**Marjory Stephenson ScD FRS (1885-1948)**

## Introduction

As Head of the Biochemistry Department in Cambridge in the early years of the twentieth century, Frederick Gowland Hopkins encouraged and recruited a number of women scientists. One of the most distinguished was Marjory Stephenson who later became the first woman biological scientist to be elected to the Fellowship of the Royal Society in 1945, for her work on bacterial metabolism. Marjory's research career started late because at first she had to earn a living through teaching; it was also interrupted by the First World War in which she served abroad with the British Red Cross Society. So it was not until January 1919 (the month of her 34th birthday) that Marjory joined Hopkins' Department, where, for the next 30 years, she played a leading role in developing biochemical studies in bacteria.

There was no conventional career path for academic scientists in the early part of the 20th century, especially for women in Cambridge where the University was the last in the country to admit women to full membership on equal terms with men – that happened in 1948, the year that Marjory died. It has been suggested that, at this time, women were more likely to find their place in new disciplines such as biochemistry and X-ray crystallography because ambitious young men with families to support considered those fields to be too risky, both scientifically and financially (1). Although Marjory did not have all the opportunities open to the men of her generation, she was skilful in making the most of those that came her way. Even before her arrival in Hopkins' Department, she had built skills and experience across a range of disciplines through a series of moves in which serendipity and preparedness of mind both played their part. During the 1920s she also benefitted hugely from the support of two powerful men – Hopkins who provided moral support and mentorship, and Sir Walter Morley Fletcher, the first Secretary (equivalent to Chief Executive) of the Medical Research Council, who provided financial support. It was Fletcher who offered Marjory a permanent MRC contract in 1929 – a privileged position for any scientist, male or female.

## Early life and career

Marjory Stephenson was born in the village of Burwell, about 12 miles North-East of Cambridge. While both her grandfathers had been racehorse trainers at Newmarket, her father, Robert Stephenson, took an apprenticeship with an estate agent and then moved to Burwell in 1866 firstly as a tenant farmer and later with land and property of his own (2). He became a local dignitary, holding such posts as alderman, Justice of the Peace and County Councillor, as well as having a number of business interests. By all accounts he was a workaholic and had a strong sense of duty which he aimed to instil in his children. Robert and Sarah Stephenson raised a son and three daughters, of whom the eldest and youngest were the achievers of the family. The eldest was Alice Mary Stephenson (1870-1940), known to the family as May, who read history at Newnham College (1889-1892) and went on to have a distinguished career as a school teacher eventually becoming Head Mistress of Francis Holland School in London where she spent the years 1912-1920 (3).

As Marjory recalled much later in life (4), she was the youngest and separated by 8½ years from her nearest sibling, so she grew up 'almost an only child'. Both parents had significant influences on Marjory. From her father she took, whether by nature or nurture, the Stephenson characteristic of being an unsentimental realist (2) as well as the strong sense of duty. Her father was also "extremely interested in scientific agriculture. He devoured such scientific books as were available to him. He was a believer in Darwin and possessed many of his books. Later he became interested in Mendelian genetics". Her mother was a disciplinarian when it came to housework but also had a softer side with an interest in art and literature. Marjory says "It is due to my Mother rather than my Father that my eldest sister and I went to Newnham College, though he did not oppose it". The other significant

childhood influence was her “beloved” governess Anna Botwright who lived with the Stephenson family for the best part of 20 years, providing primary education to all four children. It is likely that Anna would have been the first to see Marjory’s intellectual potential and to recommend that she be sent away to secondary school. Marjory boarded for 6 years at Berkhamsted School in Hertfordshire before going up to Newnham College in 1993 to read Natural Sciences.

At Newnham Marjory studied chemistry, zoology and physiology. She records that “of these, physiology alone was taught in the University laboratories as the others were not open to women at that date (4). She was thus taught zoology in the Balfour Laboratory (a joint enterprise between Newnham and Girton Colleges) and chemistry by Ida Freund in Newnham’s own laboratory in the College grounds (5). During this period, Marjory attended a lecture given by Frederick Gowland Hopkins which was to have lasting influence. She notes in a tribute to Hopkins towards the end of her life (6) that he did not generally teach undergraduates but on this occasion substituted for the Professor of Physiology. “…he talked about lactic acid production and muscle contraction and though much that he said was speculative, it opened a new world of thought which the didactic form of teaching previously handed out to us had never even hinted at.” Marjory obtained a Class II result in the part I exams in 1906, though as a woman she was unable to take a degree at that time.

After Newnham, Marjory “was obliged to teach as no funds were available to proceed to medicine (then my ambition)” (4). This she did by going to Gloucester Training College where, as well as teaching, she studied domestic science. From 1908 she was also a Visiting Lecturer in Domestic Science at Cheltenham Ladies’ College (a girls’ public school). In 1910 she took up a post at King’s College for Women in London and again supplemented this with part-time school teaching. In London Marjory shared a flat in Ravenscourt Park with Myra Curtis who was a friend from undergraduate days and who went on the become Principal of Newnham College in 1942.

Having dropped her ambition to become a doctor, it seems likely that Marjory moved to London to get closer to an academic life and this paid off in 1911 when she was offered some advanced teaching and laboratory space by Dr RHA Plimmer (4) who had set up a biochemistry laboratory at the Institute of Physiology at University College London under Professor EH Starling. Together with a maintenance grant from Newnham College and research expenses from the Government Grant Committee of the Royal Society this provided a base from which she could apply successfully for a Beit memorial fellowship to study the metabolism of fats and carbohydrates in animals. She published 2 papers as sole author in the Biochemical Journal in 1912 and 1913 on animal lactase, and esters of palmitic acid respectively. Her third paper, on diabetes in a canine model, was published in 1915 together with two other Beit fellows. These studies would have provided experience in a range of techniques in what was still one of very few biochemistry laboratories in the country outside of Cambridge. Furthermore, the diabetes paper was praised by Hopkins in his review of Physiological Chemistry for the year 1915 published by the Royal Society of Chemistry in 1916.

***Miss Stephenson, Principal Commandant, VAD Salonika, outside the Sisters' Convalescent Home, Salonika.***

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In 1914 Marjory volunteered for war service with the Red Cross, joining the London 146 branch of the Voluntary Aid Detachment (VAD). There is no record of her thoughts at the time, so we can only speculate that she felt she had something to offer and a duty to offer it. From October 1914 until May 1915 she worked as a cook in rest stations in France, following which she was appointed as 'Head Cook', and worked successively in two Red Cross hospitals in Normandy. In these postings her dual knowledge of human physiology and domestic science will have been put to good use. In May 1916 she was one of the first three VAD cooks to be sent to Salonika in Greek Macedonia where she stayed until she completed her service in June 1918. A note pinned to her Red Cross record states that she 'organised our Red Cross Kitchen work in Salonika with great success, then our Sisters' Convalescent Home and finally was promoted to Chief Commandant of VADs. Rendered very valuable services. Very capable and hard working and very competent as Principal Commandant.' The card was signed by Colonel HL Fitzpatrick, who was the area Commissioner for the Red Cross, and who also judged her character to be 'Excellent' (7).

Recently re-published Red Cross reports of the time (8) show that conditions in Salonika were often harsh – very cold in winter, very hot and insect-ridden in summer. Many reports praised the work led by Col Fitzpatrick, and in these the success of the hospital kitchens and the nurses' convalescent home are frequently singled out. By the end of 1917 the number of kitchens had risen to 17 and the beds in the nurses' home had been increased from 20 to 40. All of this activity appears to have been under Marjory's management though she is never mentioned by name in the reports. At the time of her departure in mid-1918, Lt-Gen Sir GF Milne (Commander-in-Chief of British troops in Macedonia) wrote to Fitzpatrick "in connection with the departure of the Principal VAD Commandant", speaking of "the very high appreciation I have of her work as Superintendent of VAD cooks, of her continuous devotion to her care of convalescent sisters in the most admirable convalescent home, and for her very valuable help…to the Hospital Economy Committee." Marjory was mentioned in despatches in 1917, and in 1918 was awarded the Royal Red Cross 2nd class and the MBE. She received these awards from the King at an investiture at Buckingham Palace on 12 December 1918.

***Marjory Stephenson with Judith***

**1920s**

When Marjory returned to Cambridge in her early thirties, she was thus already highly accomplished with substantial teaching experience, a modest publication record as an independent experimental scientist, and proven ability as an organiser and manager, not to mention Royal recognition for her war service. Thus she came to Hopkins, not as a student, but as a team leader in the making.

Marjory brought with her the unused portion of her Beit fellowship and it took her a couple of years to find her niche in Hopkins' department. As ever with his recruits (he was by now 57 himself), Hopkins suggested topics and approaches without ever directing her work. At first she joined in the work on fat soluble vitamins and this led her to think about studying fat metabolism in bacteria. She was not the first person in the department to work on microbes – Hopkins had done so briefly whilst working on the amino acid tryptophan in the early 1900s and then Harold Raistrick had studied bacterial amino acids during the period 1915-1920 (the latter had been ineligible for national service during the war for medical reasons). Raistrick left to pursue a career in industry, leaving a gap for Marjory to step into. It was a gap that suited her perfectly. Like Hopkins, Marjory Stephenson had been trained in both chemistry and physiology and her thinking embraced both. In this context, bacteria were attractive as model systems. According to one of her obituarists (9a): "Her attitude was that in the bacteria she had cells of great chemical activity, free from the complication of morphological differentiation within the individual organism, in which the chemical processes were in peculiarly close and direct relation to an environment which could be controlled by the experimenter."

With her first PhD student, Margaret Whetham (later Anderson), Marjory studied the metabolism of the Timothy Grass Bacillus and *Bacterium coli* (later renamed *Escherichia coli*), using a 'balance sheet' approach to ascertain the fate of carbon from glucose or other substrates supplied in the growing medium. After her PhD, Margaret Whetham went on to work with Juda Quastel in the department, and all three collaborated on studies in anaerobiosis, using washed suspensions of resting cells that became a trademark of Marjory's work.

By now Marjory was funded by an MRC grant, which was renewed on an annual basis. In 1922, Hopkins had written a begging letter to Walter Fletcher at the MRC (10a) "She was as you know trained at Cambridge but had a large experience of research in Stirling's Department and a thorough grounding in biochemical methods under Plimmer. Since she

has been with me, she has made herself a sound Bacteriologist and from the stand-point of metabolic studies of micro-organisms may be reckoned a real expert." This last point looks like an exaggeration as her first paper on bacteria had only just come out. However Fletcher trusted Hopkins' judgement and replied two weeks later with the offer of an MRC grant of £400 pa (the same as Marjory had been paid by Beit).

In 1926, Marjory spent 3 months in the Pathology department in Manchester learning some of the techniques of the medical bacteriologists (10a).The Department Head was WC Topley and here she also met Graham Wilson who later wrote of having taught her to count viable cells (11). With this method she was able to counter the criticism that her 'resting' cells were in fact dead. Topley & Wilson went on to become household names for students of medical bacteriology, publishing the first edition of their hugely successful textbook in 1929. This has its legacy today in the tenth edition of 'Topley & Wilson's Microbiology & Microbial Infections', an 8 volume set compiled by an international editorial board.

Marjory began lecturing to Part II (third-year) students in 1925 but she did not enjoy formal teaching, nor was she very good at it (9a, 9b). As Ernest Gale recalled much later (12) "Revere her as we may, no-one could call her a brilliant lecturer. The lectures might well begin in the middle and end at the beginning but at least we gathered that someone had done something terrific. At least you went away and read all about it". According to the same sources, where Marjory did score very highly was in her ability to enthuse and encourage students in one-to-one discussion in the laboratory. She led by example, encouraging her young charges to be persistent, thorough and hard-working. At the same time she did not spoon-feed and expected her students to work independently, developing their own experimental plans. Notwithstanding her limitations as a lecturer, she gave a radio talk for the BBC which in May 1930 so enthralled the schoolboy Donald Woods that he became determined to study biochemistry at Cambridge, which he duly did, going on to work with Marjory for his PhD (13). Marjory also contributed to teaching through Newnham College where she became an associate soon after her return to Cambridge, later becoming a fellow and serving on the Governing Body and various College committees throughout her career.

In the latter part of the 1920s, Marjory spent a significant amount of time writing her book *Bacterial Metabolism*, the first edition of which came out in 1930. The book was written at the suggestion of Hopkins and was published in the Longman's monograph series, which he co-edited with Plimmer. While she does not claim this to be a comprehensive review, Marjory does cite around 600 papers in French and German as well as English. In the Preface she likens her task to trying to understand the life of a household by 'a careful scrutiny of the persons and material arriving at, or leaving the house', acknowledging that it is not yet possible to produce a fully coherent picture.

Among Marjory's original work at this time, her isolation of lactic dehydrogenase from *B. coli* was the first isolation of a bacterial enzyme in a cell-free state (9a). Fortuitously, she had found that thick suspensions of *B. coli* allowed to lyse in buffer would release active enzyme into the medium. This turned out not to be a generally applicable method and the isolation of other enzymes was delayed until the late 1930s when a wet-crushing mill became available.

In 1928 Harold Raistrick decided he wanted to escape the confines of industry and return to academia. Hopkins and Fletcher discussed the possibility of him returning to Cambridge (10b; 14) but Raistrick really wanted a Chair which Hopkins could not offer and which he eventually found at the London School of Hygiene and Tropical Medicine. There is no record of how Marjory might have felt about Raistrick coming back, but as soon as it was clear that Raistrick was to go elsewhere, Walter Fletcher wrote, on 19 March 1929, to offer Marjory an appointment to the MRC staff "tenable during the pleasure of the Council" at an increased salary of £500 pa and enrolment in a superannuation scheme. In these times, there was no peer review as we know it now, Marjory had written no job application, career résumé, or

research proposal, and Fletcher's letter did not specify any programme of work though it did refer to general conditions of service. It is little surprise that Marjory replied the following day to "gladly accept the appointment". She goes on the say "The change from a temporary to a permanent basis, leaving me attached to Professor Hopkins' department offers a combination peculiarly attractive to me" (10c). Whilst her new position was well short of the Chair and salary level demanded by Raistrick, Marjory found herself exactly where she wanted to be, free to pursue her interests as they arose in a sympathetic and secure environment.

**1930s**

1929 had been a watershed year for Marjory. She had begun her permanent MRC appointment in April and her father had died later in the year. Both events contributed to her financial security and with her inheritance she was able to build her house at 16 Latham Road where she lived from 1934 until she died. The publication of *Bacterial Metabolism* in 1930 led to wider recognition both nationally and internationally and in 1931 she undertook her first visit to the USA, which at that time involved a 6-day sea crossing in each direction. Shipping records show that she sailed from Southampton on 24 July and arrived back in the same port on 30 October. During her time there, she visited laboratories, gave lectures and took holiday with friends (10a).

Back in the Cambridge, Marjory and her colleague Leonard Stickland were studying anaerobic organisms taken from the River Ouse where the waste from sugar beet processing was causing a fermentation that gave off noxious fumes. The MRC was somewhat bemused by her choice of work and Marjory received a letter from Sir Landsborough Thomson (Fletcher's deputy) suggesting that this might be a matter for the Committee on River Pollution of the Department of Scientific and Industrial Research, rather than the MRC (10a). Perhaps he was unaware that Marjory was a child of the fens, and he would not have known that her late father had been Chair of the Ouse Drainage Board. It is no surprise therefore that Marjory had obtained her river sample from the engineer of the Ouse Drainage Board – indeed he may even have taken advantage of the family connection to seek Marjory's help with the problem. Before replying to Thomson, Marjory was careful to discuss the matter with Hopkins so that she could tell the MRC that he was fully in favour of her taking the work a little further before taking it to the Committee on River Pollution. Having obtained her tenure, Marjory intended to exercise her academic freedom, even if it was not obvious how studies of river mud would contribute to medicine.

These studies did, however, lead to fundamental discoveries about anaerobic metabolism in bacteria. The mixed culture of river bacteria was found to reduce sulphate to sulphide (hence the bad smell) and to produce methane, hydrogen and carbon monoxide from formic acid. Further studies identified three organisms responsible for these reactions and led to identification and study of a hydrogenase which turned out to be found widely in bacteria and formic hydrogenlyase which was an 'adaptive' enzyme (today we would say inducible) only produced when the appropriate substrate is present. These studies continued over a number of years with co-workers Leonard Stickland, Donald Woods, John Yudkin and others (9).

In 1936, Marjory was awarded the degree of Doctor of Science by the University of Cambridge. In the same year she recruited a new assistant, Ernest Gale, who had just graduated from the Part II class in biochemistry. He was to be the mainstay of the laboratory during her remaining years, soon becoming an independent investigator in his own right and ultimately Marjory's successor in the Biochemistry Department, supported by the MRC and the University. When Gale completed his PhD and moved on to a fellowship, Marjory recruited Ronald Davies as her assistant and he helped her with her work during the Second World War. During 1939, she says to the MRC "my time is more and more eaten into by visiting foreign students and with helping people who come along wanting to use bacteria for

some problem or another" (10d) She had also been updating her book, *Bacterial Metabolism*, the second edition of which was published in 1939. Now citing a larger body of work, it was presented as a textbook rather than a monograph.

***Marjory Stephenson with Dorothy Wrinch & P.B.Armstrong***

**1940s**

Again the end of a decade marked a turning point, bringing as it did the start of the Second World War. During the first week of September 1939, Marjory and Ernest Gale were at the Third International Congress for Microbiology in New York. Notwithstanding that war in Europe was declared on 3 September – the second day of the conference - the event was attended by over 1500 delegates from 46 countries (15). Not for the first or last time, the scientific community showed its disdain for international conflict by adopting an attitude of 'business as usual'.

During the second war, Marjory and colleagues worked on a number of projects thought to be of national interest, but none of these really fired her enthusiasm and she published very little herself. So far as secret war work is concerned, it was the medical bacteriologist Paul Fildes, then based at University College London, who was seconded to Porton with a small team to work on bacteriological warfare, following intelligence reports that Germany was developing a capability in this regard (10e).

Marjory's role had in any case become more of an advisory one than hands-on: she became Secretary to the MRC Committee on Chemical Microbiology which was set up in 1943 to coordinate existing work and make proposals for new studies. After the war she became involved in a variety of activities designed to promote training in microbiology, including a 2-week 'summer school' in bacterial chemistry that she organised in 1946 and a new Part II course in Microbiology to be run with half the lectures in common with the mainstream Biochemistry course – this began in 1947 (10f). The expansion in teaching also led to the microbiologists moving in 1947 to separate temporary accommodation alongside the main Biochemistry department building – known as the 'bug hut.' The separate Part II courses which had been brought in under AC Chibnall as Head of Department only lasted for 5 years as his successor Frank Young decided to reorganise and reintegrate the classes again.

In March 1944, whilst writing to Sir Edward Mellanby who had succeeded Fletcher at the MRC, Marjory adds a final query to her letter, asking whether it might be a good plan if papers from the unit were in future described as coming from the 'Medical Research Unit for Microbiology, The Biochemical Laboratory, Cambridge' (10d). Until that point the affiliation for Marjory and her co-workers had been simply 'The Biochemical Laboratory, Cambridge'. In the absence of a reply to the query, Stephenson and Gale went ahead with their plan: Gale published a letter in *Nature* on 16 June 1945 in which his affiliation was given as the MRC Unit of Chemical Microbiology, Biochemical Laboratory, Cambridge. This did elicit a

reaction from Mellanby who wrote on 2 July to JT Saunders, Secretary to the General Board of the University, referring apologetically to the fact that the term 'unit' had been in use informally and had now crept into print. As there was at this stage no agreement between the MRC and the University as to the existence of such a unit, Mellanby asked for advice on the need to regularise the situation. Saunders replied that the General Board had agreed to review the position of units and pseudo-units (sic) and that it would be good to regularise the position. There the matter rested for some years while Marjory's team continued to publish as, and become known as, the MRC Unit of Chemical Microbiology (with some variation in the exact wording), with Marjory also styling herself as Director of the Unit (16). After the war, the MRC acknowledged in internal correspondence that the unit had come into being as a matter of custom rather than formal agreement (10g), whilst publicly they were content to take credit for its success. Marjory did receive more formal personal recognition from the University when she was made Reader in Chemical Microbiology in 1947.

Joan Mason has written in detail about the process leading up to the election of the first two women Fellows of The Royal Society in 1945 (17). While Hertha Ayrton had been rejected in 1902 because of the doubtful legal status of married women, The Sex Disqualification (Removal) Act of 1919 took away any bar to membership of learned societies on the grounds of gender or marital status. Why then did it take the Royal Society another 26 years to give recognition to the best women scientists? A number of factors would have been at work. The 'Old Guard' would have been resistant to change; women were not lobbying to be allowed in, perhaps feeling they would not be welcome, and as long as no woman was actually rejected, it was possible for male only lists to be published each year without challenge. In 1943, the then President Sir Henry Dale decided that the time had come to get rid of the anomaly, perhaps influenced by the obvious contribution being made by women during the 2nd World War and public debate about equal pay for equal work. Correspondence among a number of Fellows led to certificates proposing Marjory Stephenson and the physicist Kathleen Lonsdale being presented to the Royal Society towards the end of 1943. After further lengthy process, both were elected in March 1945. There was no public comment, perhaps because of the War. The American Magazine *Science* went as far as to publish the list of "scientific men" who had been elected without apparently noticing that the list included two women. While the precedent had now been set, there was no opening of floodgates. As recently as 1984 the Society elected an all-male list, and of fellows elected in the first 14 years of the twenty-first century only about 10% have been women.

Marjory was one of the founders of the Society for General Microbiology (SGM) and at the time of her death in 1948 she was its second President, in succession to Sir Alexander Fleming. At the inaugural meeting of the SGM in February 1945, she presented her five levels of microbiological investigation, each characterised by a different technical approach. This paper, which contemporaries saw as summarising the essence of her scientific method (9) was not published at the time, although the author's abstract was reprinted as an appendix to Gabe Knight's Marjory Stephenson Memorial Lecture in 1962 (18).

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| A | Mixed cultures growing in natural environments |
| B | Pure growing cultures in laboratory media |
| C | Non-proliferating cells in pure culture on chemically defined substrates |
| D | Pure growing cultures in highly purified media |
| E | Cell-free enzymes and co-enzymes on pure substrates |

Marjory did not intend any of these levels to be regarded as more or less valuable than the others; they were all necessary at different times. In conclusion she stated "Unless work is to grow first stale and then sterile it must be refreshed by contacts with work at other levels". She foresaw that as time went on this would need more interdisciplinary collaboration which she hoped the new Society would foster.

**Illness and death**

In September 1944, at the age of 59, Marjory was diagnosed with breast cancer for which she was treated with surgery in the Evelyn Nursing Home[1], returning to work before the end of the year. She had lost weight and the portraits taken the following year to celebrate her FRS showed her looking frail. In October 1948, Marjory wrote to Mellanby at the MRC to say that since May 1947 she had been receiving treatment for secondary tumours in the lungs and that she was now having to cope with "bad memory and slow mental processes" suggestive of further secondaries in the brain. Her physical condition declined quite rapidly from this point although letters to her friend and former colleague Sidney Elsden show that her spirit was undimmed (19). Among other things she delivers a diatribe about Elsden's lecturing style (ironic in view of her own reputation in this regard), maintains a dialogue about bacterial nomenclature which was exercising the SGM at that time and instructs Sidney on the planting of fruit trees. When she speaks of her condition it is in unsentimental terms. Her last letter, dated 20 November 1948 begins:

> "I am terribly sorry to disappoint myself and you (note order) but I shall not be able to visit you and Erica as planned. Recently, such marked symptoms of secondaries have appeared, mainly dizziness and mental confusion, that I must just stay at home. You cannot cheat cancer for ever and I am lucky that so far I have no pain. I cannot undertake journeys or complicated doings of any kind, my head swims all the time."

She ends the letter by recommending that he sees the film *The Winslow Boy* if he has not already done so, and looks forward to seeing him at Christmas though she must have known that was unrealistic. Marjory was admitted to the Evelyn Nursing Home on 26 November 1948 and died there on 12 December, 30 years to the day after receiving Honours from the King at Buckingham Palace.

A memorial service for Marjory was held in King's College Chapel on Saturday 15 January 1949. According to the report in The Times of 17 January, many distinguished people were there to pay tribute, including the Vice-Chancellor (Dr Charles Raven, Master of Christ's College), her old friend and by now Principal of Newnham College, Dame Myra Curtis, Sir Edward Mellanby, Secretary of the MRC and Sir Alexander Fleming. Others were there to represent Berkhamsted School, and the Society for General Microbiology as well as many research institutes and academic departments with which she had connection.

The Society for General Microbiology set up a memorial fund which was used to establish a biennial lecture in memory of Marjory Stephenson, the first of which was delivered by Donald Woods in 1953. The series of lectures continues today.

The third edition of *Bacterial Metabolism* was published posthumously in 1949, and as with the second edition Marjory acknowledged help from many colleagues in the preparation of individual chapters. In the Preface which is dated March 1948, she writes that "Bacterial metabolism is now such a wide study that it is no longer convenient for one person to attempt to cope with all its branches; I can confidently assert that this is the last edition that will appear over the name of one author." This book, and Marjory's death, mark the passing of an era in which bacterial metabolism could be regarded as a single specialism with which one person could be fairly fully conversant.

Ernest Gale was formally appointed as Director of the MRC Unit early in 1949, and in 1952 the General Board of the University finally considered the terms of an agreement with the MRC for the operation of the Unit (10g). Negotiations were difficult both financially (who

[1] Today this is the private Nuffield Health Cambridge Hospital in the same location on Trumpington Road, close to Marjory's home in Latham Road. The NHS was being formed in the year that Marjory died, so she only knew private healthcare.

should pay for what in a fully embedded unit) and in terms of accountability, with Gale and the MRC insisting on the freedom to pursue their own research programmes, and the Head of Department, by now Frank Young, taking the view that everything in his Department should be under his control. Eventually an accommodation was reached and Gale was given the same title that Marjory had had, of Reader in Chemical Microbiology. The Unit continued until 1962 when it was 'absorbed' into the University, in the run-up to which a Sub-Department of Chemical Microbiology had been created within the Biochemistry Department, with Gale as Professor and Head. The Sub-Department closed when Gale retired in the 1980s.

**Personality and Life beyond science**

As a student at Newnham, Marjory was said to have a lively disposition and high spirits (9a) and later her personality was described as vivid and arresting (9b). She was very much at home in the Biochemistry Department of the 1920s where people were "vigorous, self-confident and not always tactful" (9c). Ernest Gale recalled that "MS was forthright and believed in striking while the temper was hot. There were days when we tiptoed round the lab, hoping that lightning really did not strike twice in the same place. Then the storm would pass, enthusiasm bubbled out of her room and we all joined in argument and riotous assembly while MS's laughter rang through the building" (12).

Marjory's outbursts could be of some heat but had no malice. She entertained friends and colleagues generously at her home in Latham Road where good conversation was said to flourish (9a). Margaret Whetham Anderson who remained a lifelong friend after leaving science to raise a family, described her personality as "envigorating, perhaps to be likened to a fire in the hearth, shedding a generous inspiring warmth and glow, sparkling with wit and vivacity, yet with scorching disdain for any shiftiness, jealousy or insincerity" (9d). This last point was echoed by Donald Woods who said that she was intolerant of all forms of pretentiousness, personal or scientific. In their obituary, Sidney Elsden and Bill Pirie (9c) also referred to her being "unsparing in her condemnation of secretiveness, personal vanity and competiveness in scientists and [she] jeered at most of the medals and awards that scientists confer on each other." After the announcement of each year's elections to the FRS she would say "That means a few more scientists can settle down to their work instead of fussing about their reputations". She was nevertheless gracious about accepting an FRS herself when the time came although there is no evidence that she sought such accolades.

For all her feistiness, Marjory was also said to have a fundamental humility which enabled her to listen, learn and if necessary change her mind (9e). She saw the good in people and was not given to pessimism or cynicism (9a). She formed lasting friendships with both men and women and was particularly welcoming of political refugees who joined the department, who included Hans Krebs. She was affectionately known by everyone as 'MS'. While she never married and no evidence has yet been found of any romantic relationships, Marjory appears to have been emotionally grounded, and very content with her independent status and the freedom it gave her.

Outside of science Marjory read widely, and particularly enjoyed novels, poetry and history. She listened to classical music, saw plays and appreciated art, especially the Dutch School and French paintings of the nineteenth century. She was interested in politics without toeing any particular party line or being as left wing as some of her friends in the Department. During the 1930s she supported various anti-war activities and at the time of her death was a Vice-President of the Association of Scientific Workers, one of the predecessor trade unions to what is now Unite. Marjory also travelled widely during the 1930s, for example spending some time visiting the Soviet Union in 1936 with her friends Dorothy Needham and Kits Van Heyningen. At home, she enjoyed gardening, and following her father's experience

in later life she planted fruit trees in her garden at Latham Road, and became an expert in their growth and propagation through links with friends at the East Malling Research Station in Kent (5, 9).

**Scientific Legacy**

Hans Krebs' biographer wrote "Of all the researchers in the Cambridge laboratory, Krebs was most impressed with Marjory Stephenson whom he remembered later as 'scientifically… the best of the whole lot. (20)" Donald Woods (9b) commented that she was essentially an experimentalist, and that her papers rarely contained a discussion section, while JBS Haldane says, in correspondence leading up to her election to the Royal Society "I have no doubt at all that had [Dr Stephenson] been a man she would have been elected to the Fellowship some time ago. I was particularly impressed with the accuracy of her work, and the very large amount of research which it directly inspired" (17). These views (and others in similar vein) all speak to her focus on experimental rigour and commitment to a full investigation before publication. At the same time, her lack of interest in hypothesis frustrated Juda Quastel when he was starting to develop ideas of an enzyme 'active site' forming an architecture around reactive molecules. "Hopkins was only mildly interested. Marjorie (sic) Stephenson seemed to have no interest in them at all – she was, if anything, hostile (21)". Marjory was also criticised for her lack of interest in medical application by another MRC staff member, Paul Fildes, a medical bacteriologist based at UCL: he described her in 1934 as "hopelessly out of date with the medical aspects of these matters…" (10a). However, in spite of their criticisms of Marjory, both Fildes and Quastel respected her enough to sign the certificate proposing that she be elected FRS.

Picking up Haldane's remark, it is not a simple matter to catalogue the body of work which Marjory directly inspired. She never put her name to a paper unless she had undertaken a full share of the "actual manual labour" (9a). Many of her co-workers published independently. For example, a browse through the Biochemical Journal for the years 1935-1938 shows that Donald Woods, who was a PhD student and then postdoctoral fellow under Marjory, published 7 papers whilst in her laboratory, of which 5 are his name alone and 2 in collaboration with Charles Clifton, a visiting worker from Stanford. Marjory's encouragement and advice is acknowledged at the end of all these papers, but that is all. Marjory also never published an original paper in collaboration with a laboratory outside the Biochemistry Department though, for example, it is clear from letters in the Krebs archive that they collaborated both in Cambridge and after he had moved to Sheffield (21). These practices mean that today, Marjory's output looks not only modest but perhaps isolationist which may not do her justice.

Much as it does today, funding for research assistants, students and fellows came from a variety of sources. For many years, Marjory's annual reports to the MRC covered only her own work and that of any others who were MRC-funded at the time. In 1941 she wrote "I have this year included the work of all the group whether they are paid for by the Council or by someone else, as this seems the practice of others in a like case" (10d). Thus it is only from this date that we have a reasonably full listing of papers being published from Marjory's laboratory.

A more visible component of Marjory's legacy is the success of many of her students. Sidney Elsden (1952), Donald Woods (1955), and Ernest Gale (1960) all went on to become Professors of Microbiology in Oxford, Sheffield and Cambridge respectively. All paid tribute to Marjory later in their careers and all moved from their initial grounding in fundamental studies to interests with greater application to medicine and beyond. Woods worked in medical bacteriology with Paul Fildes for a time, although he returned to more fundamental studies in Oxford. Gale became interested in antibiotics and Elsden had a more eclectic

career encompassing animal physiology and the Directorship of the Agricultural Research Council's Food Research Institute as well as microbiological research.

Evaluation of Marjory's work is also made difficult by the fact that biochemistry was revolutionised within 5 years of her death with the discovery of the structure of DNA by Watson & Crick. The study of enzyme adaptation in bacteria was picked up by Jacques Monod and others at the Pasteur Institute in Paris. In his obituary of Monod, Anton Lwoff speaks of how Monod began work in this area in 1940 and that one of the texts he urged him to read was Marjory Stephenson's *Bacterial Metabolism* (22). He also states that the work did not start to move on conceptually until 1948, and it was not until 1960 that the term 'operon' was first used in a paper from Monod's laboratory, in connection with control of the expression of the β-galactosidase gene in *E. coli.* In 1965 Lwoff, Monod and François Jacob shared the Nobel Prize in Physiology or Medicine for this work.

One can only imagine what Marjory would have made of these events of the 1950s and 1960s, and how she might have further contributed, had she not died at the relatively young age of 63.



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