7

WOMEN OF NATURAL KNOWLEDGE

Londa Schiebinger

"L'esprit n'a point de sexe" ("the mind has no sex"), declared François Poullain de la Barre (1647–1723) in 1673 in an effort to level what he considered "the most remarkable of all prejudices": the inequality of the sexes. [1] An ardent Cartesian, he set out to demonstrate that the mind – distinct from the body – has no sex. New attitudes toward women, such as those voiced by Poullain and others, raised questions about female participation in natural knowledge, itself a novel enterprise struggling for recognition within established hierarchies. In the sixteenth and seventeenth centuries, the relation of natural inquiry to church, king, households (grand and humble), princely coffers, and global and local marketplaces was in a state of flux. Important questions remained to be answered about natural knowledge – its ideals and methods, its proper limits, and who should mold them.[2] The looser institutional organization and openings in attitudes allowed women to enter into natural inquiry through a number of informal arrangements and, in some cases, make important contributions to natural knowledge.

At a time when participation in natural inquiry was regulated to a large extent by social standing, men and women seeking to understand nature came primarily from two distinct social groups: learned elites and artisans (see Shapin, Chapter 6, this volume). The humanistic literati mixed in

[1] François Poullain de la Barre, *De l'égalité des deux sexes: Discours physique et moral* (Paris: Jean du Puis 1673), preface. Materials in this chapter are drawn in part from Londa Schiebinger, *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989), pp. 1–101.

[2] Alexandre Koyré, *From the Closed World to the Infinite Universe* (Baltimore: Johns Hopkins University Press, 1957); Robert Merton, *Science, Technology, and Society in Seventeenth Century England* [1938] (New York: H. Fertig, 1970); A. Rupert Hall, *The Revolution in Science, 1500–1750* (New York: Longmans, 1983); H. Floris Cohen, *The Scientific Revolution: A Historiographical Inquiry* (Chicago: University of Chicago Press, 1994); S. A. Jayawardene, *The Scientific Revolution: An Annotated Bibliography* (West Cornwall: Locust Hill Press, 1996). The notion that universities stood in the way of the new sciences has been challenged in Mordechai Feingold, *The Mathematicians' Apprenticeship: Science, Universities, and Society in England, 1560–1640* (Cambridge: Cambridge University Press, 1984).

courtly circles, scientific academies, and salons, while skilled craftsmen and craftswomen fashioned telescopes and astrolabes, made maps, and refined techniques for capturing with exactitude the minutest details of natural phenomena. In addition to these two groups, European peasants, fishermen, women who gathered medicinal herbs, and others served as informants to naturalists. William Eamon (Chapter 8, this volume) discusses how Ulisse Aldrovandi (1522–1605) visited fish markets to learn the names, habits, and unique characteristics of fish. Harold Cook has argued against a historiography that emphasizes too stringent a separation of head and hand, suggesting that especially in the Dutch Republic (and one might add the German lands) precisely the marriage of book learning and craft skills produced that ferment in knowledge still sometimes instructively referred to as the Scientific Revolution.[3] Nonetheless it is useful to highlight the nonacademic training offered within artisanal workshops that worked to the advantage of women and men of lower estates.

This chapter investigates the shifting institutional foundations of natural knowledge during the revolutions that marked its origins in the sixteenth and seventeenth centuries, and the changing fortunes of women within those institutions. We look first at the world of learned elites: universities, princely courts, informal humanist circles, scientific academies, and Parisian salons. These networks of literati are contrasted with the workshops of the skilled craftsmen and craftswomen. The chapter closes with a look outward from Europe, investigating the naturalists who undertook long and arduous journeys during the expansive voyages of scientific discovery.

LEARNED ELITES

Without proper training, access to libraries, instruments, and networks of communication, it is difficult for anyone – man or woman, highborn or lowborn, European or non-European – to make significant contributions to knowledge. Historically, women have not fared well in European institutions of learning. From their origins in the twelfth century, universities were, in principle, closed to women. Unlike religious houses, which had been centers of learning for both men and women, universities provided formal training in theology, law, and medicine aimed at preparing young men for careers in the church, government, or teaching. Women, barred from these learned professions, were not expected to enter the university.[4]

[3] Harold Cook, "The New Philosophy in the Low Countries," in *The Scientific Revolution in National Context*, ed. Roy Porter and Mikuláš Teich (Cambridge: Cambridge University Press, 1992), pp. 115–49. For a critique of the notion of a "scientific revolution," see Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996).

[4] Paul Kristeller, "Learned Women of Early Modern Italy: Humanists and University Scholars," in *Beyond Their Sex: Learned Women of the European Past*, ed. Patricia Labalme (New York: New York

Although today it would be difficult for anyone prohibited from entering universities to work in science, this was not the case in the early modern period. At this time, as Steven Shapin discusses (Chapter 6, this volume), "men of science" cultivated natural knowledge in a variety of settings: Galileo Galilei (1564–1642) was a resident astronomer at the court of Cosimo de' Medici; Francis Bacon (1561–1626) and Gottfried Wilhelm Leibniz (1646–1716) were government ministers as well as men of letters; and René Descartes (1596–1650), Christiaan Huygens (1629–1695), and Robert Boyle (1627–1691) were men of independent means.

In the absence of clearly established prerequisites of education and certification, participation in natural knowledge was regulated largely by networks of princely, aristocratic, and ecclesiastical patronage. The key to courtly and private patronage was power – not raw military might, but rather a highly ritualized exchange of gifts and status. A prince's courtiers, some of whom, such as Galileo, were mathematicians and philosophers, added to the luxurious ostentation of a court where displays of self-glorification affirmed the prince's title and power. In their turn, courtiers basked in the reflected glory of their patrons. Such an exchange is portrayed in the frontispiece to Johannes Kepler's (1571–1630) *Tabulae Rudolphinae* (Rudolphine Tables, 1627); here Emperor Rudolf II's imperial eagle drops talers from its beak and spreads protective wings over Kepler's "temple of astronomy."[5] The development of informal intellectual circles worked to the advantage of wellborn women whose high social standing allowed them to wield influence in the learned world, as it did in other domains of culture. Genteel women insinuated themselves into networks of learned men by exchanging patronage or public recognition for discourse with men of lesser rank but of significant intellectual stature.

Women in princely courts and the informal scientific circles that emerged from them served as important patrons, interlocutors, hostesses, and ready consumers of natural knowledge and curiosities – matters of import in an age when patronage often structured a naturalist's identity and career.[6] In the exchange characteristic of this system, Christina (1626–1689), queen of Sweden, invited Descartes to her court in the 1640s to serve as her tutor in natural philosophy and mathematics and to draw up regulations for her scientific academy. In the 1690s, Sophie Charlotte (1668–1705), electress of Brandenburg and later queen of Prussia, supported Leibniz in founding the

University Press, 1984), pp. 117–28; David Noble, *A World without Women: The Christian Clerical Culture of Western Science* (Oxford: Oxford University Press, 1993).

[5] I. Bernard Cohen, *Album of Science: From Leonardo to Lavoisier, 1450–1800* (New York: Scribner, 1980), p. 53, n. 68; Bruce Moran, ed., *Patronage and Institutions: Science, Technology, and Medicine at the European Courts, 1500–1750* (Rochester: Boydell Press, 1991); and Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago Press, 1993).

[6] On the creation of identities, see Stephen Greenblatt, *Renaissance Self-Fashioning: From More to Shakespeare* (Chicago: University of Chicago Press, 1980); on the economy of discourse characteristic of this period, see Anne Goldgar, *Impolite Learning: Conduct and Community in the Republic of Letters, 1680–1750* (New Haven, Conn.: Yale University Press, 1995), pp. 12–53.

Societas Regia Scientiarum, with its new astronomical observatory, in Berlin.[7] To my knowledge, however, no woman served as court philosopher; there was, in other words, no female Galileo, a client of princely patronage whose charge it was to plumb the depths of natural philosophy.[8] Although a few wellborn women, such as the Princess Elisabeth (1618–1680) of Bohemia, proved themselves acute natural and moral philosophers (as Elisabeth did in her correspondence with Descartes), most served as patrons rather than as producers of natural knowledge.

In the late seventeenth century, the scepter of learning passed from courtly circles to learned academies. Historians of science have identified the founding of Europe's scientific academies – the Accademia dei Lincei in Rome, the Accademia del Cimento in Florence, the Royal Society in London, and the Académie Royale des Sciences in Paris – as key steps in the emergence of modern natural knowledge.[9] These princely academies provided social prestige and often religious and political protection for the fledgling natural knowledge. State recognition of natural knowledge also coincided with a more stringent exclusion of women from scientific institutions.[10] This exclusion of women, however, was not a foregone conclusion and requires explanation.

The seventeenth-century scientific academies had their roots in two distinct traditions – the medieval university and the Renaissance court. Insofar as academies were rooted in universities, an explanation for women's exclusion is easily found in the traditions of those all-male institutions. It is also possible, however, to see scientific societies as descendants of courtly circles and the informal intellectual gatherings that emerged alongside them.[11] If we emphasize the continuities between scientific academies and Renaissance courtly culture – where women were active participants – it becomes more difficult to explain the exclusion of women from these academies.

Take the case of the Parisian Académie Royale des Sciences. Women joined in the informal *réunions*, salons, and scientific circles that flourished in late sixteenth- and early seventeenth-century Paris.[12] They gathered among the curious every Monday at Hermeticist Théophraste Renaudot's (1586–1653) Maison du Grand Coq on the Ile de la Cité in Paris to observe his

[7] Adolf von Harnack, *Geschichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin* [1900], 3 vols. (Hildesheim: Georg Olms, 1970), 1: 124.

[8] At the French court, Christine de Pizan (ca. 1363–ca. 1431) wrote several commissioned works in the fifteenth century.

[9] David Lux, *Patronage and Royal Science in Seventeenth-Century France: The Académie de Physique in Caen* (Ithaca, N.Y.: Cornell University Press, 1989); and Alice Stroup, *A Company of Scientists: Botany, Patronage, and Community at the Seventeenth-Century Parisian Royal Academy of Sciences* (Berkeley: University of California Press, 1990).

[10] Joan Landes, ed., *Feminism, the Public and the Private* (Oxford: Oxford University Press, 1998).

[11] Frances Yates, *The French Academies of the Sixteenth Century* (London: Warburg Institute, 1947), p. 1; and Martha Ornstein, *The Role of Scientific Societies in the Seventeenth Century* (Chicago: University of Chicago Press, 1928). On women as cultural ambassadors, see Susan Groag Bell, "Medieval Women Book Owners: Arbiters of Lay Piety and Ambassadors of Culture," *Signs*, 7 (1982), 742–68.

[12] G. Bigourdan, "Les premières sociétés scientifiques de Paris au XVII[e] siècle," *Comptes rendues de l'Académie des Sciences*, 163 (1916), 937–8.

experiments. Women were also present among the Cartesians, persons of "all ages, both sexes, and all professions," who gathered every Wednesday at Jacques Rohault's (1620–1675) home to watch him attempt to give an experimental base to Descartes' physics.[13] In the years preceding the founding of the Académie Royale des Sciences, women attended the Palais Précieux pour les Beaux Esprits des Deux Sexes and flocked to the salons of the Marquise de Sévigné (1626–1696) and the Duchess of Maine (1676–1753). The number of women attending informal academies grew at such a rate that Pierre Richelet (1626–1698) added the word *académicienne* to his famous dictionary in the 1680s, explaining that this was a new word signifying a person of the fair sex belonging to an academy of *gens de lettres*, coined on the occasion of the election of Madame des Houlières (1638–1694) to the Académie Royale d'Arles.[14]

Despite their prominence in informal scientific circles, women were not to become members of the Académie Royale des Sciences. Why not? Certain aspects of the French academic system could have encouraged the election of gentlewomen. Seventeenth-century academies perpetuated Renaissance traditions where learning mixed with elegance, adding grace to life and beauty to the soul. The Académie retained a conviviality in its program, with rules of etiquette and a routine of dinners and musical entertainment, all of which tended to blur the boundaries that would later separate the academies from the salons.[15] This was an atmosphere in which wellborn women might have flourished. At the same time, the Académie was monarchical and hierarchical. At its head sat twelve honorary nobles whose presence was largely ornamental; working naturalists – the new aristocracy of talent – found themselves on a lowlier rung. Yet noble birth was not enough to secure even an honorary place for women. The closed and formal character of the academy discouraged the election of women. Membership in the academy was a public, salaried position with royal protection and privileges.[16] Although a salaried position in itself might not preclude women – the illustrious Marie le Jars de Gournay (1565–1645), for example, received a modest *pension* from Richelieu until her death in 1645 – in the case of the Académie, with the membership limited to forty, the election of a woman would have displaced a man.

[13] Claude Clerselier, ed., *Lettres de Mr. Descartes* [1659], 6 vols. (Paris: Charles Angot, 1724), 2: preface. On Renaudot's gatherings, see Howard Solomon, *Public Welfare, Science, and Propaganda in Seventeenth Century France: The Innovations of Théophraste Renaudot* (Princeton, N.J.: Princeton University Press, 1972).

[14] Pierre Richelet, *Dictionnaire de la langue françoise, ancienne et moderne*, 3 vols. (Lyon, 1759), 1: 21.

[15] Harcourt Brown, *Scientific Organizations in Seventeenth-Century France, 1620–1680* (Baltimore: Williams and Wilkins, 1934); and Roger Hahn, *The Anatomy of a Scientific Institution: The Paris Academy of Science, 1666–1803* (Berkeley: University of California Press, 1971).

[16] Members supplemented the modest salary of 2,000 livres per year with private funds. Charles Gillispie, *Science and Polity in France at the End of the Old Regime* (Princeton, N.J.: Princeton University Press, 1980), pp. 81–2.

Women fared no better in England with the founding of the Royal Society of London in 1662. The Royal Society was open – at least ideologically – to a wide range of people. Thomas Sprat (1635–1713), the first historian of the society, emphasized that valuable contributions were to come from both learned and vulgar hands: "from the Shops of *Mechanicks*; from the Voyages of *Merchants*; from the Ploughs of *Husbandmen*; from the Sports, the Fishponds, the Parks, the Gardens of *Gentlemen*."[17] In fact the Royal Society never made good its claim to welcome men of all classes; the entrance fees and weekly dues alone discouraged those of humble means. Merchants and tradesmen comprised only four percent of the society's membership; the vast majority of the members (at least fifty percent in the 1660s) came from the ranks of gentlemen virtuosi, or wellborn connoisseurs of the new natural knowledge.[18] Considering that the Society relied for its monies on dues paid by members, the absence of noblewomen from the ranks of enthusiastic patrons is difficult to explain.

One woman in particular, Margaret Cavendish (1623–1673), Duchess of Newcastle, was a qualified candidate, having written some eight books on natural philosophy. Fellows of noble birth bestowed prestige upon the new Society; men above the rank of baron could become members without scientific qualifications. However, when Cavendish – a duchess – asked for nothing more than a visit, her request aroused great controversy. Her now famous visit took place in 1667. Robert Boyle prepared his "experiments of . . . weighing of air in an exhausted receiver; [and] . . . dissolving of flesh with a certain liquor."[19] The duchess, accompanied by her ladies, was much impressed and left (according to one observer) "full of admiration."[20] She did not, however, when asked, contribute funds to the Royal Society.[21]

Margaret Cavendish's one fleeting encounter with the men of London's Royal Society indeed appears to have set a precedent – a negative one: no woman was elected to full membership until 1945. This pattern did not hold uniformly across Europe. The Académie Royale des Sciences did not admit

[17] Thomas Sprat, *History of the Royal Society of London* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667), pp. 62–3, 72, 435.

[18] The society required new members to pay an admittance fee of 10, and later 20, shillings. (Peers were required to pay £5.) Fellows were expected to pay a weekly subscription of 1 shilling. See Michael Hunter, *The Royal Society and Its Fellows, 1660–1700: The Morphology of an Early Scientific Institution* (Chalfont St. Giles: British Society for the History of Science, 1982), pp. 15, 24, tables 5–7.

[19] Thomas Birch, *History of the Royal Society*, 4 vols. (London: Printed for A. Millar, 1756–7), 2: 175.

[20] Samuel Pepys, *The Diary of Samuel Pepys*, ed. Robert Latham and William Matthews, 11 vols. (London: Bell, 1970–83), 8: 243. See also Samuel Mintz, "The Duchess of Newcastle's Visit to the Royal Society," *Journal of English and Germanic Philology*, 51 (1952), 168–76; Douglas Grant, *Margaret the First: A Biography of Margaret Cavendish, Duchess of Newcastle, 1623–1673* (London: Hart-Davis, 1957); Kathleen Jones, *A Glorious Fame: The Life of Margaret Cavendish, Duchess of Newcastle, 1623–1673* (London: Bloomsbury, 1988). For other women, see Lynette Hunter, "Sisters of the Royal Society: The Circle of Katherine Jones, Lady Ranelagh," in *Women, Science, and Medicine, 1500–1700*, ed. Lynette Hunter and Sarah Hutton (Gloucestershire: Sutton, 1997), pp. 178–97.

[21] Michael Hunter, *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge: Boydell Press, 1989), pp. 167, 171.

women until the 1970s, but Italian academies in Bologna, Padua, Rome, and elsewhere did admit a few accomplished women, such as Madeleine de Scudéry (1607–1701) in the seventeenth century, and Laura Bassi (1711–1778) and Emilie du Châtelet (1706–1749) in the eighteenth century. The Académie Royale des Sciences et Belles-Lettres in Berlin (as it was styled in the eighteenth century) also admitted honorary luminaries, including Catherine the Great of Russia (1729–1796) and Duchess Juliane Giovane, a poet and woman of letters.[22]

The focus of historians on academies has drawn attention away from another legitimate heir of courtly circles – the salons. In contrast with the massive public receptions of the Italian *saloni*, the French salons offer a unique example of intellectual institutions run by women. Featuring intimate intellectual gatherings in the sitting rooms of socially prominent women, these elegant gatherings of diverse character competed with academies for the attention of the learned. Like the French academies, the salons created cohesion among intellectual elites; Bernard de Fontenelle (1657–1757), for example, longtime secretary of the Académie Royale des Sciences, became *président* of Madame Lambert's (1647–1733) salon. They also played a crucial role in assimilating the rich and talented into the French aristocracy.[23] The discussion of natural knowledge – examination of the exact characteristics of the two chameleons sent to Scudéry by the consul of Alexandria in 1672, for example – was fashionable in Scudéry's salon as well as in the salons of Madame Rochefoucauld and Madame Tencin (1685–1749).[24] Despite their informal and private character, salons wielded influence in public matters: Women, such as Madame Lambert, served as intellectual power brokers at a time when natural knowledge was organized through highly personalized patronage systems.

[22] Kathleen Lonsdale and Marjory Stephenson were elected to the Royal Society in 1945 (*Notes and Records of the Royal Society of London*, 4 [1946], 39–40). See also Joan Mason, "The Admission of the First Women to the Royal Society of London," *Notes and Records of the Royal Society of London*, 46 (1992), 279–300. On du Châtelet, see Mary Terrall, "Emilie du Châtelet and the Gendering of Science," *History of Science*, 33 (1995), 283–310; and Terrall, "Gendered Spaces, Gendered Audiences: Inside and Outside the Paris Academy of Sciences," *Configurations*, 3 (1995), 207–32. On Bassi, see Paula Findlen, "Science as a Career in Enlightenment Italy: The Strategies of Laura Bassi," *Isis*, 84 (1993), 441–69; and Beate Ceranski, *"Und Sie Fürchtet sich vor Niemandem": Die Physikerin Laura Bassi, 1711–1778* (Frankfurt: Campus Verlag, 1996). See also Paula Findlen, "A Forgotten Newtonian: Women and Science in the Italian Provinces," in *The Sciences in Enlightened Europe*, ed. William Clark, Jan Golinski, and Simon Schaffer (Chicago: University of Chicago Press, 1999), pp. 313–49.

[23] Carolyn Lougee, *Le paradis des femmes: Women, Salons, and Social Stratification in Seventeenth Century France* (Princeton, N.J.: Princeton University Press, 1976), pp. 41–53; and Dena Goodman, *The Republic of Letters: A Cultural History of the French Enlightenment* (Ithaca, N.Y.: Cornell University Press, 1994), chap. 3.

[24] Madeleine de Scudéry wrote her *Histoire de deux caméléons* as a rebuttal to Claude Perrault's *Description anatomique d'un caméléon*. Her paper was eventually published in the Académie's *Mémoires pour servir à l'histoire naturelle des animaux* (Papers for a Natural History of Animals, 1671–6). See Erica Harth, *Cartesian Women: Versions and Subversions of Rational Discourse in the Old Regime* (Ithaca, N.Y.: Cornell University Press, 1992), pp. 98–110; Gillispie, *Science and Polity in France*, pp. 7, 94.

Salonnières experienced the same limits to their power as other highborn women in this period: They maneuvered to ensure the election of favored male candidates to prestigious posts, but not women. Because women were barred from the centers of scientific culture, such as the Royal Society of London and the Académie Royale des Sciences in Paris, their relationship to knowledge was inevitably mediated by a man, whether that man was their husband, companion, or tutor.

Some historians have taken the case of women as consumers of natural knowledge as the paradigmatic example of women's participation in natural inquiry. Yet relegating women to the status of hostess or amateur diminishes the contributions that women such as Maria Sibylla Merian (1647–1717) made to natural knowledge. Not all natural inquiry in early modern Europe was transacted within elite social settings. In the workaday world of artisanal workshops, women's contributions (like men's) depended less on learned discourse and more on practical innovations in illustrating, calculating, or observing.

ARTISANS

Sociologist Edgar Zilsel was among the first to point to the skills of "artist-engineers" as being central to the development of modern natural knowledge.[25] It has become commonplace to malign scholarship on artisans' contributions as the product of Marxist historiography (as indeed it was in the 1930s and 1940s). One might today, however, join scholarship in this area to laboratory studies (see Smith, Chapter 13, this volume). To be sure, gentlewomen such as Mary Sidney Herbert (1561–1621), Countess of Pembroke, built elaborate laboratories in their private residences and employed men of humbler origins, such as Adrian Gilbert, half-brother to Sir Walter Raleigh (1552–1618), as her "Laborator" to assist her in compounding household medicines, such as "Adrian Gilbert's Cordiall Water."[26] By the same token, princes welcomed court engineers and architects – men unskilled in learned discourse but with considerable technical expertise – to construct ostentatious gardens and waterworks and fabulous facades, and undertake other feats of artistic and technical virtuosity in improving fortifications and ballistics.[27] Independent craftsmen and women, who employed keen observational skills within household workshops, also secured an empirical base for fields such as astronomy and natural history. Women were at best bystanders in gentlemen's laboratories (even when present among the spectators,

[25] Edgar Zilsel, "The Sociological Roots of Science," *American Journal of Sociology*, 47 (1942), 545–6; Arthur Clegg, "Craftsmen and the Origin of Science," *Science and Society*, 43 (1979), 186–201.

[26] Margaret Hannay, "'How I These Studies Prize': The Countess of Pembroke and Elizabethan Science," in Hunter and Hutton, eds., *Women, Science, and Medicine*, pp. 108–21.

[27] William Eamon, "Court, Academy, and Printing House: Patronage and Scientific Careers in Late-Renaissance Italy," in Moran, ed., *Patronage and Institutions*, pp. 25–50, esp. pp. 31–2.

they – like the humble male "laborants" or "operators" – rarely featured among the "modest witnesses" whose signatures validated experiments in early modern England). Nonetheless they were prominent within artisanal workshops, especially on the Continent (see Cooper, Chapter 9, this volume).[28]

The new value attached to the traditional skills of artisans in this period helps explain the success women enjoyed as astronomers in this period. Between 1650 and 1710, some fourteen percent of astronomers in German lands were women (a higher percentage even than is true in Germany today).[29] Astronomy was never officially an organized guild, yet craft traditions that molded much of working life in early modern Europe were very much alive in the practices of astronomy, especially in Germany, the Low Countries, and parts of Poland. Astronomers, for example, derived income from artisanal activities, such as preparing popular almanacs and calendars – what Leibniz called "libraries for the common man." By choosing astronomers known for their calendar making and establishing a monopoly on the sale of calendars, the Royal Society of Sciences in Berlin hoped to capture this income for itself.[30]

Women's exclusion from universities set limits on their participation in astronomy; for instance, Maria Margarethe Winckelmann's (1670–1720) sighting of an important comet was attributed to her husband in part because she was not educated in Latin and could not easily publish her finding in the *Acta eruditorum*, then the leading journal for natural knowledge in German lands.[31] The actual work of observing the heavens, however, took place in this period largely outside the universities and was commonly learned under the watchful eye of a master. Gottfried Kirch (1639–1710), one of Germany's leading astronomers, for example, studied at Johannes Hevelius's (1611–1687) private observatory, built across the roofs of three adjoining houses in Danzig in 1640; this was as important for his astronomical career as his study of mathematics at the University of Jena.

Whereas men's work in the trades was typically regulated by their occupational status (apprentice, journeymen, master), women's was more commonly governed by their familial and marital status.[32] Trained by her father (or occasionally by her mother), a woman moved, in typical guild fashion,

[28] Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994); Donna Haraway, *Modest_Witness@Second_Millennium* (New York: Routledge, 1997), pp. 29–32.

[29] This estimate is drawn from Joachim von Sandrart, *Teutsche Academie der edlen Bau-, Bild- und Mahlerey-Künste* (Frankfurt: J. P. Miltenberger 1675); Friedrich Lucae, *Schlesische Fürsten-Kron oder eigentliche, wahrhaffte Beschreibung Ober- und Nieder-Schlesiens* (Frankfurt am Main: Knoch 1685); Frederick Weidler, *Historia astronomiae* (Wittenberg: Gottlieb Heinrich Schwartz, 1741).

[30] Harnack, *Geschichte der Königlich Preussischen Akademie der Wissenschaften*, 1: 48–9.

[31] Schiebinger, *The Mind Has No Sex?* pp. 82–98.

[32] Margaret Wensky, *Die Stellung der Frau in der stadtkölnischen Wirtschaft im Spätmittelalter* (Cologne: Bohlau, 1981); and Merry Wiesner, *Working Women in Renaissance Germany* (New Brunswick, N.J.: Rutgers University Press, 1986).

from being an assistant to her father to becoming an assistant to her husband. Elisabetha Koopman of Danzig (1647–1693), like other women in this period, wed with care to ensure her place in astronomy. In 1663, she married a leading astronomer Hevelius, a man thirty-six years her elder. Hevelius, a brewer by trade, took over the lucrative family beer business in 1641. His first wife, Catherina Rebeschke (1613–1662), had managed the household brewery, leaving him free to serve in city government and to pursue his avocation, astronomy. When she died in 1662, Hevelius married Koopman, who had been interested in astronomy for many years. In appropriate guild fashion, Elisabetha Hevelius served as chief assistant to her husband in both the family business and the family observatory. In her pathbreaking work, Margaret Rossiter has described "women's work" in nineteenth- and twentieth-century science (and especially in astronomy) as typically involving tedious computation, lifelong service as an assistant, and the like – all of which are a legacy of the guild wife.[33] The role of the guild wives, however, cannot be collapsed into that of a mere assistant; wives were of such import to production that every guild master, at least in Germany, was required by law to have one.[34] The very different structure of the workplace in the early modern period allowed the wife a more comprehensive role. For twenty-seven years, Elisabetha Hevelius collaborated with her husband, observing the heavens in the cold of night by his side.[35]

COLONIAL CONNECTIONS

Historians have lavished attention on universities, princely courts, scientific academies, salons, and even artisanal workshops as loci of intellectual ferment in early modern Europe. Today, new attention is being brought to bear on another aspect of early modern natural knowledge – overseas exploration. In this context, domestic and colonial botanical gardens (and later menageries and natural history museums) served as displays of princely élan, experimental stations for economic and medicinal horticulture, collection points for voyagers, and, last but not least, innovative institutions of the new natural history.[36] One could argue that the opening of the Jardin Royal des Plantes

[33] See Margaret Rossiter, " 'Women's Work' in Science, 1880–1910," *Isis*, 71 (1980), 381–98; and Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins University Press, 1982), pp. 51–72.

[34] Merry Wiesner, "Women's Work in the Changing City Economy, 1500–1650," in *Connecting Spheres: Women in the Western World, 1500 to the Present*, ed. Marilyn Boxer and Jean Quataert (New York: Oxford University Press, 1987), pp. 64–74, esp. p. 66.

[35] After her husband's death, Elisabetha Hevelius edited and published their joint works: *Catalogus stellarum fixarum* (1687); *Firmamentum Sobiescianum* (1690), containing fifty-six star maps; and *Prodromus astronomiae* (1690), a catalogue of 1,564 stars and their positions.

[36] Lucile Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (New York: Academic Press, 1979); Alfred Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (New York: Cambridge University Press, 1986); Nicholas Jardine, James A. Secord,

Médicinales (Jardin des Plantes) in Paris in 1635 was as important to the new natural knowledge as the founding of the much celebrated Académie Royale des Sciences. Plants were shipped from abroad to gardens in Paris, Pisa, Leiden, Montpellier, Heidelberg, and elsewhere in attempts to create a microcosm of the world's flora for the purposes of acclimatizing useful medical herbs, identifying profitable woods and agricultural plants, satisfying popular demand for ornamental exotics, and developing classification schemes on a global basis.

Europeans making forays into nature and foreign scientific traditions in the sixteenth and seventeenth centuries came from varied backgrounds. Jesuit missionaries served as major conduits for scientific knowledge into Europe (though Protestants were often suspicious of knowledge so transmitted, as was the case with quinine, originally known as "Jesuits' Bark").[37] Physicians such as Paul Hermann (1640–1695) collected as they served in various parts of the world for the various India companies; Hermann later became a professor of botany at the university in Leiden. Even merchants, such as Jakob Breyne (1637–1697), occasionally joined the frenzied exchange of exotic plant and animal stuffs characteristic of this period.

Female naturalists, however, rarely figured in Europe's rush to know exotic lands. Moral and bodily imperatives discouraged women from voyaging to unknown lands; physicians warned that white women taken to very warm climates succumbed to "copious menstruation, which almost always ends, in a short space of time, in fatal hemorrhages of the uterus."[38] There was also the often-expressed fear that women giving birth in the tropics would deliver children resembling the native peoples of those areas.[39]

The German-born Maria Sibylla Merian was one of the few women who undertook her own course of study (of insects) and traveled independently

and Emma C. Spary, eds., *Cultures of Natural History* (Cambridge: Cambridge University Press, 1996); David Miller and Peter Reill, eds., *Visions of Empire: Voyages, Botany, and Representations of Nature* (Cambridge: Cambridge University Press, 1996); Marie-Noëlle Bourguet and Christophe Bonneuils, eds., *De l'inventaire du monde à la mise en valeur du globe: Botanique et colonisation*, special issue, *Revue française d'histoire d'Outre-Mer*, 86 (1999); Tony Rice, *Voyages: Three Centuries of Natural History Exploration* (London: Museum of Natural History, 2000); Emma C. Spary, *Utopia's Garden: French National History from the Old Regime to Revolution* (Chicago: University of Chicago Press, 2000); Richard Drayton, *Nature's Government: Science, Imperial Britain, and the "Improvement" of the World* (New Haven, Conn.: Yale University Press, 2000); Roy MacLeod, ed., *Nature and Empire: Science and the Colonial Enterprise*, special issue, *Osiris*, 15 (2000); Pamela Smith and Paula Findlen, eds., *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (New York: Routledge, 2002); and Londa Schiebinger and Claudia Swan, eds., *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2005).

[37] Cromwell considered Peruvian bark a "Popish remedy." Saul Jarcho, *Quinine's Predecessor: Francesco Torti and the Early History of Cinchona* (Baltimore: Johns Hopkins University Press, 1993), p. 46.

[38] Johann Blumenbach, *The Natural Varieties of Mankind* [1795], trans. Thomas Bendyshe [1865] (New York: Bergman, 1969), p. 212, n. 2. Blumenbach codified notions long current in Europe.

[39] Marie Helene Huet, *Monstrous Imagination* (Cambridge, Mass.: Harvard University Press, 1993); Londa Schiebinger, *Nature's Body: Gender in the Making of Modern Science* (Boston: Beacon Press, 1993).

in pursuit of natural history in this period. The daughter of the well-known artist Matthäus Merian the elder, Merian had been trained from an early age in the workshop of her stepfather (her own father died shortly after her birth) in the arts of illustration and copper-plate engraving.[40] In 1665, she married Johann Andreas Graff, one of her stepfather's favorite pupils. The couple set up their own household workshop in Nuremberg, where her husband published Maria Sibylla (now) Graffin's *Blumenbuch* (Book of Flowers, 1675–1680), a collection of illustrations to be used as patterns for artists and embroiderers.

In 1699, having left her husband and reclaimed her father's famous name, Merian set sail for Surinam, then a Dutch colony. She had some connections to Surinam through her merchant son-in-law and the Labadists, an experimental religious community with holdings in both the Netherlands and its colonies. She was not, however, schooled, as the great Joseph Pitton de Tournefort (1656–1708) had been, to be sent into the field, nor had she been commissioned to make the journey by a trading company, scientific society, or Crown as were many of the naturalists in this period. Her interest was self-generated and largely self-supported, part of her lifelong quest to find another variety of caterpillar as economically significant as the silkworm. For two years, she collected, studied, and drew the insects and plants of the region.[41]

Despite her rarity as a female naturalist, Merian's practices in the field were by and large similar to those of her male colleagues. Like Hans Sloane (1660–1753), physician to the English governor in Jamaica from 1687 to 1689 and future president of London's Royal Society, she was keen to collect from the local inhabitants the best information concerning the exotic plants and insects she encountered.[42] Like the German astronomer Peter Kolb (1675–1726), who wrote an early ethnology of the Africans at the Cape of Good Hope, Merian developed deep friendships with several Amerindians and displaced Africans in Surinam who served as her guides to desirable specimens and provided access to dangerous, often impassible regions.[43] Like the men, Merian had

[40] Women had long been active as illustrators; nuns had illuminated manuscripts, and other women were active members of painters' guilds. See Ann Sutherland Harris and Linda Nochlin, *Women Artists, 1550–1950* (Los Angeles: Los Angeles County Museum of Art, 1976); Madeleine Pinault, *The Painter as Naturalist: From Dürer to Redouté*, trans. Philip Sturgess (Paris: Flammarion, 1991), pp. 43–6.

[41] On Merian, see Elisabeth Rücker, *Maria Sibylla Merian, 1647–1717* (Nuremberg: Germanisches Nationalmuseum, 1967); Margarete Pfister-Burkhalter, *Maria Sibylla Merian: Leben und Werk, 1647–1717* (Basel: GS-Verlag, 1980); Natalie Zemon Davis, *Women on the Margins: Three Seventeenth-Century Lives* (Cambridge, Mass.: Harvard University Press, 1995); Helmut Kaiser, *Maria Sibylla Merian: Eine Biographie* (Düsseldorf: Artemis and Winkler, 1997); and Kurt Wettengl, ed., *Maria Sibylla Merian, 1647–1717: Artist and Naturalist*, trans. John Southard (Ostfildern: G. Hatje, 1998).

[42] Hans Sloane, *A Voyage to the Islands Madera, Barbadoes, Nieves, St. Christophers, and Jamaica; with the Natural History . . .* , 2 vols. (London: Printed by B. M. for the author, 1707–25); and Maria Sibylla Merian, *Metamorphosis insectorum Surinamensium* [1705], ed. Helmut Decker (Leipzig: Insel-Verlag A. Kippenberg, 1975), introduction, p. 38.

[43] Peter Kolb, *The Present State of the Cape of Good Hope*, trans. Guido Medley (London: W. Innys, 1731).

assistants: her twenty-one-year-old daughter, whom she had trained, and her slaves, who served as her guides and hacked paths for her through dense "thorns and thistles."[44] Merian also followed the practice common up to that time of retaining native names and recording much else that native peoples told her about the plants and animals she studied. In the introduction to her celebrated *Metamorphosis insectorum Surinamensium* (Metamorphosis of the Insects of Surinam, 1705), which she advertised as the "first and strangest work done in America," she wrote: "The names of the plants I have kept as they were given by the natives and Indians in America."[45]

Although Merian's homespun enterprise was similar in many respects to those of a number of male naturalists, such as Sloane and others working in the Caribbean, it contrasts sharply with that of Hendrick van Reede tot Drakenstein (1636–1691), a military man and colonial administrator, whose interest in botany was driven by the need to protect his troops from beriberi, dysentery, cholera, jaundice, malaria, and other tropical diseases. (Merian and van Reede are linked for posterity through Carolus Linnaeus's, 1707–1778, contempt of the botanical nomenclatures of both.)[46] As governor of Malabar for the Dutch East India Company from 1670 to 1677, van Reede produced a magisterial twelve-volume opus, *Hortus Malabaricus* (Flora of Malabar, 1678–1693), describing 740 plants of the region. To compile his complex text, van Reede coordinated the efforts of at least twenty-five men from many distinct cultures, castes, and classes, and two continents.[47] Only an administrator of van Reede's stature could command the necessary resources, contacts, and personnel to mount a project of this magnitude.

The negotiation between European and exotic natural knowledge traditions is a complicated story that remains to be told. In many instances, indigenous informants included unlettered women who passed along hard-won knowledge to lettered naturalists who, by systematizing it, were able to make previously local knowledge more universally available. Historian Richard Grove has claimed that some of the collecting and much of the cataloguing for Garcia da Orta's (1500–1568) well-known *Coloquios dos simples e drogas . . . da India* (Colloquies on the Simples and Drugs of India, 1563), for example, was done by a Konkani slave girl known only as Antonia.[48] Charles Clusius (1526–1609; also da Orta's translator) praised country "women root

[44] Merian, *Metamorphosis*, commentary to plate no. 36.

[45] Merian, *Metamorphosis*, introduction, p. 38. See also Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, Mass.: Harvard University Press, 2004).

[46] Carolus Linnaeus, *Critica botanica* (Leiden: Conrad Wisshoff, 1737), no. 218.

[47] Hendrik Adriaan van Reede, *Hortus Malabaricus* (Amsterdam: Johan van Someren and Johan van Dyck, 1678–93); van Reede provided an extensive description of how the text was compiled in vol. 3, pp. iii–xviii. See also J. Heniger, *Hendrik Adriaan van Reede tot Drakenstein and Hortus Malabaricus* (Rotterdam: Balkema, 1986); and K. S. Manilal, ed., *Botany and History of Hortus Malabaricus* (Rotterdam: Balkema, 1980).

[48] Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origins of Environmentalism, 1600–1860* (Cambridge: Cambridge University Press, 1995), p. 81.

cutters" (*rhizotomae mulierculae*), who supplied him with information about the medical properties of plants indigenous to his own country.[49] Herman Busschof (1625–1672), working for the Dutch East India Company in Batavia, wrote a treatise on an "Indian Doctress" who provided an ingenious cure for his troublesome gout.[50] Women's role in the voyages of scientific exploration is an area where research remains to be done.

The more fluid state of scientific culture in early modern Europe left room for innovation. New institutions and new calls for equality provided openings in intellectual culture that allowed a few women to contribute to the making of natural knowledge. Although women did not fare well in traditional institutions of learning, such as universities, they had a foothold (however tenuous) in courtly circles, learned salons, artisanal workshops, and other settings fostering the emergence of modern science. The sixteenth and seventeenth centuries saw a number of women studying the medicinal qualities of plants, collecting exotic insects, and studying the movements of the heavens. In many instances, their efforts were supported by natural philosophers – Descartes, Poullain de la Barre, and Leibniz among them. Sustained negotiations over sites and boundaries in this period set the stage for women to work at the margins of Enlightenment science – before the twentieth century, one of the high tides of women's contributions to natural knowledge.

[49] Charles de l'Ecluse, *Rariorum aliquot stirpium, per Pannoniam, Austriam, et vicinas . . . historia* (Antwerp: C. Plantin, 1583), p. 345. See also Jerry Stannard, "Classici and Rustici in Clusius' *Stirp. Pannon. Hist.* (1583)," *Festschrift anlässlich der 400 jährigen Widerkehr der wissenschaftlichen Tätigkeit von Carolus Clusius (Charles de l'Escluse) im pannonischen Raum*, ed. Stefan Aumüller (Burgenländische Forschungen herausgegeben vom Burgenländischen Landesarchiv, Sonderheft 5) (Eisenstadt: Amt der Bürgenländischen Landesregierung, Landesarchiv, 1973), pp. 253–69. I thank Claudia Swan for this reference.

[50] Herman Busschof, *Two Treatises* (London: Printed by H. C. and are to be sold by Moses Pitts, 1676). I thank Roberta Bivins for this reference.