Book Reviews

Works intended for notice in this column should be sent direct to the Book-Review Editor (J. H. Robertson, School of Chemistry, University of Leeds, Leeds LS2 9JT, England). As far as practicable books will be reviewed in a country different from that of publication.

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William Henry Bragg 1862–1942: man and scientist. By G. M. Caroe. Pp. xii + 212. Cambridge Univ. Press, 1978. Price £8.95.

When I saw the title of the book *William Henry Bragg* 1862–1942: *man and scientist*, written by his daughter G. M. Caroe, I tried to make guesses about the possible content. With probably many other Europeans on the continent, I shared the belief that English Nobel laureates can grow up only in either Cambridge or Oxford as precious orchids and flourish really well only in a greenhouse under well controlled conditions. On the whole the book proved me wrong.

It is true that WHB spent three years, between 1882 and 1885, at the Trinity College of Cambridge, but in mathematics, not physics. He applied successfully for the post of professor of mathematics and of physics at the then 12-year-old University of Adelaide – it was then 1886 – and had to learn physics in Australia where he was to spend 23 happy years. There are charming stories in the book on the (literally) warm Adelaide atmosphere, on WHB's marriage to Gwendolyn Todd (born there), daughter of Sir Charles Todd, General Postmaster, Inspector (and builder) of Telegraphs and ... astronomer! No wonder that all W. H. Bragg's children were born in Australia, including Sir W. Lawrence Bragg who graduated from Adelaide University.

Of course WHB became perfectly aware of contemporary physics and popularized the newest findings not by presenting equations or photographs, but by redoing the experiments for the largest possible audience. Röntgen's discovery of X-rays was materialized in WHB's laboratory in spite of protests of some members of the clergy against the 'revolting indecency of the invention'. WHB was not only a marvellous teacher but wrote long papers on how and what to teach, which were initially published in the local press, but later developed into government reports. This crusade for education lasted for his entire long life. Education was his favourite subject in his Presidential Address to the Royal Society. His 'Children's Lectures' at the Royal Institution of London became famous and the BBC was keen to use WHB as a popularizer of science until the end. In fact in the series *Science lifts the veil*, organized by WHB, his dialogue with J. D. Bernal on *The problem of the origin of life* was broadcast on Monday 12 March 1942, three days before WHB's death.

Now what about crystallography? You might be surprised to learn that WHB's interest in research arose in the field of radioactivity when he was already over forty. In fact in 1904 he had the courage to start a correspondence with Rutherford, then in Canada. This reviewer does suspect – without any proof – that there were metaphysical links between WHB's stay in Australia and Rutherford's birth in New Zealand. Anyhow there was an everlasting friendship between these men, testified by letters as long as 30 pages! Whilst Rutherford was interested in the transformed atoms, WHB studied the radiation emitted by radioactive materials. At that time the identity of γ-rays from a radioactive emitter and of X-rays from a Röntgen tube was by no means evident. Bragg, to explain the effects of γ-rays, had invented a theory of a 'neutral pair'; for him γ-rays were neutral (whence the doublet) and corpuscular. There was a long fight between Barkla and WHB, which is reported in the book. Whilst Barkla had shown the light-wave-like nature of (soft) X-rays by a beautiful polarization experiment (Nobel prize, 1917), WHB continued to defend with vigour his corpuscular theory, feeling that the light wave was not the whole story. He wrote to Rutherford with imaginative prescience (letter of 18 January 1912) 'the energy travels from point to point like a corpuscle: the disposition of the lines of travel is governed by wave theory'. (Much later Louis de Broglie and Erwin Schrödinger solved the wave *versus* particle dichotomy.) The Barkla controversy darkened WHB's stay in Leeds until he saw the famous paper by von Laue, Friedrich and Knipping, realized its importance and called it at once to the attention of his son William Lawrence (WL).

At this point the educated reader would guess that the Bragg father WHB, a learned mathematician, had discovered the 'Bragg law' $n\lambda = 2d \sin \theta$ and that the Bragg son, WL, had helped with the experiment. It was just the other way around.

There is no doubt that WL had 'his brain wave', says the book, and discovered the famous diffraction equation. There is no doubt either that WHB's X-ray spectrometer was the first reliable tool for elucidating structures and that WHB recognized at once the potential of X-ray crystallography.

In another circumstance it was WHB who originated the idea of representing the electron density by a Fourier expansion and WL who wrote the paper. WL remarks regretfully 'he (WHB) should have published the idea and I should have published the application of diopside'.

In fact their fruitful collaboration lasted only two years, 1912–1914, and brought the Nobel prize in 1915, shared by father and son, a unique event in the history of science. There is no mention about the ceremony itself, 'wartime had stopped them working together suddenly and completely' and, after the war was over, they decided to divide the huge field; WHB would attack the organic part and WL the inorganic crystallography. 'Together they put British X-ray crystallography in a position of pre-eminence which lasted for two generations' says Caroe's book.

Astbury, Bernal, Kathleen Lonsdale (Mrs Yardley), Muller and Shearer were co-workers of WHB. This does not mean that crystallography in organic chemistry ceased with WHB's death. His son, Sir Lawrence Bragg (knighted in 1941), godfathered organic crystal chemistry with quite concrete results, manifested in other Nobel prizes: Perutz, Kendrew (proteins), Dorothy Hodgkin (B12), Crick, Watson and Wilkins (DNA).

In view of the current impact of crystallography in almost all branches of science, it is amazing to learn that in World War I there was no opportunity to continue research work. Instead WHB was contributing efficiently to the fight against submarines; he invented new acoustic hydrophone detectors and laid the foundations of the ASDIC ('Anti-Submarine Division-ics') techniques, initiated by Langevin in France.

When peacetime returned, WHB was named President of the Royal Institution and brought it back from the decline in which he found it to its present fame: 'RI has produced more fundamental breakthroughs per square foot than any other establishment in the world'.* Eight Nobel laureates have been professors there. With the years, the crystallographer WHB became a 'national figure representing science'. President of the Royal Society from 1935, he had firm views on all aspects of science and education and when World War II came he expressed his views in strong words: 'the authoritarian state tends to decision without enquiry; the democracy tends to enquiry without decision' and Winston Churchill accepted his idea of the SAC (Science Advisory Committee to the government during wartime).

The book fairly reflects the quasi-religious sense of responsibility of WHB proven throughout his whole life. 'He is a great man of science and he is also a very great man.'†

The only criticism addressed by this reviewer to the lucidly written and well documented book on WHB, which G. M. Caroe dedicated to the memory of her brother WLB, is that while the reader is quite happy to see pictures of WHB, of his wife and also of WLB, there are no pictures of the author's other brother, Robert Charles, killed during World War I at Gallipoli (1915) . . . or herself. But this might be the reaction of a French temperament.

E. F. Bertaut

Laboratoire de Cristallographie
CNRS Grenoble
25 avenue des Martyrs
38042 *Grenoble CEDEX*
France

* Sir George Porter, present director.

† Rutherford in a discussion with the anatomist Arthur Keith about who should become President of the Royal Institution.

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Molecular and crystal structure models. By Anne Walton. Pp. 201. Chichester, England: Ellis Horwood, 1978 (distributed by John Wiley). Price: \$19.95, £9·00.

This is a timely book on model construction in chemistry by a highly experienced author. This little book, which reflects the author's enthusiasm for model building, offers considerably more than a consumer guide although this is clearly one of its principal aims. It brings some necessary order into the profusion of new types of models, many of which differ solely in some detail which can be readily overlooked. (As an afterthought, though, one cannot help wondering how the same ideas have been reinvented time and again.) The advantages as well as the limitations of a great variety of currently available models and model parts are thoroughly reviewed. These models range from simple demonstration equipment for schools and inexpensive student sets to expensive high-precision models used at research level.

The book opens with a brief survey and a chapter on space-filling models dealing with Stuart–Briegleb and related models in considerable detail. The remaining chapters (making up over two thirds of the volume) are for the most part devoted to crystal structure models. A chapter on sphere packing is followed by a full account of ball-and-spoke models. The next chapter on skeletal models is also quite comprehensive whereas the subsequent chapter on polyhedral assemblages is rather more limited in scope. Models depicting atomic and molecular orbitals (used in teaching) and dynamic models are also dealt with in subsequent chapters. Somewhat brief chapters on construction devices and two-dimensional aids complete the text part of the book.

Apart from omissions, which are naturally unavoidable in a book like this, there are relatively few shortcomings. Among the more serious omissions are universal orienting drills for accurate crystal structure models and other aids used in crystallographic model design. With respect to sphere packing it should be noted that a small amount of a suitable solvent for joining plastic spheres (such as ethylene dichloride in the case of acrylic resins) is in most cases preferable to the use of glue or adhesives like 'Blu-Tack'. This little recognized fact would merit mention as it gives by far the best results in the least time and, if desirable, models made on this basis can also be readily disassembled without serious damage to the spheres. Not much space is devoted to models assembled from solid polyhedra and more representative examples than those presented would no doubt include shear or Wadsley-type structures and intermetallics (*e.g.* assemblages of icosahedra).

This well produced book also contains numerous references and an extensive list giving names and addresses of suppliers of models and model parts. Crystallographers and chemists pursuing various activities in different fields will find this book a great asset.

W. M. Meier

Institute of Crystallography
ETH Zürich
Switzerland

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Molecular structure and bonding: the qualitative molecular orbital approach. By B. M. Gimarc. Pp. x + 224. New York: Academic Press, 1979. Price: US \$18.00.

This book is a very useful survey of the applications of the qualitative molecular orbital approach to relatively simple molecules. In the first chapter there is a brief summary of MO 'rules'; these are well illustrated by reference to the bonding and antibonding σ orbitals of H_2. Chapter 2 gives a short account of H_3 and H_4 activated complexes and the role they may play in gas-phase reactions of the type $H + H_2 \rightarrow H_2 + H$. This chapter is slightly out of place at this point perhaps, since the book is concerned primarily with molecular shape.

The bulk of the book (Chapters 3–7) deals with specific classes of compounds, namely hydrides (AH_2, AH_3 and AH_4), non-transition-metal complexes (AB_4, AB_5 and AB_6), molecules of the HAB type that are either linear or bent about atom A, symmetrical molecules containing A–A