MicroDiscoverer Hero: Marjory Stephenson (1885-1948, UK)

(Carlos Medina Morillas)

Picture (Marjory Stephenson). Adapted with the permission of the 'Department of Biochemistry, University of Cambridge'. Included in 'The History of the Biochemistry Department - Volume 1', University of Cambridge, collected for Sir Frederick Gowland Hopkins, early 1930s. Weblink https://www.bioc.cam.ac.uk/about-us/history/photographic-archive

Claim to fame: Pioneered the field *chemical microbiology* and wrote "the book" *Bacterial metabolism*

Background: description of the problem faced

Despite the obvious global importance of microbes in disease, food production and spoilage, etc. at the beginning of the 20th century, little was known about microbial processes and metabolism. The initial biochemical training of Marjory Stephenson was key to being able to approach the study of microorganisms from a biochemical point of view, which ultimately led to the establishment of "Chemical Microbiology" as an independent discipline. Marjory specialized in bacterial metabolism, and it would be unfair to mention only one achievement in this regard, as her initial findings and observations served as the basis for numerous subsequent discoveries. To highlight some of her achievements, Marjory was the first person to isolate an active enzyme, lactic dehydrogenase, from a bacterium. She also initiated studies on the optimal conditions for research on the anaerobic metabolism of microorganisms, highlighting the discovery of

hydrogenases and their induction in the presence of substrate, which led to the coining of the term "adaptive or inducible enzymes".

The Approach taken

To analyze bacterial metabolism, Marjory proposed her five levels of microbiological research, each characterized by a different technical approach.

1. Mixed cultures growing in natural environments
2. Pure growing cultures in laboratory media
3. Non-proliferating or **resting cells** in pure culture on chemically-defined substrates
4. Pure growing cultures in highly purified media
5. Cell-free enzymes and co-enzymes on pure substrates

She proposed that all the levels were necessary for different purposes, and none was more or less valuable than the others.

Breakthroughs

Again, it would not be fair to recognize only one solution to only one problem solved by Marjory Stephenson, since many major scientific breakthroughs were made in her laboratory. Her greatness was taking a holistic approach versus a reductionist point of view to understand a biological system, something that at that time was challenging. In her opinion, in order to study a whole organism, an interdisciplinary approach must be adopted involving inorganic and organic chemistry, biochemistry, genetics, metabolism and finally physiology, disciplines that were well established at the time.

Applications

It is not possible to enumerate all the applications resulting from Marjory's work, and it suffices to exemplify one of the fields in which her contributions were most prolific, such as the establishment of anaerobic metabolism research in bacteria. Using sediments from the Great Ouse River near Cambridge, and an observation made 50 years earlier in which river mud samples could transform formic acid into CO_2 and H_2, her studies paved the road for a field of research as novel and important as the production of biohydrogen. Following the *step by step* approach from mixed cultures from the river, then pure cultures tested in chemically defined medium and finally resting cells derived from them, her research group discovered in a coliform bacterium (probably of the genus *Escherichia*) the hydrogen-evolving formate hydrogenlyase reaction. This initial observation led to a series of discoveries fundamental to current microbiology, such as the fact that this enzyme was only active in the presence of its substrate (formate), which led to the concept of enzyme induction. This subsequently led to the first description of hydrogen-dependent methane production or *methanogenesis*, and the revelation of the central role of biohydrogen in driving anaerobic microbial processes as *syntropy*.

Its Significance and how it changed microbiology, humanity

Marjory Stephenson's contributions to the field of microbiology and her innovative biochemical methods resulted in the publication of her book *Bacterial Metabolism*, which appeared in three editions, and led to her national and international recognition. The first edition in 1930 was conceived as a monograph with a compendium of more than 600 papers, but the second edition in 1939 was presented as a textbook to help, guide and inspire students, but serving as well as a reference text for senior scientists. The third edition was published after her death in 1949; in the Preface she had written one year earlier she commented "*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 affirmation and her rightful recognition of the many colleagues who helped her in the preparation of individual chapters, complete the picture of Marjory Stephenson's hallmark. *Bacterial metabolism* was *de rigueur* reading for generations of microbiology and biochemistry students and researchers who entered the field of *chemical microbiology*, a field that has contributed enormously to our understanding of biochemical mechanisms and metabolic processes in microbes and, indeed, all organisms, with all the applications that ensued from this.

Marjory Stephenson – the person

Marjory Stephenson was born in the Cambridgeshire and was encouraged by her parents to study in Newnham College where she was introduced to chemistry, zoology and physiology. Despite her outstanding qualifications, she had no funds to study medicine and was obliged to teach *Domestic Science* in several girls' colleges. But her real ambition was to pursue a research and academic career. Following several years of research training in London, and after her First World War Red cross volunteering in France and Greek Macedonia, she returned to Cambridge in 1919 where she joined the department of Sir Frederick Gowland Hopkins. He persuaded her to study the biochemistry of microorganisms, thus beginning a new scientific discipline. Due to her numerous scientific achievements, the publication of her textbook and her keen interest in microbial biochemistry, Marjory was awarded in 1936 the degree of Doctor of Science by the University of Cambridge. But the greatest recognition of her work was her election to the Royal Society in 1945, together with Dr. Kathleen Lonsdale, the first women to be elected to the Society. She was also one of the founders of the Society for General Microbiology and its second president, after Sir Alexander Fleming. Marjory Stephenson was a pioneer woman in science and a champion of science communication. She was instrumental in establishing outreach programs to educate the public about the importance of bacteria and biochemistry, and so is revered along with others like Haldane, Krebs and Szent-Györgyi trained in Hopkins' Cambridge Biochemistry Institute.

https://www.youtube.com/watch?v=hr5b9f8hIVk