Women and Science

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Abstract

This essay provides an overview of women and science, both as practitioners and subjects of scientific enquiry, from the late-eighteenth century through to the first decades of the twentieth. It introduces the processes by which science acquired a masculine culture and describes the ways in which male-focused histories of science have misunderstood the landscape of science and, as a result, ignored women's scientific contributions. Feminist scholarship has rendered visible the ways in which women negotiated access to science, became part of scientific networks, collaborated as peers and made significant contributions to scientific knowledge. This essay also discusses the ways that scientific women in the past made their own feminist interventions to counter their exclusion.

Feminist questions for science

Science and women's place within it is an issue that has been contested since the birth of modern science, then called natural philosophy, in the late-seventeenth century. Feminist engagement has focused on women as the subject of scientific enquiry, women's exclusion/inclusion as practitioners, the masculine culture of science as manifested in its institutions, practices and language, and the historical tension between a woman's identity as a scientist and her femininity. Although there have been efforts to reclaim and make visible women scientists of the past, still only a few key figures – 'heroines' of science such as Marie Curie and Ada Lovelace – dominate our popular historical imagination. Scholarship in the history of women and science, therefore, seeks to go beyond simply replicating the 'great man of science' model; it aims to uncover not only the special or exceptional, but to develop frameworks with which to understand how everyday women practitioners negotiated their access to and participation in science. Recognition of women's historic scientific contribution, and the obstacles they faced, is important; today women are seriously underrepresented in most scientific disciplines, as evidenced by the many organisations across the globe dedicated to promoting the role of women in science. In the twenty-first century the landscape of science remains, for the most part, resolutely male.

One of the key issues that has impacted on our understandings of women and science is the very definition of science itself. Historically, the dominant understanding of science as an epistemic product - a body of knowledge and technology – has obscured the processes of sciences, that is the methods, practices and team work involved in the scientific project. This has rendered invisible the work of assistants and collaborators, especially women. It has also marginalised the areas of science which, historically, were seen as more suitable for women such as science writing for a popular audience or children, translating, scientific illustration and, at times, botany and mathematics. As science professionalised in the later-nineteenth century and moved out of the home to new

institutional and laboratory spaces, women for the most part were left to pursue their science in the domestic sphere where they became 'obligatory amateurs' neglected by history. (Ogilvie, 2000)

This essay presents an overview of these issues and is organised thematically to provide an introduction to the history of women and science from 1776-1928 and feminist engagements with it. It will describe how feminism has questioned scientific objectivity - generally taken as the defining hallmark of science - and laid bare gendered colourings which have affected not only the scientific project but also the ways in which science has been interpreted and represented.

Cultures of science: woman as subject

Across the eighteenth and nineteenth centuries, modern science and the experimental method acquired a privileged status as producer of reliable, unbiased knowledge about the natural world. In classic feminist critiques, scholars Carolyn Merchant (1976), Evelyn Fox Keller (1985), Ludmilla Jordanova (1993) and Londa Schiebinger (1991, 1993) demonstrated how the establishment of modern science in the late-seventeenth century embodied an overt masculine perspective which expunged femininity and continued to do so for the next two centuries. In this way, they kick-started a sociologically informed history of science which lifted the discipline's veil of objectivity to make visible the masculine constructs at its heart.

In particular, Schiebinger argues that femininity, associated with passivity and contemplation, became the antithesis of a new, virile experimental method which took as its object the active investigation of nature. Here we have a founding opposition of male scientist to female nature in a relationship often represented as the scientist dominating and penetrating his object of enquiry in order to reveal her deepest secrets. Science was commonly personified as a woman up until the early twentieth century; in early illustrations she was often equipped with the latest scientific accoutrements such as a barometer, telescope or vacuum jar, and appeared typically on the frontispiece of scientific texts. (Schiebinger, 1991, 119-44) This understanding of science as a masculine pursuit presented a challenge to the femininity of any woman inhabiting the role of scientist and is a tension still recognisable today.

Science has long sought to establish the biological differences between the sexes and this investigation acquired urgency in the late-eighteenth to early-twentieth centuries. If science could discover such knowledge, then reason suggested that society could be ordered in such a way to ensure that women and men fulfilled the social roles which were natural to them. Enlightenment scientists found anatomical and intellectual differences which taught that women were disqualified by their sex from certain intellectual pursuits, including science. This naturalised contemporary prejudices with regards to women and turned tradition and habit into immutable scientific fact, limiting women's opportunities for education and participation in science. Philosopher Immanuel Kant believed that a woman should not receive instruction in science as it may diminish her womanly charms: 'We must leave abstract speculation, useful knowledge to the laborious and solid mind of man… Thus women should not learn geometry'. (Whaley 2003, 124) Dr J.J. Sachs agreed in 1830 that men's bodies were designed for strength, understanding and independence, equipping them for life in government and the arts and sciences. By contrast, the female body with its roomy pelvis for motherhood and weak, soft limbs, was 'witness of woman's narrower sphere or activity, of home-bodiness and peaceful family life' (Schiebinger, 1991, 214) Some women – and men –

challenged this scientific interpretation of women's inferior bodies and brains; for example, Mary Wollstonecraft devoted chapters two and three of her 1792 text *A Vindication of the Rights of Woman* to discussing what she called 'the prevailing opinion of a sexual character'. (Wollstonecraft, 2004, 28)

In the nineteenth century, science's search for a biological basis for physical and intellectual differences between the sexes continued. The differing size and weight of men's and women's brains was put forward as evidence of women's inferiority by scientists including French craniologist and anthropologist Paul Broca, German anatomist Carl Vogt and Cambridge physiologist George Romanes. Inspired by Charles Darwin, in 1888 Romanes published *Mental Differences in Man* in which he argued for the innate intellectual incapacity of the female brain. For Romanes, as for Darwin, this was the explanation as to why history gives us few if any examples of women who have achieved in intellectual spheres, including science. (Whaley, 2003, 148). Although Darwin only briefly contemplated human evolution in the last chapter of *The Origin of Species* (1859), he later applied his theories of natural and sexual selection to man. Evolution, Darwin argued, privileged the development of men's reasoning and produced an inequality in intellect that made men abler in the more demanding abstract disciplines, including science. In *The Descent of Man* (1871), Darwin devoted a section to 'Differences in the Mental Powers of the Two Sexes'. According to sexual selection, men competed with each other to win the best females and it was this competition that developed men's brains. Men acquired a greater mental capacity and cunning in order to outwit opponents and, since only the best men won, they were able to pass their greater intelligence on to their sons, reinforcing men's intellectual advantages over women. (Darwin, 2004, 631; Erskine, 1995). Women, by contrast, were led by their instincts and emotions and were evolved for motherhood not brainwork. It should be noted however, that despite his theoretical misgivings as to women's capacity for science, Darwin corresponded and collaborated with many women on scientific projects and typically proved supportive of women's intellectual aspirations and education. (Cambridge Darwin Correspondence Project, 2013).

Despite scepticism as to the capacity of the female mind, women were not deterred from taking their place in science. Learned women presided over salons in Enlightenment Europe where the latest scientific findings were a favourite topic of conversation. Women also contributed to the growth of scientific knowledge, for example mathematician Sophie Germain (d. 1831) and astronomer Caroline Herschel (d. 1848). In the later nineteenth and early twentieth centuries, increasing numbers of women studied science at university and some women achieved standing and recognition, despite the ideas of contemporary sexual science. Yet, the masculine colouring of science left a mark which sometimes created a tension in feminine identity. For example, the mathematician Mary Somerville was described as having a 'masculine mind of a very high order' and it was not unusual for intellectual women to describe themselves in these gendered terms. (Koblitz, 2013, 112) Amongst her achievements, Somerville (d. 1872) had not only translated the text of La Place's notoriously difficult *Mechanism of the Heavens*, but had extended it with explanatory notes and had the book adopted as the standard text for higher mathematics at Cambridge. William Whewell, a leading man of science of the mid-nineteenth century, believed that there was 'sex in minds' and announced Somerville one of a very special and select group of female mathematicians who had the power to illuminate mathematics. (Neeley, 2001, 13) Reflecting this idea of complementarity rather than equality in science, anthropologist Clémence Royer (d. 1902) argued that women found their own, feminine way to scientific truth and that their participation was

essential to de-bias science. (Harvey, 1997) Similarly, women's special way of reasoning was why, in 1913, author and scientist H.J. Mozens made a plea for male and female collaborations in science. (Mozens, 1991, 384-7)

These historical theories about women and science suggest that science – like other disciplines - is never value neutral but is, to a lesser or greater extent, socially constructed and situated within the beliefs and value systems of its time. How scientific women have negotiated these gendered configurations in order to find a role for themselves as scientists will be discussed below.

Women's spheres in science

Science is a broad term that encompasses many different disciplines – mathematical sciences, technology, biology, physics, astronomy, engineering, medicine and more – each with its own traditions, aesthetics and gender colouring. The idea of hard and soft sciences, with the latter particularly suited to women, is a hierarchy which still has meaning today. For much of the eighteenth century, botany had a special affinity with femininity. In contrast to physics, botany was a taxonomic rather than an experimental science which, to a large extent, remained in the domestic sphere and considered phenomena as they occurred in nature. Ann Shteir (1997) explains how women enjoyed more culturally sanctioned access to botany than to any other science; working in their homes and gardens, women collected plants, drew them, studied them and named them, taught their children about plants and wrote popularizing books on botany. However, during the second half of the nineteenth century, the study of plants transformed into botanical science and moved away from describing and classifying the natural world after the Linnaean system and instead focused on investigating the structure of plants. This process involved the defeminisation of the discipline including strategies to set women's botanical activities, now coded as amateur, apart from those of the new male professionals.

Change in gender associations can also be identified in other fields of science. For example, as experimental and applied science consolidated itself as a discipline in the later nineteenth century, it came to be gendered radically masculine, especially when carried out in the male space of the laboratory. Even when women entered higher education and studied science, they were often discouraged from entering the laboratory for research as opposed to teaching purposes and, as at University College London, warned against seeking admission to chemistry classes as they could be 'scarred for life and have their clothes burnt off them as the men threw chemicals around'. (Dyhouse, 1995, 144). At Cambridge, hostility to women in the laboratory resulted in the development of parallel facilities (Richmond, 1999). In contrast to experimental science, mathematics - which had long been the prestige degree for gentlemen - became understood as a passive subject suitable for study by women. By its very nature, mathematics was clean, sedentary, safe (unlike the laboratory) and mostly removed from the grim and sometimes immoral realities of the real world. (Jones, 2009) British universities began opening their doors to women from around 1869 and by the first decade of the twentieth century significant numbers of female students were accessing a formal education nearly equivalent to their brothers. However, the tensions surrounding the study of science remained and mapped an additional layer on to the more general unease about the suitability of higher education for women.

It would be mistaken, however, to assume that women's engagement with science and mathematics began with their access to higher education. From the mid-eighteenth century women read and studied science as a leisure pursuit and mathematical puzzles were a common element of women's magazines. In 1716, *The Ladies Diary* was the first publication for women to concentrate on science and mathematics (Phillips, 1990, 155) while Algarotti's *Newtonianism for Ladies*, published in 1737, became an eighteenth-century bestseller. (Mazzotti, 2004). Women were enthusiastic attendees of scientific lectures in the nineteenth century, including those by Humphrey Davy and Michael Faraday at the Royal Institution. Women were also highly visible in the audience of meetings of the peripatetic British Association of the Advancement of Science, admitted on special Ladies Tickets from circa 1850 onwards. (Higgitt and Withers, 2008) Women were not only consumers of scientific knowledge, they also produced it. Women contributing to the development of science at this time include mathematicians Maria Gaetana Agnesi (d. 1799), Sophie Germain (d. 1831) and Sophia Kovalevskaia (d. 1891); astronomers Maria Mitchell (d. 1889) and Annie Russell Maunder (d. 1947); entomologist Eleanor Ormerod (d. 1901); logician and psychologist Christine Ladd-Frankin (d. 1930) and botanist Ethel Sargant (d. 1918) to name just a few.

Certain spheres of scientific activity across the late eighteenth to early twentieth centuries were especially populated by women and understood as complementary to femininity. Women found roles in science as writers, popularisers and translators of science, often writing for an amateur or child audience. (Benjamin, 1991). Between 1806 and 1815, Margaret Bryan published well-received texts on astronomy and natural philosophy (including optics, hydrostatics, pneumatics and acoustics) (Ogilvie and Harvey, 2003) Earlier, Priscilla Wakefield wrote equally successful natural history books for girls, including her popular 1796 *Introduction to Botany*. Wakefield was a Quaker and so benefitted from a reformist background which was typically rational in outlook and supportive of science education for girls as well as boys. The importance of liberal, middle-class dissenting networks in nurturing a woman's interest in science is evidenced by the number of women scientists that emerged from this tradition. (Watts, 2007, 91) One female scientific writer merits particular attention: among her other texts, Jane Marcet's *Conversations on Chemistry, intended more especially for the Female Sex*, was an enormous success when published in 1805 and inspired Michael Faraday to take up science. (Phillips, 1990, 110-11). Later in the century, Agnes Clerke wrote highly-respected texts on astronomy, including her monumental *A Popular History of Astronomy During the Nineteenth Century* (1885) and *Problems in Astrophysics* (1903). In 1903 Clerke and fellow astronomer Margaret Huggins were awarded honorary membership of the Royal Astronomical Society (which did not admit women as ordinary members) joining a small and select group including astronomers Caroline Herschel and Mary Somerville who both received the honour in 1835. (Brück, 2002, 174)

Women also found an outlet for their scientific interests in illustration, especially botanical drawing or providing the sketches for scientific texts. One of the best known female scientist illustrators is Marianne North who, typically for a woman, was self-taught. North grew plants and travelled widely to collect them as part of her scientific quest. She discovered five new species of plants, four of which were named after her. (Watts, 2007, 106). Today, the Marianne North Gallery at Kew Gardens conserves her some 800 botanical paintings. Teaching was also an outlet for scientific women; a significant number of women who studied science at university taught in the new schools for girls which were being established from the late-nineteenth century, for example mathematician Sara Burstall (d. 1939) who became head of Manchester High School for Girls. The women identified here

were all active scientists who found an outlet for their science in roles which were more accessible to women at the time and which situated them within the confines of respectable womanhood.

Professionalization, Collaboration and Learned Societies

From the late nineteenth century, science professionalised and moved away from its traditions as an activity carried out in the home and instead became increasingly dependent on institutional settings. Women were mostly excluded from these new professional spaces of science and so continued to pursue their science in the domestic sphere. This not only rendered them invisible to the history of science but also led to their classification as amateurs with all the connotations of marginality to serious science associated with that status. However, there is a growing body of scholarship excavating these scientific women and analysing the complex mechanisms of inclusion and exclusion around which they navigated. For example, Dorothea Bate (d. 1951) was a distinguished palaeontologist who, despite her scientific standing, had always to scavenge for excavation funds because, as a woman, she was not eligible for professional employment. Bate was associated with the Natural History Museum from 1898 yet was never paid or made a member of staff until 1948 when she was in her late sixties. (Shindler, 2005) Recent case studies have also focused on science in the home by following women into their marriages and collaborative scientific partnerships. (Becker 1996, Orr, 2015, Jones 2015)

Collaboration and the role of a male mentor in facilitating women's access to professional science has proved a key explanatory framework for feminist historians of women and science. Despite the usefulness of this model, female scientists who collaborated in the home have been typically assigned the role of assistant, regardless of the nature of their participation. This was something identified by Margaret Rossiter in 1993 and coined 'The Matthew/Matilda effect'. (Rossiter 1993) Astronomer Margaret Huggins (d.1915) took a pivotal role in research with her celebrated husband, Sir William Huggins, whom she married in 1871. Margaret brought her own photographic expertise to the partnership, developed new techniques of research and carried out many investigations by herself. Despite this, Barbara Becker (1996) has demonstrated how the couple colluded to present a traditional and romanticised image of themselves with William as the principal investigator and Margaret as his able assistant. Another example of a woman collaborating as a peer is Sarah Bowdich Lee (d. 1856) who carried out research independently as well as with anatomist and palaeontologist Georges Cuvier. (Orr, 2015)

Along with professionalization came women's exclusion from the fellowship of elite scientific societies. In Britain, women were not elected as Fellows of the Royal Society until 1945; the French Academy of Science admitted its first female fellow in 1979 (after turning down Nobel laureate Marie Curie in 1910). However, the admission of women was a complex issue and the cause of much co-ordinated lobbying by feminist women, and male supporters, from the late nineteenth century onwards. Cryptogamic (evolutionary) botanist Marian Farqharson, physicist and electrical engineer Hertha Ayrton and Marie Stopes (a distinguished paleobotanist before moving into birth control) were among women pushing for change in the years around 1900. They achieved some success when, after an acrimonious debate, the Linnaean Society, founded in 1788, admitted its first female fellows in 1904 (Gage and Stearn, 2001, 91) As reported in *Nature* on 13 October, The Entomological Society, 'formally so exclusive that ladies who contributed papers were not even admitted to be present when they were read' elected its first woman member in 1904 too. Hertha Ayrton's

nomination for a fellowship of the Royal Society in the same year was not so successful however. Ayrton was refused - ostensibly due to being married - and the Royal Society waited another forty years before electing its first female fellows. (Mason, 1991). As already discussed with reference to the Royal Astronomical Society, women were sometimes given honorary fellowships. Mary Anning (d.1847), one of a number of women active in geology, is known popularly as a fossil hunter but she had a deep understanding of her subject and was an expert in fossil anatomy. Anning discovered new types of skeleton and enjoyed a reputation as a palaeontologist which won her honorary fellowship of the Geological Society, albeit it near the end of her life, in 1846. (Watts, 2007, 106).

As science continued to specialise and fragment, so new societies emerged specifically to cater for amateurs, including women. For example, the British Astronomical Association was founded in 1890 to provide an alternative to the Royal Astronomical Society and was advertised as 'open to Ladies as well as Gentlemen'. Several women were active in the Association, participating in expeditions, serving on its council and editing its journal. (Ogilvie, 2000, 77). A founder member was Elizabeth Brown, Director of the Solar Section of the influential Liverpool Astronomical Society. (Brück, 2002, 98-99) In response to this changing landscape, elite scientific societies began to regard the retention of male exclusivity as a safeguard of their status – a status embodied, literally, in the bodies of their fellows or members. To admit women was to be tainted with amateurism. As the president of the elite Chemical Society muses in a fictionalised biography of Hertha Ayrton (d. 1923), permitting women to present papers or become fellows would 'discredit the Society' and 'reduce its meetings to frivolous functions'. (Zangwill, 24). Darwinist Thomas Huxley had prevented women's admission to the Geological Society and engineered their exclusion from the Ethnological Society specifically to upgrade its professional status in relation to the breakaway anthropologists. (Richards, 1997) At times conflicted attitudes to women could lead to inconsistency and fudge. On 12 Feb 1905 the *New York Times* considered the issue and remarked that the British Royal Microscopical Society admits women to the extent of accepting full fees from them, although they are not allowed to attend meetings of the Society or to take part in its discussions. 'The money they supply in the way of fees, however, is quite as sound as that of their male fellows'.

By the early twentieth century, women had largely won their acrimonious battle to be allowed access to a medical education and to have their names put on the professional medical register. The British Medical Association admitted Elizabeth Garrett Anderson in 1873 as an exception only and other women were admitted from 1892. Some medical organisations fought more strongly to retain their masculine exclusivity, such as the Royal College of Physicians which elected its first fully-fledged female fellow in 1934. Barred from most medical networks, early women doctors set up their own. In May 1879 the Association of Registered Medical Women was founded, despite there being only a limited number of women eligible to join. (Crawford, 2002, 43-108) At the outbreak of the Great War, offers of service from women medics were initially spurned, although eventually women doctors made huge and significant contributions. Largely ignored by the literature on women and war, women worked on key world War One scientific research projects while men were away, funded by the universities and government, with little reward or acknowledgement. (Fara, 2015)

Given the spaces of participation of scientific women up to 1928 however, we must look beyond professional settings or the fellowship of learned societies in order to discover women's activities as scientists. For example, although the first female fellows of the Royal Society were not elected until

1945, some sixty women contributed from the periphery in the years between 1880 and 1914 by submitting papers, publishing articles, demonstrating their research at scientific conversaziones and being recipients of Royal Society research grants. (Jones, 2009). Women's research in the domestic sphere, and the networks of science that women were a part of as peers alongside men, is evident from the discussions throughout this essay. So why have women been largely absent from histories of science until recently?

Women, science and historiography - new directions

Feminist scholarship in the history of science has recognised that historiography has imposed a particularly narrow, gendered view on how science operated during the last two centuries. As demonstrated above, women have always contributed to science but to find them we need to look in the right places. Women have been active in technology as well as science, including widows running family businesses, often hidden under their husband's name. For example, London instrument maker and writer Janet Taylor (d 1870) wrote on nautical astronomy and navigation and ran a nautical academy and mathematical instrument making firm in London from 1845-1858. She produced new texts and a handbook for officers of the British merchant navy, taught navigation in her academy and, on retirement in 1859, received a civil-list pension from the government. (Ogilvie and Harvey, 1270-1) Women also have a long history as inventors and holders of patents. (Stanley, 1995; Jaffé, 2004)

In other spheres too, there has been a tendency for history to misunderstand the practice of science in the past and, as a result, superimpose a modern, gendered hierarchy upon it. According to a first scholarly account of lepidopterist Margaret Fountaine (d.1940), stereotypes about the way science operates, together with gendered ideas of the eccentric woman traveller, have conspired to misrepresent Fountaine's science and trivialise her contributions to natural history. (Waring, 2015) In addition, the 'great man' view of science remains remarkably persistent; this is a framework which fails to recognise the central place of teamwork in scientific production and which renders invisible not only women but non-elite male technicians and assistants too. For example, the women who were instrumental in laying the foundation of the science of genetics from 1900-1910 were largely ignored until Martha Richmond rescued them. These women were natural sciences students at Newnham College, Cambridge, working with William Bateson. Bateson's Mendelian approach to heredity was not yet a legitimate subject of study, so he turned to women researchers whose services were not so much in demand. (Richmond, 2001) Recent scholarship in the history of science has begun to investigate scientific masculinity – alongside femininity - as a way to assess gendered cultures of science over time. (Milam and Nye, 2015; Golinski, 2002) Masculinity and femininity are, of course, intimately entwined; we cannot analyse women's scientific experience and the meanings attached to it without understanding the way that science became appropriate to a man's identity yet, as illustrated here, became mostly antithetical to women.

In the early 1840s, the very word scientist was coined by William Whewell for, and with direct reference to, the work of a woman: mathematician Mary Somerville. That science in the century that followed continued to become overwhelmingly associated with men and masculinity is a process which still requires feminist attention and explanation today.

References

Brück, Mary (2002) *Agnes Mary Clerke and the Rise of Astrophysics*, Cambridge: Cambridge University Press

Becker, B.J., 'Dispelling the myth of the able assistant: Margaret and William Huggins at work in the Tulse Hill Observatory' in H.M. Pycior, N.G. Slack and P.G. Abir-am eds, *Creative Couples in the Sciences,* New Brunswick, N.J.: Rutgers University Press, 98-111

Benjamin, M. (1991) ' ''Elbow room'': Women Writers on Science, 1790-1840', in M. Benjamin ed., *Science and Sensibility: Gender and scientific enquiry 1780-1945,* Oxford: Basil Blackwell, 27-59

Cambridge Darwin Correspondence Project (2013) *Darwin's Women*, http://www.cam.ac.uk/research/news/darwins-women [accessed 17 February 2016]

Crawford, Elizabeth (2002) *Enterprising Women: The Garretts and their Circle,* London: Francis Boutle

Darwin, Charles (2004), *The Descent of Man* (1871), London: Penguin

Dyhouse, Carol (1995), *No distinction of sex? Women in British universities, 1870-1939*, London: UCL Press

Erskine, Fiona (1995) 'The *Origin of Species* and the science of female inferiority', in David Amigoni and Jeff Wallace eds, *Darwin's 'The Origin of Species': New interdisciplinary essays*, Manchester: Manchester University Press, 95-121

Fara, Patricia (2015) 'Women, science and suffrage in World War 1', *Notes and Records of the Royal Society of London*, 69 (1) 11-24

Fox Keller, Evelyn (1985) *Reflections on Gender and Science*, New Haven: Yale University Press

Gage, A.T. and Stearn, W.T. (2001) *A Bicentenary History of the Linnaean Society of London*, London: Academic Press

Golinski, J. (2002) 'The care of the self and the masculine birth of science', *History of Science*, Vol. 40, 125-145

Harvey, Joy (1997) "*Almost a man of genius": Clémence Royer, feminism and nineteenth-century science,* New Brunswick, N.J.: Rutgers University Press

Higgitt, Rebekah and Withers, Charles W.J. (2008) 'Science and Sociability: Women as Audience at the British Association for the Advancement of Science, 1831-1901', *ISIS*, 99 (1) 1-27

Jaffé, Deborah (2004) *Ingenious Women: From Tincture of Saffron to Flying Machines*, Stroud: The History Press

Jones, Claire G (2009) *Femininity, Mathematics and Science, 1880-1914*, Basingstoke: Palgrave Macmillan

Jones, Claire G (2015) 'The Tensions of Homemade Science in the work of Henderina Scott and Hertha Ayrton' in Donald L. Opitz, Staffan Bergwik and Brigitte Van Tiggelen eds, *Domesticity in the Making of Modern Science*, Basingstoke: Palgrave Macmillan

Jordanova, Ludmilla (1993) *Sexual Visions*: *Images of gender in science and medicine between the eighteenth and twentieth centuries,* Wisconsin: University of Wisconsin Press

Koblitz, Ann Hibner (2013) *Science, Women and Revolution in Russia*, London: Routledge

Mason, Joan (1991) 'Hertha Ayrton and the admission of women to the Royal Society of London', *Notes and Records of the Royal Society of London*, 45 (2) 201-220

Mazzotti, Massimo (2004) 'Newton for Ladies: gentility, gender and radical culture', *British Journal for the History of Science*, 37 (33) 119-146

Merchant, Carolyn (1976) 'Isis' Consciousness Raised' in Sally Gregory Kohlstedt ed., *History of Women in the Sciences: Readings from ISIS* (1999), Chicago: University of Chicago Press, 11-22

Milam, Erika and Nye, Robert A. eds. (2015) *Scientific Masculinities: Osiris Vol. 30*, Chicago: Chicago University Press

Mozens, H.J. (1991) *Women in science, with an introductory chapter on woman's long struggle for things of the mind* (1913), Indiana: University of Notre Dame Press

Neeley, Kathryn A. (2001) *Mary Somerville: Science, Illumination and the Female Mind*, Cambridge: Cambridge University Press

New York Times (1905) *Society at Home and Abroad* [online] Newspapers.com. Available at http://libweb.anglia.ac.uk/referencing/harvard.htm [accessed 17 February 2016]

Ogilvie, Marilyn (2000) 'Obligatory amateurs: Annie Maunder (1868-1947) and British women astronomers at the dawn of professional astronomy', *British Journal for the History of Science*, 33 (1) 67-84

Ogilvie, Marion and Harvey, Joy (2003) *The Biographical Dictionary of Women in Science: Pioneering Lives from Ancient Times to the Mid-20th Century* [Electronic Text] London: Routledge

Orr, Mary (2015) 'Women peers in the scientific realm: Sarah Bowdich (Lee)'s expert collaborations with Georges Cuvier, 1825-33', *Notes and Records of the Royal Society of London*, 69 (1) 37-52

Phillips, Patricia (1990*) The Scientific Lady: A Social History of Woman's Scientific Interests 1520-1918*, London: Weidenfeld and Nicolson

Richards, Evelleen (1997) 'Redrawing the boundaries: Darwinian science and Victorian women intellectuals' in Bernard Lightman ed., *Victorian science in context*, Chicago: University of Chicago Press, 119-142

Richmond, Marsha L. (1999) ' "A lab of one's own": The Balfour biological laboratory for women at Cambridge University, 1884-1914' in Sally Gregory Kohlstedt ed., *History of Women in the Sciences: Readings from ISIS*, Chicago: University of Chicago Press, 235-268

Richmond, Marsha L. (2001) 'Women in the early history of genetics: William Bateson and the Newnham College Mendelians, 1900-1910', *ISIS* 92 (1) 55-90

Rossiter, Margaret W. (1993) 'The Matthew/Matilda effect in science', *Social Studies of Science* (23) 2 325-341.

Schiebinger, Londa (1991) *The mind has no sex? Women in the origins of modern science*, Cambridge, MA: Harvard University Press

Schiebinger, Londa (1993) *Nature's Body: Gender in the Making of Modern Science*, Boston: Beacon Press

Shindler, Karolyn (2005) *Discovering Dorothea: The Life of Pioneering Fossil Hunter Dorothea Bate*, London: HarperCollins

Shteir, Ann B. (1997) 'Gender in "Modern Botany" in Victorian England', *Osiris* 12, 21-38

Stanley, Autumn (1995) *Mothers and Daughters of Invention: Notes for a Revised History of Technology*, New Brunswick N.J.: Rutgers University Press

Waring, Sophie (2015) 'Margaret Fountaine: a lepidopterist remembered', *Notes and Records of the Royal Society of London*, 69 (1) 53-68

Watts, Ruth (2007) *Women in Science: A Social and Cultural History*. London: Routledge

Whaley, Leigh Ann (2003) *Women's History as Scientists: A Guide to the Debates*, California: ABC Clio

Wollstonecraft, Mary (2004) *A Vindication of the Rights of Woman* (1792*)*, London: Penguin

Zangwill, Edith Ayrton (1924) *The Call*, London: Allen and Unwin