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Walter Thomas James Morgan: 1900–2003

Walter Morgan was born in Ilford, London, on October 5, 1900, and died peacefully on the evening of February 10, 2003. Walter was an extraordinary person who made major contributions to the field of human blood groups and the chemistry of complex polysaccharide structures. He maintained an active research program until he was 89 years old and participated actively in scientific meetings until 1997. In 2000, when he was 100 years old, Walter attended the meeting of the International Society for Blood Transfusion to celebrate the 100th anniversary of the discovery of the A, B, and O blood groups by Landsteiner. He remained mentally alert and interested in science until the very end. Perhaps the greatest gifts that Walter gave to the world of science were the high standards he applied to his research and the warmth and humanity that radiated from him towards everyone who came in contact with him.

Walter left school at the age of 16 and obtained a job as a technician in the gas industry. He next worked as a chemist in a government factory that was producing synthetic phenol for the war effort, a potentially dangerous procedure with explosive possibilities. As his 18th birthday approached, he knew that he would be called up for military service and volunteered to serve in the Royal Navy. He was first posted to a land-based research and manufacturing station for the production of toxic agents and other materials for the Navy, but later he was given a job as a stoker on a Foden steam wagon used for delivery of the station's products to the Navy's depots.

After the war, Walter was given a government grant that enabled him to study at London University where he graduated with a Bachelor of Science degree in chemistry in 1922. It was Walter's good fortune that in 1925 he met Professor Arthur Harden, who was then professor of Biochemistry at the Lister Institute of Preventive Medicine. Impressed by Walter's work and youthful enthusiasm, Professor Harden invited him to apply for a research studentship tenable in the Biochemistry department at the Lister Institute. Walter accepted with alacrity and considered this decision to be the most important formative event in his scientific career. The Lister Institute, which he entered in 1925, remained his scientific home for the next 50 years.

Walter's enrollment as a doctoral student was not only the beginning of his academic career but also his introduction to carbohydrate biochemistry. His first investigation was concerned with the development of methods for the isolation of hexose mono- and di-phosphates and other sugar esters that were the products of the controlled fermentation of glucose by yeast juice, a subject that was being studied in depth by Arthur Harden and for which he was awarded a Nobel prize in 1930. Walter earned his Ph.D. in 1927, followed by the award of a Beit Memorial Research Fellowship, which enabled him to pursue his studies on carbohydrate metabolism for a further 2 years. In 1929, he was appointed as biochemist to the Lister Institute's Serum and Vaccine department, which was housed just outside

London in Elstree, Hertfordshire. Walter took the opportunity to learn some immunology and the problems associated with the production and testing of antisera and bacterial toxins.

Walter's aim was to prepare bacterial antigens in a form more suitable for prophylactic inoculation than the crude suspensions employed at that time. He was successful in isolating serologically specific polysaccharides from several Gram-negative organisms by extracting them with neutral, water-soluble anhydrous polyhydroxy organic solvents, such as diethylene glycol. He established that the antigens were carbohydrate–lipid–protein complexes, and succeeded in preparing powerful antibodies specific for the carbohydrate determinants. The need to analyze the composition of bacterial polysaccharides led Walter and his coworker Leslie Elson to develop procedures for measuring the amounts of both hexosamine and *N*-acetylhexosamine. These famed procedures, published in 1933 and 1934, remained in use for nearly 40 years. However, Walter felt that he did not possess in sufficient abundance the qualities of persistence and enduring patience required for successful development of good analytical procedures. He resolved never again to become involved in this type of work.

In 1936, Walter was awarded a Rockefeller Foundation Fellowship that enabled him to work with Professor Tadeusz Reichstein in the School of Organic Chemistry at the Eidgenössische Technische Hochschule (the Swiss Federal Institute of Technology) in Zurich. He acquired not only practical skills in the chemistry of ascorbic acid and its analogues, but also an enduring friendship with Professor Reichstein.

On his return to the Lister Institute in 1938, Walter and his colleague S.M. Partridge continued to work on bacterial antigens. With the outbreak of the Second World War in 1939, Walter ended this work and never again made more than minor excursions into this field. Although the advent of sulfonamides and antibiotics have obviated the use of the bacterial antigens for prophylactic purposes, his studies remain as a starting point for work by others on Gram-negative bacterial antigens. The growing emergence of antibiotic-resistant bacterial strains may yet render necessary the preparation of purified antigens for therapeutic use.

Plans for an Emergency Blood Transfusion service were set up in the United Kingdom early in 1939 in anticipation of war casualties. Walter thought that his previous experience would be useful in studies on the antigen-antibody reactions leading to incompatible blood transfusion reactions. He perceived this to be both of immediate practical importance in the rapidly developing clinical practice of blood transfusion and of fundamental importance to an understanding of human biochemical genetics. Winifred M. Watkins joined Walter in 1942 soon after the blood group work began. Despite the rather stark physical condition of the biochemistry department of the Lister Institute during the war, Walter's infectious enthusiasm for his chosen subject was an antidote to the surrounding gloom. All who joined the group were quickly caught up in the excitement of the research. The ABO groups had been discovered at the beginning of the century by Landsteiner, and much had been learned on their serology and inheritance in the ensuing years. However, very little was known about the nature of the substances responsible for antigenic specificity when Walter and Winifred began their work. From the outset, Walter's aim was to correlate genetic status with chemical structure. He realized the necessity of using materials from single individuals rather than pooled samples and of using human substances rather than the animal tissues known to carry the same specificities. The fact that there were water-soluble substances present in tissues and secretions with the same antigenic activity as the antigens on red cells had been known since the 1930s. Walter's demonstration, with Ruth van Heyningen, in the early 1940s that ovarian cyst fluids were a powerful source of secreted soluble blood group substances provided the starting materials for the isolation and characterization of the ABO and Lewis blood group determinants.

It was not until 1967 that the A, B, Le^a, and Le^b antigens were fully characterized. This epic work required a variety of different approaches and the efforts of many co-workers. Complementary studies were reported by Elvin Kabat's group in the United States. The soluble blood group substances were carbohydrate–amino acid complexes, but their compositions were all very similar and gave no clues as to why they carried such distinctive immunological specificities. Walter, Winifred Watkins, and their co-workers used a variety of analytical methods, many of which were novel at the time, to probe the purified ovarian cyst materials, *e.g.,* antibody, lectin, and enzyme inhibition experiments with well-defined oligosaccharides, sequential degradation with exo-glycosidases, and partial chemical degradation. The methods available in the 1960s for characterization of carbohydrate fragments were primitive compared with the standards of today, but Walter's insistence on a multidisciplinary approach enabled sound deductions to be made. When the antigens on the erythrocyte surface were eventually identified by others, the determinant structures were found to be identical with those established on the ovarian cyst glycoproteins. These pioneering studies laid the basis for later work that led to the explosion of interest in the 1990s in cell surface carbohydrate molecules closely related to the blood group structures that are involved in cell–cell recognition, metastasis, and the inflammatory response.

Walter Morgan retired as head of the Lister Institute's Biochemistry Department in 1968, but he continued to do research as a guest worker. In 1972, he was called from retirement to be Director of the Lister Institute at a time when the financial status of this institution was becoming less secure. In 1975, he had the sad duty of overseeing the closure of the institute where he had spent so many productive years. Walter then joined Winifred Watkins at the MRC Clinical Research Centre at Northwick Park Hospital where he continued to work at the bench until 1989. His last project concerned another carbohydrate blood group substance, the Sda determinant. Once again, a soluble source, this time human urine, was used for the

isolation and eventual characterization of the Sda determinant structure.

Over the years, Walter Morgan found time to serve on a number of government committees concerned with the development of biological sciences in the United Kingdom. His scientific contributions were recognized by many honours and awards such as the election to the Royal Society, the award of a Royal Medal of the Royal Society, an honorary degree from the University of Basle in Switzerland, an honorary degree from the University of Michigan in the United States, Honorary Fellowship of the Royal College of Physicians, the Paul Ehrlich-Ludwig Damstadter prize in Germany, the Landsteiner award of the American Association of Blood Banks, and the Philip Levine award of the American Society of Clinical Pathologists. The early experience of attempting research with limited facilities taught Walter the value of carrying out simple experiments, and he sought to pass on this lesson to students and colleagues. Throughout his career, his work was characterized by originality, a willingness to step into the unknown, and extreme dedication to the task in hand. For those who shared his enthusiasm, he was most generous with his time and support and he won the esteem and affection of colleagues and friends throughout the world. Walter Morgan will be sorely missed.

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