OUT OF OBSCURITY: CONTEXTUALIZING FORGOTTEN WOMEN CHEMISTS

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Abstract

Over the last decade, the past contributions of more and more pioneering women chemists have come to light (1, 2). In this contribution, we will address some of the ways that accounts of the lives of women chemists do, and should, collectively differ from biographical accounts of male chemists.

Conventional biographies of male chemists of the dominant culture, such as in the *Biographical Memoirs of Fellows of the Royal Society of London*, focus almost totally upon their chemical accomplishments (one of the few exceptions being that of Dennis Evans, inventor of the Evans balance (3)). Often, that is because their life-paths were so straightforward: born, educated, academic position, research contributions, died. Detailed context is redundant; the role of others in their life-paths is often minimal or ignored.

To appreciate the accomplishments of pioneering women chemists, it is necessary to see them through the lens of gender. That is, in addition to their chemistry achievements, it is important to chronicle the challenges which they faced in their own time and place. Only by researching and acknowledging these obstacles can we truly appreciate their contributions to the progress of chemistry. In this essay, we will use case studies to highlight some of the generic challenges uniquely faced by early women scientists. For more detailed biographical accounts of these women chemists, the Reader should consult the appropriate reference source.

Background

How did our interest in uncovering the lives and work of forgotten women chemists begin? It all started with a cameo portrait in a book—a portrait of a young woman in among the endless photos of mostly elderly males. The portrait was of Canadian researcher in the field of radioactivity, Harriet Brooks (1876-1933), and the book was *Discovery of the Elements*, by Weeks and Leicester (4). According to the figure caption, Brooks (Figure 1) worked with Ernest Rutherford. Curious, we decided to spend a few weeks researching who she was, and why she was featured in the book. We uncovered some information about her, which led us to archives, which led us to her surviving family, which led us … to a total of two years of research. Finally, we assembled all we could find. With a Canada Council grant towards publication, we submitted the manuscript. It was rejected.

As scientists, we had written "just the facts," focusing largely on university grades, details of her experiments, together with transcriptions of complete letters to-and-from friends and members of her family. It was a historian of science, Marianne Ainley (5), who mentored and taught us how to attempt to think like a science historian. We needed to answer questions such as: Why did Brooks go to university? What was life like for an intelligent young woman in Victorian Canada? Why was there a separate women's college at McGill University at the time? Why would Rutherford take on a

young woman as a research student? Why did Brooks go to the Adirondacks? Why did she give up an apparently promising career? Why did she die at a comparatively young age? And many others. After undertaking years of contextual research, we completed our first published voyage into the history of women in science (6).

***Figure 1**. Harriet Brooks (permission, McCord Museum, Montreal, Canada)*

Lack of Educational Opportunities

For male chemists of the dominant culture, gaining an education was never (or rarely) a problem. For women who had become fascinated by some aspect of chemistry, a formal education was sometimes an insurmountable hurdle. Probably the best exemplar is that of the German amateur chemist, Agnes Pockels (1862-1935) (Figure 2). Pockels' research on surface films laid the foundation for subsequent research in the field (7). As a girl, she was fortunate for her time in obtaining an academic grade-school education, where she developed her interest in science. At that time, women were barred from attending German universities, and later, when women were admitted, Pockels' parents forbade her from applying. This did not stop her, as she stated in her own recollections (8):

> I attempted to continue my education by my own devices, first of all by the use of a small text book by Pouillet-Müller and since 1883 by means of books provided by my brother, Friedrich Pockels, who is three years younger than I … who at that time was a student at Göttingen.

Unable to access a laboratory, Pockels used the family kitchen sink. As her sister-in-law explained (8): "In this way, Agnes made her first observations in the field of capillarity." In many of the accounts of women chemists, a male mentor was necessary to open doors barred to a woman who had no academic credentials. In Pockels case, it was Lord Rayleigh. She wrote to him informing him of her research (9):

> Having heard of the fruitful researches carried on by you last year on the hitherto little understood properties of water surfaces, I thought it might interest you to know of my own observations on the subject. For various reasons I am not in a position to publish them in scientific journals …

Rayleigh could well have ignored this communication from an unknown German woman amateur scientist. Instead, he submitted it to the prestigious journal *Nature*, with an accompanying recommendation that it be published (10). The initial communication, co-authored by Rayleigh (11), and a subsequent paper with Pockels as sole author, were duly published (12).

***Figure 2**. Agnes Pockels (Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Agnes_Pockels_ca1892.jpg)*

Lack of Academic Positions

In 1947, the Chemical Society, London, published a book titled *British Chemists* (13). This book contained brief biographical accounts of famous British chemists up to that date: they were all male. Why were there no "outstanding" professional women chemists in the book? The simple answer was that women were rarely permitted to hold academic rank and therefore they occupied the fringes of academia.

As we have described in *Pioneering British Women Chemists: Their Lives and Contributions*, in her early career, Dorothy Crowfoot Hodgkin (1910-1994), Nobel-Laureate-to-be, provided an example of a marginalized woman chemist (14):

> Though Crowfoot had made important contributions to [X-ray crystallographic] science, at the end of the [Second World] War, her rank at Oxford was still only that of a Tutor. Deeply in debt, she realized that most of her male colleagues had university positions,

as well as research appointments, so she asked Cyril Hinshelwood, Professor of Chemistry, to help her acquire a better position. With his help, Crowfoot was appointed as a University Demonstrator in Chemical Crystallography in 1946, her first appointment as an Oxford University employee.

Lack of Academic Recognition

Chemists, like all scientists, become famous usually by peer recognition, especially by means of awards from professional societies. However, for many national chemical societies, women were barred from even being members or fellows (15). As an example, it took 40 years from the first (unsuccessful) motion in 1880 by Augustus Vernon Harcourt for the admission of women chemists as Fellows of the Chemical Society (London) until the goal was accomplished (16). Even then, it came about through the British Government's 1919 Sex Disqualification (Removal) Act, legislation which removed barriers against women in general (17).

The pathway to recognition of academic exceptionality in Britain came through election as Fellow of the Royal Society. However, the Royal Society was an even greater barrier to the progress of women chemists. Though the 1919 Act removed the barrier in principle, it was not until twenty-five years later that anything transpired. As Hilary Rose wrote (18):

> This extraordinary gap suggests at best a collective amnesia—or perhaps a repression of memory—within the Royal Society, in which the fact of legal eligibility and the political likelihood of success become conflated to become an unstated and legally false, but socially powerful consensus that women were not admissible.

It was an article in 1943, in the British communist-leaning newspaper, the *Daily Worker*, which raised the issue. Evolutionary biologist J. B. S. Haldane was asked for his view on who would be the strongest candidate from the biological sciences. His reply was that biochemist, Marjory Stephenson (1885-1948), was his choice (19): "I think the strongest claim is that of Dr. Marjory Stephenson who was the first person in the world to do work on bacterial metabolism as exact as that on mammalian metabolism …" Stephenson was duly elected as one of the two first women Fellows in 1945 (the other being Kathleen Lonsdale). Had she been elected earlier in her career, Stephenson would likely have been nominated for a Nobel Prize. As it was, her untimely death in 1948, age 63, precluded such an honor.

The Imposter Syndrome

For the "great men," many of them realized that fame would come and they saved their correspondence in the expectation that their letters would be posthumously presented to a university archive. By contrast, for most of the women chemists, there was the assumption that their humble contributions would not be worthy of remembrance, and, for the most part, their letters have long since vanished. A letter of Harriet Brooks to Ernest Rutherford (in whose voluminous correspondence this letter was found) makes the point very succinctly (20):

> I am afraid I am a terrible bungler in research work, this is so interesting and I am getting along so slowly and so blunderingly with it. I think I shall have to give it up after this year, there are so many people who can do it so much better and in so much less time than I that I do not think my small efforts will ever be missed.

Yet Rutherford, himself, had contrary views. He wrote to Arthur Schuster, Head of Physics at the Victoria University of Manchester that (21):

> … next to Mme Curie she [Brooks] is the most prominent woman physicist in the department of radioactivity. Miss Brooks is an original and careful worker with good experimental powers …

The Matilda Effect

A common problem for junior women researchers is that they are subsequently "written out" of the discovery. This can also be true for male co-researchers. In this context it is called the Matthew Effect. The originator, Robert Merton described it as (22):

> … the accruing of large increments of peer recognition to scientists of great repute for particular contributions in contrast to the minimizing or withholding of such recognition for scientists who have not yet made their mark.

The Matthew Effect was named by Merton after the saying in the Bible, New Testament, The Gospel according to Matthew: "For unto everyone that hath shall be given, and he shall have abundance; but from him that hath not shall be taken away even that which he hath."

Convinced that such an Effect was of far greater significance in the case of women scientists, American historian of science, Margaret Rossiter, proposed the use of the term the Matilda Effect to describe the achievements of those women scientists whose work is attributed

to their male colleagues (23). This Effect had been first described by suffragist and abolitionist Matilda Joslyn Gage (1826-1898). The Matilda Effect can be illustrated by the work of Brooks when she was working with Rutherford at McGill University, Montreal, Canada. Their research culminating in the discovery of a "new gas from radium" (now known as radon) was published under both their names (24). However, subsequently, at least one account of the discovery was attributed to Rutherford alone (25).

Appropriation

While the Matilda Effect can account for the disappearance of many women chemists from the record, it is dangerous to simply attribute all "disappearances" to one single cause. In other cases, it is because their work has been appropriated. Sometimes the appropriation may have been accidental, but other cases, deliberate. One case of appropriation, which is debatable whether it was accidental or deliberate, is that of the priority of demonstrating the "greenhouse effect" (26). American amateur scientist, Eunice Foote (1819-1888), was clearly the first to do so, though John Tyndall is given credit. As Roland Jackson has commented (27):

> In 1856, an American woman, Eunice Foote, discovered the absorption of thermal radiation by carbon dioxide and water vapour. That was three years before John Tyndall, who is generally credited with this important discovery—a cornerstone of our current understanding of the greenhouse effect, climate change, weather and meteorology. Tyndall did not reference Foote's work.

The most egregious case of appropriation was probably that of Alice Augusta Ball (1892-1916) (28). This young African-American woman chemist had been appointed Instructor in Chemistry at Hawaii College. She was also undertaking research in natural products chemistry towards an M.S. Having such skill in the field, Ball was approached by Assistant Surgeon, Dr. Harry T. Hollman. At the time, the best palliative treatment for Hansen's disease (leprosy) was oil extracted from the chaulmoogra tree. As it was water-insoluble, it could not be given by the preferred means, that of injection.

Hollman asked Ball to convert the oil to a water-soluble form. This she did by converting the parent compounds, fatty acids, to ethyl esters. Many patients' lives were vastly improved by this injectable method. Sadly, Ball died at the age of 24. An account of her death stated (29):

> Just over 100 years ago, as World War I raged in Europe, a chemistry professor named Alice Ball was demonstrating the use of a gas mask when something went tragically wrong. The brilliant, young chemist died a few months later at age 24, likely from accidentally inhaling chlorine gas.

As one of her biographers, Jeannette Brown, recounted (30):

> After her death, Dr. Arthur L. Dean who was a chemist and President of the College of Hawaii continued Ball's research. Large quantities of this new drug were made and distributed to patients worldwide. Dean published his results without mentioning the work of Ball and it became known as the Dean method. Later, in a medical journal publication in 1922, Hollman mentioned the contribution of Alice Ball. Still, it took years before Alice Ball was recognized for her accomplishments. The neglect may have been due to both sexism and racism …

Figure 3*. Alicia Ball (Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Alicia_Augusta_Ball.jpg)*

The Marriage Problem

The termination of a woman chemist's career upon marriage was referred to in earlier times as "matrimonial mortality." Though there are some notable examples of couples collaborating and thriving together (31, 32), even then, the woman usually held a more junior academic position, or none at all. Two examples of the woman chemist holding a more junior rank were both Nobel Laureates: Marie Sklodowska Curie in radiochemistry, and Gerty Radnitz Cori in biochemistry.

From our own research, for the large majority of women chemists, marriage spelled the end of their professional aspirations. As Flora Garry (1900-2000), a graduate of King's College, University of Aberdeen, Scotland, wrote (33):

> 'Learnin's the thing,' they wid say,
> 'To gie ye a hyste up in life.'
> I wis eence a student at King's.
> Noo I'm jist a professor's wife.

The large majority of male chemists married. This enabled the male researchers to "off-load" domesticity and concentrate upon their research. The point was made succinctly by Terri Apter in *Professional Progress: Why Women Still Don't Have Wives* (34):

> A retired woman Lecturer at the University of Cambridge, when asked whether she regretted not marrying, responded that she would have been glad to marry had she only found someone who would have made a good wife.

Some women chemists were able to assist in their husband's career, though their roles have often been forgotten. An early example was Grace Coleridge Toynbee (1858-1946). Following marriage to British chemist Percy Frankland, she continued active research. One of Frankland's obituarists noted (35):

> Probably in few cases have husband and wife collaborated so effectively and enthusiastically in both research and professional work. On one occasion it was said, "Many women in the past have helped their husbands, but Percy Frankland is the first man who had the chivalry to admit it."

The 1920s saw the Lapworth-Robinson "golden age" of organic chemistry at the Victoria University of Manchester. Yet it is rarely mentioned that these two relied heavily upon their spouses, Kathleen Holland (Mrs. Lapworth, 1879-1960) and Gertrude Walsh (Mrs. Robinson, 1886-1954). In a review of the Chemistry Department, it was stated (36):

> An unusual feature of the life of the School of Chemistry at this time was the presence in it of the wives of both professors. Mrs. Lapworth as her husband's secretary helped him greatly with the detail of the heavy administrative responsibilities in the department. Mrs. (later Lady) Robinson, as an Honorary Research Fellow, worked on long-chain acids in the professor's laboratory. Both took a kindly and active interest in staff and students.

For some married women chemists, an active chemistry career required a role reversal. Thomas Lonsdale and crystallographer Kathleen Yardley Lonsdale (1903-1971) provided one such example. Thomas Lonsdale reflected (37):

> When the apple fell on Newton's head someone gathered it and the other windfalls and made a pie for his dinner, thats [sic] my job now a bit, it always has been. … Even before we were married I knew she had one of the most powerful intellects of the time. … I only know enough about her work to realize its importance and value and how fortunate I have been associated with it, "in getting Newton's dinner."

One unique challenge in tracking the life and work of women chemists is that of changing family name upon marriage. As a result, a literature search for contributions would cease at that point in time, not always to be connected to the subsequent married name. Sharon McGrayne has provided one such example, that of Dorothy Crowfoot Hodgkin (38):

> Dorothy published her penicillin studies under her maiden name "Crowfoot" and announced vitamin B_{12} as "Hodgkin." Years later some scientists still did not know that the Crowfoot of penicillin fame was the Hodgkin of B_{12} fame.

For lesser-known women chemists, the link between birth and married names is even less likely to be identified.

The Woman "Super-Chemist" Phenomenon

In cases where women chemists were being considered for an academic position, the bar was often set unreasonably high, excluding them from consideration. Any candidate was expected to be of a caliber far higher than that of a male candidate. Margaret Rossiter described the effect of Marie Curie's visit to the United States in 1921 as raising the bar for American women chemists to unattainable levels (39):

> Before long most professors and department chairmen were … expecting that every female aspirant for a faculty position must be a budding Marie Curie. They routinely compared American women scientists of all ages to Curie, and finding them wanting, justified not hiring them on the unreasonable grounds that they were not as good as she, twice a Nobel Laureate!

In Britain, it was the outstanding woman biochemist, Ida Smedley Maclean (40), who was the benchmark for female hiring. For the position of Reader (Professor) in Chemistry at King's College of Household and Social Science, London in the 1930s, it was stated that (41): "… it would be of great value to the Department to secure the services of a woman with the high scientific standing and personality of Dr. Ida Maclean." It seems highly unlikely that any male candidate for the position would be expected to undergo a "personality" test—or have any benchmark to be compared against.

Importance of Male Supporters

In accounts of HerStory, it is sometimes overlooked that with the constraints of society, women could not make progress without empathetic male mentors or facilitators. In the societal context, this has been discussed in *Traitors to the Masculine Cause* (42). In the context of British chemistry, we have identified Augustus Vernon Harcourt, William Tilden, and others as promoters of the rights of women chemists (43).

Some, such as the biochemist F. Gowland Hopkins, promoted the careers of many British women biochemists (44) (including that of Marjory Stephenson—see above). As Mary Creese has eloquently stated (45):

> At the time when there were practically no women research workers in any of the other university departments at Cambridge, Hopkins gave them places in his, despite the criticism which this brought him. Even in the 1920s and 1930s, when, as a Nobel laureate with a world-wide reputation he received hundreds of applications for places in his laboratory, nearly half of the posts in his Department went to women scientists.

However, as we have established for many female-friendly departments, simply hiring women chemists was not enough. The environment was of paramount importance. J. D. Bernal's crystallography group epitomized such a positive workplace. Dorothy Hodgkin was a member of Bernal's group at the University of Cambridge from 1932 to 1934. In the Obituary for Bernal, written by Hodgkin, she described the very pleasant working atmosphere and convivial lunches (46):

> Every day, one of the group would go and buy fresh bread from Fitzbillies [which still exists in Cambridge], fruit and cheese from the market, while another made coffee on the gas ring in the corner of the bench. One day there was talk about anaerobic bacteria on the bottom of a lake in Russia and the origin of life, another, about Romanesque architecture in French villages, or Leonardo da Vinci's engines of war or about poetry or printing. We never knew to what enchanted land we would be taken next.

It is noticeable that, in our research, comments upon such conviviality in this, and in other research groups (such as Hopkins's), came always from women researchers. It was for them that the working environment particularly mattered.

Where Does One Begin "Discovering" Forgotten Women Chemists?

Whereas with male chemists of the past, there are many, many, compilations of names and research fields, this is not true for female chemists. In our own work, there has not been one definitive route for "discovering" a forgotten woman chemist. Often, a name was mentioned in a correspondence or listed as a publication co-author which gave us the new avenue of research. One example was our "discovery" of the contributions of Polish researcher in radioactivity, Stephanie Horowitz (47), which began from a brief mention in a letter from Otto Hönigschmidt to Lise Meitner (48): "… Miss Horovitz and I worked like coolies. On this beautiful Sunday we are still sitting in the laboratory at 6 o'clock."

But are there many women chemists left to research? From our own experience, the answer is "yes." As a starting point, for the 19th century, Mary Creese produced an incredible four-volume sourcebook of women scientists (49-52). Many of the individuals described therein are worthy of much more thorough research.

For the early 20th century, probably the most fruitful source of "forgotten" women chemists is that of women-friendly research groups, for example, Frederick Gowland Hopkins at the University of Cambridge (44); Martha Whiteley at Imperial College, London (53); Lafayette Mendel at Yale (54); and Julius Stieglitz at the University of Chicago (55). Many of the American women chemists obtained their first degrees at U.S. women's colleges (55); likewise, British women chemists most often graduated from U.K. women's colleges (56), making women's college archives a fruitful source of names. Also, many women chemists were recruited for synthesis and research laboratories in the First World War (57).

There is much searching yet to be done. More pioneering women chemists to be discovered. Many more contributions to chemistry to be found.

Acknowledgement

We thank the Editor and one of the Referees for thoughtful comments which we have endeavored to accommodate.

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Marelene Rayner-Canham and Geoff Rayner-Canham have undertaken extensive research on the history of women in chemistry. In addition to authoring many publications, their most recent books are: *A Chemical Passion: The Forgotten Story of Chemistry at British Independent Girls' Schools, 1820s-1930s* (Institute of Education Press) and *Pioneering British Women Chemists: Their Lives and Contributions* (World Scientific Publishing Co.). Geoff is also the author of *The Periodic Table: Past, Present, and Future* (World Scientific Publishing Co.).