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1 It is a lamented truism that women in in science, technology, engineering, mathematics
2 and medicine (STEMM) face barriers in their education and difficulties in breaking
3 through glass ceilings in their careers. Women also make up less of scientific
4 workforces. In the UK in 2017, for example, estimates of the percentage of STEMM
5 posts held by women range from 15-23% (Price Waterhouse Cooper 2017, WISE 2018).
6 This situation is paralleled in Australia, the wider European Union and North America
7 (Jones and Hawkins 2015). Moreover, this underrepresentation is greatest in later, more
8 senior career stages. For example, in natural and physical sciences in Australia a 2016
9 study found that at undergraduate level, women make up over 50 percent of students
10 (SAGE 2016). At PhD level, representation of women and men was about even.
11 However, in professional science grades, women were underrepresented: 47.1% of junior
12 academics were women and only 16.3% of senior positions were held by women (SAGE
13 2016). In the UK, women occupy 13% of management positions in STEMM (WISE
14 2018). This vertical segregation parallels other contexts such as in the European Union
15 (Caprile *et al.* 2012).

16 Women scientists should rightly be recognised because of the merit of their professional
17 achievements, like the marine ecologist Emma Johnston of UNSW, for example.

18 However, for some women scientists, even the highest scientific achievement does not
19 necessarily correspond to academic career standing. A case in point is Donna Strickland
20 who became only the third woman in history to receive the Nobel Prize for physics in
21 2018. Upon the announcement of this award for her work on ultra-short laser pulses, her
22 status as an Assistant rather than full Professor attracted most press attention and debate.

23
24 There are all sorts of reasons for this situation, ranging from scientific culture itself, to
25 the construction of gender within scientific roles; from the socialisation of young women
26 in education, to low pay, lack of opportunities, and relatively precarious and slow career
27 progression for women in STEMM professions. Yet, despite knowledge of these
28 reasons, women in the history of science are in the curious position of being regarded as
29 either wholly extra-ordinary, or invisible. The effect of this is an acknowledgement that
30 (super-talented, highly notable) women scientists are thin on the ground, leading to a
31 false conclusion that women are justifiably absent from the history of science. We
32 suggest that we need to tell more ordinary ‘herstories’ of science. We need, that is, to tell
33 the stories of women scientists who are generally unacknowledged - to adopt an
34 historical perspective that recognises that not all women scientists working in the
35 twentieth century were exceptional, but that their part in science should be made visible
36 nevertheless.

37

38 We are not alone in suggesting that, historically, the research of women scientists has
39 frequently been conducted in the face of a general lack of opportunity and overt official

40 and unofficial discrimination much more prevalent than that which we witness today.
41 When women in the nineteenth and early twentieth centuries were, however, given
42 opportunities to access scientific education and work they often seized it, sometimes in
43 the face of opposition. One example of this is the Balfour Biological Laboratory for
44 Women, established at Cambridge University between 1884-1914 which educated
45 women who were directly excluded from scientific education at Cambridge (Richmond
46 1997). A further example is the range of hidden histories of women scientists who,
47 during the First World War, became doctors, chemists developing weapons, biologists
48 studying pathogens and mathematicians working in signals and ciphers (Fara 2015;
49 2018).

50

51 Of course, there is now awareness of examples of women scientists' work being ignored
52 and obscured from the historic record. The example of Eunice Foote from the nineteenth
53 century has become something of a cause celebre. Foote read a short paper about her
54 experiments on solar heat absorption by climate gases to the August 1856 meeting of the
55 American Association for the Advancement of Science (AAAS) (Foote 1856). This
56 presentation (women were not permitted to publish full papers), apparently received only
57 polite and patronizing acknowledgement, partly perhaps because she was, after all, not a
58 full AAAS Fellow; women's scientific status allowed them only membership (Warner
59 1978). John Tyndall's similar theory published a few years later, omitted to
60 acknowledge Foote's experimental and theoretical work, (Tyndall 1859; 1861). Tyndall
61 has subsequently gained recognition as the first theorist of climate change.

62

63 Research has revealed how women with scientific training and qualifications in the
64 twentieth century were subtly and not-so-subtly steered towards editing, teaching and
65 librarianship, and away from the laboratory and the field (Des Jardins 2010). They were
66 frequently relegated to repetitive, relatively low status scientific tasks, that would have
67 frustrated men with comparable scientific training. Their careers were also held back by
68 the assumption that marriage required them to resign from their scientific posts (this
69 ‘marriage bar’ was official policy in the UK until 1946 and in British colonies until the
70 mid-1950s). If we recognise such women scientists who managed to deal with and, even,
71 flourish in such a climate and can tell their stories, then we should reveal detailed and a
72 more nuanced history of (women) scientists and science.

73

74 To take our own area of research interest, the history of women in freshwater science is a
75 case in point. Our archival research into gender and science at the Freshwater Biological
76 Association (FBA) shows that the freshwater sciences provided opportunity for women
77 during the first half of the twentieth century when science was widely segregated by
78 gender. In the context of the UK, at least 20 women were working or training at this
79 institution in its early years before and after the Second World War. The FBA was part
80 of a network of universities, and colonial and Commonwealth science providing
81 openings for women scientists in then novel and expanding aquatic sciences. There are
82 some specific, largely biographical, accounts of the history of particular aquatic sciences
83 (see Balon et al, for example), but none that focus on women scientists and the cultures
84 of research they entered and helped create.

85

86 We can give some examples of these women here. Penelope Jenkin, graduated from
87 Cambridge University in freshwater biology in 1925 – although Jenkin would have
88 received a certificate rather than a degree as Cambridge did not award degrees to women
89 until 1948 (Dyhouse 1995). Jenkin was encouraged by her supervisor at Cambridge,
90 John Saunders, who also was on the FBA Council. Her research on the zooplankton of
91 Windermere, started in 1932, has a claim to be the first research undertaken at the FBA,
92 yet, apart from the eponymous sediment corer named after her, little is known about
93 Jenkin's career, her interactions with other scientists at the FBA, and whether she
94 influenced other women to get into science, for example.

95
96 Marie Rosenberg arrived at the FBA in 1934 to conduct research into aquatic algae
97 (Anonymous 1936). In January 1938, she became the first female to obtain a permanent
98 paid naturalist position. Despite this status, as an Austrian émigré she was interred early
99 in the Second World War and, after a year in a camp on the Isle of Man, strict official
100 requirements meant she had to leave the FBA as it was geographically located in a
101 coastal county. Although little is known of her career after that, it seems that she did not
102 depart the freshwater science network, however, and moved to work at Saunders'
103 Cambridge laboratory, possibly in late 1941 or early 1942.

104
105 In 1939, Winifred Frost, an ichthyologist, became the second full-time female
106 professional naturalist at the FBA (Anonymous 1939). Frost and her protégé Rosemary
107 Lowe's field and experimental work on eels (*Anguilla anguilla*), including on otoliths,
108 produced a thorough understanding of the autecology of the species. Winifred Frost

109 notably went on to collaborate with Charlotte Kipling and Margaret Brown on
110 Salmonidae (Frost and Brown 1967).

111

112 A woman scientist from the FBA who has achieved a certain amount of wider
113 recognition is Winifred Pennington, who first came to the FBA in 1936. Her early
114 explorations of lake sediments in Lake Windermere became “the seedbed for the
115 flowering of British limnology” (Lund 1984, 2), and her later wartime and post-war work
116 on post-glacial vegetation changes was pioneering in the field of paleolimnology
117 (Pennington 1943, 1947).

118

119 We could continue to list more women freshwater scientists from the inter- and post-War
120 period who worked at the FBA, such as Hilda Canter, Vera Collins, Elizabeth Howarth,
121 Brenda Knudson, and Peggy Varley, who, outside of their specific fields are
122 unacknowledged and, importantly, whose founding roles as scientists and as women in a
123 particular scientific culture are generally unexplored. We do not know, for example,
124 whether FBA women scientists were subject various phenomena described by the
125 sociology of science. For example, the ‘Matthew effect’ (Merton 1968), defines the way
126 social and cultural process in science confer cumulative advantages for male scientists of
127 opportunity, recognition and enhancement, thereby disadvantaging women. Another
128 issue to explore was whether women freshwater scientists were subject to the comparable
129 ‘Matilda effect’ – in which male scientists take credit for women scientist collaborators’
130 work - impacting upon their achievement (Rossiter 1993). Lastly, and perhaps the
131 ultimate definition of historical invisibility, is the converse of the ‘scientific pipeline’, the
132 ‘vanish box principle’, a metaphor that describes women who drop-out, or are pushed out

133 of scientific careers (Etzkowitz *et al.*2000). This could apply to scientists whose lives
134 and work we are interested to trace, such as Marie Rosenberg.

135

136 These scientific lives are increasingly gaining attention, yet the history of science still
137 tends to isolate women scientists, rather than think of women working in scientific
138 cultures. The aquatic sciences have, it seems, a rich history. It is about time to open these
139 up, to simultaneously consider science and women in the twentieth century, and more
140 recently, and to define their wider significance.

141

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143

144

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148

149

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