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Edited by

KATHARINE PARK

LORRAINE DASTON

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1340–1400). Stylistic changes and the search for the "real character" (eventually realized, in part, in the mathematization of the natural sciences, not to mention the totalizing intentions of such descriptive enterprises as botany and zoology) are fundamentally at odds with the literary investment in dense signification, ambiguity, and polysemy. Language as an object of interest, as a creature developing in time (rather than the set of rules elaborated by grammarians and linguists), became the province of writers cut off in this way from the objectives of thinkers for whom natural language was nothing but a medium – and increasingly not a medium of choice.

Tables, taxonomies, graphs, and mathematical formulas are all more concise, more determinate, and more pragmatic than the sentences and paragraphs (never mind the poetic lines!) of living languages. These attributes are important to a discipline that sees its texts as a means to immediate collective ends. They belong to the economy of "getting things done." The alchemical text that tested the mind and purified the spirit while giving chemical recipes did not often succeed at facilitating quick success in the last of these areas. With the speedy growth and maturity of modern scientific publishing, the literary became a category not of knowledge but of recreation (in many senses), and the Poet became not the Monarch "of all Sciences" but their Other: moral, tenuous, unsystematic, individual, florid, and trivial.

The literary antagonism I have been discussing, to science in general and the "new science" in particular, was based partly, perhaps, on a dawning anxiety among many writers and readers over the loss of cultural power and status in the domain such loss carved out and would in the late eighteenth century honorifically label "literature." But this antagonism can also be seen as an emergence of the literary function of critique. If these two fundamentally different and deeply related modes of observing and representing are mutually excluded, then they can (or will) observe and represent each other: science representing literature through philology, linguistics, and criticism; and "literature," more evaluatively, representing science through parody, hoax, satire, "true histories," fantasy, and pornography – forms that test and mock and transgress the boundaries of the real and the true. The poet and artist William Blake's (1757–1827) scorn for Isaac Newton (1642–1727), who saw, as did so many of the objects of Blake's scorn, with his "corporeal eye," is unfair but illuminating. It was clear enough by the end of the eighteenth century what the now normative respect for category, measurement, and boundary had cost, and how reduced was the scope or social function of nonscientific representation: A mimetic struggle would henceforth maintain the divided world of the "two cultures."[45]

[45] For an elaborated and profound account of a related contest (between the "religious and poetic institutions") for "possession of the sufficient means of representation" (p. 53) – less historical but attending in part to the phenomenon as manifested in Europe's Enlightenment – see Allen Grossman, "The Passion of Laocoön: Warfare of the Religious against the Poetic Institution," *Western Humanities Review*, 56 (2002), 30–80.

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ART

Carmen Niekrasz and Claudia Swan

During the epistemic shift conventionally called the Scientific Revolution, the study of nature came to depend on images. Investigation of the plant world, which was still tied to medical aims but was beginning to take shape as the morphological discipline we now call botany, is a case in point. The implementation of new printing techniques in the late fifteenth century enabled the production of publications that featured images that were precisely reproducible, at least in theory, and therefore understood as trustworthy.[1] Gradually, standard classical texts such as herbals, which had previously circulated as hand-copied manuscripts, were made available in printed form and came to be heavily illustrated (Figure 31.1). The accessibility of standard visual references in relatively affordable printed editions permitted enterprising doctors, pharmacists, and amateurs of the plant world to compare the plants they had at hand and that grew in their native lands with the plants described by classical authorities, among them the Greek naturalists Theophrastus (third century B.C.E.), Dioscorides (first century C.E.), and the Roman encyclopedist Pliny the Elder (d. 79 C.E.). Numerous varieties not contained in the classical texts were "discovered" by learned botanists throughout Europe. Like prints, drawings also served as a basis for comparison of local varieties with the plants the classical authors had described and, in those cases where the plants at hand could not be matched with plants previously described, came to serve as means for recording and cataloguing them.[2]

Beginning in the mid-fifteenth century, European artists increasingly engaged in recording nature. Artistic interest in depicting the natural world

[1] See William M. Ivins, Jr., *Prints and Visual Communication* [1953] (Cambridge, Mass.: MIT Press, 1969).

[2] On illustrated botany, see Agnes Arber, *Herbals: Their Origin and Evolution, a Chapter in the History of Botany, 1470–1670* [1912] (Cambridge: Cambridge University Press, 1986); William T. Stearn, *The Art of Botanical Illustration: An Illustrated History* [1950] (New York: Antiquarian Society, 1994); and David Landau and Peter Parshall, *The Renaissance Print, 1470–1550* (New Haven, Conn.: Yale University Press, 1994), esp. "Printed Herbals and Descriptive Botany," pp. 245–59.

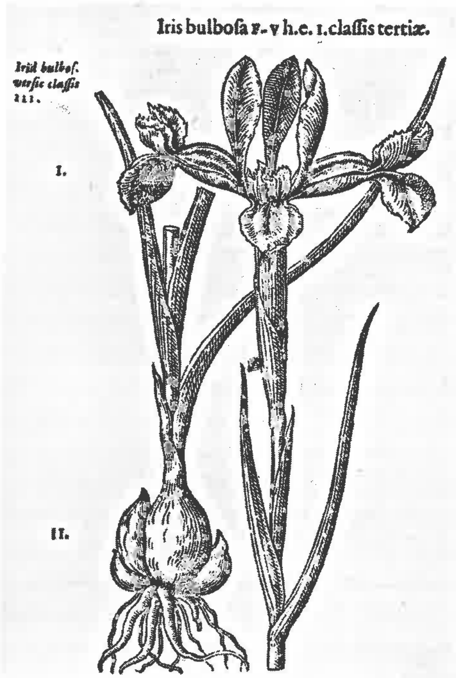

Figure 31.1. *Iris bulbosa*. In Carolus Clusius, *Rariorum plantarum historia* (Leiden: Plantin, 1601), p. 214. Reproduced by kind permission of the National Herbarium Nederland.

coincided with the sorts of close observation and morphological description that structured many scientific endeavors. Beyond illustrated natural history, other areas in which artistic and scientific interests overlapped in the early modern period include the collection and organization of naturalia in cabinets, *musea*, gardens, or *vivaria* and menageries, in which princes, pharmacists, academic doctors, and artists alike took interest. The microscope, the telescope, and the mobile *camera obscura* are optical devices whose features and uses were exploited for artistic and experimental ends. The rise of botanical still-life painting, the involvement of artists in natural history and ethnography both at home and abroad, and widespread interest in the material and metaphysical effects of foreign and exotic products are some of the other relevant areas of intersection. The laboratory and the artist's workshop were both spaces for the intensive exploration of nature, and each borrowed tools, technologies, materials, and even methods of observation from the other. In this chapter, we have chosen to focus upon the variety of standards for naturalism in the early modern period, the features and functions of scientific illustration, the changing role of images in anatomical instruction, and shared practices, as well as potentially instructive ways of excavating the connections between early modern art and science in future scholarship.

NATURALISM

Of all the paradigms for artistic achievement under which early modern visual artists labored, none had as venerable a heritage and was as consistently reiterated as the encouragement to imitate nature. Over and over, the mimetic feats of the late fifth-/early fourth-century B.C.E. Greek painters Zeuxis and Parrhasius (none of whose works are known to survive) were recounted in biographical and theoretical works of the sixteenth and seventeenth centuries. Pliny the Elder had first told of Zeuxis stunning observers by painting grapes so naturalistically that birds swooped down to eat them, and of Parrhasius astonishing Zeuxis in turn by painting a curtain so convincingly that Zeuxis demanded it be pulled aside to reveal the picture beneath.[3] (Grapes and fictive curtains are a topos in early modern painting, which frequently cited these precedents directly.)[4] From the Italian sculptor and author Lorenzo Ghiberti (1378–1455) to the Dutch theorist and painter Samuel van Hoogstraten (1627–1678), countless early modern authors cited Zeuxis and his fellow artist Parrhasius as paragons of mimetic accomplishment, spurring contemporaries to similar feats. "Le Chevalier," an interlocutor in a treatise by the French man of letters Charles Perrault (1628–1703), relates an encounter between an animal and a painting, which he calls "as flattering to modern painting as Zeuxis's grapes is to that of the Ancients, and vastly more entertaining."

> The door of Monsieur Le Brun [Charles le Brun, 1619–1690] was open, and a freshly painted picture had been taken out into the courtyard to dry. In the foreground of this painting was a perfect representation of a large thistle. A woman came past leading an ass, which, when it saw the thistle, plunged into the courtyard; the woman, who was hanging on to its bridle, was dragged off her feet. If it hadn't been for a couple of sturdy lads who gave it some fifteen or twenty blows each with their sticks to force it back, it would have eaten the thistle – and I say *eaten*, because the paint was fresh and would all have come off on its tongue.[5]

Even ironic invocations of the Zeuxian/Parrhasian paradigm worked to instill it. "L'Abbé," "Le Chevalier's" interlocutor, replies by disparaging "such *trompe l'oeil* effects . . . commonly found today in works of no repute whatsoever." "Often enough," he explains, "cooks have reached out for accurately represented partridges or capons, intending to put them on the spit, and

[3] Pliny, *Natural History*, 35.36, trans. H. Rackham, 10 vols. (Cambridge, Mass.: Harvard University Press, 1986), 9: 308–11.

[4] See Sybille Ebert-Schifferer, *Deceptions and Illusions: Five Centuries of Trompe l'Oeil Painting* (Washington, DC.: National Gallery of Art, 2002).

[5] Charles Perrault, *Parallèle des anciens et des modernes*, 4 vols. (Paris: Jean-Baptiste Coignard, 1688–97), 1: 189.

what happens? Everyone laughs, and the painting stays in the kitchen."[6] "L'Abbé" insists that however convincing and indeed praiseworthy depictions of "stuffs" may be, they only amount to "stuffs" – mere things of the world. A painted thistle provides as little nourishment to the ass as the painted capons. (The reference here may be to paintings of game or *xenia*, the Latin term for gifts of food offered by hosts to their guests, which were hung in the dining and kitchen quarters of early modern homes.)

The drive to render nature in images ran deep, and it found differing expressions among artists, theorists, observers, and others.[7] Leonardo da Vinci (1452–1519) championed and practiced several complementary approaches to the imitation of nature. "Painting," he wrote, "which is the sole imitator of all the manifest works of nature, [is] a subtle invention, which with philosophical and subtle speculation considers all manner of forms: sea, land, trees, animals, grasses, flowers, all of which are enveloped in light and shade."[8] His defense of painting is amply supported by his numerous landscape and meteorological studies, his drawings of the movement of water and of plants, and his anatomical studies. Elsewhere, Leonardo expressed bemusement at the uncanny ability of paintings to deceive their viewers, and he described a mimesis-induced confusion of "dogs barking and trying to bite painted dogs," while "swallows fly and perch on iron bars which have been painted as if they are projecting in front of the windows of buildings."[9] Albrecht Dürer (1471–1528) pronounced of nature that the painter should "diligently . . . orient [himself] to it and not neglect it. . . . In truth, art is lodged in nature; he who can extract it has it."[10] Art was seen to "imitate" nature in a number of senses: It might mimic and by so doing supplant nature, as in Perrault's observations; or render the underlying "truth" of nature, for example, as suggested by Dürer.

Fidelity to nature was not always an end in itself, however; artists were encouraged to temper their observations of nature with ideal conceptions. Those who strove to represent ideal forms relied on their mental and manual powers of analysis and synthesis in selecting elements of existing entities and recomposing them to form a perfect whole. As the English statesman and natural philosopher Francis Bacon (1561–1626) observed, however, the ideal was not necessarily beautiful: "A man cannot tell whether [the Greek painter] Apelles or Albrecht Dürer were the more trifler; whereof the one would make a personage by geometrical proportions; the other, by taking the best parts

[6] Ibid., p. 190.

[7] Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998), chap. 7: "Wonders of Art, Wonders of Nature," pp. 255–301.

[8] Martin Kemp, ed., *Leonardo on Painting*, trans. Martin Kemp and Margaret Walker (New Haven, Conn.: Yale University Press, 1989), p. 13.

[9] Ibid., p. 34.

[10] *Dürer: Schriftlicher Nachlass*, ed. Hans Rupprich, 3 vols. (Berlin: Deutscher Verein für Kunstwissenschaft, 1956), 3: 295.

out of divers faces, to make one excellent. Such personages . . . would please nobody but the painter who made them."[11]

The imitation of nature was not always a straightforward endeavor, given the inevitable gap between the actual forms of the observable world and their two- or (in the case of sculpture) three-dimensional representations. It has been pointed out that many of the early modern images we hold up as being most naturalistic – watercolor depictions of animals by Dürer (Figure 31.2) and pen drawings of anatomical structures by Leonardo, for example – offer highly mediated views of observable reality.[12] The morphological detail provided by a drawing was far more comprehensive than what a viewer perceived when faced with a live specimen, a paradox of which early modern artists were wholly aware. We might think of early modern artists as aiming not to transcribe reality but rather to achieve pictorial "truth to nature," a kind of inspired interpretation of the subject shaped by the artist's selection and synthesis of observations.[13]

Paradoxically, the effect of these calculated manipulations of appearances was an astonishing mimesis. "A perfect painting," wrote Samuel van Hoogstraten, "is like a mirror of Nature, in which things that are not there appear to be there, and which deceives in an acceptable, amusing, and praiseworthy fashion."[14] The Bolognese naturalist and professor Ulisse Aldrovandi (1522–1605) described the Medici court artist Jacopo Ligozzi (1547–1626) as "an excellent painter, who day and night devotes himself exclusively to depicting plants, animals of all sorts . . . and birds . . . , [some of them] from India, and snakes, from Africa . . . and all that is missing from these images is the soul of the thing represented."[15] Among other things, Aldrovandi's praise for

[11] Francis Bacon, "Of Beauty," in *The Major Works*, ed. Brian Vickers (Oxford: Oxford University Press, 1996), pp. 425–6.

[12] See James S. Ackerman, "Early Renaissance 'Naturalism' and Scientific Illustration," in Ackerman, *Distance Points: Essays in Theory and Renaissance Art and Architecture* (Cambridge, Mass.: MIT Press, 1991), pp. 185–207, at pp. 187–8; Martin Kemp, "'The Mark of Truth': Looking and Learning in Some Anatomical Illustrations from the Renaissance and Eighteenth Century," in *Medicine and the Five Senses*, ed. W. F. Bynum and Roy Porter (Cambridge: Cambridge University Press, 1993), pp. 85–121; and Kemp, "Temples of the Body and Temples of the Cosmos: Vision and Visualization in the Vesalian and Copernican Revolutions," in *Picturing Knowledge: Historical and Philosophical Problems concerning the Use of Art in Science*, ed. Brian Baigrie (Toronto: University of Toronto Press, 1996), pp. 40–85.

[13] Peter Galison, "Judgment against Objectivity," in *Picturing Science, Producing Art*, ed. Caroline A. Jones and Peter Galison (New York: Routledge, 1998), pp. 327–59, at p. 328.

[14] Samuel van Hoogstraten, *Inleyding tot de Hooge Schoole der Schilderkonst: anders de Zichtbaere Werelt* (Rotterdam: Fransois van Hoogstraeten 1678), p. 25. See Celeste Brusati, *Artifice and Illusion: The Art and Writing of Samuel van Hoogstraten* (Chicago: University of Chicago Press, 1995).

[15] Ernst Kris, "Georg Hoefnagel und der wissenschaftliche Naturalismus," in *Julius Schlosser: Festschrift zu seinem 60sten Geburtstag*, ed. A. Weixlgärtner and L. Planiscig (Vienna: Amalthea, 1927), pp. 243–53, at p. 251. On Ligozzi, see also Lucia Tongiorgi Tomasi and Gretchen Hirschauer, *The Flowering of Florence: Botanical Art for the Medici* (Washington, DC.: National Gallery of Art, 2002); Lucia Tongiorgi Tomasi, *I ritratti di piante di Iacopo Ligozzi* (Pisa: Ospedaletto, 1993); and Tongiorgi Tomasi, "The Study of the Natural Sciences and Botanical and Zoological Illustration in Tuscany under the Medicis from the Sixteenth to the Eighteenth Century," *Archives of Natural History*, 28 (2001), 179–93.

Figure 31.2. *The Young Hare*. Albrecht Dürer, 1502, watercolor and gouache on paper. Reproduced by permission of Graphische Sammlung Albertina, Vienna. Photograph courtesy of Marburg/Art Resource, New York.

Ligozzi provides evidence that artistic naturalism was aligned with scientific interests of the time. Students of Dutch art may be struck by the similarity between Aldrovandi's recommendation and the terms in which the statesman and poet Constantijn Huygens (1596–1687) praised Dutch landscape painting. Huygens wrote in 1629 that "It can even be said, as far as naturalism is concerned, that in the works of these clever [landscape painters] nothing is lacking but the warmth of the sun and the movement caused by the gentle breeze."[16]

Art historians have noted that whereas some artists applied mathematical methods such as perspectival or optical theory for artistic ends, others put art – its mimetic capacity to replicate the forms of nature, for example – to empirical use. Dürer's splendid natural historical watercolors of grasses, birds, or a hare are a case in point. One central line of argument, for example, holds that Dürer's naturalism inspired the tremendous increase in the use of images

[16] Constantijn Huygens, *Mijn Jeugd*, trans. C. L. Heesakkers (Amsterdam: Querido, 1987), p. 79.

by students of nature in the sixteenth century and beyond.[17] Another focuses on the utility for some natural inquirers of training in artistic techniques and perceptual skills. Thus, Galileo Galilei's (1564–1642) first sketches of the pocked lunar surface reveal his understanding of chiaroscuro; indeed, it was the astronomer's extensive training as a draftsman (he was admitted to the Accademia del Disegno in Florence in 1613) that enabled him, unlike his contemporary the mathematician and astronomer Thomas Harriot (1560–1621), to comprehend the strange pattern of shadows at the other end of his telescope as three-dimensional forms.[18]

By the mid-seventeenth century, some naturalists, immersed in the attempt to represent natural appearances pictorially, had become as keenly aware as artists of the instability underlying all efforts to see and represent nature "as she is," even with the aid of new optical technologies that extended vision to the realms of the very small and the very far away. In the preface to his *Micrographia* (1665), the first illustrated account of observations made through the microscope, Robert Hooke (1635–1703) acknowledged of his tiny specimens that:

> Of these kinds of objects there is much more difficulty to discover the true shape, than of those visible to the naked eye, the same Object seeming quite different in the one position of the light, from what it really is. . . . And, therefore I never began any draught before by many examinations in several lights, and in several positions to those lights, I had discovered the true form.[19]

Like Galileo, Hooke was an accomplished draftsman, which sharpened his eye for the potential deceptions of light and shadow and the need to interpret, not just reproduce, visual appearances in order to find "the true shape."

SCIENTIFIC ILLUSTRATION

The same Pliny who recommended the virtuoso mimetic feats of Zeuxis and Parrhasius also condemned artists' efforts to render plants for scientific purposes, arguing that nature is too mutable to be fixed in images and that images are less reliable than text in any case. Pliny referred to the use of illustrations in natural-historical accounts as

[17] See Fritz Koreny, *Albrecht Dürer and the Animal and Plant Studies of the Renaissance*, trans. Pamela Marwood and Yehuda Shapiro (Munich: Prestel-Verlag, 1985).

[18] Samuel Y. Edgerton, Jr., "Galileo, Florentine 'Disegno,' and the 'Strange Spottedness' of the Moon," *Art Journal* (Fall 1984), 225–32; see also Horst Bredekamp, "Gazing Hands and Blind Spots: Galileo as Draughtsman," *Science in Context*, 13 (2000), 423–62.

[19] Quoted in Martin Kemp, "Taking It on Trust: Form and Meaning in Naturalistic Representation," *Archives of Natural History*, 17 (1990), 127–88, at pp. 131–2.

a most attractive method, though one which makes clear little else except the difficulty of employing it. . . .[N]ot only is a picture misleading when the colors are so many, particularly as the aim is to copy Nature, but besides this, much imperfection arises from the manifold hazards in the accuracy of copyists. In addition, it is not enough for each plant to be painted at one period only of its life, since it alters its appearance with the fourfold changes of the year.[20]

Classical disparagements notwithstanding, numerous early modern artists and scientists participated actively in the representation of the natural world. The German naturalist Otto Brunfels (1488–1534) was the first of several authors to publish extensive accounts of local flora that included systematically descriptive images.[21] In its organization and text, Brunfels's *Herbarum vivae eicones ad naturae imitationem* (Living Images of Plants in Imitation of Nature, 1530–6) differed little from its classical sources (principally Pliny and Dioscorides), but the images – the very subject of the book's title – heralded an entirely new form of engagement with nature. In 1542, Brunfels's compatriot Leonhart Fuchs (1501–1556) published *De historia stirpium* (On the History of Plants), in which roughly 550 plants were recorded and illustrated. Fuchs outlined his descriptive project in a page-long qualifying subtitle, where he explained that his (verbal) descriptions of the habitats, nature, and medicinal properties of plants were accompanied by the most artful and expressive illustrations, made "*ad naturam*."[22] Like Brunfels, who referred to the images of plants his book contained as "portrayed with great diligence and artifice," Fuchs advertised the artistic quality of the woodcuts he published (Figure 31.3). The degree of artistry was closely monitored, however. Fuchs specified that "shading and other less crucial things with which painters sometimes strive for artistic glory" have been discouraged in the interest of making "the pictures correspond [more] to the truth."[23]

As the triple portrait Fuchs included in his herbal shows, the production of early modern scientific illustration involved complex negotiations – among

[20] Pliny, *Natural History*, 25.4, 9: 140–1. To the first two of Pliny's complaints, woodcuts and engravings offered a remedy. See also Karen Meier Reeds, "Renaissance Humanism and Botany," *Annals of Science*, 33 (1976), 519–42, at p. 530; David Freedberg, "The Failure of Color," in *Sight and Insight: Essays on Art and Culture in Honour of E. H. Gombrich at 85*, ed. J. Onians (London: Phaidon, 1994), pp. 245–62, esp. pp. 245–8; and Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: University of Chicago Press, 2002), esp. pt. IV, pp. 347–416.

[21] The inclusion of roots, the description of surface texture, and the effort to show leaves and flowers from a variety of angles distinguish Brunfels's work from all previous publications of the sort. Emphasis on the specific characteristics of individual specimens and the inflections of shadows were criticized, and avoided in later publications, demonstrating that the literal demands of working from life were tempered by the necessity of communicating visual information. See Landau and Parshall, *The Renaissance Print*, pp. 254–5.

[22] See T. A. Sprague and Ernest Nelmes, *The Herbal of Leonhart Fuchs* (London: Linnean Society of London, 1931).

[23] Leonhart Fuchs, *De historia stirpium . . .* (Basle: Isingrin, 1542), fol. 7v; see also Arber, *Herbals*, p. 206.

Figure 31.3. Self-portraits of the artists Heinricus Füllmaurer, Albertus Meyer, and Vitus Rudolph Speckle. In Leonhart Fuchs, *De historia stirpium commentarii insignes* (Basel: Isingrin, 1542). Reproduced by permission of the McCormick Library of Special Collections, Northwestern University Library.

individual producers, artists, blockcutters, authors, editors, publishers, and readers, for example, as well as between word and image on the one hand and classical learning and empirical evidence on the other.[24] By the mid-sixteenth century, so many new plant species had been identified (thanks in large part to the power of pictures to communicate ever finer morphological

[24] See Sachiko Kusukawa, "Illustrating Nature," in *Books and Sciences in History*, ed. Marina Frasca-Spada and Nick Jardine (Cambridge: Cambridge University Press, 2000), pp. 90–113; and Lucia Tongiorgi Tomasi, "L'Illustrazione naturalistica: Tecnica e invenzione," in *Natura-Cultura: L'Interpretazione del mondo fisico nei testi e nelle immagini*, ed. Giuseppe Olmi, Lucia Tongiorgi Tomasi, and Attilio Zanca (Florence: Leo S. Olschki, 2000), pp. 133–51.

distinctions) that naturalists began to suffer from "information overload."[25] To some extent, morphological images enabled students of the natural world to organize their experience.[26] Although complaints about the usefulness of static images to capture the variable forms of nature continued to be lodged, nonetheless a characteristically pictorial natural history asserted itself in the sixteenth and seventeenth centuries.[27]

The compulsion to record nature in the early modern period generated not only a substantial corpus of images of plants, humans, and animals but also a remarkably diverse one, incorporating a variety of media, from woodcuts and engravings to watercolor drawings, oil paintings, and even tapestry. These images served a variety of uses, among them description, identification, instruction, substitution for the real item (in collections, for example, where images supplanted unavailable specimens), and elicitation of wonder. Whereas Dürer might aim by rendering nature to capture the external appearance of flora and fauna, Leonardo appears to have used drawings as vehicles for understanding the laws and universal forms embodied within particular phenomena.[28] For Leonhart Fuchs, naturalistic images of plants enabled students of botany to learn to grasp in a glance the essence of a species, distilling its taste, smell, and medicinal powers into a single mnemonic sign.[29] For a collector such as the Holy Roman Emperor Rudolf II (1552–1612), lavish albums of zoological and botanical paintings celebrated the virtuosity and inventiveness of the Divine Creator even as they honored the patron's own erudition, power, and wealth.[30]

ANATOMY LESSONS

Among the most renowned illustrated works of early modern science are the publications of Andreas Vesalius (Andreas van Wesele, 1514–1664) – his *Tabulae sex* (Six Figures) of 1538 and his *De humani corporis fabrica* (On the Fabric of the Human Body) and *Epitome* of 1543. The innovative method of anatomical instruction developed by Vesalius, in which Galenic texts were explored and sometimes corrected through comparison with a human body,

[25] Brian Ogilvie, "The Many Books of Nature: Renaissance Naturalists and Information Overload," *Journal of the History of Ideas*, 64 (2003), 29–40, at pp. 32–3.

[26] See Claudia Swan, "From Blowfish to Flower Still Life Painting: Classification and its Images ca. 1600," in *Merchants and Marvels: Commerce, Art, and the Representation of Nature in Early Modern Europe*, ed. Pamela Smith and Paula Findlen (New York: Routledge, 2002), pp. 109–36.

[27] David Topper, "Towards an Epistemology of Scientific Illustration," in *Picturing Knowledge*, pp. 215–49.

[28] Dagmar Eichberger, "*Naturalia* and *Artefacta*: Dürer's Nature Drawings and Early Collecting," in *Dürer and His Culture*, ed. Dagmar Eichberger and Charles Zika (Cambridge: Cambridge University Press, 1998), pp. 13–37, at p. 15.

[29] Sachiko Kusukawa, "Leonhart Fuchs on the Importance of Pictures," *Journal of the History of Ideas*, 58 (1997), 403–27, at pp. 412–16.

[30] See *Le Bestiaire de Rodolphe II: Cod. min. 129 et 130 de la Bibliothèque Nationale d'Autriche*, ed. Manfred Staudinger, H. Haupt, and Thea Vignaud-Wilberg, trans. Léa Mavcou (Paris: Citadelles, 1990).

permanently changed the way that medicine was taught starting in the mid-sixteenth century. Performing dissections in university lecture rooms and temporary structures, Vesalius instituted a form of anatomical instruction in which the formerly triangulated practices of the professor (who presided *ex cathedra*), the *demonstrator* (who performed the dissection according to the order of the text read aloud by the professor), and the *ostensor* (who pointed out the various parts of the body as they were uncovered) were carried out by the demonstrator/anatomist alone.[31] The body itself became the prevailing authority when discrepancies arose between text and physical evidence; Vesalius's close attention to empirical fact is in turn reflected in the prominent role illustrations played in his anatomical publications.

By the middle of the sixteenth century, empirical observation in medicine had become de rigueur. The causes – and the effects – of the shift many European medical curricula underwent are complex. Karen Meier Reeds and Roger French, writing about early modern botany and anatomy, respectively, have described the subtle interplay between the humanist culture devoted to the revival of classical texts in the sixteenth century and the new practices of observation and demonstration.[32] Just as Vesalius insisted on corroborating the dissected body with the written word, privileging the physical specimen over inherited texts when faced with inconsistencies, so, too, did botanical study come to involve direct and sensory study of its objects. Simples (the makings of medicines) were gathered for and by professors of medicine and their students and were cultivated in the gardens newly attached to universities, and their properties were demonstrated in the course of lectures.

Vesalius's professor at the University of Paris, Jacobus Sylvius (Jacques Dubois, 1478–1555), was the most celebrated lecturer on anatomy in the 1530s; his classes were typically attended by as many as 400 or 500 students and in effect spawned the subsequent generation of medical studies. In his *In Hippocratis et Galeni physiologie partem anatomicam isagoge* (Introduction to the Anatomical Part of the Physiology of Hippocrates and Galen), published in 1555 but written earlier, Sylvius recommended the following:

> I would have you look carefully and recognize by eye when you are attending dissections. . . . For my judgment is that it is much better that you should learn the manner of cutting by eye and touch than by reading and listening. For reading alone never taught anyone how to sail a ship, to lead an army, nor to compound a medicine, which is done rather by the use of one's own sight and the training of one's own hands.[33]

[31] For the observations of Baldasar Heseler, a German student present at one of Vesalius's dissections, see Ruben Eriksson, *Andreas Vesalius' First Public Anatomy at Bologna 1540: An Eyewitness Report* (Uppsala: Almqvist and Wiksell, 1959).

[32] Reeds, *Botany in Medieval and Renaissance Universities*; and R. K. French, *Dissection and Vivisection in the European Renaissance* (Aldershot: Ashgate, 1999), chaps. 3 and 4.

[33] Jacobus Sylvius, *Opera medica* (Geneva, 1635), p. 127, as cited in M. F. Ashley Montagu, "Vesalius and the Galenists," in *Science, Medicine, and History: Essays on the Evolution of Scientific Thought and*

Sylvius also taught materia medica and cultivated a medicinal garden of both indigenous and foreign varieties for the benefit of his students, who might learn by inspection and observation.[34] Vesalius echoed his teacher's values in his criticism of a senior colleague at Bologna, Matthaeus Curtius (ca. 1474–1544): "The essential thing is to teach the contents and to speak more clearly than eloquently. We cure with things or herbs, not with verbs."[35] Vesalius vehemently rejected textual study in favor of empirical study, where firsthand evidence challenged accepted learning. In his influential illustrated treatises as well as the larger, evolving practice of medical instruction, images proved crucial to this new empirical practice. Early modern scientific images both spurred and attest to investment in autoptic observation of phenomena.

A close reading of a landmark painting by Rembrandt reveals the ways in which Vesalius's example both complicated and bolstered the role played by images in early modern anatomical instruction and, by extension, scientific study generally. *The Anatomy Lesson of Dr. Tulp* may be the most renowned early modern image of medicine in action and as such represents, literally and emblematically, a significant point of intersection between early modern science and art (Figure 31.4).[36] Completed in 1632 for the Surgeons' Guild of Amsterdam, the canvas features a pyramidal grouping of staid professionals, gathered attentively around the body of a cadaver the workings of whose left arm a black-hatted doctor expertly demonstrates. The painting has been understood to represent an actual event that can be located in historical time and place. That time is the winter of 1631–2 and the place the newly founded Atheneum – later the University – of Amsterdam. In combination with the fact that the painting is signed and dated on the scroll hanging on the far wall, the records of the Amsterdam Surgeons' Guild have been adduced to demonstrate that it documents an actual dissection conducted by the praelector of the guild, the prominent Amsterdam physician Nicolaas Tulp (1593–1674). Because it is known that Dr. Tulp demonstrated that winter on the body of the miserable criminal Adrian Adrianszoon, alias het Kint, a multiple offender who was hanged on 31 January 1632, it has been presumed that Rembrandt's painting records the appearances not only of the seven members of the guild in the presence of their praelector, but also of Aris 't Kint. Avidly craning and bending to view the events at hand, the seven surgeons portrayed are respectably engaged in the pursuit of the knowledge on which their trade depended.

Medical Practice Written in Honour of Charles Singer, ed. E. Ashworth Underwood, 2 vols. (London: Oxford University Press, 1953), 1: 374–85, at p. 378.

34 See Montagu, "Vesalius and the Galenists," 2: 378.

35 Eriksson, *Andreas Vesalius' First Public Anatomy*, pp. 54–5.

36 See Norbert Middelkoop, Ben Broos, Jorgen Vadum, and Petria Noble, *Rembrandt under the Scalpel: The Anatomy Lesson of Dr. Nicolaes Tulp Dissected* (The Hague: The Mauritshuis, 1998); W. S. Heckscher, *Rembrandt's Anatomy of Dr. Nicolaes Tulp: An Iconological Study* (New York: New York University Press, 1958); and W. Schupbach, *The Paradox of Rembrandt's Anatomy of Dr. Tulp* (London: Wellcome Institute for the History of Medicine, 1982).

Figure 31.4. *The Anatomy Lesson of Dr. Nicolaes Tulp*. Rembrandt van Rijn, 1632, oil on canvas. Reproduced by permission of The Mauritshuis, The Hague. Photography courtesy of Erich Lessin/Art Resource, New York.

Although Rembrandt's naturalism – his ability to capture the gestures, postures, facial expressions, and unique characteristics of the men gathered here – may corroborate the sense that this painting records an actual event, numerous aspects of the work are entirely artificial. Even if Dr. Tulp is meant to be conducting this particular demonstration in a makeshift location (the official Amsterdam Atheneum anatomical theater was not built until 1639), the setting is quite generic and the standard accoutrements of such demonstrations – linens, candles, lavender for the stench – are conspicuously absent. Moreover, as has frequently been noted, anatomical dissections never begin in the limbs of their subjects but in the abdominal cavity. (Indeed, the records indicate that the abdominal cavity was the primary focus of Dr. Tulp's second public demonstration of the winter of 1631–2.) What does this artifice convey? Paradoxically, the painting might more accurately reflect the teaching and practice of anatomy precisely by virtue of its being so artificially constructed. The multiple and ricocheting gazes of the men at work establish three foci: the pallid expanse of the corpse; the weighty folio-size volume propped up at 't Kint's feet, in the lower right of the composition; and the sheet of paper that the doctor to the left of Dr. Tulp is holding. This sheet of paper contains the sketchy lines of an anatomical drawing, painted to simulate a chalk drawing (occluded by the later addition of a list of names of the doctors present). The faint outlines of at least two arms can still be made out. This group portrait depended originally on and worked to iterate a three-way relationship among what were in the early modern period the fundamental components of medical study – namely, the corpse, the relationship between the dissection being performed and the text at the corpse's feet, and the relationship between the drawing and the actual observed specimen.

The relationship among the book, which we may presume to be an anatomical treatise, a generic but clearly anatomical drawing, and the body under examination is crucial. The published text and the drawing, or on-the-spot record, frame the body. In sum, what Rembrandt has engineered here is not merely a portrait of a number of the members of the guild, in the presence of their praelector, but an enactment of the production of medical knowledge as it was institutionalized starting in the mid-sixteenth century. Rembrandt's *Anatomy Lesson* demonstrates more than just biographical and professional associations among medical practitioners in the Netherlands. It illustrates the structure of anatomical study in the early modern period. The surgeons of the Amsterdam guild who elected to be painted here are portrayed in the act of producing medical knowledge, even as we observe them.

THE ARTIST AS SCIENTIST

Leonardo da Vinci exemplifies perhaps better than anyone else the close relationship between art and science in the early modern era, as well as the importance of trying to understand what these terms meant to contemporaries rather than taking them as self-evident and transhistorical categories. In his notes toward a projected treatise "On Painting," he observed:

> He who despises painting loves neither philosophy nor nature. . . . Truly this is science [*scientia*], the legitimate daughter of nature, because painting is born of that nature; but to be more correct, we should say the granddaughter of nature, because all visible things have been brought forth by nature and it is among these that painting is born. Therefore we may justly speak of it as the granddaughter of nature and as the kin of god.[37]

Although *scientia* has the general meaning of "knowledge" in this passage, it seems clear that Leonardo meant further to associate the art of painting with one type of knowledge in particular: the disciplined examination of nature. Among the features he emphasized in this latter connection were both mathematical demonstrations and experience, "without which nothing can be achieved with certainty."[38] By mathematical demonstrations, he meant to invoke arithmetic and geometry; from these, he wrote, perspective is born,

[37] Kemp, *Leonardo on Painting*, p. 13.
[38] Ibid., p. 14.

which is "devoted to all the functions of the eye and to its delight with various speculations."[39]

In the early modern era, accomplishments of all sorts were measured against a standard of artistic achievement: To be proclaimed the "Michelangelo" of one's field was to be accorded the highest honor. In 1612, the Florentine painter known as Cigoli (Ludovico Cardi, 1559–1613) compared Galileo with Michelangelo Buonarotti (1475–1564) in a letter to the mathematician in which he speaks of the propensity of both men to break rules and set new standards.[40] In many other respects, too, Galileo and his career bear comparison with his artist contemporaries; scholars have called him "close to being an artist in social terms and in practice"[41] and the "Michelangelo of mathematicians."[42] (When he was named court philosopher in 1610, he was granted a form of freedom very like that of the court artist). When early modern Europeans reflected on the enormous advances in human knowledge associated with their own period, they did not invoke theoretical innovations, such as Copernicus's rearrangement of the planets, but rather progress in technology and the arts. Commenting on the stasis of natural philosophy, in his *Novum organum* (New Organon, 1620), Bacon contrasted the plight of philosophy with the flourishing state of the "mechanical arts," which, he noted, "are always thriving and growing."[43]

Throughout the early modern era, artists were celebrated for their inventions: Jan van Eyck (1390–1441), the progenitor of early Netherlandish painting, was hailed repeatedly as the inventor of oil paint. Similarly, Filippo Brunelleschi (1377–1466) is still considered the inventor of pictorial perspective; and artists throughout the early modern era laid claim to their works by signing them with some variations on the term "invented."[44] In these cases as in others, artistic inventions were the result of experimentation. Countless authors have attempted to reconstruct Brunelleschi's every step as he produced the first perspectivally structured pictures (now lost) in the square of Florence's Duomo in the second decade of the fifteenth century. These were not self-sufficient paintings but components of an exercise or an experiment involving optics and pictorial representation.

Giorgio Vasari (1511–1574), best known for his monumental *Vite* (Lives) of Italian artists (first edition 1550), and the Dutch painter and author Karel

[39] Ibid.
[40] Bredekamp, "Gazing Hands and Blind Spots," p. 425. A long-standing historiographical tendency to equate Michelangelo and Galileo in particular is traced here and at p. 426.
[41] Ibid., p. 426.
[42] Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago Press, 1993), pp. 86–7. See also Martin Warnke, *The Court Artist: On the Ancestry of the Modern Artist*, trans. David McLintock (Cambridge: Cambridge University Press, 1993).
[43] Francis Bacon, *Novum organum*, trans. and ed. Peter Urbach and John Gibson (Chicago: Open Court, 1994), p. 84.
[44] See Evelyn Lincoln, *The Invention of the Italian Renaissance Printmaker* (New Haven, Conn.: Yale University Press, 2000), p. 6.

van Mander (1548–1606), who produced equally heroizing biographies of local artists half a century later in his *Schilder-Boeck* (Book of Painting, first edition 1604), wove yarns about the process by which van Eyck made his signal discovery. Van Mander wrote of his compatriot:

> What was never granted to either the Greeks, Romans or other peoples to discover – however hard they tried – was brought to light by . . . Johannes van Eyck. When he had finally thoroughly explored many oils and other natural materials, he found that linseed and nut-oil dried best of all; by boiling these along with other substances which he added, he made the best varnish in the world. And since such industrious, quick-thinking spirits strive toward perfection through continually researching, he discovered by much experimentation that paint mixed with such oils blended very well, dried very hard and when dry resisted water well; and also that the oil made the colors much brighter and shinier in themselves without having to be varnished. . . . Johannes was highly delighted with this discovery and with good reason: for an entirely new technique and way of working was created, to the great admiration of many.[45]

Van Mander credited van Eyck's invention as a crucial means to a venerable end: "Our art needed only this invention to approximate to, or be more like, nature in her forms."[46]

The attribution to van Eyck of the invention of oil glazes (the technique that enabled him and his followers to produce such striking effects of light and color and, in sum, such mirror-like painted surfaces) held fast in early modern artistic legend. The Flemish-born printmaker and draftsman Johannes Stradanus (Jan van der Straet, 1523–1605) included a visual account of van Eyck's invention in his series of prints illustrating new discoveries (the *Nova reperta*, ca. 1600) (Figure 31.5). The fourteenth plate in a series of twenty, which opens with the discovery of America and includes such other discoveries as the compass, the astrolabe, windmills, book printing, copperplate engraving, the calculation of longitude, and gunpowder, depicts the master painting in his commodious studio, surrounded by various assistants and apprentices (see Park and Daston, Chapter 1, this volume).[47]

In their encomia of van Eyck, Vasari and van Mander described the process of experimentation that led to his discovery. Vasari actually compared him to an alchemist, writing that he "set himself to make trial of various sorts of

[45] Karel van Mander, *Het Schilder-Boeck* (Haarlem: Paschier van Wesbusch, 1604), fol. 199r–199v.

[46] Ibid.

[47] The engraving is implausible in numerous respects: Jan van Eyck is not known to have painted St. George slaying the dragon, as he is depicted doing, nor did he ever paint on canvas or at the scale of the work propped up before him. The staging of van Eyck's invention in this setting is telling, nonetheless, on account of these discrepancies with the actual record. As the inscription implies, van Eyck's invention was of use to painters at large ("*Colorem oliui commodum pictoribus, Inuenit insignis magister Eyckius*"); in this sense, his studio may represent more the general expectations for how a painter worked in around 1600 than the Flemish master's actual domain.

Figure 31.5. *The Invention of Oil Paint by Jan van Eyck*. Jan Baptist Collaert after Johannes Stradanus (Jan van der Straet), ca. 1580, engraving, plate 14 of *Nova reperta*. Reproduced by permission of the McCormick Library of Special Collections, Northwestern University Library.

colours, and, as one who took delight in alchemy, to prepare many kinds of oil for making varnishes and other things dear to men of inventive brain, such as he was."[48] Was the artist's studio a sort of laboratory? The scientific laboratory had yet to be institutionalized in the sixteenth century, but the arenas of empirical observation and experiment had much to do with the domain of artistic production: Both were, in general, well-lit spaces in which material objects mediated between thought and praxis (see Smith, Chapter 13, this volume). Both were spaces for simulation and staging, often using elaborate full-size or small-scale models; both could be found in urban areas, attached to courts, or later as part of academies. In some cases, the substances and the practices were similar as well: It is difficult not to think of early modern science when we read recipes for paints or varnish, for example, or about devices such as a board featuring a peephole and an elaborate system of threads for constructing perspectival views.[49] The elevation of individuals deemed capable of invention and discovery through long experimentation,

[48] Giorgio Vasari, "Antonello da Messina," in *Lives of the Painters, Sculptors and Architects*, trans. Gaston du C. de Vere (New York: Alfred A. Knopf, 1996), pp. 424–9, at p. 425.

[49] Jane Turner, ed., *The Grove Dictionary of Art*, 34 vols. (New York: Grove's Dictionaries, 1996), 29: 850–5.

and the communication of ideals, techniques, and practical advice through what historian Paula Findlen has called the "paper republic" of European naturalists (or the generations of art theorists cited in this chapter) are factors that shaped both disciplines (see Bennett, Chapter 27, this volume).[50]

Stradanus's print (Figure 31.5) shows an environment set up for collaborative work. Making paintings (preparing drawing tools and brushes, grinding and mixing pigments, and constructing and assembling panels, canvases, and frames) involved multiple individuals, as the image shows. The workshop was also a place for education and training; assistants were learning the craft that they themselves aspired to master eventually. Apprentices and assistants such as are shown busy at work in van Eyck's studio were ultimately painted out of the master's work: They would have learned to work in the master's style, so that collaborative products would be seamless. Generally speaking, commissions were obtained and works conceived and supervised by the master. Where signed, they would bear only the name of the master. Authorship came to be negotiated carefully, particularly in the wake of the development of printing techniques.

With regard to the division of labor, the relationship between master and pupil or technician, and the attribution or proclamation of authorship, the operations of early modern artists' studios bear comparison with the structure of contemporary scientific endeavors. Both Rembrandt van Rijn (1606–1669) in Amsterdam and Peter Paul Rubens (1577–1640) in Antwerp accepted numerous apprentices into their care in exchange for which the masters were handsomely paid. A late seventeenth-century account of Rembrandt's studio attributes his financial and critical success at mid-career to the presence of so many ("all but countless") pupils in the master's studio.[51] Rembrandt and Rubens alone signed their works, however. In general, the visual arts revolved around a single-author model in spite of (and because of) the contribution of what the historian of science Steven Shapin, writing about early modern laboratories, has called "invisible technicians." The "collective character of empirical knowledge-making and knowledge-holding" in experimental science, whereby technicians' (or pupils') "skilled manipulations," "records," and "occasional inferential corollaries" were part and parcel of the finished work of the laboratory, maps very efficiently onto the production of art in the

[50] Paula Findlen, "The Formation of a Scientific Community: Natural History in Sixteenth-Century Italy," in *Natural Particulars: Nature and the Disciplines in Renaissance Europe*, ed. Anthony Grafton and Nancy Siraisi (Cambridge, Mass.: MIT Press, 1999), pp. 369–400.

[51] A. R. Peltzer, ed. *Joachim von Sandrarts Academie der Bau-, Bild-, und Mahlerey-Künste* (Munich: TK, 1925), p. 203. See Josua Bruyn, "Rembrandt's Workshop: Its Function and Production," in *Rembrandt: The Master and His Workshop*, ed. Christopher Brown, Jan Kelch, and Pieter van Thiel (New Haven, Conn.: Yale University Press, 1991), pp. 68–89. For a more daring interpretation, see Svetlana Alpers, *Rembrandt's Enterprise: The Studio and the Market* (Chicago: University of Chicago Press, 1988).

context of early modern studios.[52] Moreover, just as Robert Boyle's (1627–1691) and Robert Hooke's laboratories were extensions of domestic space, so, too, Rembrandt and Rubens accommodated the teaching and collaboration with pupils and apprentices in their homes (see Cooper, Chapter 9, this volume).[53]

Collaborative production took place under the shadow and in the domestic sphere of the master and was geared toward earning prestige and recognition for him alone. Evidence of the prevalence of this model of authorship and production in art is legion; its actual legislation is recorded in a guild regulation issued in 1651 in Utrecht that expressly forbade masters "to keep or employ any persons (whether foreign or native) as disciples or painting for them if they work in another [than the master's] manner (*handelinge*) or sign their own name."[54] Another, final example of ways in which artistic and scientific labor and practice resembled one another lies in the status of secrets in these respective domains.[55] Numerous celebrated early modern artists – Michelangelo, Hendrick Goltzius (1558–1617), and others – were adamant that they not be observed at work. Rembrandt is said to have devised a technique for the production of his etchings that allowed him to obtain the extraordinary effects for which they are still hailed and to have taken the technique with him to his grave.[56]

SCIENTIFIC NATURALISM

Despite its centrality to early modern explorations of nature, whether characterized as artistic or scientific, natural history illustration has occupied only a marginal place in the study of art history.[57] The art historian E. H. Gombrich referred disparagingly to early modern images intended to impart truthful records of their subjects as "illustrated reportage."[58] Erwin Panofsky wrote

[52] Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994), p. 358.

[53] On Boyle and Hooke, see Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis*, 79 (1988), 387–420.

[54] As cited in S. Muller Fz., *Schilders-vereenigingen in Utrecht* (Utrecht: Beijers, 1880), p. 76.

[55] Jacopo Ligozzi developed a set of secret techniques for layering colors and varnish in his botanical and zoological paintings for the Medici family; see Tongiorgi Tomasi, "The Study of the Natural Sciences," pp. 182–3. See also William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J.: Princeton University Press, 1994).

[56] Arnold Houbraken, *De groote schouburgh der Nederlantsche konstschilders en schilderessen, waar van'er veele met hunne beeltenissen ten toneel verschynen, en welker levensgedrag en konstwerken beschreven worden: zynde een vervolg op het SchilderBoek van K. v. Mander*, 3 vols. (Amsterdam: For the author, 1718–21), 1: 271.

[57] See, for a formidable exception, Eugenio Battisti, *L'Antirinascimento* (Milan: Feltrinelli, 1962), esp. chap. 9: "L'Illustrazione scientifica in Italia."

[58] Ernst Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation* (Princeton, N.J.: Princeton University Press, 1960), pp. 78–83.

of Leonardo's drawings of embryos that they "defy the borderline between scientific illustration and 'art'" – thereby excluding the former from the province of the latter.[59] Art historians have conventionally maintained that works of art and scientific images differ from one another constitutionally and irreconcilably: The former are vehicles for aesthetic expression, whereas the latter convey information, not truth or even style, quasi-anonymously. The distinction between the documentary status of scientific representation and the fictive or aesthetic potential of art and the impulse to categorize works as either artistic or scientific as such are legacies of Kantian aesthetics, which was extremely influential in shaping the discipline of art history. Relative values assigned to the two sorts of images are consistent with the hierarchy of the academic ranking of genres of painting, which prizes narrative compositions (*istorie*) over modes of representation concerned "merely" with mirroring the world at hand and the stuff of nature. In addition, the canon of fine arts has long depended on the Kantian notion that interest precludes the aesthetic. That is, the use to which scientific images are put largely disqualifies them from inclusion in studies of fine art.

We have seen that relationships between early modern art and science were rife at the level of praxis. However, the mid-nineteenth-century opposition between art and science, in which polarities such as subjective art versus objective science emerged, and the development of distinct disciplinary models in art and science (as well as in the history of art and the history of science) have occluded significant areas of overlap. More recent developments in the history of science encourage further examination of how intersections between art and science might be traced. Sociologist of science Bruno Latour has subsumed the abundance of pictures, words, diagrams, and signs produced as part of the working life of a laboratory under the elastic heading of "immutable mobiles," offering a way to treat diverse representational practices without the interference of familiar distinctions such as art/science or image/fact.[60] Scholarly attention has also been devoted to the spectacularization of experimentation and demonstration, and to social practices associated with the investigation of the natural world.[61] In both the history of art and the history of science, more recent scholarship has emphasized the importance of excavating the categories of the historical actors themselves in order to avoid anachronistic projections of later models of art, science, and their interactions onto phenomena in early modern Europe. Our conclusion

[59] Erwin Panofsky, "Artist, Scientist, Genius: Notes on the Renaissance-Dämmerung," in *The Renaissance: A Symposium* (New York: Metropolitan Museum of Art, 1953), pp. 77–93, at p. 87.

[60] Bruno Latour, "Drawing Things Together," in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar [1988] (Cambridge, Mass.: MIT Press, 1990), pp. 19–68.

[61] In her analysis of the art collection of the Leiden physicist Franciscus dele Boë Sylvius (1614–1672), Pamela Smith has demonstrated that the relationships between art and science in the early seventeenth century by no means traveled a one-way street. See Smith, "Science and Taste: Painting, Passions, and the New Philosophy in Seventeenth-Century Leiden," *Isis*, 90 (1999), 421–61.

illustrates the difference in interpretation this can make by comparing two models for interpreting early modern relationships between art and science. One is a critical category introduced by a twentieth-century scholar, and the other is a term used by early modern artists and their audiences to describe a particular mode of representation.

The Austrian art historian and psychoanalyst Ernst Kris (1900–1957) coined the term "scientific naturalism" (*wissenschaftlicher Naturalismus*) in reference to works by the Flemish artist Joris Hoefnagel (1542–1601), who was renowned for the extraordinary books he illuminated for Rudolf II in the 1580s and 1590s.[62] Kris showed that Hoefnagel's celebrated attentiveness to the characteristic morphology of naturalia such as plants and insects is as much a feature of his courtly works as of his early chorographic works, which were done in the employ of the Antwerp cartographer Abraham Ortelius (1527–1598). Kris identifies Hoefnagel's interest in nature as "the most acute and characteristic expression of an attitude" more widely held during the period; indeed, he proposes that we speak of "a naturalistic style circa 1600." Citing Dürer as the spiritual patron of this style, Kris defined it as follows: "For the first time it was meaningful to represent a piece of turf or an animal as a picture unto itself, with no aim other than to penetrate as deeply as possible the characteristics of nature."[63] Under the rubric of *wissenschaftlicher Naturalismus* Kris also cited the naturalist painters Hans Hofmann (ca. 1545–ca. 1591) and Daniel Froeschl (1563–1613), who worked at the Hapsburg court in Prague and for the Medici in Florence, and still life and nature painters Roelant Savery (1576–1639; Savery also painted for Rudolf II in Prague), Ambrosius Bosschaert (1573–1621), and Jan Brueghel the Elder (1568–1625).[64] Kris traced the practice of *wissenschaftlicher Naturalismus* south of the Alps as well by adducing the extraordinary watercolors of birds and plants by Ligozzi. Although Kris stated that the style practiced by Hoefnagel and his contemporaries had its roots outside of the domain of art (and, instead, in intellectual and cultural developments), his interest in scientific naturalism lay ultimately in its usefulness in describing a form of artistic expression that is more committed to nature than to the precepts and conventions of Renaissance and Baroque art.

"Scientific naturalism" is certainly useful in helping to organize a broad and frequently overlooked domain of artistic production. Yet *wissenschaftlicher Naturalismus* is a stylistic diagnostic applied a posteriori that fails to take into account the conditions under which these works were produced and the extent to which the naturalism in question served the ends of science.

[62] Kris, "Georg Hoefnagel und der wissenschaftliche Naturalismus."

[63] Ibid., p. 252.

[64] See Koreny, *Albrecht Dürer and the Animal and Plant Studies of the Renaissance*; Thomas DaCosta Kaufmann, *The School of Prague: Painting at the Court of Rudolf II* (Chicago: University of Chicago Press, 1988); and Paul Taylor, *Dutch Flower Painting, 1600–1720* (New Haven, Conn.: Yale University Press, 1995).

It serves instead as an additional stylistic category that might usefully supplement existing art-historical taxonomies. A more probing investigation of the area of overlap between artistic and scientific modes of picturing the world is to be found in art historian Svetlana Alper's interpretation of seventeenth-century Dutch art. The distinctively Netherlandish descriptive mode of picturing, she argues, is inherently compatible with early modern empiricism: "Already established pictorial and craft traditions, broadly reinforced by the new experimental science and technology, confirmed pictures as the way to new and certain knowledge of the world."[65] Alpers, however, is explicitly uninterested in images actually employed in early modern science; her purview is, ultimately, fine works of art.[66] A potentially more helpful tool for analyzing artistic and scientific naturalism and the countless early modern images that instantiate it may lie in the conception of works made *ad vivum* or from the life. Numerous early modern authors and purveyors of images promised – in print and in inscription – that their pictures were made "from the life."[67] The phrases *ad vivum*, *naer het leven*, *nach dem Leben*, *au vif*, and *al vivo* were widely applied to portraits, maps, and botanical and other natural-history images. Such works, claimed to have been done from life, did not all look alike: What conjoins them are the claims made for how they were produced. The mimetic potential of images made in this way came to be exploited for artistic as well as documentary ends: From 1530 on, illustrated natural history depended heavily on this qualifying term, and by 1600 the phrase had been integrated into art theory.

The rapid spread of the phrase *ad vivum* is a curious and crucial fact.[68] It was, moreover, associated with special skills. In 1591, Flemish botanist Joseph Goedenhuize (Giuseppe Casabona, 1535–1595) wrote a letter to his patron the Grand Duke of Tuscany, Ferdinand de' Medici (d. 1609), in which he mentioned a "young German artist" (Georg Dyckman, dates unknown), whom he had paid to paint all the plants of Crete *al vivo*. Goedenhuize added that the young artist was "rather talented in this profession."[69] Goedenhuize

[65] Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983), p. xxv.

[66] "I shall not take up here the interesting problem of the nature and role of illustration in the works of the Dutch naturalists." Ibid., p. 84.

[67] *The Oxford English Dictionary*, 2nd ed., ed. J. A. Simpson and E. S. C. Weiner, 20 vols. (Oxford: Clarendon Press, 1989), 8: 911, where "the life" is defined as "the living form or model" or "living semblance," and "after, from the life" are defined as "(drawn) from the living model." See "to the life": "with life-like presentation of or resemblance to the original (said of a drawing or painting); with fidelity to nature; with exact reproduction of every point or detail." The earliest examples of the use of the English phrases are 1599 (William Shakespeare) and 1603 (Ben Jonson), respectively. See also Claudia Swan, "*Ad vivum, naer het leven*, from the Life: Considerations on a Mode of Representation," *Word and Image*, 11 (1995), 353–72.

[68] This claim was already made in the text of the early *Gart der Gesundheit* (Mainz, 1484); these woodcuts are vastly more schematic than those published by Brunfels and his followers, all of whom invoke the same phrase.

[69] Lucia Tongiorgi Tomasi, "Daniel Froeschl before Prague: His Artistic Activity in Tuscany at the Medici Court," in *Prag um 1600: Beiträge zur Kunst und Kultur am Hofe Rudolfs II*, 2 vols. (Freren:

deemed working "from the life" a profession, but it was the great Bolognese naturalist and collector Aldrovandi who offered the most sustained commentary on images done *al vivo*.[70] Aldrovandi wrote: "There is nothing on earth that seems to me to give more pleasure and utility to man than painting, and above all paintings of natural things: because it is through these things, painted by an excellent painter, that we acquire knowledge of foreign species, although they are born in distant lands."[71] Aldrovandi also declared that painting is most honorable as an art because it can imitate "the product[s] of nature *al vivo*."[72] "I say," he wrote of images, "that they are of great utility to students, when they are painted *al vivo*, as are also other images, of fish and terrestrial animals and birds."[73] His views on the usefulness of painting and, in particular, painting that does not suffer stylistic or otherwise "artistic" embellishments, are borne out by the truly vast collection of images of the natural world he commissioned, assembled, and published.[74]

Within the context of the rapid development of illustrated natural history in the sixteenth century, the phrase *ad vivum* and its vernacular renderings served to assure viewers or readers of the documentary value of images so described. It guaranteed the images' trustworthiness by vouching for their direct connection to the world observed. Indeed, within a culture that valued the exchange of spectacular information, to make the claim that an image was done "from the life," whether true or not, secured an audience and may have increased its economic value.[75] More broadly speaking, to invoke such terms as *ad vivum* or *naer het leven* was to exercise an internationally valid password in a network of naturalists joined by correspondence and publications. In the early modern period, especially prior to the formation of scientific societies that controlled the flow of information, that community depended upon

Lura Verlag, 1988), 2: 289–98, at pp. 289–91. However, for the correct identification of the artist as Georg Dyckman, see Giuseppe Olmi, "'Molti amici in varij luoghi': Studio della natura e rapporti epistolari nel secolo XVI," *Nuncius*, 6 (1991), 3–31, at p. 25.

[70] On Aldrovandi, see Sandra Tugnoli Pattaro, *Metodo e sistema delle scienze nel pensiero di Ulisse Aldrovandi* (Bologna: Cooperative Libraria Universitaria Editrice Bologna, 1981); Olmi, *L'Inventario del Mondo: Catalogazione della natura e luoghi del sapere nella prima età moderna* (Bologna: Il Mulino, 1992), esp. pp. 21–117 and bibliography; and Findlen, *Possessing Nature*.

[71] Bibliotheca Universitaria, Bologna, MS Aldrovandi, 6 vols., 1: fol. 35r, as quoted in Olmi, *L'Inventario del Mondo*, p. 24.

[72] Biblioteca Universitaria, Bologna, MS Aldrovandi, 6 vols., 2: fol. 129v, as quoted in Olmi, "Osservazione della natura e raffigurazione in Ulisse Aldrovandi (1522–1605)," *Annali dell'Istituto Storico Germanico Italiano in Trento*, 3 (1977), 105–81, at p. 109.

[73] Biblioteca Universitaria, Bologna, MS Aldrovandi, 6 vols., 1: fol. 35r, as quoted in Olmi, "Arte e natura nel Cinquecento bolognese: Ulisse Aldrovandi e la raffigurazione scientifica," in *Le arti a Bologna e in Emilia dal XVI al XVIII secolo*, ed. Andrea Emiliani, 4 vols. (Bologna: Cooperative Libraria Universitaria Editrice Bologna, 1982), 4: 151–73, at p. 155.

[74] Biblioteca Universitaria, Bologna: Fondo Ulisse Aldrovandi Tavole di Piante, Fiori e Frutti, vol. 01–1, fol. 76, and vol. 04-Unico, fol. 35. The BUB maintains a Web site containing reproductions of all of Aldrovandi's natural-history drawings: http://www.filosofia.unibo.it/aldrovandi.

[75] On the representation of natural wonders and other miraculous or curious phenomena, see especially Peter Parshall, "Imago Contrafacta: Images and Facts in the Northern Renaissance," *Art History*, 16 (1993), 554–79, esp. pp. 564 ff. See also Jean Céard, *La nature et les prodiges: L'Insolite au XVIe siècle, en France* (Geneva: Droz, 1977); and Daston and Park, *Wonders and the Order of Nature*.

what Shapin has called "epistemological decorum."[76] Of the expansion of factual knowledge that was a hallmark of the period, and of how it came to be managed, he has observed: "The work of prying open the inherited box of plausibility and restocking it with new things and phenomena was fundamental to the emergence of new intellectual practices. In the process, new and modified forms for the making and warranting of empirical truth had to be proposed and put in place."[77]

The two-step movement of questioning ancient authority and, at the same time, gathering the evidence of natural particulars, impartially and in accordance with what Lorraine Daston has branded "the factual sensibility," underlies much early modern natural history, as systematized by Bacon and his many followers.[78] The natural historians who practiced their discipline correctly were, Bacon declared, "faithful secretaries [who] do but enter and set down the laws themselves of nature and nothing else," who compile a warehouse of particulars from which true induction might proceed.[79] The catalogues of the plant world described *ad vivum*, the numerous drawings by Dürer and Leonardo, among others, and so many other early modern scientific images amount to warehouses, inscribed by faithful secretaries – or, at least, scribes who declared their epistemological decorum by way of this mode of representing nature's particulars.

[76] Shapin, *A Social History of Truth*, esp. chap. 5: "Epistemological Decorum: The Practical Management of Factual Testimony," pp. 193–242.

[77] Ibid., p. 195.

[78] Lorraine Daston, "Baconian Facts, Academic Civility, and the Prehistory of Objectivity," *Annals of Scholarship*, 8 (1991), 337–63. On Bacon's scientific method, see Paolo Rossi, *Francis Bacon: From Magic to Science* [1957], trans. Sacha Rabinovitch (Chicago: University of Chicago Press, 1968), esp. chaps. 2 and 4; and *The Cambridge Companion to Bacon*, ed. Markku Peltonen (Cambridge: Cambridge University Press, 1996).

[79] Francis Bacon, "Preparative towards a Natural and Experimental History," 10 (on "scribae fideles") and 3 (on the repository of knowledge), in *The Works of Francis Bacon, Baron of Verulam, Viscount of St. Alban, and Lord Chancellor of England [1857–74]*, ed. James Spedding, R. L. Ellis, and D. D. Heath, 14 vols. (New York: Garrett Press, 1968), 4: at 262 and 254–5, respectively.

32

GENDER

Dorinda Outram

Historians have often linked two quite separate phenomena: the gendering of early modern natural inquiry as a masculine form of activity in theory and, to a large extent, in practice, and the gendering of nature as female in many early modern texts and images. There is no necessary logical connection between these two phenomena, despite persistent and profound historiographical investments in their linkage, most notably as part of broader critiques of the scientific enterprise by writers with feminist commitments. But there are important and interesting historical connections, which this chapter seeks to explore.

The critical focus on the masculine nature of scientific activity has had the longer history. Antivivisection campaigns in nineteenth-century Britain and America, for example, often (though not always) overlapped with feminist concerns. Antivivisectionists saw biological science in particular as indelibly marked by cruelty toward the animals it used as experimental subjects and by an attitude toward nature that placed more emphasis on advancing scientific knowledge than on respect for the natural world.[1] Others claimed more generally that certain qualities of the scientific enterprise reflected its "masculine" character, that is, were rooted in force and power, as were gender relations in society as a whole. One such writer was Clémence Royer (1830–1902), the first French translator of the works of Charles Darwin (1809–1882), a member of Paul Broca's (1824–1880) Anthropological Society, and a lifelong activist for feminist and other movements of social reform. In her *Le bien et la loi morale* (The Good and the Moral Law) of 1881, she described science as masculine in its practitioners and thereby "masculine" in its practices.[2]

[1] Coral Lansbury, *The Old Brown Dog: Women, Workers, and Vivisection in Edwardian England* (Madison: University of Wisconsin Press, 1985); and Roger French, *Anti-Vivisection in Victorian Society* (Princeton, N.J.: Princeton University Press, 1975).

[2] Clémence Royer, *Le bien et la loi morale; Éthique et téléologie* (Paris: Guillaumin, 1881); see also Joy Harvey, *"Almost a Man of Genius": Clémence Royer, Feminism, and Nineteenth-Century Science* (New Brunswick, N.J.: Rutgers University Press, 1997).