was it like to be an astronomer when art and mathematics were intertwined?

Exhibit Locations: "SE HALL" contains *The Sky at Night* reprise gallery. "S HALL" contains the *New Physics* gallery and the Rotating Display.



Refer to the *Exhibit Guide* for a fuller description of any book or instrument listed below, keyed to its Gallery name and object number. Ask for an iPad at the Welcome Desk or download a free copy of the *Exhibit Guide* from the iBooks Store; requires the free iBooks app (iOS or Mac).

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Gallery: *Galileo and the Telescope*

1. Galileo, *Sidereus nuncius* (Venice, 1610), "Starry Messenger." SE HALL
   In the *Starry Messenger* (1610), Galileo published the first observations of the heavens made with the telescope. His report caused a sensation, as he claimed to discover mountains on the Moon, vast numbers of previously undetected stars and four satellites of Jupiter. Galileo reported that the planet Jupiter moves through the heavens without leaving its satellites behind. The Earth and Moon both have mountains, seas, atmospheres, and both shine by reflected light. All of these discoveries might suggest that the Earth, also, is a wandering planet.

3. Giorgio Vasari, *Le opere* (Florence, 1878-85), 8 vols. SE HALL
   Galileo's scientific discoveries occurred in the context of a specific artistic culture which possessed sophisticated mathematical techniques for drawing with linear perspective and handling light and shadow. (See "Interdisciplinary connections," last page.)

8. Questar 3.5 inch telescope (courtesy *Astronomics* – added for Reprise). SE HALL

FURTHER READING:
- Stillman Drake, *Galileo: A Very Short Introduction* (Oxford, 2001); discussion guide at oulynx.org.
- Galileo, *Sidereus Nuncius*, trans. Albert Van Helden (University of Chicago, 1989).
- Maurice Finocchiaro, *The Essential Galileo* (Hackett, 2008).
- http://oulynx.org/telescope

Gallery: *Galileo and Perspective Drawing*

1. Galileo, *Sidereus nuncius* (Venice, 1610), "Starry Messenger." SE HALL
   Galileo's sensational telescopic discoveries were made possible by Galileo's training and experience in Renaissance art. When Galileo peered through his telescope and discovered mountains on the Moon, he did so because he was seeing with the eyes of an artist. Contemporaries without artistic training were not able to see what Galileo saw; they were able to look but not to see.

2. Euclid, *Elements of Geometrie* (London, 1570), trans. Henry Billingsley, "Elements of Geometry." *New Physics* gallery, S HALL

This is the first English translation of Euclid. In the chapter on the geometrical solids, this copy retains the original pop-ups. Euclid, as studied in the Florentine artisan workshops, was the starting point for optics and perspective. Optics combined geometry, experiment, vision and art.

3. Ibn al-Haytham, *Opticae thesaurus* (Basel, 1572), "Treasury of Optics." *New Physics* gallery, S HALL

4. John Peckham, *Perspectiva* (Paris, 1556), "Perspective." S HALL, ROTATING GALLERY

5. Athanasius Kircher, *Ars magna lucis et umbrae* (Rome, 1646), "The Great Art of Light and Shadow." S HALL, CENTER CASE

Euclid worked out the principles of the "camera obscura." A camera obscura, literally a "dark room," consists of a box or container in which light enters via a small hole and projects an image on an opposite wall. The image will be reversed and upside-down, but its proportions will be preserved. Artists had been familiar with the camera obscura for several hundred years, and the technique was used by astronomers like Kepler and Galileo.

6. Leon Battista Alberti, "On Painting," in *Opuscoli Morali* (Venice, 1568), "Moral Essays." S HALL, ROTATING GALLERY

7. Niccolo Tartaglia, *Opere... Nova scientia* (Venice, 1606), "Works… A New Science." S HALL, ROTATING GALLERY

8. Luca Pacioli, *Divina proportione* (Venice, 1509), "The Divine Proportion." S HALL, ROTATING GALLERY

The linear propagation of light in the camera obscura made it possible to draw with true perspective. To aid in perspective drawing, many additional instruments and tools were developed. The geometrical drawing on display, and others like it, were drawn by Leonardo da Vinci. They are the only materials published by Leonardo during his lifetime, appearing in a work on drawing by Leonardo's friend Luca Pacioli. Artists over the following century practiced the techniques and tools of perspective drawing by constructing geometrical figures like these.

9. Leonardo da Vinci, *Trattato della Pittura* (Paris, 1651), 1st ed., "Treatise on Painting." S HALL, ROTATING GALLERY

10. Albrecht Dürer, *Institutionem geometricarum* (Paris, 1535), "Principles of Geometry." S HALL, ROTATING GALLERY

This explanation of perspective drawing comes from a work by Albrecht Dürer, similar in scope to the Pacioli, yet a generation later. Dürer here shows a variation on the perspective drawing technique known as "Alberti's window." The artist is creating a drawing of a lute with true perspective by means of a string drawn from the object, through the canvas window, to the vanishing point on the wall.

11. Lorenzo Sirigatti, *La Pratica di Prospettiva* (Venice, 1596), "The Practice of Perspective." S HALL, ROTATING GALLERY

This beautiful work by Sirigatti, published when Galileo was a young man, brings the tradition of perspective drawing from Alberti, Leonardo, Pacioli and

Dürer down to Galileo's time. Sirigatti was a member of the Accademia del Disegno (Academy of Drawing); later in life, Galileo was made an honorary member of the Academy. The work contains 64 full-page engravings with accompanying exercises, to train artists and engineers in the techniques of perspective drawing. Galileo practiced the techniques of linear perspective by reproducing these and the other drawings. Any young artist or mathematician working his way through Sirigatti, like previous generations working through the exercises of Leonardo or Dürer, would master perspective and the handling of light and shadow. *Imagine the spikes on the donut ring as the same lunar mountain observed at different times under different angles of light.* Careful study of the spikes and the shadows they cast prepared Galileo's eyes to interpret the "strange spottedness of the Moon" (in the words of Galileo's contemporary Thomas Harriot) as mountains and other topographical features.

12. Jean François Nicéron, *La Perspectiva Curieuse* (Paris, 1663), "The Curiosities of Perspective." S HALL, CENTER CASE

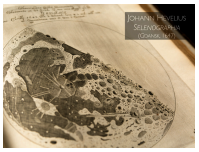
During a visit to Florence, Jean François Nicéron met with Galileo's artist friend Cigoli. Cigoli showed Nicéron a perspective drawing tool he had invented. Nicéron later published it in this book. In Florence, Nicéron also viewed examples of anamorphic drawing techniques and Alberti's perspective boxes. This Florentine artistic culture, steeped in the techniques of perspective drawing, was the midwife at the birth of Galileo's telescopic astronomy.

FURTHER READING:
•Samuel Y. Edgerton, *The Mirror, the Window and the Telescope* (Cornell, 2009).
•J.V. Field, *The Invention of Infinity* (Oxford, 1997).
•Martin Kemp, *The Science of Art* (Yale, 1992).
•http://oulynx.org/perspective

Gallery: *The Moon and the Telescope*

Galileo's *Starry Messenger* (1610) set off the 17th-century race for the Moon – not a race to go there, but a race to map its surface. To stare directly at the Full Moon is blinding at night; surface detail is entirely washed out. To map the Moon, one must examine the "shadow line" night by night as it passes across the face of the Moon. Light moves back and forth, first one way and then the other, casting shadows in both directions at opposite phases. The lunar map gradually emerges as a composite representation of many individual topographical studies. From the Renaissance to the dawn of the modern age, art and science fused together in the representation of the Moon.

1. Galileo, *Sidereus nuncius* (Venice, 1610), "Starry Messenger." SE HALL
2. William Gilbert, *De mundo nostro sublunari philosophia nova* (Amsterdam, 1651), "New Philosophy, about our World beneath the Moon." S HALL, ROTATING GALLERY
3. Francesco Fontana, *Novae coelestium terrestriumq[ue] rerum observationes* (Naples, 1646), "New Celestial and Terrestrial Observations." S HALL, ROTATING GALLERY



4. Johann Hevelius, *Selenographia* (Gdansk, 1647), "Map of the Moon." SE HALL

Johann Hevelius was the leading European telescopic observer in the mid-17th century. This massive book was the first comprehensive lunar atlas. It accurately mapped the Moon within four decades of Galileo's telescopic discoveries. 40 stunning copper-plate engravings portray topographical relief along the Moon's shadow-line, or terminator, at every conceivable angle of solar illumination. They represent the appearance of the Moon, along the terminator, over a period of five years.

5. Giambattista Riccioli, *Almagestum novum* (Bologna, 1651), Part 1, "The New Almagest." S HALL, CENTER CASE

6. Chérubin d'Orléans, *La dioptrique oculaire* (Paris, 1671), "The Optics of the Eye." S HALL, ROTATING GALLERY

In this work, d'Orléans provided a comprehensive theoretical and practical discussion of perspective, vision and optics. D'Orléans adopted the lunar map of Hevelius. On one plate, the putti are observing the Moon not only with the telescope, but with the "pantograph," a perspectival tool devised by d'Orléans. The tradition of perspective that underlay Galileo's discoveries was not yet forgotten.

7. James Nasmyth and James Carpenter, *Der Mond* (Leipzig, 1876), "The Moon." SE HALL

This is not a photograph of the Moon! No Earth-bound telescopes could discern such detail. Nasmyth was a Scottish engineer known for his invention of the steam hammer; he combined avid interests in astronomy and photography. Carpenter was an astronomer at the Greenwich Observatory. Together they constructed plaster models of the lunar surface. They photographed these plaster models using raking light. With light rays coming from oblique angles, they were able to simulate the shadow effects one might perceive on the surface of the Moon through the telescope. In this British achievement in astronomy, we see that a productive combination of art and astronomy did not end with Galileo. The shadows Galileo observed on the Moon revealed topographical relief. In the controlled conditions of their photographic laboratory, Nasmyth and Carpenter recreated the same effects in detail which Galileo had originally taught us to understand.

FURTHER READING:
•Scott L. Montgomery, *The Moon and the Western Imagination* (University of Arizona, 1999).
•Andrew Planck, *What's Hot on the Moon Tonight* (Moonscape Publishing, 2014).
•http://oulynx.org/moon

The Sky at Night – FURTHER READING:
•William B. Ashworth, Jr., *The Golden Age of the Celestial Atlas: Out of This World* and *Further Out*.
•Nick Kanas, *Star Maps: History, Artistry and Cartography*, 2d ed (Springer, 2012).
•Chet Raymo, *365 Starry Nights* (Simon & Schuster, 1990).
•http://oulynx.org/sky2

Interdisciplinary connections: How did Galileo learn to see artistically? How did he gain experience in the study of light and shadow? At that time, many young men enrolled in artisan workshops. In these artisan workshops they would study Euclidean geometry in a hands-on way by acquiring the techniques of perspective drawing. For their capstone project, students in these artisanal workshops would apply their geometrical drawing skills to a project in art such as a painting or drawing, and go on to become artists. Or they might craft a sculpture, or make a blueprint, and go on to be sculptors or architects. Or they might create a design for a complex machine, and go into engineering, as did Galileo. In artisan workshops, future artists and engineers studied mathematics side by side. As a young man, Galileo studied in the artisan workshop of Buontalenti, where lessons in geometry were given by Ostilio Ricci. Ricci's lectures there were also attended by Galileo's friend, the painter Cigoli. Galileo's later secretary, Viviani, recorded that Cigoli stated that Galileo had been his teacher in the art of perspective drawing: "in perspective, Galileo alone had been his (Cigoli's) master."

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