

## Dorothy Crowfoot Hodgkin – A Tribute

The word 'scientist' evokes different images in people. There is the conventional caricature of a scientist as an absent-minded, dry recluse pursuing a chosen problem with single-minded devotion. Then there is a current image of a scientist-manager raising large funds, filing patents, hopping from meeting to meeting, leading large teams and producing results of great import to science as well as industry. These or other images do not fit Dorothy Crowfoot Hodgkin. Undoubtedly, she was an outstanding scientist with great achievements to her credit. She was a great humanist deeply concerned with peace, justice and human well-being. Yet she remained a simple human being, a devoted wife, mother and grandmother, a person full of life, warmth and compassion.

During most of Dorothy's childhood, her father, John Crowfoot, was employed in the Education Department of Sudan, then under the British rule. She was born in Cairo, Egypt, which was then linked to Sudan, on May 12, 1910. Until her father returned to England in 1926, Dorothy and her sisters split their time between Sudan and England. Subsequently she spent time in the Middle East as well during the period when her father worked as the Director of the British School of Archaeology in Jerusalem. Perhaps, her early exposure to different countries and cultures in childhood contributed to making her the great internationalist that she was. The most important childhood event in relation to the development of her scientific interest also took place in Sudan when she visited the Wellcome Laboratories in Khartoum in 1924. The interest generated by the visit led to the setting up of a small laboratory in the attic of her home, where she spent many hours doing experiments. The Christmas lectures of Sir William Bragg, a pioneer in X-ray crystallography, and Parson's book on Biochemistry also influenced her greatly.

After completing her schooling, Dorothy joined the Sommerville College in 1928 to study chemistry at the University of Oxford. The four year degree course in chemistry at Oxford involved, and still does, a project ('Part II') in the final year. Dorothy chose to work in the field of X-ray crystallography, still a fledgling discipline. Her supervisor, H M Powell (of the inclusion compounds fame) who had just then joined as a demonstrator, was himself new to the subject and was involved in setting up the X-ray laboratory. Her work with Powell marked the beginning of her remarkable career as a great scientist.

In 1932, Dorothy moved to Cambridge to work for her doctorate under the legendary J D Bernal. Bernal has been her true mentor and the greatest influence on her development as a scientist and public figure. Their scientific collaboration lasted well beyond her Cambridge days. In the mid-thirties, Dorothy returned to Oxford to start her independent research career and remained there for the rest of her life.

Dorothy married Thomas Hodgkin in 1937. Thomas, an illustrious historian and Left intellectual, had been an extraordinarily unconventional and lovable person. Dorothy was devoted to Thomas, their three children and grandchildren. Her career and family life blended harmoniously. Dorothy's close colleagues and students have been as close to Thomas as they have been to Dorothy.

Dorothy Hodgkin was a structure analyst par excellence. It is almost axiomatic that the properties of a molecule depend upon its structure. The chemical structure refers to the covalent linkages of the atoms in the molecule. But that does not provide the whole story. The chemical structure, or the structural formula, provides only two-dimensional information. However, each molecule is endowed with a three-dimensional structure. Most X-ray crystallographers determine the three-dimensional structure of molecules with known structural formulae established by organic chemists using laborious chemical methods. But Dorothy most often undertook the analysis of complicated molecules of unknown chemical formula. She revelled in determining the chemical formula as well as the three-dimensional structure using almost entirely X-ray methods. It is often said that she liberated organic chemists from the drudgery of structure analysis.

Her choice of research problems reveals her scientific and humanistic concerns as well as her vision. The way she solved them stands testimony to the brilliance of her mind, her intuition and her mastery over the method of X-ray analysis. The most important structures she determined (in addition to that of insulin) were those of cholesterol, penicillin and vitamin B<sub>12</sub>, all very important biomolecules of considerable medicinal relevance. Each *structure solution*, at the time she performed it, represented the very frontiers of scientific endeavour. Each was a land mark in biological chemistry as well as crystallography. The solution of the very complex structure of vitamin B<sub>12</sub>, for which she was awarded the Nobel Prize in 1964, is almost unparalleled for its analytical brilliance.

Today biological macromolecular crystallography, consisting mainly of the X-ray analysis of complex proteins, is the most spectacular facet of X-ray crystallography and, indeed, structural biology. The field originated when Dorothy Crowfoot and Bernal took the X-ray diffraction photograph of the crystals of the enzyme pepsin in 1934. The second protein crystal to be so photographed was that of insulin. This was in 1935, soon after Dorothy returned to Oxford as an independent researcher. Since then insulin has remained the molecule closest to her heart. She reckons photography of the X-ray diffraction pattern from insulin crystals in 1935 as the most exciting event in her life. She describes how she, just 25 then, roamed the streets of Oxford in ecstasy the night after she developed the photograph. The next most exciting event in her life, according to Dorothy, occurred when the basic three-dimensional structure of this protein hormone was solved in her laboratory in 1969. None of her colleagues on the insulin team at that time (Guy and Eleanor Dodson, Tom Blundell and myself) were even born when Dorothy started working on the problem in 1935! Fittingly her last major scientific paper published in 1988 in the *Philosophical Transactions of the Royal Society* was a very detailed account of the insulin structure.

Dorothy was a great scientist. But she was much else. There are not many who have done as much as Dorothy did in her own unobtrusive yet effective way, to promote international understanding. She was deeply rooted in British, particularly Oxford, traditions. Yet she was a great internationalist. Of the hundred and odd scientists who worked in Dorothy's laboratory, only about 25 were British. She took care to see that her research group was cosmopolitan. Her colleagues included 7 Indians (K Venkatesan, B Basak, S Ramaseshan, M A Viswamitra, Kalyani Vijayan, M N Sabesan and myself). She visited India several times and, as in other parts of the world, has had tremendous influence on its scientific community.

Honours, awards and degrees came to her in great abundance. It is hardly possible to list even the more important ones here. The Nobel Prize has already been referred to. She was elected to the Royal Society at a comparatively early age of 37. She was the President of Pugwash for several years. She was the second woman, after Florence Nightingale, to be honoured by the Order of Merit, the highest civilian honour in the United Kingdom.

To those who have known her personally, she was indeed a very special person. As I wrote in her obituary in the 10 August, 1994, issue of *Current Science*, "the houses in which Dorothy and Thomas lived in Oxford at different times and their country home at Ilmington, Warwickshire, radiated warmth and hospitality. They kept an open house and the guests included the powerful and the famous, revolutionaries and refugees and their own innumerable students, colleagues and friends. To her students and colleagues, she was a teacher, mother, friend and guide, rolled into one. My wife Kalyani and I had the privilege and the good fortune to belong to this band. To us, she gave her indulgent affection and care in abundant measure.

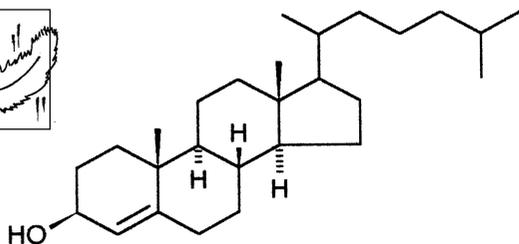
Einstein said of Mahatma Gandhi:

*'Generations to come, it may be, will scarce believe that such a one as this ever in flesh and blood walked upon this earth'.*

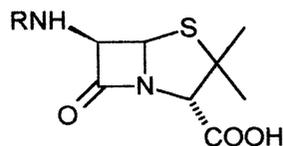
This is true about Dorothy Hodgkin to a large measure".

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Recently, Indian Academy of Sciences has brought out in 3 volumes  
"The Collected Works of Dorothy Crowfoot Hodgkin",  
edited by G G Dodson, J P Glusker, S Ramaseshan & K Venkatesan  
(pp.2230, price: Rs.4000/-, \$120, £ 80)



**Cholesterol**



**Penicillin**