A Fascinating History of Curious Careers: Women in Science and Engineering in the Netherlands, 1650-2005[1]

MINEKE BOSCH

In her article „A fascinating history of curious careers: women in science and engineering in the Netherlands", 1650-2005 Mineke Bosch demonstrates that there have always been women with more than a passing interest in science and technology.

Seventeenth-century Maria Sibylla Merian pursued her research into caterpillar's metamorphosis far into the hinterland of Surinam, while Maria Winkelmann explored the heavens together with her husband for meteors and stars. In the nineteenth-century, as a corollary of widespread educational reform the women's curriculum changed, and women were more and more supposed to dislike the exact sciences. Even so, they kept being interested, though in smaller numbers. In 1976 this led the feminist question „Women in Science: Why so few?" This question inspired numerous and still increasing activities to promote women's participation in science and technology.

Curious Careers: A Fascinating History

Women in science and engineering are even today a controversial subject. The low level of interest that girls seem to show in natural sciences and technology in 2006 is a subject that leads to heated discussions.

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Many people believe that the history of women in natural sciences and technology is a straightforward story with few positive episodes. Because even if girls had any chance at all to follow higher education in the past, most people assume they specialized only in typical „women's subjects": modern and classical languages, history, and teaching. Some might even think there is no such thing as a history of women in technology – have women and technology ever gone together? (Oldenziel 1999; Canel/Oldenziel/Zachmann 2000).

Surprisingly perhaps to the casual reader of history, there have always been women with more than a passing interest in physics, chemistry, or biology. Women like Lady Ada Byron Lovelace, who was involved right from the start in the development of computers, and the famous French mathematician Sophie Germain, who in 1816 won the *prix extraordinaire*. In terms of knowledge and fame, many other women scholars could be competed with the top male scientists of their day. Though compete might not really be the right word here. Many couples, brothers and sisters, and brothers- and sisters-in-law jointly pursued a passion for astronomy, chemistry, geology, or other fields of science as a family enterprise (Schiebinger 1989).

If history is any guide, there is no law that dictates the current small numbers of young Dutch women who choose natural sciences and technology. If we take a look around us we can see that in Turkey, for example, the representation of the sexes in these fields is much better balanced than in the Netherlands. And looking back in time, we even see that the classical languages we consider „women's subjects" today traditionally were a must for boys from the elite classes, while for girls these disciplines were taboo. And remarkably given the current calls for women go into the sciences, historically the situation was still quite different, if not the opposite. In other words, the history of girls and women in science and engineering is not a long, bumpy road, but rather it is a varied route with detours and side-roads, with ups and downs, but above all, with lot of unexpected turns. But however we look at it, its history is a story of curious careers. Maybe not always curious in the sense of unusual, but a story about the careers of curious women intrigued by the challenges and pleasures the sciences and engineering had to offer them.

First Scientific Revolution: Challenges and Opportunities, 1600-1700

The roots of modern science go back to the scientific revolution. It offered new opportunities for women. It also created new detours. When we think of the scientific revolution, names readily come to mind like Nicolaus Copernicus, Johannus Keppler, Galileo Galilei, and Isaac Newton, who fundamentally changed our ideas about astronomy and the universe in the first half of the seventeenth century. Physicians increased their knowledge of the human body by dissection and the use of the microscope. Biologists and botanists ventured – literally – into the field to discover, analyze, and categorize new species of animals, plants, and fishes. Geographers and geologists joined the discoverers in the hope of enriching not only the cause of science, but also that of trade.

In 1620, the Englishman Francis Bacon created a theoretical foundation for the new science of „experimental philosophy“. He believed that the only way in gaining true knowledge was by experimental investigation based on empirical observation. To underline his radical arguments and convince his audience, he relied on recognizable metaphors. He referred, for example, to the „male science“ that had to contend with the „female nature“ to gain access to her secrets. And following his successful rhetorical uses, other scholars conjured up similar metaphors – some of them rather violent –, such as the notion that persistent scientists had to conquer and subdue nature or tear off her veil (Merchant 1980; Fox Keller 1985). Such early modern imagery created a symbolic polarization between men as the subjects and women as the objects of science. These were mere metaphors of course. Nevertheless, they did have an effect on the lives and ambitions of curious women interested in the sciences.

The scientific revolution brought benefits to women interested in the pursuit of knowledge. The newly established Royal Society in Britain – the first scientific forum for the non-academic pursuit of science from 1660 onwards – might have denied women membership rights until far into the twentieth century, but the new way of learning was certainly not restricted to men alone. Experimental philosophy developed in opposition to the theoretical, classically-based knowledge that was taught at the century-old universities primarily to boys of the ruling classes. These traditional Latin-based universities kept a respectable distance from what they considered the vulgar and practical knowledge of nature used mainly for trading and industry. The practitioners of experimental philosophy, by contrast, advocated the use of national languages to promote the wide distribution of the new knowledge and believed that the new knowledge would bring mankind closer to God.

All these factors benefited the involvement of women in the new experimental philosophy (Phillips 1990). The public lectures-with-experiments, often held with more than a touch of theater, were usually open to people from all social stations. The term *„physique amusante“* was used for good reason. Contemporary accounts report that the audiences at the spectacular readings of the chemist Robert Boyle included women listeners who often cared for the animals that threatened to expire time after time in the demonstrations of his vacuum pump. And because new scientists published their findings in their own languages, women – obviously without the benefit of a university education – could more easily publish the results of their own scientific investigations and distribute them on a broader basis than would have been the case in classic fields of study.

The natural sciences' novel emphasis on practical knowledge benefited women in yet another way. As the mistress over the household, women could profit from the knowledge of chemistry, meteorology, natural history, and medicine. Thanks to chemistry, housewives could get better results with their washing and gain a better understanding of food preparation; metrology helped women keep their thoughts tidily arranged; and knowledge of nature simplified the preparation of medicines and caring for the sick. Women in the Dutch Republic in the sixteenth and seventeenth centuries in particular had a reputation for their ability to organize things independently of their seafaring men and held up as an example to their English sisters because of their practical knowledge. The British Batshua Makin, head of a girls' school and sister of a member of the Royal Academy, celebrated the „honest, well-bred, ingenious, industrious Dutch-woman" for their knack for enterprise and for the practical application of what was then called „useful" knowledge (Phillips 1990).

Anna Maria van Schurman and Maria Sibylla Merian

Contemporaries called the Dutch woman Anna Maria van Schurman (1607-1678) „the Pallas of Utrecht" for her exceptional wisdom and erudition (De Baar 2007). Schurman, born in Cologne, moved with her family to Utrecht at the age of seven. She stood out when she was still very young. In 1625 the renowned poet and statesman Jacob Cats sung her praises as an exceptional woman. „You jewel, just recently arisen, from whose learned youth and distinguished pen, the cities on the Rhine and I have witnessed" (ebd.). On her own accord, Schurman entered into a discussion with a famous theologian, Andreas Rivet, about whether Christianity permitted women to study. That correspondence led in 1638 to *Treatise on the suitability of the female spirit for science and letters*. The publication attracted the attention of many other highly educated women in Europe, including Marie le Jars de Gournay (1565-1645), who had issued a comparable work in 1622 entitled *De l'égalité des hommes et des femmes* and was also well known for her chemistry experiments.

Unlike many other well-educated women of her time, however, Schurman specialized in the theological debates. Gisbert Voetius, the Utrecht professor of theology and Eastern languages and minister for the reformed community, allowed her to follow his university lectures from a sort of cubicle. Following lectures in literature and medicine in similarly circumscribed conditions, she became effectively the first female student in the Netherlands. Through her brother Johan Godschalk, Schurman came into contact with the reformed preacher Jean de Labadie in Geneva, who sought to return religious practice to ascetism, meditation, and contemplation. When he radicalized further and was put out of office of the Walloon reformed church in Middelburg, Schurman accompanied him and his followers in the Walta State in the village of Wieuwerd, Friesland (Vries 1970).

A generation later, Maria Sibylla Merian (1647-1717) joined the same religious commune and gained such great fame as a highly educated woman that the memories of her have not disappeared even to this day. The tangible signs of her productive life she left behind, including a number of beautiful works on entomology (the study of insects) she compiled and illustrated herself, might have been responsible for that.

Merian was born in Frankfurt in 1647 to a family of craftsmen. „Her father, Matthäus Merian, was a renowned artist and illustrator, who was best known for his lavishly illustrated Merian bible". He died when she was three, but the man whom her mother, Johanna Heim, remarried, Jacob Marell, was an artist and a member of the artists' guild. In his workshop she learned all the techniques of illustration: drawing and painting, mixing paint, and making copper etchings. After marrying one of her stepfather's pupils, she started selling fabrics she had painted herself.

Her life's work for which she became famous was the book *Der Raupen wunderbarer Verwandlung und sonderbare Blumennahrung* (1687), that dealt with caterpillars' metamorphosis into chrysalises and butterflies and with the flowers on which they feed. It was based on years of thorough study and contained fifty copper engravings. She made the important discovery that specific caterpillars belong to specific plants, and these then develop into specific butterflies. The work made her so well known that there was an immediate demand for a second volume. In the meantime she published her *Neues Blumenbuch* in 1680 with 36 engravings intended for readers who needed samples for their paintings and embroidery.

Around 1685, Merian left her husband to move in with the Labadists in Friesland, only to move again in 1690 to Amsterdam, where she met leading families who opened their cabinets of trophies and objets d'art. Especially the cabinet of the Amsterdam mayor Nicolaas Witsen, with his many trophies from both East and West, made a big impression on her. She also met Casparus Commelin, botanist and founder of the Amsterdam Hortus botanicus, and familiarized herself with the scientific work of Jan Swammerdam and Antoni van Leeuwenhoek, the famous pioneers in the field of microscopy.

The tropical wonders she encountered in Amsterdam awakened her desire to carry out research and draw in Suriname, where both the Labadists community owned plantations and her eldest daughter lived. Financial support from the municipality of Amsterdam enabled Merian to pay for the voyage for herself and her youngest daughter in 1699. From Paramaribo she sailed the length of the Suriname River to research the hinterland. Four years after returning to Amsterdam in 1701, she published her most famous work: *Metamorphosis Insectorum Surinamiensium* (Metamorphosis of the Insects of Suriname), at first only in Latin, and later also in a Dutch translation. From that time until her death in 1717, she worked to revise and translate her first two-volume work *Der Raupen wunderbarer Verwandlung und sonderbare Blumennahrung*. A third volume was published posthumously. Although her work became at least as famous as her father's, her scientific qualities were controversial right from the start because they did not live up to the scientific standards of the time: she first did not publish in the official scientific language of Latin, while later her illustrations were considered to be too beautiful and artistic. Today she is recognized as a major entomologist and scientific illustrator.

Science Books For and By Women, 1700-1800

Women also benefited from publishing innovations that helped to break the monopoly on the production of knowledge which monasteries and classical universities had traditionally held. The popularization of the new sciences gained a great impulse from books like *Urania Practica* (1649), the first English astronomy textbook, and *Introduction to Astronomy and Geography Being a Plaine and Easie Treatise of the Globes* (1675), a real do-it-yourself book. Not long after, the predecessor of a long series of textbooks for women, Bernard le Bovier de Fontenelle's *Entretiens sur la pluralité des mondes* (1686) appeared in France. In England, Aphra Behn, reputed to be the first female author who lived from her writing, published the first translation. Almost as famous as Fontenelle's book was the Italian Francesco Algarotti's much translated, *Il Newtonianismo per le dame* of 1737, or Benjamin Martin's widely read two-part work *Young Gentleman's and Lady's Philosophy* of 1763. The first half of the eighteenth century also saw the publication of a number of periodicals aimed specially at women, such as the *Ladies Diary*, which challenged women to test their skills at „Writing, Arithmetick, Geometry, Trigonometry, the Doctrine of the Sphere, Astronomy, Algebra, with their Dependants, viz. Surveying, Gauging, Dialing, Navigation, and all other Mathematical Sciences" (Phillips 1990).

Around the end of the eighteenth century, women also started to try their hand as authors of the popular scientific handbook genre. Priscilla Wakefield's *An Introduction to Botany* of 1796, for example, reached its eleventh reprint in 1841. Her 1805 *Domestic Recreations; or Dialogues Illustrative of Natural and Scientific Subjects* was even more successful. Another best-selling author was Jane Marcet with her *Conversations on Chemistry, intended more especially for the Female Sex* (1806), the *Conversations on Political Economy* (1815), and *Conversations on Natural Philosophy* (1820).

On their part, Dutch women could imbibe the new knowledge from a mixture of translations and native works (Bosch 1997). Algarotti's Newtonian philosophy for women found his way to the Netherlands in translation in 1768. A very popular edition was the 1859 translation from the French Abbé Nollet's, *Lessons in physics, confirmed by experiments*. *In clarification of all kinds of everyday matters*. Remarkably, it showed illustrations of women actively involved in scientific experiments in its first edition. The members of the Ladies' Society for Physics in Middelburg learned their lessons from this book. And reverend J.F. Martinet wrote a very famous work *Katechismus der Natuur* (1777-1779) in four volumes that was reprinted until well into the nineteenth century. He used it for teaching a broad public, including a women's reading society in Zutphen.

Many works of this kind were advertised as „per le dame" or „specially for women". No doubt they also drew male readers. Fontenelle, for example, was translated by the Leiden professor Johan C. Gottsched, but he deliberately left out every reference to the popular nature of the work – never mind the intended female readership. Jane Marcet's *Conversations on Political Economy*, translated by another Leiden professor, H.W. Tydeman in 1925, probably also served as the basis for the first lectures in domestic science in the Netherlands. In the translation of another work of Jane Marcet, Tydeman again left out her first name, so that young readers remained ignorant about the true gender of the author. Jane Marcet's work about chemistry is reputed to have provided the spark that ignited the chemist and physicist Michael Faraday's love for the subject generations later. Women popular science writers, in short, had a major impact on science practice in the eighteenth century.

The Enlightenment: A Double Heritage, 1750-1900

The Enlightenment age was a double-edged sword for female scientists and engineers. Its promise of universal rights, equality, and liberty paved the way for equal rights and opportunities. The Enlightenment, however, also marked the era that invented and highlighted sexual differences that came to be carved in stone and also would limit the possibilities of women's advancement in science in the long run.

The establishment of both the Paris and Berlin academies of sciences in 1770 and 1666 showed that the exclusion of women, during the first scientific revolution, was neither predetermined nor simply accepted (Schiebinger 1989). In the French academy, a number of women held official functions, and in Paris a salon culture arose, in which male academy members and women continued to meet each other on an equal basis. In the first ten years of the Berlin academy's existence, astronomer Maria Winkelmann (1670−1720) was officially recognized as the assistant of her husband, who was appointed as academy astronomer. At the time, experimental philosophy (in this case astronomy) was still based on a tradition of guilds, in which science was a family business. Yet as a sign of the new times, Winkelmann was passed over as her husband's successor after his death, as had been customary with the widows of guild members, who frequently continued their husbands' businesses. Increasingly in the field of science and outside it the lines between the sexes were being drawn ever more clearly in the Age of Enlightenment.

We generally view the Enlightenment as the origin of liberal Western values such as rationality and reason and a belief in progress, universal human rights, and democracy. For women that did not always pan out in the same fashion. Some contested the commonly held views about women, including the relatively unknown French feminist and Cartesian philosopher François Poulain de la Barre, who in his treatise *The Equality of the Sexes* (1673) argued that „The Mind has no Sex". These thinkers, however, found fierce opposition from such philosophical heavyweights as Jean-Jacques Rousseau and Immanuel Kant. Rousseau, who believed a woman is a man in every respect except for her sex, argued however that her sex determined her behavior: „the female is female all her life". Immanuel Kant called on universal „man" (Mensch) to emancipate himself from his self-imposed constraints. In his series of lectures entitled *Anthropology*, however, he followed Rousseau arguing that emotions and married life dictated and ruled women, effectively excluding women from the universal category of „man".

Most thinkers derived their views of men and women from the great numbers of anthropologies that, in contrast to today's practice, were based largely on medical-anatomical research. This research increasingly regarded the natural difference between the sexes as immutable. It presented that difference as pervading the entire person. On the basis of that new logic, men were designated as active, rational, resolute, and productive; women as passive, emotional, fickle, and trivial. „For him the world, for her the home", was the rule that from then on influenced public and private life. It also shaped the organization of science. Increasingly, the practice of science became a matter of individual men making their heroic discoveries within public institutions rather than the family businesses in the private sector.

The Middelburg Ladies' Society for Physics, 1785-1887

When the library and possessions of the society Lady Hillegonda Catharina Schorer of Middelburg were auctioned in 1821, they also included an „electrifying machine", with which an „electric kiss" could be given in salon demonstrations (Sturkenboom 2004). This was done by charging a man with static electricity using an electrostatic apparatus. Then a woman from the audience was invited to place her mouth so close to the man's that a large spark jumped over to her. The „electric kiss" symbolized the natural sciences of that period, in which learning and entertainment went hand-in-hand. Experiments were shown to mixed groups of men and women in drawing-room settings. Natural science presentations, however, increasingly moved to gatherings of the numerous societies that sprung up in the eighteenth century and that, with very few exceptions, were accessible only to men. The Ladies' Society for Physics in Middelburg (in the province of Zeeland, the Netherlands), founded in 1785, represents one of the few ladies' scientific societies of the time.

The prominent citizen Adriaan van de Perre founded the society. He invited 44 women from the elite classes in Middelburg, who registered as members in 1785. A regular speaker in the early days was reverend Ballot, the father of the famous meteorologist Buys Ballot, who dealt with Abbé Nollet's work. According to the proceedings, the Middelburg ladies were taught physics in a contemporary format, in which a „knowledge of Nature“ was believed to lead to a deeper understanding of the majestic work of the Creator.

The „Physics for Ladies“ as practiced in Middelburg show that the relationship between women and natural sciences went through a period of warm mutual friendship, which did not cool down until far into the nineteenth century. A century later, around 1887, that love had faded, crowded out in part by the increasing influence of voices maintaining that women had no talent for the exact sciences. The shifts in education for girls reflected a similar change. Initially, „the sciences“ (meaning the practical, natural sciences) had formed a large part of most Dutch teaching programs at the so-called French schools. The foundation of the Girls' Secondary School, however, brought a marked decline of the share of the exact sciences in the curriculum for girls. The window of opportunity that had been opened for girls was closing again.

Second Scientific Revolution and the Changing Curriculum, 1850-1950

The nineteenth-century changes in natural sciences mark the second scientific revolution. It increased the importance of the natural sciences in the university curriculum, helped to develop the scientific researcher into a professional, and announced the specialization of research. Researchers started to demand laboratories that were equipped with the latest instruments for carrying out experiments. These developments led to a relocation of scientific research from the private to the public domain.

Subsequently, educational reforms were taking place everywhere in the Western world. In the Netherlands, the Latin School transformed into the Gymnasium that paid attention to the classical languages, modern languages, and natural sciences, and to the establishment of higher secondary school for boys from the middle classes (the HBS). The curriculum emphasized „modern“ subjects such as the natural sciences and the living languages to prepare boys for positions in trade and industry. The HBS was the jewel in the crown of the Education Act the liberal statesman J.R. Thorbecke drafted. These new schools were generously supported with innovative teaching materials. A well-equipped physics and chemistry laboratory was standard. The new high schools often maintained various collections and a garden. Although Thorbecke had not at first thought of it, he responded to debate in the Dutch parliament and the girls' education movement, pressing him to consider top open up secondary education for girls from the higher social classes. He was prepared to offer the legal framework of the Girls' Secondary School, but he believed its organization and financing was not the duty of the state, but should come from citizen initiatives (Bosch 1994).

Women's education advocates argued girls should have the opportunity of further personal development, but also they debated what its purpose should be: life as a housewife, motherhood and/or a career, and in which way. As elsewhere in Europe, Dutch education reformers mainly answered the question about the curriculum in a „modern" way: women should be housewives and mothers. Only a minority maintained that women should prepare for an independent life. As an unintended consequence the „sciences" became less valued. It represented a break with the first half of that century. But just as the HBS started to send students to the universities held as the sole right of the Gymnasium, young women also started to show an interest for these secondary education institutions, and even for the university.

Aletta Jacobs was the first woman in the Netherlands to register as a medical student, at the University of Groningen in 1871; she graduated in 1878 and earned her doctorate in 1879 (Bosch 2005). Although she encountered virtually no resistance, compared with girls and women in England or Germany, few followed Jacobs' example. Although increasing numbers of women started to show an interest in attending university lectures or registered at university to gain a secondary education diploma, it was Aletta Jacobs' sister Charlotte who in 1882 was the second woman in Holland to complete her academic studies with a degree in pharmacy. From that time until 1898, there was a slow but steady increase in the numbers of women students, many of whom had not registered for a complete study program or intended to see their studies right through to completion. Remarkably perhaps from today's effort to encourage women to pursue science and engineering, in this earlier period young women showed a strong preference for studying mathematics, physics and medicine (Kirejzcyk 1993; Bosch 2002).

Table 1: Dutch Women Students per Faculty per Year (Totals and Percentages)

	1898			1928			1940		
	Total	Wom-en	%	Total	Fe-male	%	Total	Fe-male	%
Theology	393	1		678	42	6,2	779	71	9.1
Law	476	5		1,590	262	16,5	1,610	430	26.7
Law and Arts				337	15	4,5	375	49	13.1
Medicine	1,126	29	2,3	3,125	374	12	3,470	634	18.3
Math and Natural Science	402	48	11,9	1,862	508	27,3	1,437	418	29.1
Geogra-phy and Psychol-ogy				57	15	26,3	112	52	46.4
Philoso-phy and Literature	178	18	10,8	1,224	561	45,8	865	380	43.9
Econom-ics				159	22	13,8	190	18	9.5
Veteri-nary Sci-ence				158	1	0,5	135	7	5.2
Technol-ogy and Agricul-ture					113(*)		2,778	119	4.3
Total	2,716	101	3.7	9,561	1,810	18.9	1,1251	2,044	18.2

Source: Jensma and de Vries 1997: 193, 204, 210.
Source (*): Freie 1948

Never-ending Debate about Women and Science, 1870-now

The Dutch public debate about women's education received a major impulse from the organization of the National Exhibition for Women's

Work at Scheveningen in 1898. The event provided a platform for a number of congresses, dealing with a host of topical subjects and attracted record numbers of visitors. The organizers credited the extensive publicity not least to the high-level attention the president Cécile Goekoop-de Jong of Beek en Donk had drawn in the preceding year to women's issues with her best-selling novel and social commentary *Hilda van Suylenburg* (1898). The main roles in this fascinating and wide-ranging feminist pamphlet were played by a doctor and a woman lawyer. Perhaps not coincidently, the year following the bestseller publication the number of women students suddenly increased by leaps and bounds, continuing to show a non-linear increase to 19.8 % in 1970 (in 1960 it was 17.9 %, in 1940 18.2 % and in 1928 18.9 %).

The high level visibility of women's demands sparked a never-ending debate about „women's studies" in 1898. „Are women suited to studying?" the Amsterdam gynecologist Hector Treub famously wondered during a lecture to a feminist women's society. „Yes", was his resolute answer: studying is suited to women, and women are suited to studying. But that did not bring about a revolution. The most important tasks for women were still those of marriage and motherhood. His colleague Cornelis Winkler, on the other hand, had a different view. For his argument, he rallied the opinions of numerous colleagues in the USA, England, Germany, and Switzerland. The development of „women's studies" was getting out of control, he believed. A woman who pursued a scientific career was a freak of nature, or to use the polite or scientific Latin name, a „monstrum". And a society that did not place limits on this trend ran the risk of degeneration and sterility, he argued (Bosch 1994).

The fierce 1898 debate did not mark the last stage of men's resistance to the integration of women in their „male domain". Nor was the debate a clear or final answer to those developments. Winkler had earlier indicated the limits that should be placed on what contemporaries called women's studies. As far as he was concerned, women could study medicine to become general practitioners, but not to become professors. He also used the so-called man-woman differences to reinforce the image that research in the sciences naturally suited men. From then on, polemics of this kind continued almost without interruption in different disciplinary contexts and periods, always resulting in a further determination of the (restricted) place of women in science.

The uncharitable view of girl students the influential professor of Dutch national history P.J. Blok expressed in 1909, also played a role in the long-term custom of granting women no more than assistants' positions in academia. At the same time he assessed „real historians" could only be men. In a controversial survey of women's studies, the renowned psychologist and experimental scientist Gerard Heymans relied on „common sense" notions about women, men, and science to demonstrate the value of psychological research based on interviews. Even so, he confirmed that women could perhaps go a long way on the basis of hard work and applied science, but that their stronger emotions prevented them from making great scientific achievements. The plea for stronger links between science and society in the 1930s, together with a raised status of the practical and useful natural sciences and technology at the expense of the humanities, might not have been primarily about the roles of men and women. Yet, it did have a limiting effect on the numbers of women in science in the Netherlands. Not only were they underrepresented in the sciences, but women students were also expected to study only for their „general development", instead of preparing themselves for life-long careers. The post Second World War debate about university education too may not have been primarily about women students' place and ability, but the renewed emphasis on the importance of education resulted in a separate „women's curriculum", in which there was no longer room for the exact sciences.

The ongoing debate about women's proper place in academia had a chilling effect. The proportion of Dutch women students never exceeded 20 % until 1970. It also had an effect on the „preference" of women for specific disciplines. Before 1898 the majority of women showed a preference for the exact sciences and mathematics, and medicine (48 and 29 of 101, respectively). By 1897 only the first law student was enlisted and a year later only 18 women out of 101 registered as students in the humanities. In 1940, the proportion of medicine, and natural sciences and mathematics had declined to 643 and 418, respectively, out of a total of 2044 female students. Women students in the natural sciences and mathematics still accounted for more than 50 % of the total, but still it was a declining trend. Within mathematics and natural sciences, pharmacy was by far the most popular for a very simple reason: as in medicine and dentistry, pharmacists could become self-employed. And many of them did exactly that: in 1930, 153 (out of a total of 544) women pharmacists had their own pharmacies. Self-employment gave these women the ability to determine not only their own working conditions, but also their private lives. In contrast to women in many other professions, most of these pharmacists combined a family with their work.

Special or Separate?
Women in Science, 1870-1970

The second scientific revolution in the Netherlands has been described as a second Dutch Golden Age, which led to an impressive number of Nobel Prizes (six) at the beginning of the twentieth century (Van Berkel 1998). The increasing professionalizing of science and research, however, did not always favor women scientists in the academic field. Until 1970, only exceptionally few women pursued scientific careers and only a fraction of them reached the position of professor. The journeys of many of them became bogged down in (head) assistants' positions or in lecturers' positions that were sometimes changed to professorships at the eleventh hour (on reaching the age of 65). As a group, these women remained often (highly appreciated) outsiders, both in scientific and in social terms. Most of the career women scientists remained unmarried, with all the advantages and disadvantages of that status.

Biology forms the exception to this rule. For a long time, well-educated, aristocratic „amateurs" like Anna Weber-van Bosse, who gained (as the first woman in the Netherlands) in 1910, at the Utrecht University, an honorary doctorate for her research into algae she had carried out in her own laboratory, had a respected place in the field. Male mentoring of women talent also had an from Utrecht University played a positive part in the appointment of the biologist Johanna Westerdijk as the director of the Willie Commelin Scholten small plant diseases laboratory in Amsterdam in 1906, and later in her establishment as extraordinary professor in 1917 (Bosch 1988; 1994). Two years later, the Groningen professor Willem Moll also demanded recognition for his brilliant student Jantina Tammes in establishing an extraordinary chair at his department (De Wilde 2001).

It is hard to assess the exact role of mentors, nevertheless a number of disciplines and laboratories proved to be fertile ground for Dutch women: the laboratories of the chemical engineer F.E.C. Scheffer at the Delft University of Technology, the entrepreneurial physicist Leonard Ornstein in Utrecht, the gynecologist Hector Treub in Amsterdam, Johanna Westerdijk in Baarn, or the crystallographers J.M. Bijvoet and Caroline MacGillavry in Amsterdam. (Stamhuis/Offereins 1998) Just as important is that the disciplines such as crystallography and radiology maintained an international network in which many women were actively participating. In addition, many women developed specialties all of their own or focused on newly emerging research areas. Jansje Schuiringa for instance made major advances in prosthetic dentistry in Utrecht, while Antonia Korvezee was one of the first researchers in the

Netherlands to systematically investigate radiation (De Jong 1988; 2004).

Dutch women scientists also developed other strategies to dispense with the institutional constraints of university research by working for government or industry. On the entry level the government and industry employment offered opportunities, but here too academically trained women came up against „glass ceilings“. There were some notable exceptions though. Neele Wibaut-Isebree Moens was for many years affiliated with the Public Health department of the city of Amsterdam, N. Kloppert for many years carried out research at the Amsterdam municipal Trading Standards Department (Bosch 1994). Starting one's own business, finally, offered academically trained women alternatives to the limited possibilities for career advancement at universities, the government, or business. There have been enterprising women who continued their research work in their own laboratories, possibly with profits in mind. That was the case with the physicist Carolina Bleeker. Her firm at one point even had a workforce of 150. Delft trained chemical engineers Hilda Vormer-Roosenstein and Hendrina de Wijs who were strong-minded enough to establish their own research laboratory and consultancy practice with which they were able to earn a living.

Table 2: Women Academic Scientists in the Netherlands 1948 (Universities and higher vocational-economical, technical, agricultural-education)

	Professor	Lector (Associate Professor)	Other	Total university	M.A. (Drs.)	Ph.D.	Dr. %
Theology					98	7	7.1
Law	1		2	3	1,381	160	11.5
Medicine	1	3	12	16	1,354	108	7.9
Mathematics and Natural Science	3	5 (+ 1*)	41	49	1,106	204	18.4
Biology*	1	2	22	25	239	100	41
Pharmacy*	1	2	4	7	596	22	3.6
UF2: Arts and Natural Science	2	1	3	6	134	22	16.4
Literature and Philosophy	4	4 (+5*)	24	32	1,117	243	21,8
Economics					45	1	2
Veterinary Science					8	1	12.5
Technology and Agriculture		1	2		247	12	4.8
Total	11(+2**)	14(+ 6**)	84	109	4,109	598	14.5

Source: Van der Kolf 1950.
** Only biology and pharmacy in this table are shown specifically; they are included in the overall figures for mathematical and natural science.*
*** Educated in the Netherlands; Appointed at foreign universities.*

A 1966 Feminist Challenge: Why So Few?

During the 1960s, academically educated women everywhere in the Western world started to discuss the „problem without a name“ – women's hard-to-assess feelings of dissatisfaction with a life that relegated them to the realm of housewives and mothers, or to secondary positions in the public sphere. They started to claim that „the personal is political“, arguing that women's private lives were valuable and should be understood at a political level. Fifteen years earlier, Simone de Beauvoir's classic essay *Le Deuxième Sexe* on how women were made into „the second sex“, had impressed a handful of women. Now it became one of the key texts of the second wave of feminism inspiring a whole generation of young women. De Beauvoir posited that women are *made* into women by an overwhelming and non-stop production of knowledge about women, from philosophical texts and biological evidence, to popular cultural notions and literary works. Language and culture were therefore central targets of second-wave feminists.

In the universities, women students and lecturers formed groups who – following the example of sociologist Alice Rossi – wondered: „Women in Science: Why so Few?“, after Rossi held a speech in 1966 at MIT about women in science. Indeed that question was topical, for the progress of women in the sciences had not really advanced beyond the promising strides during the 1920s, when so many women had entered academia as students. All over the Western world, the position of women students seemed to be in better shape during the decade of the 1920s than during the 1960s. Over time, various answers to this question were formulated.

One of the first was that the content of science had a unilateral male or masculine bias, and that it stereotyped or excluded women. This led to the development of women's studies (later called gender studies). Sometimes organized as a separate unit, it often sought to highlight the „blind spots“ within the existing scientific disciplines and generated new interdisciplinary knowledge. Within the new discipline, a feminist reflection of science itself was undertaken from different disciplinary perspectives: history, epistemology and sociology. This led in the Netherlands to the publication *„Cracks in the foundations. Women, Natural Sciences, and Technology“ (Vrouwen* 1986).

A second answer to the question „Why so Few?“ came from the development of a governmental emancipation policy in higher education and science and at the universities. The Dutch government initially responded to the demand for women's studies by awarding several major subsidies around 1980. By the end of that decade, a consensus developed that new policy should focus on the entire female scientific staff. For some time this did not go beyond measures to create the desired working conditions such as childcare and maternity leave or training for women. An occasional program with a more far-reaching aim to raising the number of the appointments of professors (affirmative action measures) failed because of the unwillingness of the incumbent academic staff. The universities themselves – in other words their role in the under representation of women in science – remained largely free of blame. Nevertheless, policy makers began focusing on questions such as „why do women not achieve higher positions as quickly as men?“ or „why do more women leave their scientific careers?“ At the beginning of the 1990s, it also became clear that – despite the second feminist wave – the number of female professors in the Netherlands had declined since the early 1970s, instead of increased!

It still took until 1997 before the under representation of women scientists received a degree of priority on the agenda of decision-making institutes in the Dutch academic community. Two Swedish medical researchers, Agnes Wold and Chrtistine Wennerås, showed in a study published in *Nature* supported through hard data that women had to excel twice as well at successfully acquiring specific research funding than men. In response to the study, the European Commission in Brussels decided to make gender equality one of the important pillars of the scientific policy agenda. One of the results was the publication in 2000 of a comparative international European report (the ETAN Report) about the position of women in science by a group of international experts under the title of *Research Policies in the European Union: Promoting excellence through mainstreaming gender equality*. This showed once again that in international terms the Netherlands did poorly with only 5 % female professors. Finland was on top of this list with 18.4 % professors, followed by Portugal and France with 17 % and 13.8 %, respectively. The Netherlands tied with Belgium (5.1 %) and Germany (5.9 %).

This marked the start of a new phase in tackling the under representation of women. (Bosch/Hoving/Wekker 1999; AWT-Avies 2000) The Dutch ministry instructed the Dutch Organization of Research (NWO) to develop the ASPASIA-program in cooperation with the universities. While observing the customary peer review procedures, this program offered women university lecturers the opportunity of acquiring research funding, and when successful, progressing from assistant to the position of associate professor. The ASPASIA-program was a big success. A total of 270 proposals were submitted for the planned two rounds. Impressed by the proposals' high quality and encouraged by the Advisory

Council for Science and Technology Policy's recommendation, the minister together with the NWO immediately decided to honor not two times 15, but in the first round 30 and in the second round 40 proposals. An almost equally large number of proposals were assessed as „good", but could not be honored because of lack of resources. In response to this well of talent, NWO then encouraged universities themselves to appoint these candidates as associate professor and to fund the proposals from their own local resources. Most universities indeed complied with NWO's request. Finally, 146 women were appointed as associate professor as a result of the ASPASIA-program. Between 1999 and 2004, when the second round had been completed, the percentage of female associate professors increased from 9.4 % to approximately 14.5 %.

Even more important was the fact that the NWO had shown with this program that measures could certainly be taken to increase the numbers of women appointed while maintaining its quality standards. NWO'S efforts encouraged a number of universities to push and develop their own programs to promote the appointment of qualified women.

Lisbon agreements

This is all the more important since the Lisbon agreements made by the European Commission to transform Europe into a knowledge economy set a target of 25 % for the percentage of women professors in all member states by 2010. The Dutch minister of Education, Culture and Science, Maria van der Hoeven, in her memorandum „Research Talent Gets the Valuation it Deserves" felt forced to adjust this figure downwards because she believed 15 % is a more realistic target. The poster below shows what that means the question is: will Dutch universities reach this goal? The poster Making Lisbon Happen was developed by the ESF-Equal project participation of Women as Priority for Science. It was issued March 8, 2006.

Figure 1: Making Lisbon Happen

Resource: ESF-Equal project participation of Women as Priority for Science 2006, www.participatiealsprioriteit.nl

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