Transition toward Invisibility

Women's Scientific Activities around 1800

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> Kein Frauenzimmer muß eine Gelehrte von Profession werden. [No woman needs to become a professional scholar.]
>
> *Der Gesellige,* 1748

Science, of course, constituted women's business neither before nor after 1800. Indeed, the exclusion of women from regular university attendance and academic careers is one of the fundamental continuities in the social setting of science in the early modern as well as the modern period up to at least the 1880s. Yet a marked difference exists between the late seventeenth and the eighteenth centuries on the one hand and the nineteenth century on the other. During the late seventeenth and eighteenth centuries, quite a remarkable number of women throughout Central Europe participated in science. In the first half of the nineteenth century, however, the diversity and intensity of female involvement with science suffered a considerable decline in the German states.[1] Conversely, the first half of the nineteenth century brought to German science what has been called the "great transition" from poor dispersed scholars to a vigorous university system with a strong research ethos and a scientific level soon considered the best in Europe.[2] It is therefore tempting to examine if and how these two developments are connected to one another and to the greater sociopolitical changes of that period of transition. Indeed, I will show that in some instances, a direct causal relationship exists between the two; in other respects both processes are deeply informed by the overarching changes connected with the emergence of the *bürgerliche Gesellschaft* between approximately 1780 and 1850.

To understand better what occurred in this period and disentangle the different strands that contributed to the changes in female participation, this chapter will first examine the eighteenth century, providing

a rough survey and classification of the opportunities open to women in Central Europe who wanted to become acquainted with science. In the second part of the chapter I will consider how in the German-speaking area these forms of participation were affected by the political and cultural changes of normative discourses and social practices around 1800. Finally, I will formulate some conclusions as well as new questions. The changes around 1800 resulted in science being virtually free of any visible female participation (not only on a professional level). Furthermore, science became related to masculinity in a much closer way than had previously been the case. Thus, although the exclusion of women from the professional pursuit of science represents the fundamental continuity, the new intensity in the gendering of science might represent a transition so decisive that the question of continuity or break remains very open to debate.

In this chapter, *science* is used in a broad sense of "natural science," including theoretical medical disciplines as well as (natural) philosophy. I will deal neither with the academic professions, law, divinity, and medicine (with one exception) nor with literature and the arts. "Scientific participation" is conceived as including all forms of social intercourse and human behavior bringing people into contact with science. The term may include reading a popular scientific book as well as detecting a new plant or writing (or reading) a mathematical treatise. Finally, for the sake of brevity, I will often refer to "Germany" rather than to what should be called more appropriately the German states.

Models before the "Great Transition": Visible Female Participation in Science in the Eighteenth Century

The Artisan Model: Working Together

Participating in the family business probably was the most important way into science for women outside the nobility. In some cases, such activities even led to salaried positions or to private enterprises that brought some cash. At the same time, however, institutional professionalization was already beginning to result in the exclusion of women. Astronomy provides examples of both phenomena, as Londa Schiebinger has demonstrated, pointing out the unusually high percentage of female practitioners in the seventeenth and eighteenth centuries.[3] Schiebinger attributes this finding to the close connection with medieval guild tradition, but it may also result from the fact that astro-

nomical activities generally require the collaboration of at least two persons for the uninterrupted observation of the skies. Astronomy was also the subject of one of the first German scientific instructional texts written in the vernacular, Maria Cunitz's *Urania propitia* (1650).[4] Most interesting and somewhat puzzling, this comparatively early work represents one of the very few examples of German scientific texts by women. Another woman, Caroline Herschel (1750–1848) from Hanover, is also said to have been the most gifted observer of comets in early modern astronomy. She was the sister of William Herschel, who had moved to England to pursue a career in music. At William's request, Caroline went to assist him as a singer. He subsequently changed his profession to become an astronomer, and he trained her to help him in his new occupation.[5] From 1787 onward, the English king assigned her a personal pension, independent of her brother. Such a "career" occurred within a patronage-dominated system—both brother and sister were paid directly out of the royal purse—and would not have been possible in Germany, where astronomy had already been institutionalized. Berlin astronomer Maria Winkelmann (1670–1720) demonstrates precisely how the traditional artisan patterns of female participation and responsibility for the family enterprise had to recede before the institutionalization of science. Winkelmann, who had been trained as an astronomer by a neighbor, married the astronomer Gottfried Kirch and thus secured the opportunity to continue her association with the science. For decades she shared the work of her husband, who became the official astronomer of the Scientific Society of Berlin. Moreover, the couple's children of both sexes were also instructed in astronomical observations and computations. When Gottfried died, Maria asked the society to assign to her the preparation of its calendar, but after much discussion—in which Leibniz, among others, spoke for the widow—society officials decided that they did not want to expose themselves to ridicule by having their calendar prepared by a woman. Maria and her daughters returned to work for the society only several years later, when her son, Christfried, became the society's astronomer.[6]

Although astronomy probably is the most striking example, other branches of science also had women become involved via their families. Interestingly, these are often fields with strong artisanal or artistic connotations, which may speak for the guild tradition. The best-known German woman certainly is entomologist Maria Sybilla Merian (1647–1717) from Nuremberg. The daughter of the famous copper-

plate engraver, Matthias Merian, Maria became a successful freelance observer and scientific illustrator of plants and insects and undertook a research trip to Suriname with her daughter.[7]

The Aristocratic Model: Protecting, Decorating, and Seldom Participating

In the early modern society of estates, noble women had their own opportunities to gain access to scientific conversation and instruction. They could act as the hostess or patroness of one or several scholars and thus trade high social status for access to knowledge. Such women thus generally did not come into contact with science and scholarship until adulthood. To become actively involved with scientific research was, however, decidedly outside the scope of the patroness; rather, it was her role to select and promote young—male—clients on their way to scientific as well as social achievement. Scientific societies elected female members mainly as a means to enhance social status or to ensure local patronage. The women thus honored usually did not even participate in a single session of the body to which they gave prestige and legitimation, although their names appeared publicly on membership lists. Christina of Sweden (1626–89), who not only induced Descartes to come to her court at Stockholm (and thus bore responsibility for his premature death, as many later said) but also conducted a thriving salon at Rome after her abdication, may be regarded as the archetype of this kind of female involved with science.

In the late seventeenth and eighteenth centuries, some princesses of German states became involved in various ways with the protection or institutionalization of science. Prussian Queen Sophie Charlotte (1668–1705), for example, served as an important patron for Leibniz and became instrumental in the foundation of the Scientific Society of Berlin. However, her early death hindered her from sharing the fruits of this enterprise.[8] When the University of Erlangen was founded in 1743, the erudite Markgräfin Wilhelmine von Bayreuth (1709–58), sister of Friedrich II, organized a debate that earned her the title "bayreuthische Pallas."[9] As was expected of a patroness, Wilhelmine formulated the theses and determined the participants of this disputation—she did not speak herself!

These conventions of passive protection rather than active participation notwithstanding, some women with high social standing did not confine themselves to the passive role of patroness. In undertaking research or publishing scientific books, such women clearly trans-

gressed the boundaries of their role. This is perhaps best illustrated by Emilie Du Châtelet (1706–49), the hostess of Voltaire. She published her first treatise anonymously and clandestinely conducted research at night for a scientific prize competition in which Voltaire was also participating.

The relationship between women of high nobility and science (as incarnated in scientific organizations) was highly visible from the outside—indeed, visibility was an instrumental feature of the patroness role. However, from the point of view of those who actually did the scientific research and teaching, both female and male patrons were completely invisible.

The Humanist Model: Displaying Unusual Female Erudition

Whereas the role of patroness was open only to women from the nobility, the prodigy child approach also included women from the upper bourgeoisie, such as families of merchants or academic professionals. Like the artisan model, the prodigy child role was one of long standing and had flourished during the era of Renaissance humanism in Germany and Italy. Children were carefully taught in classical as well as modern languages and/or philosophy and were then displayed as wonders of learning—for example, by having them recite poems before princely or royal guests. Although this role was open to boys and girls alike, the girls frequently created more excitement than the boys since female displays of erudition were much more rare.[10] Despite the public success, this model implied severe problems for the girls, the most important of which was its limitation to a comparatively short period in life: Even a child prodigy had to grow up at some point. When that role was finished, the only two options were *maritar o monacar*—marrying or entering a convent.[11] Yet in Renaissance humanism as well as in the seventeenth and eighteenth centuries, this model also brought unique public visibility to female erudition. It therefore plays an important part in the history of learned women although it certainly represented a very mixed blessing for the girls and women concerned.

The close relationship between the prodigy model and public acknowledgment is highlighted by the fact that virtually all early modern academic degrees conferred to women went to young women with child prodigy careers. For example, at the age of thirteen, Anna Christina Ehrenfried von Balthasar (1737–1808) from Greifswald obtained a baccalaureate degree from the local university for her recital of an erudite and much admired speech at the birthday celebra-

tion of the local prince.[12] The first doctoral degree ever given to a woman went to Elena Cornaro Piscopia (1646–84), a Venetian noblewoman who was thus honored by the University of Padua in 1678.[13] Like so many other women with similar biographies, Cornaro Piscopia refrained from scholarly activity after the conferral of the degree, marrying shortly thereafter and dying only a few years later. If Cornaro Piscopia is the first female child prodigy with a doctoral degree, Dorothea Schlözer (1770–1825) from Göttingen may be regarded as the last one. Her biography as a whole is very much that of a woman in times of transition and will be revisited in the second part of this chapter.[14] She received her degree in 1787 on the occasion of the fiftieth anniversary of the university of Göttingen. Her father, a well-known professor there had taught her a large number of subjects and had engaged some colleagues to instruct her in other areas. Dorothea appeared at the oral exam in a white gown, echoing the traditional connection between female scholarship and virginity. As with Cornaro Piscopia, Schlözer's scientific career had thus reached the summit. According to parental wishes, she married well four years after receiving her degree, and records reveal only sporadic involvement with science during her later life.

The Enlightenment Model: Women as the Audience

The Enlightenment brought a particular new opportunity for a wider circle of women, who were discovered as audience for the dissemination of scientific knowledge in both written and spoken form. One of the founders of Enlightenment thought, Descartes, dedicated his epoch-making treatise *Principia Philosophiae* (1644) to Elisabeth of Bohemia. In his correspondence with her as well as with other contemporaries, he repeatedly asserted that the female sex was both capable and worthy of dealing with philosophical subjects. Although Descartes did not publish a work specifically addressed to women, he thus encouraged a whole industry of treatises on astronomy, experimental philosophy, and other subjects specifically for women. The most successful, *Entretiens sur la pluralité des mondes,* was written in 1686 by Bernard Le Bovier de Fontenelle, the secretary of the Académie des Sciences in Paris. The book was composed as a series of conversations between a philosopher and a marquise whom he taught, mainly about astronomical subjects. With this social setting, Fontenelle revived the patronage model and gave social legitimation to women following the example of his marquise. Fontenelle was translated quickly and fre-

quently: the numerous German translations included versions published in 1698, 1726, 1730, 1738 (the last three by Johann Christoph Gottsched).[15] The popular moral weeklies recommended Fontenelle in their bibliographies for women, the "Frauenzimmer-Bibliotheken." His book also set the tone for numerous similar works, some of which, however, had poor scientific standards and rather represented collections of gallantries.[16] Nevertheless, this widely read genre of popular scientific literature presented the connection of women and science as natural part of learned culture.

Alongside this rationalist direction of Enlightenment culture there stood another, physicotheology, which facilitated women's access to scientific knowledge. Physicotheological literature aimed to demonstrate the wisdom and goodness of God by the purposefulness of creation and was often explicitly addressed to both women and men. Physicotheology had its origins in England but gained momentum in both Germany and France. Among the German-speaking authors, Johann Jakob Scheuchzer from Zurich was one of the most prominent. In addition to his famous tract, *Physica Sacra* (1731–35), and numerous other treatises on natural history and theology, he published a comprehensive philosophy textbook, the *Physica oder Natur-Wissenschaft* (1703), which addressed itself directly to "women who want to know [*wissens-begierige Frauen-Zimmer*] and who have so far been virtually excluded from this science."[17]

The flourishing literary genre was enriched by a host of experimental demonstrations on various subjects such as astronomy, optics, pneumatics, and electricity. Like the books, these presentations explicitly included or addressed women on the stage or in the audience.[18] Thus, women were presented as a collective audience and sometimes as participants in the dissemination of scientific knowledge.

The Enlightenment Model Enlarged: Teaching the Audience

Considering the strong impetus of the early Enlightenment to provide instruction as comprehensive as possible, it is fairly logical that women soon began to take an active part in the further dissemination of what they had learned from philosophers. The women who engaged in such enterprises often had gained their access to the required competence either by transforming a prodigy career or by making use of their social role as hostess and patron of scientific guests.[19] These women translated and explained scientific treatises or wrote comprehensive summaries of the state of knowledge in mathematics, chemistry, and a host of other disciplines. This form of literary activity could be justified by

referring to women's particular responsibility for the instruction of their families, thus fitting their actions into both the traditional female role and women's newly stressed responsibility for their children. This kind of publishing took place mainly outside the German speaking area—the sole notable German text is Cunitz's *Urania propitia.* This bilingual introduction to astronomy fit well into early Enlightenment endeavors to make science accessible to a greater public, for it translated astronomical technical terms and facilitated astronomical calculations by providing new tables that Cunitz had calculated. By the beginning of the eighteenth century, however, Cunitz was criticized for having neglected her household duties.[20] Perhaps this early condemnation of a woman writer provides part of the explanation for the almost complete absence of any further German scientific texts written by women in the Enlightenment, a circumstance that surely merits further research. The situation is different for many other European countries, where this form of female participation was quite well developed. Yet although writing expository scientific texts could be justified within prescribed female roles, it nevertheless supported the argument that even the most gifted women could understand and reproduce the achievements of male scientists but remained incapable of creative research.

The Exception: Doing the Same as the Male Colleagues

Rich and varied as these experiences and contributions to science may have been, one model has been conspicuously missing: that of a woman collaborating with a group of male colleagues and making a living through professional scientific practice. To my knowledge, two such examples exist: Italian physicist Laura Bassi (1711–78) and German physician Dorothea Erxleben (1715–62). Bassi gained access to scholarship through the child prodigy model and then forged a unique career within the scientific institutions of her hometown, Bologna. Papal patronage, the support of a loyal and scientifically trained husband, and the specific Bolognese scientific culture constituted the key ingredients of this unique biography, which served as a model for other women scholars well into the nineteenth century. Erxleben, of Quedlinburg, was introduced to Latin, scientific knowledge, and medicine by her brother's teacher (who encouraged her to follow Bassi's example and take a doctoral degree) and by her father, a physician. Erxleben's initial plan to study with her brother at the University of Halle could not be fulfilled for reasons of war. She married, published a treatise on the factors that prevented women from academic study, and worked as

a physician. After male colleagues at Quedlinburg tried to prevent her from further medical activity, she secured the patronage of the enlightened prince (who was also the bishop) in pursuing her medical degree, thus legitimizing her practice. Both Bassi and Erxleben highlight the possibilities occasionally available to women in the Enlightenment, but these two women also demonstrate the dependence of these exceptions on external circumstances and to a considerable degree on the luck of having supportive patrons and husbands.

The "Great Transition" toward Invisibility: How Women's Models Changed or Disappeared

The Segregation of Household and Work

The segregation of work and domestic life into two separate spheres and the assignment of the former exclusively to men was one of the central socioeconomic transformations around 1800. In science, which is in this respect like any other work, the site of experimental research, for example, changed from the private household to the university. Many private laboratories were acquired by universities and scientific institutes and thus transformed into institutional facilities. Although the private laboratories and study rooms generally had been situated apart from the living quarters of the house, the removal of experimental facilities from the scientist's home constituted a fundamental change. Maria Kirch provides an early example of the consequences of this development: When the observatory was removed from the attic of the Kirchs' house to the newly built observatory of the Scientific Society of Berlin, her participation at astronomical work became visible and was publicly—and unsympathetically—noted. The creation of special sites for scientific research effectively terminated the informal, unpaid, but highly skilled collaboration of the wife (and children) of the family.[21]

Ideologically, femininity and family became an antidote not only to the fragmented modern world but also to the burdensome pursuit of scientific activities. This process was reinforced by the tumultuous political situation between 1790 and 1815. Scientists tended increasingly to separate rather than integrate their private and professional lives.

The Administrative Class

The emergence of a powerful caste of civil servants replacing princely favorites is one aspect of political modernization that contributed to

the confirmation of science as a male enterprise. With their rise to power, the members of the administrative elites became patrons both to individual scientists and to the abundant civic and scientific societies. The latter thus no longer elected women from the local nobility as honorary members but chose instead influential civil servants. The same holds true for the dedication of scientific treatises. This change contributed to the complete disappearance of women from scientific activity. Finally, although the patronage model had not necessarily implied deep scientific involvement of the patronesses, it had provided one way of access to science, as the cases of Emilie Du Châtelet and several others illustrate.

Not only did the transition from noble female to professional male patronage have significant consequences for women's visible—albeit not functional—involvement with science, this change also involved considerable risks for the clients as well. As the Hessische Gelehrte Gesellschaft at Giessen (founded in the 1760s) learned, for example, politicians ran special risks. The society chose as its main patron chancellor Friedrich Karl von Moser, not, as might have been the choice some thirty years earlier, the Große Landgräfin Henriette Caroline of Hessen-Darmstadt (1721–74). This learned society could not survive Moser's fall into disgrace.[22]

The Invisibility of Female Erudition

Probably the most radical disappearance was that of the model of the learned female child prodigy. Even in the best of times, learned women were subjected to a strong norm of female virtue and above all modesty. This was fulfilled by the ritualistic *captationes benevolentiae* in letters, prefaces to books, and so forth. If convention was thus satisfied, extraordinary female erudition could become the object of pride and honor of a city or university. In the nineteenth century, however, no form of public display of female learning was celebrated or even found tolerable. Profound scholarship by a woman could no longer be balanced by her virtues and modesty but was to be rejected entirely since it transgressed the boundaries of the female roles as wife, housewife, and mother. In this respect, a marked break occurred between the early and the late Enlightenment, manifesting itself in pedagogical treatises as well as in the scientific literature for women.[23] Dorothea Schlözer's 1787 doctoral degree represents an offspring of the late Enlightenment: a number of its features point to the accompanying considerable public unease, which makes this degree different from those conferred in

the earlier Enlightenment. As in previous cases, the event was duly reported to the world, and celebration poems were written. But in marked contrast to the cases of Dorothea Erxleben and Laura Bassi, the exam was held in a private residence and, most importantly, Dorothea Schlözer was not present publicly at the official conferral of the degree: she watched the solemn ceremony through a window from an adjacent room. Thus, a young woman was openly honored for her learning but remained invisible. This contradiction reflects the various strands of Enlightenment attitude toward female learning coexisting at Göttingen in the 1780s. The liberal position of August Ludwig Schlözer, who rejected differentiation in the instruction of boys and girls and educated his daughter as a living example of what girls could achieve if suitably instructed, represented the minority position. The girl's remarkable progress was an object of concern rather than pride to her friends, which shows that female erudition could not go unquestioned. Considering the doubts of her sympathetic friends, it is perhaps not surprising that Schlözer's degree also earned her some harsh, unprecedented contempt.[24]

On a more practical level, the opportunities for girls to enjoy such an education diminished considerably with the changes in the secondary school system in the first three decades of the nineteenth century. The introduction of the *Abitur* and of a compulsory exam for gymnasium teachers made the thorough instruction of boys a matter of public concern. In contrast, the education of girls remained a family responsibility. With a high level of instruction at school, however, boys no longer needed private tutors, which meant that girls could no longer gain education by accompanying their brothers to lessons. Apart from those public lectures open to girls, reading thus became their main source of knowledge.

Thorough Instruction Thoroughly Concealed

My observations here are drawn from recent studies of popular chemistry books and should be compared to evidence from other scientific disciplines,[25] although little research has occurred on nineteenth-century German popular scientific literature. As discussed earlier, the tradition of popular scientific literature had begun in the early Enlightenment and persisted through the nineteenth century. An analysis of the books published between 1780 and 1830 reveals a profound tension between the prefaces and the content of the books. Virtually all authors declared in their prefaces that they wanted to teach women what they needed to know to lead their households, care for their fam-

ilies, and be agreeable wives and mothers. Authors frequently stressed that they did not intend for women to become professional scientists. This approach of course fell completely within tradition, since women never, even in the times most enthusiastic about female scientific instruction, had been intended to become professional scholars. Yet with their outspoken reference to the conceptions of femininity developed in the late Enlightenment by Campe, Pestalozzi, and others, these authors took great care to respect the newly developed conventional boundaries between male and female instruction. Prior to about 1850, however, the main text often failed to distinguish between knowledge useful for women and that for men in either the scope or the depth of issues covered.[26] This contradiction at times carried into the text—for example, when an author declared in his 1808 textbook that the description of strontium could be interesting only to the professional chemist since it was important neither for daily life nor for medical purposes. This statement, however, formed the introduction to an extended section in which he explained virtually everything about strontium.[27] Such contradictions are so numerous that they cannot be accidental. I believe that authors wanted to present their subject as fully and comprehensively as possible for whatever reasons. Their ritualistic declarations must then be read as the means to ensure that their work fitted into what was regarded as the binding concept of female learning. In other words, after the convention for gender roles had been satisfied (usually in the most prominent part of the book, the preface), the exposition was no longer gendered. However, this inconsistency would be seen only when the text was actually read, and perhaps it did not even strike most contemporary readers. Female scientific instruction could thus achieve the contemporary state of the art, but this achievement had to be carefully hidden. I find this attitude paradigmatic for the scientific participation of women in the nineteenth century in a broader sense. Women could involve themselves in science much more deeply than convention permitted as long as they did not become publicly visible. Any forthright display of their knowledge, however, was unthinkable.

Conclusions and Questions: Further Fundamental Transitions?

Returning to the question of whether and how women's scientific participation changed from the eighteenth to the nineteenth centuries, one sees that underneath the continuity of institutional exclusion (from

university attendance, professorships, and so on), a profound if gradual break occurred as far as the less spectacular (yet real) female scientific practices and possibilities are concerned. Apart from private reading, the manifold possibilities of women's access to science that had existed in the eighteenth century disappeared around 1800. In most cases, such opportunities do not seem to have been abolished by design; rather, they vanished as consequences of major social and political changes such as moving laboratories out of houses and administrative modernization. Yet in some instances—for example, confining girls' education to the realm of the family—women's disappearance from scientific activities directly related to the new concepts of femininity developed by the spokesmen for a middle-class ideology who articulated the new social order of modernity.[28] The most conscious and most radical of the transformations discussed in this chapter—that is, the disappearance or at least the relegation to the realm of invisibility of female erudition—originated in mainstream Enlightenment philosophy, as Dorothea Schlözer's biography well illustrates.

These reflections bear directly on avenues for further research. If my conclusions are correct, then looking for women of science in the first two-thirds of the nineteenth century is an inherently difficult task, since female scientific inquiry was possible only if it remained invisible. A possible avenue for further research would be the search for scientific couples and scientific households, which has been quite fruitful in the context of other countries but which is generally lacking for the German states.[29] On a more structural level, one could explore the allegedly important family dynasties in the early modern university system, which have never been studied in detail. This phenomenon retained considerable importance through the 1800s and represents a strong element of continuity between universities of the eighteenth and nineteenth centuries, something often overlooked in the concentration on the emergence of the research university.[30] In this context, to point only to one issue, I would consider it worthwhile to contemplate the fundamental asymmetry between sons and daughters. Nineteenth-century families could influence a daughter's choice of a son-in-law with scientific abilities and ambitions, but a son could not be exchanged.

If, as we have assumed and in some instances have shown, Germany's new middle-class culture was formed basically by its concept of gender and if science became an integral and increasingly important part of this society's activities, then the gendering of science should be manifest not only in the exclusion of women but also in a positive depiction of science

as a masculine enterprise full of hardships and dangers and conquests—in short, an enterprise for heroes. This hypothesis opens up intriguing new questions and avenues for further research.

Notes

1. In this chapter, the "nineteenth century" refers to only the period before the beginning of female university education in the 1880s.

2. See Steven Turner, "The Great Transition and the Social Patterns of German Science," *Minerva* 25 (1987): 56–76.

3. See Londa Schiebinger, *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, 1989), chap. 3.

4. For an analysis of this text mainly from the point of language, see Ingrid Guentherodt, "Urania Propitia (1650)—in zweyerlei Sprachen: Lateinisch- und deutschsprachiges Compendium der Mathematikerin und Astronomin Maria Cunitz," in *Res Publica Litteraria: Die Institutionen der Gelehrsamkeit in der frühen Neuzeit,* ed. Sebastian Neumeister and Conrad Wiedemann (Wiesbaden, 1987), 619–40.

5. See Ian Hacking, *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science* (Cambridge, 1983), 180–81. For Herschel, see Schiebinger, *Mind Has No Sex?* 262–63; Marilyn Bailey Ogilvie, *Women in Science: Antiquity through the Nineteenth Century: A Biographical Dictionary with Annotated Bibliography,* 4th ed. (Cambridge, 1993), 96–99.

6. Londa Schiebinger was the first to discuss the case of Maria Kirch in "Maria Winkelmann at the Berlin Academy: A Turning Point for Women in Science," *Isis* 78 (1987): 174–200. For a new approach to this family of male and female astronomers, see Monika Mommertz, "Schattenökonomie der Wissenschaft: Geschlechterordnung und Arbeitssysteme in der Astronomie der Berliner Akademie der Wissenschaften im 18. Jahrhundert," in *Frauen in Akademie und Wissenschaft,* ed. Theresa Wobbe (Berlin, 2002), 31–63.

7. For an introduction to Merian, see Schiebinger, *Mind Has No Sex?* 68–79; see also Natalie Zemon Davis, *Women on the Margins: Three Seventeenth-Century Lives* (Cambridge, 1995), pt. 3; Helmut Kaiser, *Maria Sibylla Merian: Eine Biographie* (Düsseldorf, 1997).

8. See Gerda Utermöhlen, "Die gelehrte Frau im Spiegel der Leibniz-Korrespondenz," in *Res Publica Litteraria,* ed. Neumeister and Wiedemann, 603–18.

9. Renate Wittern, "Wilhelmine von Bayreuth und Daniel de Superville: Vorgeschichte und Frühzeit der Erlanger Universität," *Erlanger Universitätsreden* 46 (1993): 16. Wilhelmine is also credited with having contributed considerably to the foundation of the university.

10. For German humanism, see Heide Wunder, *"Er ist die Sonn, sie ist der Mond": Frauen in der Frühen Neuzeit* (Munich, 1992), 64, 206–15. For Italian humanism, see Margaret L. King, *Le Donne nel Rinascimento* (Rome, 1991), pt. 3.

11. Patricia Labalme, introduction to *Beyond Their Sex: Learned Women of the European Past,* ed. Labalme (New York, 1980), 4.

12. See Beatrix Niemeyer, "Weiblichkeit und Wissenschaft–Zur Entstehung eines Widerspruchs am Beispiel von Anna Christina Ehrenfried Balthasar (1737–1808)," in *Frauen in pädagogischen Berufen,* ed. Elke Kleinau (Bad Heilbrunn, 1996), 1:127–39.

13. Although Cornaro Piscopia was well beyond the age of a prodigy child when she received the degree, her biography fits into this model. Moreover, negotiations about the degree had taken several years. See Lucia Toschi Traversi, "Verso l'inserimento delle donne nel mondo accademico," in *Alma Mater Studiorum: La presenza femminile dal XVIII al XX secolo* (Bologna, 1988), 15–37.

14. Bärbel Kern and Horst Kern, *Madame Doctorin Schlözer: Ein Frauenleben in den Widersprüchen der Aufklärung* (Munich, 1988).

15. See Karin Reich, "Nachwort," in Bernard LeBovier de Fontenelle, *Dialogen über die Mehrheit der Welten* (1780; Weinheim, 1983), 409–62.

16. For French popular scientific literature of the Enlightenment, see Andreas Kleinert, *Die allgemeinverständlichen Physikbücher der französischen Aufklärung* (Aarau, 1974).

17. Johann Jakob Scheuchzer, *Physica oder Natur-Wissenschaft* (Zurich, 1703). Scheuchzer polemicizes against those authors who obscure physics by using complicated concepts and difficult Latin language.

18. A strong desideratum exists for research on popular scientific culture in the eighteenth and early nineteenth centuries, notably in the German-speaking area. For England, see Patricia Phillips, *The Scientific Lady: A Social History of Women's Scientific Interests, 1520–1918* (London, 1990); for France, see Jeanne Peiffer, "L'Engouement des Femmes pour les Sciences au XVIIIe Siècle," in *Femmes et pouvoirs sous l'Ancien Régime,* ed. Danielle Haase-Dubosc and Eliane Viennot (Paris, 1991), 196–222.

19. The former holds for mathematician Maria Agnesi, who wrote the first comprehensive treatise on calculus; the latter holds true, for example, for Émilie Du Châtelet, who wrote both a synthesis of Newtonian and Leibnizian philosophy and the authoritative French translation of Newton's *Principia matematica.* For further analysis of their careers, see Beate Ceranski, *"Und sie fürchtet sich vor niemandem": Die Physikerin Laura Bassi (1711–1778)* (Frankfurt, 1996); Beate Ceranski, "Wunderkinder, Vermittlerinnen, und ein einsamer Marsch durch die akademischen Institutionen: Zur wissenschaftlichen Aktivität von Frauen in der Aufklärung," in *Tugend, Vernunft, und Gefühl: Geschlechterdiskurse der Aufklärung und weibliche Lebenswelten,* ed. Claudia Opitz, Ulrike Weckel, and Elke Kleinau (Münster, 2000), 271–92.

20. Johann Eberti, *Eröffnetes Cabinet des gelehrten Frauenzimmers* (Frankfurt, 1706).

21. It is no accident that the vast majority of examples for marital scientific collaboration in the nineteenth century come from field sciences such as

botany or anthropology, not from laboratory sciences such as physics or chemistry.

22. Volker Press, "Die Hessische Gelehrte Gesellschaft: Das Gießener Akademieprojekt im 18. Jahrhundert," in *Academia Gissensis: Beiträge zur älteren Gießener Universitätsgeschichte,* ed. Peter Moraw and Press (Marburg, 1982), 313–59.

23. For a survey on normative texts on female education and erudition, see Ulrich Engelhardt, "'. . . geistig in Fesseln'? Zur normativen Plazierung der Frau als 'Kulturträgerin' in der bürgerlichen Gesellschaft während der Frühzeit der deutschen Frauenbewegung," in *Bildungsbürgertum im 19. Jahrhundert,* pt. 3, *Lebensführung und ständische Vergesellschaftung,* ed. Rainer Lepsius (Stuttgart, 1992), 113–75. This article also cites the pertinent older literature.

24. [Wilhelm Friedrich August Mackensen], *Letztes Wort über Göttingen und seine Lehrer: Mit einem Nachwort und Erläuterungen von Ulricht Joost* (1791; Göttingen, 1987).

25. I am indebted here to Ildikó Szász, *Chemie für die Dame: Fachbücher für das "Schöne Geschlecht" vom 16. bis 19. Jahrhundert* (Königstein, 1997). Szász, however, does not interpret the contradictions inherent in her material. See also Barbara Orland, "Chemie für den Alltag: Populäre deutsche Chemiebücher, 1780–1930," *Mitteilungen der Fachgruppe Geschichte der Chemie der Gesellschaft Deutscher Chemiker* 13 (1997): 39–74.

26. The women's chemistry books grew considerably narrower—more focused on household chemistry—and more superficial in their treatment of chemistry after approximately 1850.

27. See Szász, *Chemie,* 227.

28. Ute Frevert, "Bürgerliche Meisterdenker und das Geschlechterverhältnis: Konzepte, Erfahrungen, Visionen an der Wende vom 18. zum 19. Jahrhundert," in *Bürgerinnen und Bürger: Geschlechterverhältnisse im 19. Jahrhundert,* ed. Frevert (Göttingen, 1988), 17–48.

29. Pnina Abir-Am, Heleny Pycior, and Nancy Slack, eds., *Creative Couples in the Sciences* (New Brunswick, 1996).

30. Peter Moraw makes this point in "Humboldt in Gießen: Zur Professorenberufung an einer deutschen Universität des 19. Jahrhunderts," *Geschichte und Gesellschaft* 10 (1984): 47–71.