BRITISH WOMEN CHEMISTS AND THE FIRST WORLD WAR

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The First World War is sometimes called the 'Chemist's War' as its prosecution demanded ever increasing quantities of explosives, poison gases, optical glass, synthetic dyes, and pharmaceuticals (1). As the war progressed and severe shortages of chemicals occurred, more and more women were pressed into chemical-related work. Very little has been published about the skilled women chemists who were assigned to war duties (2). They were obviously much fewer in number than the hundreds of thousands of unskilled women who worked in the explosive factories (3), though they certainly did exist. Fortunately, the Women's Work Collection of the Imperial War Museum (IWM) has a significant amount of documentary evidence on the wartime women scientists. This useful material was compiled in 1919 by Agnes Ethel Conway of the Women's Work Sub-Committee of the IWM. Conway circulated a questionnaire to universities and industries informing them that the Committee was compiling a historical record of war work performed by women for the National Archives. In particular, Conway adds: "they [the Sub-Committee] are anxious that women's share in scientific research and in routine work should not be overlooked ..." (4). A sufficient number of replies were received to provide a sense of the breadth of employment of scientifically trained women during the War.

The Availability of Women Chemists

Had it not been for the significant increase in the number of women taking chemistry degrees during the first 15 years of the twentieth century (5), it is apparent from the replies to Conway's enquiries that the British war machine would have faced a severe shortage of chemists. Fortunately, there was a pool of qualified women chemists ready and willing to do their part towards the war effort. As illustration, K. J. P. Orton, the Professor of Chemistry at the University College of Wales, Bangor, commented in a report that "The demand for young women who have received a training in Chemistry, both for educational and professional work, has increased greatly during the past Session. The demand is far in excess of the supply ..." (6). There were three areas where the contributions of women chemists were of particular importance: employment in analytical laboratories; the filling of academic posts vacated by men drafted for war work or for military service; and employment in the synthesis of essential chemicals.

Analytical Chemistry

Throughout the War there was a demand for analytical chemists: some to determine purities of explosives and of their precursors; and others to analyze samples of the iron and steel used in the production of military items, such as ships and tanks. It is not surprising, then, that Sheffield, the center of the British steel industry, became the focus for training of women for this latter purpose. In a response to Conway, Fred K. Knowles of the Faculty of Metallurgy at the University of Sheffield noted that when the war started, the men in the analytical and research laboratories of the industry were barred from joining the armed forces, because of the essential nature of their occupation (7). By the Autumn of 1916, however, the demand for "cannon fodder" became so great that even these individuals were drafted. Knowles continued (7):

> In these laboratories there is a large amount of routine repetition work which can be carried out by semi-trained assistants, as distinct from chemists and physicists. To meet this emergency, special one month Intensive Courses for Women were started in the Metallurgical Department of the Faculty of Applied Science, University of Sheffield: the aim being to give a training in accurate weighing, filtration, titration, general manipulation and calculations. At the end of the Course those students who passed an Examination in the rapid determination of the elements:- carbon, silicon, manganese, sulfur, phosphorus, readily found remunerative employment. The Classes commenced on the 6th November 1916, and continued practically for 2 full University years: during this time 96 women students entered for this work.

Sheffield also provided specialized courses in other areas. For example, six women were trained as analysts for coke oven laboratories (8).

Some of the steel companies welcomed the women analysts. The Chief Supervisor of the Women's Welfare Department of Thos. Frith and Sons Ltd. of Sheffield wrote to Conway to inform her that four women had worked in the research laboratory and sixteen in the general laboratory at the company, primarily on the analysis of iron and steels and in microphotography. He added (9):

> I understand that this Firm was one of the first (if not the first) in the Country to employ women at such work and the results have been quite satisfactory to the Heads of the two Laboratories.

Not all companies were effusive in their praise of women chemists. William Rintoul of Nobel Explosives Company in Ayreshire reported to Conway (10):

> Only routine work was entrusted to women. Our experience agrees with the generally accepted view that, in the main, women are unsuitable for the control and carrying out of research work unless under strict supervision.

At the National Physical Laboratory (NPL), too, women chemists played their part, again mainly in the analysis of iron and steel samples for the Admiralty. It is noticeable, though, that 10 of the 12 Junior Assistants at the NPL were female, while all of the Assistants, the Senior Assistants, and the Supervisor, were male (11). The reports listing women's contributions, such as that of the NPL, provide only names and assigned duties. For many of the women chemists, little other information exists. We do know more about one analyst, Ada Hitchins (12). Hitchins, a graduate of the University of Glasgow, became the stalwart research assistant to Frederick Soddy, working with him from 1913 until 1927, except for the period from 1916 until 1921. It was in September 1916 that Hitchins left Aberdeen (where Soddy was at the time) to undertake war service in the Admiralty Steel Analysis Laboratories. When the former male occupants of the analytical laboratories returned upon the end of hostilities, Hitchins lost her position. However, the wartime analytical experience enabled her to find employment as a chemist with a Sheffield steel works until Soddy, then at Oxford, obtained funding to rehire her (13).

Academic Staff Positions

Though some especially talented women had obtained junior academic positions, such as demonstrator, prior to the outbreak of war, it was the war itself that opened up the possibility of academic advancement (14). The best documented example is that of the University of Sheffield. By 1915, Professor William Palmer Wynne (15) was the sole remaining faculty member of the chemistry department, the others having departed for war work. Wynne hired Emily G. Turner and Dorothy M. Bennett as Assistant Lecturers and Demonstrators; and Annie M. Mathews, as Demonstrator and Lecture Assistant (16). All of the women held M.Sc. degrees in chemistry from Sheffield. In 1918, Mathews left to be replaced by May Walsh for the 1918-19 year. Bennett and Turner were known as the "Tartrate Twins." Though none of the former Sheffield students that we contacted (17) were able to recall the reason for this appellation, it was probably due to the fact that they worked so much as a team, they were like mirror images. In contrast to the hiring of most women, whose positions terminated after the war, the "twins" continued in their posts. Their major responsibility was teaching, but Turner was able to co-author three research papers, two with Wynne and one with G. M. Bennett. Turner, born in 1888, stayed as Assistant Lecturer until 1952 and died in 1958. Bennett resigned her academic position in 1934 in order to marry (becoming Mrs. Leighton), but she kept her posts as Tutor for women students (1926-1947) and Warden of University Hall (1936-1947). She died on May 11, 1984, twelve days after her 100th birthday (18).

At East London College (later Queen Mary College), it was Kathleen Balls, B.Sc. (later Mrs. Stratton), who as Lecturer and Demonstrator in Chemistry enabled courses to be run through the war period (19). She and the Head, F. G. Pope, were the only members of the Chemistry Department during part of that time. At the outbreak of war, Balls was a high school science teacher, but the greater urgency for academic staff led to her re-

lease from the County School, Enfield, for the duration of the war (20). In fact, her appointment at the College stipulated the occupancy of the position as being for the length of hostilities only. Despite this limitation, she actually continued until 1924, when she submitted her resignation (21). Though the resignation was accepted, she was asked to continue as Lady Superintendent at the College. It is probable that Balls did accept, for she certainly continued to be active in chemistry at Queen Mary College, co-authoring three publications with J. R. Partington (22) between 1922 and 1936. In addition, Balls and Partington co-authored a book on chemical calculations (23).

Organic Synthesis

Prior to the First World War, the Allied nations had relied heavily on the German chemical industries for their pharmaceuticals and other fine chemicals. With the supply cut off as hostilities began, there was an urgent need to produce drugs and medications. Until proper chemical facilities could be built, a committee of the Royal Society was set up to coordinate production of these chemicals. Arthur Schuster, on behalf of the Committee, contacted all of the chemistry departments of British universities, asking them to contribute to the production of the relevant organic chemicals (24). As late in the war as 1917, the universities were still supplying chemicals for the war effort, including β-eucaine, arabinose, atropine, and butyl chloral hydrate (25).

The University of Sheffield β-eucaine Team, 1915-16. Front row (left to right): M. Walsh, two unidentified women assistants, E. Foster. Second row: E.G. Turner, Professor W.P. Wynne, A. Matthews. Photo credit: Chris Lumley, Univeristy of Sheffield.

It will probably come as no surprise to the reader of this study that the University of Sheffield was one of the participants in the organic synthesis. Wynne assembled a team of six women chemists, including Turner, Mathews, and Walsh, to synthesize β-eucaine (16). However, the most noteworthy production was that at the Imperial College of Science, London University, in the group run by Martha Whiteley, whose biography has recently been described in this *Bulletin* (26). Whiteley was another of the women who benefited career-wise from the First World War, becoming lecturer at Imperial College in 1914. As well as the production of b-eucaine, the group also undertook research for the chemical warfare department of the Ministry of Munitions for War (27). Whiteley's seven assistants, all women, included Frances M. G. Mickelthwait, who received an M.B.E. for her contributions to the war effort (28). Mickelthwait was born in 1868 and, after a private education, attended the Swanley Horticultural College, where she gained her love of chemistry. In 1898 she attended the Royal College of Science, obtaining an Associateship in 1901. She continued as a research student in organic chemistry until the war, being one of the most prolific women authors of chemistry publications of her time. At the outbreak of war, she came under the wing of Whiteley. After the war, she worked briefly in the research laboratory of Boots Pure Drug Company and then returned to Swanley Horticultural College, where she taught until 1921. From then until 1927, she compiled the index for the second edition of *Thorpe's Dictionary of Applied Chemistry*, a series co-edited by her friend, Whiteley. She died on March 25, 1950 at the age of 83.

Even small colleges took part in the synthesis program. One of these was the University College of Wales, Aberystwyth, where much of the work was performed by Margaret K. Turner. Turner, too, had been hired at

the beginning of the war, in her case, with the rank of Demonstrator (29). She wrote a stirring letter to the War Committee, volunteering for additional duties (30):

> I was one of the workers in the preparation of diethylamine some weeks ago and should be very glad to hear of any further help I could give. I can put all my time and energy at your service for the next 6 weeks, and am anxious to know whether the few helpers down here could not be allowed to contribute further to the needs of the country? I should be much obliged if you would inform me whether there is any other preparations we can make, as I, for one, am willing and eager to give up all ideas of holiday while there remains so much to be done .

Of all the women chemists, Phyllis Violet McKie of the University College of Wales, Bangor, seems to have been the most productive during the war period. McKie was part of the team at Bangor producing paraldehyde (31). In addition, she authored and co-authored a number of studies for the war effort, including a new method for the preparation of the explosive tetranitromethane for the Ministry of Munitions and a study of methods of preparation of saccharin and vanillin for war purposes (32). Unfortunately, we have been unable to find any information on McKie's later life.

Millicent Taylor of the Cheltenham Ladies' College was another contributor to the war effort. Taylor (33), born in October 1871, attended the Ladies' College, Cheltenham, between 1888 and 1893. It was from Cheltenham that she obtained an external B.Sc. (London) in 1893, the same year that she was appointed to the staff at the College. The following year, Taylor was made Head of the Chemistry Department, and then Head of the Science Department in 1911, a position that she held until 1919. Between 1898 and 1910 she devoted most of her spare time to research work in organic and physical chemistry at the University College of Bristol (now the University of Bristol), producing a range of papers in those fields. On weekends, she would often cycle the eighty-mile round trip (34). She received an M.Sc.(Bristol) in 1910 and a D.Sc.(Bristol) in 1911. During the war she was involved in production of b-eucaine and then, in 1917, she was appointed a research chemist at H.M. Factory, Oldbury. In 1919 she returned briefly to her post at Cheltenham but left to accept an appointment as Demonstrator in Chemistry at the University of Bristol in 1921. In 1923 she was promoted to Lecturer, a position that she held until her retirement in 1937. But this was not the end for Taylor. Upon retirement, she was given the use of a small laboratory in an army hut on the grounds of the Bristol Chemical buildings. She continued research in this personal laboratory until her death in December 1960, at the age of 89.

Finally, we should mention the University, St. Andrews, Scotland. The women chemists at St. Andrews worked on the production of synthetic drugs and bacteriological sugars, research on explosives and poison gases, and the improvement of industrial processes. The report sent to Conway noted that (35):

> It should be stated that the whole of this work was unpaid from Government sources, the workers receiving only their University salaries, in cases where they were members of staff, or the value of their Scholarships, if they held any such distinctions. Not only so, but the demand for chemists throughout the war was continuous, so that the workers who remained with me gave up many opportunities for professional advancement. I mention these facts as an index of public spirit with which these women gave their services, services which have not received any public recognition.

Other Duties

Just as male faculty members were drafted for war duties, so were most male graduate students. Thus for the duration of the war, many researchers depended upon women students for the maintenance of their activities. For example, at the University of Edinburgh, Charles Barkla, the X-ray spectroscopist and 1917 Nobel Laureate, relied on Margaret Pirie White (Mrs. Dunbar) and Janette Gilchrist Dunlop for the continuation of his work (36). He later lost the services of Dunlop, who was "compelled by war-time teacher shortage" to become a high school teacher of mathematics and science (37). Ruth King was another wartime researcher. She was born on May 13, 1894 and graduated from East London College in 1914 (38). She was hired by the organic chemist, J. T. Hewitt, to study the synthesis of picric acid (39). At the conclusion of the war, she was appointed Lecturer in Organic Chemistry at the University College of South West England (later the University of Exeter) as well as Warden of Hope Hall, the women's residence (40). Like the other women chemists given academic positions, she was assigned a high proportion of the teaching duties. In fact, from 1919 to 1945 she was the only organic chemist in the department. King stayed at Exeter until 1955, when she took early retirement to move to Canada to help care for her aged mother. The mother died while King was crossing the Atlantic; but, undaunted, she continued to Vancouver, where she obtained a post as Lecturer at the University of British Columbia and remained until 1961.

Some women chemists were assigned specific tasks necessary for the war effort. For example, May Sybil Leslie, a graduate of the University of Leeds and a former researcher with Marie Curie (1909-11) and Ernest Rutherford (1911-12), was appointed in 1916 as a research chemist at His Majesty's Factory in Litherland, Liverpool (41). The following year she was promoted to Chief of Laboratory, having been given the task of improving the synthesis of nitric acid, a vital reagent in explosives production. Her wartime contributions were highly valued and resulted in the award of a D.Sc. degree by the University of Leeds in 1918. In the citation, it was noted that (41):

> The problems she has had to solve are not only of the first importance at the present time, but have been attacked in a manner showing unusual resource as well as novel methods of procedure.

The biochemist Dorothy Jordan Lloyd, a researcher with F. Gowland Hopkins at Cambridge, was also given a specific task. On the outbreak of war, the Medical Research Committee assigned her the study of culture media for meningococcus, one of the anaerobic pathogens involved in trench diseases, and of causes and prevention of "ropiness" in bread (42). Another "draftee" chemist was Nora Renouf, a research fellow with Professor A. W. Crossley at the research laboratory of the Pharmaceutical Society. She spent the war period as a survey officer with the Fuel Research Board (32).

Many women researchers in radioactivity were drafted to operate X-ray machines at the war front. Thus Marie Curie and Irène Joliot-Curie joined the service of the French forces (43) while Lise Meitner volunteered as an X-ray nurse with the Austrian army (44). A British example was Jesse Slater, assistant lecturer in chemistry and physics at Newnham College and former researcher with J. J. Thomson. After working initially as a nurse, she was called for full-time duty as a radiographer at British military hospitals in France and later held the rank of Officier de l'Instruction Publique with the French army (13).

The bacterial biochemist Marjorie Stephenson took up the traditional role of nursing (45). She left her research position at University College, London, to join the British Red Cross in France and then Salonika, where she was in charge of a nurses' convalescent home and also had responsibilities for invalid diets. She was mentioned in dispatches in 1917 and awarded an M.B.E. for her war work.

The End of the War

With few exceptions, the end of the war resulted in the termination of employment for women chemists (46). The government closed the explosives factories, while the male chemists returned from their war duties and reoccupied their former faculty and research positions. The women chemists with specialized training stood the best chance of survival: for example, according to Knowles' letter to Conway, the graduates of the metallurgical analysis course at Sheffield seemed to survive (7):

> That women have been an undoubted success in this branch of industry, is proved by the fact that notwithstanding so many of the men (who are now demobilized) have resumed duty, a large proportion of the women who desired to stay on have retained their positions to the present time.

This was a different opinion from that of the respondent from the Sheffield Steel Company of Thos. Frith who noted (9):

> On the signing of the Armistice most of the women were replaced by returning soldiers, but two [of 16] in the General Laboratory have become so proficient that their services have been retained.

Most responses pointed to bleak post-war opportunities for women chemists in industry as Dorothy Adams described succinctly in a letter to Conway (47):

> With regard to the prospects of scientifically trained women after the war my experience has led me to the conclusion that there will be practically no scope for them in industry. There is, and will continue to be for some time, a far larger supply of male Chemists than will be needed. Under such circumstances women with the same qualifications will stand the poorest chances of employment. As teachers and lecturers there is still some demand for such women, but in industry there is next to none. I have been led to this conclusion by my experience in endeavouring to obtain a fresh post myself. I do not stand alone in my opinion, Mr. Pilcher, the Registrar of the Institute of Chemistry whom I consulted on the subject told me exactly the same things as I learnt later from my own experience.

Her fears proved to be justified as the biochemist Kathleen Culhane (Mrs. Lathbury) discovered in 1922 (48). Culhane was offered interviews with biochemical companies only when she signed her application letters "K. Culhane;" and once her gender was revealed at the interview, she was denied the position. In fact, the lack

of employment prospects for women scientists became one of the reasons for the slump in women's enrollment in university science programs during the late 1920s and the 1930s (5).

In conclusion, the First World War provided a wider variety and a much larger number of employment prospects for British women chemists than they had experienced before, though they have been forgotten in most historical accounts,. Unfortunately, with the closure of war-related factories and the return of male chemists from their war duties, most of the opportunities vanished; and it was to be the Second World War before the situation improved (5, 49).

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2. Neither paper cited in (1) discusses the role of women chemists, though Macleod mentions one woman in a passing comment "And so, too, left without an offer from the [Reserved Occupations] Committee, the only woman of whom we have record, Margaret Turner, of the Chemical Laboratories at Aberystwyth." In a history of early twentieth-century chemical industry, Haber notes that in Britain "The number of women in the chemical trades ... rose from 17 000 to 25 000 and their relative importance from 14 to 20 per cent between 1907 and 1924. At the former date they were especially prominent in the match and explosives trades, at the latter they also formed a large minority of the sector comprising chemicals, dyes, and drugs, specifically of the expanding pharmaceutical preparation business. Women did not become important in the offices and laboratories of chemical manufacturers until the war" [L. F. Haber, *The Chemical Industry 1900-1930*, Clarendon Press, Oxford, UK, 1971, 378].
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14. This employment of women as faculty during the war seems to have been long forgotten. Fortunately, during the 1950s, the *Journal of the Royal Institute of Chemistry* published a series of articles entitled "Schools of

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Lake Como and Pavia, Italy
Sept. 15 - 19, 1999
Registration: $200 (by July 1, 1999); $230 thereafter
Final date for submission of papers: May 1, 1999
Contact: Dr. Enrico Antonio Giannetto, Dipartimento di Fisica 'A. Volta,' Universita di Pavia, Via A. Bassi 6, 27100 Pavis, ITALY. volta99@pv.infn.it

ROYAL INSTITUTION CENTRE FOR THE HISTORY OF SCIENCE AND TECHNOLOGY.
As part of the celebrations to mark the bicentenary of the founding of the RI, seminars in 1999 will all deal with topics relating to its history.
The next seminar: Tuesday, March 30, 1999:
Professor David Knight, Durham, University, "Theoretical Improvements Accompanied by Practical Advantages: Rumford, Banks, Davy"