Book Section:
Jenkins, EW and Brock, WH (2014) Frederick W. Westaway and science education: an endless quest. In: Matthews, MR, (ed.) International Handbook of Research in History, Philosophy and Science Teaching. Springer Netherlands, 2359 - 2382. ISBN: 978-94-007-7653-1.

https://doi.org/10.1007/978-94-007-7654-8

Frederick W. Westaway and Science Education: An Endless Quest

WILLIAM H. BROCK and EDGAR W. JENKINS

Department of History, University of Leicester, Leicester, UK.
william.brock@btinternet.com

School of Education, University of Leeds, Leeds, UK.
e.w.jenkins@education.leeds.ac.uk

Abstract: The chapter discusses and appraises the contributions to science education practice and theory made by the Englishman Frederick William Westaway (1864-1946). After several teaching appointments as a science teacher and headmaster, Westaway was one of His Majesty's Inspectors of Schools (Science) from 1895 until his retirement in 1929. An influential science educator, Westaway wrote several books on the history and philosophy of science teaching. His prolific writings raised questions about the techniques and functions of science education that still challenge us today.

William H. Brock is Emeritus Professor of History of Science at the University of Leicester. He read chemistry at University College London before turning to the history of science which he taught at Leicester between 1960 and his retirement in 1998. His publications include *The Atomic Debates* (1967); *H. E. Armstrong and the Teaching of Science* (1973; paperback 2012); (with A. J. Meadows) *The Lamp of Learning. Taylor & Francis and the Development of Science Publishing* (1984); *Justus von Liebig und August Wilhelm Hofmann in ihren Briefen 1841-1973)* (1984); *From Protyle to Proton. William Prout and the Nature of Matter 1785-1985* (1985); *The Fontana History of Chemistry* (1992); *Science for All. Studies in the History of Victorian Science and Education* (1996); *Justus von Liebig. Gatekeeper of Science* (1997); *William Crookes and the Commercialization of Science* (2008); and *The Case of the Poisonous Socks. Tales from Chemistry* (2011).

Edgar W. Jenkins is Emeritus Professor of Science Education Policy at the University of Leeds where he was Head of the School of Education (1980-84 and 1991-95) and Director of the Centre for Studies in Science and Mathematics Education (1997-2000). From 1984 to 1997 he edited the journal *Studies in Science Education.* His principal books include *From Armstrong to Nuffield* (1979); *Technological Revolution?* (1986); *Inarticulate Science?* (1993); *Investigations by Order* (1996); *From Steps to Stages* (1998); *Learning from Others* (2000); and *Science Education, Policy, Professionalism and Change* (2001). He is currently co-editing a volume to mark the fiftieth anniversary of the founding of the Association for Science Education.

Introduction

> I fear that during my professional career, I advocated the claims of science teaching much too strongly, and I am now quite sure that the time often devoted ... to laboratory practice, and to the purely mathematical side of science, more especially chemistry and physics, was far too great (Westaway 1942a, p.v).[1]

So wrote F. W.Westaway, teacher, headmaster, His Majesty's Inspector (HMI) and eloquent advocate of science education, in the preface of his last book, published in 1942, with the intriguing title *Science in the Dock: Guilty or Not Guilty?* Who was Westaway, what influence did he have upon school science teaching and what had prompted him to raise and address this question?

Frederick William Westaway was born on 29 July 1864 at Cheltenham, Gloucestershire, the first of seven children of William and Caroline Westaway, three of whom died in infancy. It seems clear that the family circumstances were extremely modest. His father was a travelling blacksmith and his mother (to judge from the mark she made on Frederick's birth certificate) was unable to write. Westaway later recalled receiving his first chemistry lesson at the age of ten in 1874. It was given by the Gloucester Public Analyst.[2]

> There was no laboratory available, but there was a well-fitted lecture room, and in later lessons a few gases were prepared. But the first lesson, which extended over an hour, was frankly a lecture on the atomic theory. No experiments whatever were performed, but the formulae and equations which covered the blackboard impressed at least one small boy (Westaway 1937a, p. 490; Westaway 1929, p. 18).

By 1881 the family had moved to Ruardean in Gloucestershire's Forest of Dean, where Frederick's father was landlord of a public house.[3] By then Frederick was a pupil-teacher at the village school from where he enrolled at St John's Training College in Battersea and began his formal teaching career in London in 1886 (Westaway 1929, p. 19). Concerning this experience, he provides a personal anecdote of some historical interest. He was allocated two hours for chemistry and two hours for mechanics.[4] He had no laboratory or demonstration bench, and only a balance that he had made himself. The Bunsen burner had to be fed from the gas pendant above the pupils' heads. Using Ira Remsen's revolutionary American textbook, he proceeded to teach (Remsen 1886).

---

[1] The preface was dated September 1941. He had expressed similar doubts following WW1 in a new preface to the 2nd ed. of (Westaway 1919, p. xii).

[2] Probably John Horsley, a founder member of the Society of Public Analysts in July 1874. He specialised in the analysis of milk and dairy products. Westaway joined the Chemical Society in June 1892.

[3] Later, between 1897 and 1901, William Westaway was landlord of the George Inn, Market Street, Gloucester.

[4] This may imply that the bulk of his timetable was spent in teaching more general subjects such as English and Latin.

> In the middle of a lesson on equivalents, two visitors whose names I did not catch were shown in, and they sat down and listened. When I had finished they came up and showed what I thought to be a surprising appreciation of what I had been doing, and eventually one of them said: "Do you happen to know Roscoe's book on chemistry?" "Yes," I replied, "and a thoroughly unsatisfactory book it is. The writer makes unjustifiable assumptions about chemical theory before he had established necessary facts. It is the kind of thing that no teacher ought to do." At this stage the second visitor interposed and said, "I think, perhaps, you are asking for trouble. Let me introduce you to Professor [afterwards Sir Henry] Roscoe." However, in spite of the criticized book, I learnt more about the teaching of chemistry in the next quarter of an hour than I might have learnt in the next ten years. In particular, I learnt a much needed lesson – that there is more than one avenue of approach to the teaching of science, and that it is sheer folly to assume that science must be taught according to one pedagogue's prescription (Westaway 1929, pp. 19-20).[5]

He lodged in Lambeth, joined the rifle volunteer movement, passed his London Matriculation examination in 1887 and graduated BA from the University of London in 1890. It was a career path followed by a significant number of the more able pupil-teachers in the last two decades of the nineteenth century and many of them found employment in the growing number of post-elementary schools, known as Higher Grade Schools, established by the School Boards in larger towns and cities (Vlaeminke 2000). From hints in his later books it appears that Westaway continued his self-improvement by attending evening classes and the summer schools for science teachers that were run by Frankland (chemistry), Guthrie (physics), and Huxley (biology) at South Kensington under the auspices of the Department of Science and Art (DSA).

In May 1892, when teaching at a school at Stockwell in south-west London, Westaway married Mary Jane Collar, the daughter of a pianoforte maker and herself a teacher.[6] Her two brothers, George and Henry, were also teachers, and both eventually became headmasters of London schools. The newly-married couple immediately moved to Dalton in Furness[7] where he had been appointed headmaster of the Higher Grade School, the local Board School having been established in 1878. Westaway thereby began his formal connection with South Kensington since the school would have been recognized as an organized science school for the purposes of DSA grants. The chief local industries were iron

[5] For Roscoe's textbook, ironically published in the same Macmillan's Primer Series as Remsen's book, see Roscoe (1866; new ed. 1886). The other visitor was the chemist and educationist John Hall Gladstone, as revealed in his Westaway (1936, p. 313).

[6] The ceremony was conducted at St Matthew's Church, West Kensington (Mary Collar's parish) by Edwin Hobson, the Principal and Chaplain of St Katherine's College, Tottenham, where Mary had trained to be a teacher. The college, which had been set up originally by the Society for the Promotion of Christian Knowledge in 1878, is now part of Middlesex University. Hobson had been Vice-Principal of St John's College, Battersea from 1874 to 1877 before Westaway was a student there.

[7] Dalton in Furness lies on the southern edge of the Lake District in Cumbria (until 1974 in Lancashire). It is famed for its castle and for Furness Abbey. The school, which opened in 1877, survives as an infant school.

ore mining and quarrying and the School Board, like that in other northern towns in England, recognized the need for a better-informed and technically-competent work force. It is alleged that Westaway grew a beard to hide his relative youth. Their only child, Katherine Mary, was born in the School House in 1893 and her father was to exert an important influence upon her upbringing and career. She eventually became a distinguished classical scholar and an outstanding headmistress of Bedford High School from 1924 until her retirement in 1949.

Clearly ambitious, Westaway moved from Dalton in Furness to Bristol in 1894 to become headmaster of the newly-built St George's Secondary and Technical School which contained "a thoroughly well-appointed Chemistry Laboratory, a large Science Lecture Room, a Workshop, a Dining Room and accommodation of every kind conducive to the well-being of the scholars".[8] Its finances were entirely contingent upon the school's ability to earn grants by Westaway's pupils gaining high passes in the examinations run by the DSA. A local newspaper reported:

> The [School] Board considered a number of applications for the appointment of the St George Higher Grade School. Mr *F. W. Westaway*, at present holding an appointment at the higher grade schools, Dalton-in-Furness, was appointed unanimously. In his application his University distinction was stated to be (a) B.A. London; Inter B.Sc., final examination, deferred until 1895; (c) Member of Convocation of the University of London. The list of qualifications, particulars of past experience, copies of testimonials, and prospectus of present school were considered by the Board highly satisfactory (Anon 11 October 1894).[9]

Vlaeminke's study of the school's log books reveal that Westaway taught all the science and mathematics himself and triumphantly gained passes for his pupils in the DSA examinations that were the best in the Bristol area. No doubt this was noticed by the Department of Science and Art for, within a year, Westaway was offered a sub-inspectorship in the Department. On the face of it, accepting this offer was an odd decision, for although the character of the DSA was changing during the 1890s, the task of its inspectors largely remained one of ensuring that its militaristic rules and regulations for the conduct of examinations and payment by results were strictly adhered to (Butterworth 1982, pp. 27-44). The appointment to the Inspectorate probably involved a drop in salary, though this would have been compensated by the prospect of a very good pension.[10]

Westaway's movements between 1895 and the passing of the (Secondary) Education Act of 1902 are unclear. He was undoubtedly not content to sit on his laurels, but continued his studies at the Royal College of Science at South Kensington in London where he was a Prizeman in mathematics and physics. By 1901, however, his post in the civil service had

[8] This was Bristol's first state secondary school created by local entrepreneurs in 1894. Its premises, which are currently used as a Sikh temple, were opened in 1894. Following various changes of name, it moved to new premises in 2005 as St George City Academy.

[9] The school development is analysed in Vlaeminke (2000).

[10] On the recruitment of inspectors, see Gosden (1966, p. 25).

become that of one of Her Majesty's Inspectors of Education with responsibilities for secondary education in the area of Essex.[11] It was here that their daughter Katherine, together with two friends, began her first lessons with a governess (Kitchener 1981; Hunt 2004), and Westaway cultivated a friendship with Lord Rayleigh, who kept a private laboratory at his home at Terling Place, near Chelmsford. Within a year, however, Westaway took over responsibilities for inspection in the Bedfordshire area. The family moved to Pemberley Crescent in Bedford, close to Bedford School.[12] He remained an HMI until his retirement in 1929, when he moved to the village of Aspley Heath, adjacent to Woburn Sands in Bedfordshire. He was intensely proud of his profession and of the intellectual attainments of the colleagues with whom he mixed. He sometimes indulges in name-dropping: for example, when mentioning the Irish physicist Thomas Preston (1860-1900) he refers to him as "for some time an esteemed colleague of the present writer's" (Westaway 1937a, p. 364).[13] Preston did, indeed, combine his chair of natural philosophy at Trinity College Dublin with a government post as an inspector of science and art for Irish schools, but it seems unlikely that Preston ever came into direct contact with Westaway.

The Philosophy of Science

During his long life, Westaway authored some sixteen books, many of which ran into several editions, although not all were concerned with science education. His first book, *Scientific Method: Its Philosophy and Practice* was published in 1912. The date is significant since it coincides with the growing scholarly interest in the history and philosophy of science, evident, for example, in the first publication of the journal *ISIS* by George Sarton in Belgium in 1913. Westaway dedicated his book to the physicist Lord Rayleigh (1842-1919) "to whose work and whose teaching the author is deeply indebted" (Westaway 1912, p. 439).[14] The first edition of *Scientific Method* was in four parts. The first examined philosophical issues and offered a commentary upon the ideas of a range of philosophers including Plato, Aristotle, Francis Bacon, Descartes, Locke and Hume. This was followed by attention to Victorian "methodologists" such as Whewell, Mill and Herschel, and a discussion of what might be meant by such terms as induction, deduction, scientific law and hypothesis. The third part of the book turned to the history of science and was devoted to "Famous men of science and their methods." In this section scientists such as Harvey, Newton, Black, Priestley, Faraday, Wallace, Darwin, Clerk Maxwell, Ostwald, and J. J. Thomson were largely allowed to speak

[11] The 1870 Education Act abolished the denominational character of the inspectorate and reorganized HMIs territorially to reduce their travel. This system continued after the reorganization of secondary education following the Education Act of 1902. See Gosden (1966, pp. 27 and 111). The Westaway family moved from Bristol to 87 Camden Villa, Fuller's Road, Woodford, Essex.

[12] According to 1901 and 1911 Census data, the Westaway's employed one servant girl.

[13] For Preston, see Weaire & O'Connor (1987).

[14] Also Westaway (1919, 2nd ed., p. 426); Westaway (1924, 3rd ed.); Westaway (1931, 4th ed."revised and enlarged, present-day methods critically considered"; Westaway (1937, 5th ed.). Most of these editions are available online. According to the *World Catalogue,* Chinese translations were made in 1935 and 1969.

for themselves through the form of generous quotations. The book ended with a practical section for science teachers entitled "Scientific method in the classroom" in which Westaway offered examples, drawn from botany, chemistry and physics, of what today would be called teaching by investigation.

Nature thought the book "a model of clearness" and ideal for both science teachers and the general reader. Its sole fault, if any, was the use of excessive quotations, though the reviewer put this down to the fact that Westaway was exceptionally well-read (JAH 1912).[15] The reviewer missed the fact that Westaway was concerned with more than promoting a greater understanding of the history and philosophy of science. As he made clear in his preface, he was anxious to bring humanists and realists (i.e. scientists) closer together and to reconcile the ideals which they represented. The need for such reconciliation was to become particularly urgent during the First World War when something of a battle of the books broke out between the scientific community and those representing the humanities, over the contribution that science could make to liberal education.[16] One outcome was the claim, already promoted in Westaway's book, that the history and philosophy of science offered a means of humanising a narrow, specialised and otherwise dehumanising scientific education.

The second edition was published immediately after the war had concluded in 1919. A new Preface blamed Britain's industrial problems on its "continued use of haphazard methods". It would be the undoing of the nation if this were continued.

> On the one side we have Germany, clear-headed and thorough; America, original and enterprising; Japan, self-denying and observant; France, pain-staking and clever: all four nations believers in *work*. On the other side we have Britain, insular and unsystematic, looking upon work as a nuisance because interfering with pleasures (Westaway 1919, p. xii).

An appendix, "Retrospect and Reflections 1912-1918", continued this theme, going so far as to assert that Britain had not won the war because of science or education, but because of the reawakening of the nation's dormant national qualities. For their part, the Germans had lost because of their servility to authority and inability to think for themselves. Westaway's solution, overtly political, involved the redistribution of wealth and the wholesale application of scientific method. The "Retrospect" surveyed the functions and influence of science and scientific method on national life. This time the *Nature* reviewer, noting how the Thomson Report on Natural Science Teaching had urged science teachers to become acquainted with the history and philosophy of science, recommended the volume enthusiastically as enlightening and helpful. "Clearly presented" with "apt and instructive" examples, "any

[15] The reviewer, J.A.H., has not been identified.

[16] There is a large literature on the theme of humanising the science curriculum. See Jenkins (1979, 54-55; Brock (1996, chap. 19); Mayer (1997); Donnelly (2002 and 2004); and Donnelly & Ryder (2011.

science teacher, whether at university of school, who reads the book, cannot fail to derive profit and interest from it" (Anon 1920).[17]

By the time the 4th "revised and enlarged" edition had appeared in 1931 (a third edition in 1924 merely expanded the chapter on the theory of relativity), Westaway was a lot more sanguine about Britain's future. Post-war society, he suggested, had become less rule-of-thumb, more rational and systematic. He expressed delight in the progress of mass-production with its implicit inclusion of specialisation, expertise and machinery in the operations of industry. Even so, there was still need for "the development of the scientific study and impartial examination of all the complex factors, economic, social, political, and racial, involved in controversial problems which are the sources of international friction" (Westaway 1931b, p. xii). Westaway clearly believed that the revised version of his book would help teachers produce a workforce geared to a mass-production society. To that end he added a fourth section on present day methods in contemporary science – including nuclear physics and quantum mechanics; and a fifth section on how scientific method could be inculcated in the classroom and lecture theatre.

In the final edition, published well into his retirement in 1937 and which received a Chinese translation, two further sections were added; one giving excerpts from the writings of "distinguished workers of the day" whom he obviously admired;[18] the other offering further examples of the application of scientific methods for advanced students (Westaway 1937a). This extraordinary section included the analysis of historical facts using the example of the causes of the decline and fall of the Roman Empire, as well as an open-ended discussion of whether there was a criterion of excellence in aesthetics – a subject that he was to expand in another book.

Science Teaching

Westaway had included a short section on scientific method applied in the classroom in *Scientific Method* in 1912 and the subsequent editions, but it was not until his retirement that he expanded it as a separate book in 1929. Dedicated to his friend and superior in the inspectorate, Francis B Stead, *Science Teaching: What it Was, What it is, What it might be*, was a volume that sought to assert the liberal values of a scientific education, providing always that science was well taught. From this perspective, *Science Teaching* follows the tradition of earlier works by Mach (1893) and Dewey (1900, 1902, 1916)[19], a tradition that was to be sustained in subsequent years by the writings of Schwab (1982), Conant (1947,

[17] The unsigned review was probably by the editor, Richard Gregory whose much reprinted book *Discovery* (Gregory 1916) was admired by Westaway.

[18] These included Bertrand Russell, Hyman Levy, Herbert Dingle, Walther de Sitter, Max Born, James Jeans, Max Planck and Julian Huxley.

[19] Mach (1893) first appeared in German in 1883. It remained in print throughout Westaway's career. Westaway frequently cited and recommended Mach in his writings, but not Dewey.

1957), Holton (1952) and many others. It also owes something, and not simply as far as its title is concerned, to Edmond Holmes' seminal volume, published in 1911, *What is and what might be* (Holmes 1911),[20] and to Stead's work as Secretary (and compiler) of J. J. Thomson's influential wartime report on *Natural Science in Education* (Stead 1916).[21] Drawing upon his experience as an HMI - he speaks of witnessing "1000 lessons a year for over 30 years" (Westaway 1929, p. xii) - Westaway argues in *Science Teaching* for a broadening of school science education to include, for example, some biology, astronomy and palaeontology, and sets out the case for making science a compulsory part of the school curriculum. But the book is more than this. It is also a primer of practice and a challenge to those whose educational "claims on behalf of science ... are sometimes tinged with a good deal of arrogance and intolerance, and whose advocacy is thus better calculated to make enemies than enlist friends" (Westaway 1942b, back cover).[22] Once again, Westaway is seeking to promote a middle way in education, one in which there is "no natural antagonism between science on the one hand and humanism on the other" and one in which the history and philosophy of science play a key part. Such an ethos was shared with another significant HMI, the historian and positivist, Francis Sydney Marvin (1863-1943).[23]

Westaway's definition of a successful science teacher (ignoring his gender bias) may be demanding and an ideal, but it still suggests what is required in the profession.

> He knows his own special subject through and through, he is widely read in other branches of science, he knows how to teach, he knows how to teach science, he is able to express himself lucidly, he is skilful in manipulation, he is resourceful both at the demonstration table and in the laboratory, he is a logician to his finger-tips, he is something of a philosopher, and he is so far an historian that he can sit down with a crowd of boys and talk to them about personal equations, the lives, and the work of such geniuses as Galileo, Newton, Faraday, and Darwin.

---

[20] Holmes (1850-1936), who became Chief Inspector of Elementary Schools in 1905, resigned in 1911 over criticisms of HMIs who had formerly been elementary school teachers. See Gordon (1978) and Shute (1998).

[21] Chaired by the physicist J. J. Thomson, the report was actually compiled by the Committee's secretary, Francis Bernard Stead (1873-1955), H. M. Chief Inspector of Secondary Schools and a close friend of Westaway's. Stead, a Cambridge NST graduate, had worked at Plymouth's Marine Biology Association and Clifton College before joining the inspectorate in 1908. The science report was one of four (science, classics, English, modern languages) eventually prepared by the Board of Education. See *Nature*, 175 (1955), 148 and Jenkins (1973), 76-87.

[22] A 4-page publisher's pamphlet of "press appreciations" (c. 1930) in the possession of WHB carries the quotation from *Journal of Education*: "Get the book and read it; it is the best thing yet."

[23] Marvin, August Comte's principal spokesman for positivism in Britain, was an HMI from 1890-1924. He played a major role in improving the teaching of history in schools. See Mayer (2004). Marvin's papers are in the Bodleian Library at Oxford. Curiously, despite his influence on the teaching of History, Marvin has not been included in the *OxfordDNB,* whereas his wife, Edith Mary Marvin (née Deverell) (1872-1958), a fellow HMI, has. The same has happened with Westaway and his daughter, Katherine.

> More than all of this, he is an enthusiast, full of faith in his own particular work (Westaway 1929, p. 3).

Little wonder that he admitted that he thought a teacher was not really fully equipped to teach effectively until he was in his thirties.

Science Teaching, with its extensive syllabus suggestions and advice on laboratory accommodation and equipment, as well as its helpful discussion of classroom practice, was well received by the reviewers ("a book of outstanding usefulness," "remarkable, critical and stimulating") and it became a staple of initial training courses for graduate science teachers.[24] His suggestions that the periodic law and wave motion (not energy) should be the pole stars of the school chemistry and physics syllabuses were undoubtedly influential, as was his emphatic insistence on the introduction of biology into the secondary curriculum. Like the rest of Westaway's books, it is characterised by a directness and lucidity of style and by the author's capacity to engage with a wide range of disciplines and to draw his arguments and examples accordingly. The book was reprinted in its year of publication and again in 1934, 1942 and posthumously in 1947. Even today, much of Westaway's advice to those learning to teach science has the ring of experience. Some of his questions for young science teachers or pupils leaving school remain both challenging and of interest. For example:

> Do you consider that the estimates of stellar distances and electronic magnitudes correspond approximately with actual fact? What part of the available evidence is experimental and what part is inferential? Is the latter evidence convincing?
>
> How would you estimate the number of flaps made in a second by the wings of a flying bluebottle?
>
> Some years ago a science teacher, working single handed, was trying to extinguish the burning woodwork (pitch-pine) of a fume cupboard ... when he was called to a boy who had become unconscious through the inhalation of chlorine. How would you have coped with the double emergency?

Further insights into Westaway's views on science teaching are revealed by an appreciation he wrote for *The School Science Review* of Henry Edward Armstrong, following the death of the latter in July 1937. Westaway had come into contact with both Armstrong and Thomas Henry Huxley as early as the 1880s while studying at the Royal College of Science, and he thus constitutes a direct link with some of the leading figures in late nineteenth-century education.[25] It is clear from Westaway's *Science Teaching* that it was

---

[24] For an appreciative review by the science teacher and historian of science, Eric Holmyard, see Holmyard (1929). Note also the appreciation of the Latymer School science teacher George Fowles (1937, pp. 13, 501, 513, 527).

[25] "Faith in my own old teachers –Thomas Henry Huxley, John Tyndall, John Hall Gladstone, and (the 3rd) Lord Rayleigh – is as strong as ever, all of whom, in season and out of season, insisted on laboratory and field work first and always, on *facts* and ever more facts (Westaway 1936, pp. ix, 359,

Huxley who exercised the greatest influence upon his ideas, and he was intensely proud to have been personally examined by Huxley in biology. For Westaway, the purpose of a scientific education was the making of Huxley's "cold logic engine," in which "the desire for discrimating evidence" would become a "predominating factor" in thinking.[26] Nonetheless, he found Armstrong's heurism, with its commitment to teaching "scientific method," an approach to science teaching in which "practice simply would not yield to precept (Westaway 1929, pp. 20-27).[27] The imparting of information was a vital function of teaching and this was the cardinal fault of heurism in its pure form. Moreover, heurism was "not new" but, in essence, a strategy "used by intelligent teachers all down the ages." For Westaway, therefore, Armstrong's great contribution to science education was not heurism itself but the fact that he compelled others to keep their "defensive weapons keen and bright" and be "ever ready to defend alternative methods." Armstrong, he thought, had given hostage to fortune by calling his system the heuristic method instead of, say, "the search" or "discovery method" (Westaway 1929, p. 20). However, he admired Armstrong as a teacher and had high praise for his account of chemistry in the 13th edition of *Encyclopaedia Britannica* (1926) for the way it cast light on the inner nature of chemistry.

Mathematics Teaching

It would seem that Westaway's first love as a practising teacher was mathematics. In several places he lamented the loss of Euclid due to the efforts of the former Association for the Improvement of Geometrical Teaching. Nevertheless, he became a keen member of its successor, the Mathematical Association and a regular reader of its *Mathematical Gazette* (Price 1994). He published two geometry textbooks for private and state secondary schools and technical colleges which differed only in that the latter contained additional material for middle form boys up to the age of 14 (Westaway 1928a and 1928b).[28] The texts were addressed directly to both teachers and pupils, the latter being expected to read a chapter before it was discussed with them. In line with contemporary feelings about geometry teaching, Westaway avoided deductive proofs from first principles. Long chains of reasoning were also avoided, intuitive reasoning was frequently used, while practical examples from

---

and 745). He also recalled the wonderful lecture demonstrations of Charles Vernon Boys in Westaway (1936, 692).

[26] Westaway was quoting from Huxley (1905, 76-110).

[27] See Brock (1973; reprint 2012).

[28] Westaway (1928a) covered the geometry syllabus from age 8 to 13 when the Common Entrance Examination for admission to a Public School was taken. (Westaway 1928b) must have been published a few months after the other geometry textbook. Both texts mentioned Westaway's admiration for the geometry lessons of his "friends" Frederick William Sanderson (1857-1922), headmaster of Oundle School, and Edward Mann Langley (1851-1933), a teacher at Bedford Modern School and founder-editor of *The Mathematical Gazette.*

surveying and carpentry demonstrated the practical significance of geometrical reasoning.[29] Typically, Westaway supplied a list of Latin words and the mathematical expressions derived from them in the expectation that teachers and pupils would correlate their mathematical and classical learning.

In 1931, following the tremendous success of his book on *Science Teaching*, Westaway's publishers suggested that a similar book addressed to mathematics teachers was a desideratum. The result was another remarkable handbook offering young inexperienced teachers advice and useful hints on putting mathematics across in the classroom (Westaway 1931a). Although entitled *elementary* mathematics education, the 28 chapters in fact ranged from simple addition and subtraction to teaching the calculus, and thus covered the whole of school mathematics from the level of infants to university entrants. As one reviewer remarked (Anon 1931), Westaway's standard for what a pupil should know was very high, citing as evidence the casual remark that a 4th-form boy was apt to forget the factors of $a^4 + 2a^2b^2 + b^4$ [*i.e.* $(a^2 + b^2)^2$]. (Was this a reflection of a decline in expectations, or merely due to the fact that Westaway's treatment smacked of the nineteenth, rather than, the twentieth century, as the same reviewer suspected?) There were also sections on mathematics in astronomy and biology (a field Westaway foresaw as developing in significance), time and the calendar (which he thought was the job of mathematics staff to teach), as well as on non-Euclidean geometry and the history and philosophy of mathematics. Westaway specifically addressed *new* teachers rather than experienced accomplished instructors, thus ensuring, like his treatise on science teaching, the book's heavy use in British teacher training colleges and ready sale among tyros. Its valuable suggestions for organising the maths curriculum throughout a school must also have recommended it to senior staff as well. Curiously, and surprisingly, the Mathematical Association ignored the book, though it was reviewed favourably and at length by the Harvard geometer Ralph Beatley who recognised that many of the problems delineated by Westaway were common in America as well (Beatley 1933).

Language Teaching

Westaway had clearly taught Latin at an early stage of his career and had a deep respect for classical education.[30] Although we think of him primarily as a science educator, he also made an informative contribution to classical teaching in the form of his second book *Quantity and Accent in the Pronunciation of Latin*, which he published in 1914 (Westaway 1914).[31] Westaway was adamant that it was not a textbook and that it was not aimed at school teachers. His targets were private students of Latin and those whose knowledge of the rules of

[29] This practical aspect was praised by Dobbs (1929).

[30] His love of the classics was inherited by his daughter Kathleen who lectured in classics at Royal Holloway College (1920-24) before becoming headmistress of her old school. See Westaway K. M. (1917, 1922, 1924).

[31] This was the only one of his books not published by Blackie. Note also Westaway (1933a).

pronunciation was rusty. The context was a contemporary debate between an older generation of classicists who wanted to continue using an Anglicised "easy-going" form of pronunciation and the younger generation of classicists whose knowledge was informed by research in philology and phonetics. "Mr Westaway's heart is in the right place," that of a reformer, concluded Edward Adolf Sonnenschein, the professor of Greek and Latin at the University of Birmingham, and "he writes with conviction" (Sonnenschein 1914, pp. 213-214). That the text did well in modernising the teaching of Latin is suggested by the fact that it remained in print in the 1920s and that an enlarged edition appeared in 1930. The text had been read with approval by both John Percival Postgate (1853-1926), professor of Latin at the University of Liverpool and the founder (with Sonnenschein) of the Classical Association in 1903; and by Westaway's superior in the Education Department, John William Mackail (1859-1945), an eminent Virgil scholar. Westaway became a life member of both the Classical Association and the Modern Languages Association in 1903. Like the British Association for the Advancement of Science, which he also joined in 1903, Westaway must have seen these organizations as a valuable way for an HMI to keep up to date.

In *Scientific Method*, Westaway's concern for logical thinking took him into one of his many other interests, language and clarity of thought and expression, and hence into the use of words to express causality. It seems he regarded English grammar as offering important philosophical insights for the science teacher. In his inspections of schools and technical colleges, not unexpectedly, Westaway came across poorly-expressed written reports of experiments. More surprisingly, he came across ungrammatical and illogical prose in reports by scientists in periodicals such as *Nature*, which he evidently read each week. Another periodical he read regularly, but never contributed to, was the *Mathematical Gazette* which had been founded by the Mathematical Association in 1894. Westaway joined the Association in 1914. He was impressed and inspired by his chief in the Inspectorate, W. C. Fletcher, who published an article in the *Gazette* in March 1924 stressing that mathematicians should write good prose between their symbols (Fletcher 1924).[32] Fletcher's essay, together with the earlier appearance of George Sampson's influential report on the teaching of English in 1921 (Sampson 1921),[33] probably inspired Westaway to publish *The Writing of Clear English* in 1926. While significantly sub-titled *A Book for Students of Science and Technology* its clear exposition of the principles of English grammar and advice on sentence and paragraph construction and logical writing style would have made it useful to a generally-educated readership that found itself in need of English improvement (Westaway

[32] Fletcher (1865-1959) is best known for "Fletcher's trolley", an improvement on Atwood's machine for teaching mechanics. After graduating from Cambridge as 2nd wrangler in 1887, Fletcher taught at Bedford School (1887-96) before becoming headmaster of the Liverpool Institute (1896-1904). He was appointed Chief Inspector of Secondary Schools in 1904. He retired in 1926 only to teach at the girls' school where his daughter was headmistress. See obituary (Anon 1959).

[33] Sampson (1873-1950) followed a similar path to Westaway – pupil teacher, London Matric, teacher, headmaster, District Inspector for London County Council.

1926).[34] In retirement, Westaway revised and enlarged the book as *The Teaching of English Grammar Function versus Form* (Westaway 1933b).[35]

In 1932 Westaway persuaded his publishers to launch a series of books offering instruction and advice to teachers under the umbrella title of The Teachers' Library. Although Westaway did not write a book specifically for the series, he recruited the help of other HMIs and acted as the advisory editor for the series. The Library was planned "for the guidance of teachers whose daily work is concerned with children of eight and upwards" (Finch & Kimmins 1932, Preface).[36]

History of Science.

As we have seen from both his *Scientific Method* and *Science Teaching*, Westaway believed that teachers should tell stories about great mathematicians and scientists. He also thought sixth form students should be encouraged and challenged to read, among other original works, Newton's *Opticks*, Faraday's *Researches on Electricity*, and Darwin's *Earthworms* (Westaway 1929, p. 383). The inter-war years were a particularly productive time for Westaway. In addition to books on the teaching of mathematics, geometry and English (for science specialists), he wrote a large volume of over 1000 pages entitled *The Endless Quest: Three Thousand Years of Science* (Westaway 1934).[37] This huge, richly-illustrated, volume is something of a *tour de force* and, even today, when specialised degree courses are available in history of science, as a history of science published in 1934, it makes appealing and, in places, challenging reading. Westaway's originality is shown in his deliberate attempt to write a critical appraisal of scientific development and to show its weaknesses as well as its strengths. He acknowledged the influence of his departmental colleague, the positivist historian Sydney Marvin, who was a friend of George Sarton and who was keen to see history of science taught by history teachers. An anonymous reviewer in *The School Science Review* described the book as "a veritable encyclopaedia of science," adding that only "a writer of extreme scientific versatility" could attempt to write it (Anon 1935; Dingle 1935).

Internal inspection shows that Westaway's sources included the British Library and books borrowed from H. K. Lewis, the scientific and medical library in Gower Street, the *Encyclopaedia Britannica* and *Nature*, as well as his own well-stocked library. The ready availability of Boyle's *Sceptical Chymist* and Harvey's *On the Motion of the Heart* in the Everyman Library enabled him to give detailed accounts of their experiments and reasoning.

---

[34] One teacher thought he had "done his work well". See Anon (1927).

[35] For context, see Hudson & Walmsley (2005).

[36] Unfortunately, because in most scholarly libraries books are catalogued by authorship, it is not possible to identify all the books in the series except serendipitously.

[37] 2nd ed. 1935 with minor corrections only; reprint 1936. Chinese translations 1937 and 1966, Czech in 1937. The book of 1080 pp was dedicated to his daughter.

Westaway's historiography was surprisingly sophisticated for a period when accounts of science were usually triumphalist and Whiggish. When discussing Babylonian mathematics and astronomy, for example, he scorns any reader who condemns the Babylonians for not formulating hypotheses to explain their observations of heavenly events. How would the reader determine the length of a solar year? No reference books allowed, the problem had to be solved by thought alone. By setting the reader such rhetorical questions, the Babylonians' ability to determine that the solar years was $365^{1}/_{4}$ days long without using instruments became all that more impressive. The same device is used at the end of the book when Westaway sets the reader twenty thoughtful and probing questions. Two contrasting questions, one based on bookwork, the other more diffuse and philosophical, will suffice to illustrate his purpose.

> What is an explosion? How long does it take a high explosive like T.N.T. to be converted into a gas? Explain why such a gas is so remarkably destructive, why its downward action is so violent, and why it does not expend its force upwards into the atmosphere.
>
> On being established in 1899, the Board of Education adopted the traditional views of the Science and Art Department of the Privy Council, which the Board succeeded, that physics and chemistry were the most suitable subjects of science for teaching in schools, views which still generally survive. To what extent do you consider this to be the cause of (1) the ignorance of, and (2) the lack of interest in, science by the average educated Englishman? If it is the cause, what is the remedy? If not the cause, what *is* the cause? (Westaway 1936, pp. 1037-1040).

Broadening Science Education

When looking back on his long career as an educator Westaway was pleased by the way changes in teaching and educational practice had remoulded the minds of the younger generation. He was particularly struck by the way that the creation of sixth forms in secondary schools had led young people to become critical, well-informed and opinionated. In one of his last, and perhaps oddest, books, Westaway encouraged intellectual debate among young people by providing raw materials for philosophical discussion and debate. He agreed completely with the views of the political historian Sir Ernest Barker who had written in *The Times*:

> At the end of a life spent in teaching, I am an educational anarchist so far as concerns the growth of true minds. When I find a true mind, I want to let it grow. Conscience used to make a coward of me, and I was once resolved to be a good tutor. Either I have lost my conscience, or it has acquired a finer edge. At any rate, I am now disposed to be very tender to the liberty of young minds. Their liberty includes their freedom from me. I insult them if I tell them first what to read – still more if I tell them what is 'the right view'. They need their own intellectual adventures. If they ask me to go with them, I am proud to be asked: if they ask me questions, I will tell them what I think – and I will add that I am far from being sure about it (Barker 11 August 1937).[38]

[38] Sir Ernest Barker (1874-1960), as quoted in Westaway 1938a, p. xi).

Westaway's curiously-titled *Obsessions and Convictions of the Human Intellect* (Westaway1938a) from which this quotation comes, contained a variety of informative and unbiased essays on subjects that were likely to interest young people between the ages of 16 and 25. Carefully excluding politics, the subjects ranged from astrology and alchemy, perpetual motion, and the fourth dimension, to questions about the nature of space and time, miracles, religious persecution down the ages, and the concept of Hell ("atrocious" and "immoral"). Much of this curious work, which was aimed at providing a critical synoptic view of modern knowledge for pupils exposed to over-specialisation, was cannibalised (albeit reworked) from his other books. The first impression sold out immediately and was reprinted with a different, and probably more appropriate, title *Man's Search after Truth* (Westaway 1938b).[39] The book, which must have been an essential volume for school libraries, ends typically with a series of questions for the reader, but in this case they were questions that had all been suggested by young people when talking to Westaway.

The idea for *Appreciation of Beauty*, which Westaway published in 1939 soon after Chamberlain had negotiated "peace in our time" with Germany, came from the chapter on aesthetics that he had added to the third edition of *Scientific Method* in 1924. Echoing Robert Bridges' famous poem, and dedicated to his wife Mary, on first reading it appears to address science students and scientists who may lack an appreciation of the arts; but a closer reading suggests that he had in mind a more general readership that felt it lacked an appreciation of "high culture" (Westaway 1939).[40] The book is, in fact, a *vade mecum* of culture offering guidance on how to understand and appreciate painting, sculpture, the history of art, architecture, ornament, arts and crafts, landscape and garden design, literature and music all underpinned by a philosophical discourse on aesthetics. In the final chapter, "What is meant by the beautiful", partly reworked from the third edition of his *Scientific Method* (1924), he concluded that Art "in the highest sense" involved "the reproduction of the phenomena of nature (e.g. sights and sounds), an "expression of the thoughts and emotions of the artist", and the embodiment of both these factors in "an external product like a painting, a statue, a cathedral, a piece of ornament, a garden, a poem, or a symphony" (Westaway 1939, p. 195). At the end of the day, beauty, he decided, had nothing to do with accepted canons of beauty or the consensus of experts. Nor could it be a Darwinian evolved sense that provided some kind of survival value. The appreciation of beauty was a form of communication from one human spirit to another, and because this communication was individual and personal, it was incapable of objective examination. Although the appreciation of beauty was undoubtedly a variable function of a person's education, experience, beliefs, traditions and customs, ultimately Westaway agreed with Robert Bridges that man's appreciation of nature and man-

[39] Pagination and content were identical to *Obsessions and Convictions* (Westaway 1938a). See the enthusiastic review in *Nature* (Anon 1938).

[40] Robert Bridges' final poem, *the Testament of Beauty*, had appeared in 1929.

made art was God-given – a conclusion he instantly qualified as an unverifiable hypothesis, but one that gave him the greatest degree of personal satisfaction.[41]

The Appreciation of Beauty is fascinating in respect to what it reveals about Westaway's own tastes, as well as implying that he had studied art at the Royal College of Art in the 1880s where he had learned to draw accurately. In contrast to his progressive appreciation of modern science, he stands revealed as a very conservative connoisseur of painting. Good art had to be representational and to tell as story. Although well-read on Victorian and Edwardian art criticism, Westaway completely ignored artistic developments since the Pre-Raphaelites. Indeed, art since the Impressionists deserved to sink without trace. Not for him Kandinsky's appreciation of the spiritual nature of abstraction. The literary canon ended with Arnold Bennett. He detested jazz bands: "what front-rank musician has any real respect for a Jazz Band?" Live music was better than recorded music or music transmitted by wireless. Such opinions make him sound like an elderly schoolteacher whose fixed opinions had never altered. Despite this conservatism, Westaway's guide would have undoubtedly benefited a reader who wanted to improve their appreciation of high culture. Despite some "old-fogey" opinions and a decidedly deficient coverage of culture after about 1890, any reader would have received a lot of sensible advice of how to view pictures (e.g. where best to stand), how painters and sculptors achieved their optical effects, the need to know the Bible, classical myths and saint's lives to fully appreciate an artists's intentions, and a contemporary guide to Britain's best museums and art galleries..

Westaway's Religious Views

Anyone reading Westaway's *Appreciation of Beauty* in isolation from his other writings might well assume that he held extremely orthodox religious views. They would be mistaken. There was a general tendency among thinkers to take stock of the human race after the cataclysmic First World War. Westaway was but one of many philosophers, theologians and scientists who, in the light of evolution and the emergence of modern physics and cosmology, published their views on the relationship between science and theology (Bowler 2001).[42] Like many other early twentieth-century scientists, theologians and philosophers, he was concerned to re-integrate science and religion by demonstrating that the Victorian forms of materialism no longer appealed to scientists. That being the case, the churches had to modernise and bring their teachings into line with contemporary science. *Science and Theology: Their Common Aims and Methods* appeared in 1920 and was re-issued in an enlarged edition in 1934. It can be considered as an appendix to his *Scientific Method*.[43] His

[41] Westaway acknowledged that in writing the final chapter he had received "great help and friendly criticism" from the philosopher and statesman, Arthur Balfour (1848-1930).

[42] Bowler did not notice Westaway's contribution to the debate.

[43] Indeed, chapter1, "problems of philosophy," is largely a reprint of the final chapter of *Scientific Method* (Westaway 1912).

aim was to present the scientific developments of the past fifty years in layman's language and show their provisional nature. Because science was now a fundamental factor in human life and progress, he argued, any religious system had to find ways to accommodate it. Religious divisions were largely caused by a failure to accommodate new knowledge, and he appealed to Christians especially not to consider only their own doctrines as true and valid.

Reviewers were delighted by the book's directness and lucidity of style in dealing with matter, space and time, the genesis of the earth, the evolution of animal species, the antiquity of man and the emergence of life and consciousness (Sarton 1921; Anon 1920).[44] Westaway's conclusions were blunt: the belief that the same atoms of our bodies would reassemble on the day of judgement to form a human being was a pagan superstition; to express a belief in the resurrection of the body merely emphasised the material aspect of religion and was unnecessary; what really counted was a belief in the survival of personality. It followed that a belief in Christ's literal resurrection was unnecessary since what counted was the survival of Jesus's personality. Westaway accepted that the Bible had not been divinely inspired, but in accepting evolution he made it clear that it was meaningless if not teleological. A long, and erudite, section on controversies and heresies within the early church demonstrated how much theological clutter and primitivism needed to be eradicated from Christian doctrines. The "unbending institutionalism" of the church had to be eradicated. Westaway's convictions were clearly those of the Broad Church, an idealist philosophy and theistic belief.

> Theism has been aptly described as a systematized body of doctrine in which it is shown that an intelligent First Cause is the necessary and inevitable presupposition of experimental science, of reasoned knowledge, of aesthetics, of ethics, as well, of course, as of religion. If we want to explain our conceptions of the Real, the True, the Beautiful, or the Good, in each case alike we are inevitably driven to the conclusion that without an intelligent First Cause as a Beginning or Foundation, the whole of our scheme must dissolve and leave not a rack behind (Westaway 1932, p. vii).

Once again he thanked Lord Rayleigh, who had died in June 1919, for his help with the manuscript, which was completed two months' later. In a note added in proof, he observed that Einstein's "hypothesis" of relativity had been apparently verified – or, rather, just one of its consequences had. He remained doubtful, however, because he could not see how gravity acted in a void and he found the theory contradictory regarding the variability of time. However, by the time of the second, enlarged edition in 1932, Westaway had come to terms with relativity, stressing that we must carefully distinguish between *abstraction* which subtracts from observations, and *hypotheses* (like relativity) that added to observations. The whole tendency of modern science, he noted in the light of quantum mechanics, was away from dogmatism and towards less certainty.

---

[44] Sarton (1921, p. 120) thought the book "very good indeed". The *Nature* reviewer (Anon 1920, p. 608) thought "the theology student is left without excuse".

Westaway's Personal Beliefs

What of the man himself? As a teacher, he was evidently both successful and something of a pioneer, using, for example, three-dimensional molecular models in the earliest days of his classroom career – namely the 1880s.

> When I first taught organic chemistry... I bought ... a gross of small wooden balls into which I screwed midget hooks. I wanted the boys [sic] to visualise molecules as three –dimensional things (Westaway 1937b, p. 311).[45]

Westaway was not, of course, beguiled by this use of molecular models. Noting that his pupils "loved to play about with and interchange the coloured sub-groups of atoms", he asks:

> Which was the more immoral – to let the boys think that those 'molecules' were truly representative of nature, or to waste the school time in that way?

His answer was that "scientific laws are fundamental, and scientific hypotheses are useful, but scientific shams are an abomination."

It is clear from all of Westaway's writing that he was a notable scholar, with an unusual breadth of knowledge and an abiding commitment to understanding and promoting science as an endeavour dedicated to improving the sum of human happiness and well-being. The use and meaning of words were important to him, although he was no pedant, and in several of his writings he exposes the ways in which convictions and prejudices hold sway in matters that should be governed by reason. His commentary upon the teaching of general science being promoted by the Science Masters' Association in the late 1930s is characteristically balanced. Although he welcomes the broadening of the science curriculum that the innovation represented, he commented that while "all reformers see pretty clearly the effects of action, ... they seldom look far enough ahead to see the ultimate effects of a reaction," a warning that general science should not be reduced to serving up "juicy tit-bits all the year round." (Westaway 1937b).

He was also a man of his time, writing favourably of positive eugenics and sarcastically of anti-vivisectionists,[46] and although careful to deny gender bias and that he consistently referred to boys (rather than pupils) for convenience, the general impression one has from reading all of his books is that he did not think girls benefited much from courses in science. His professional duties and his writing inevitably meant that he worked to a strict timetable but it is clear that he doted upon his daughter. He found time to teach her mathematics for two hours each Saturday morning to help her prepare for her secondary

---

[45] Such "glyptic "models had been first demonstrated by August Wilhelm Hofmann in the 1860s and could be purchased from instrument makers – to the disgust of the anti-atomist, Sir Benjamin Collins Brodie, professor of chemistry at the University of Oxford. See Brock (1967).

[46] "When the Anglo-Saxon or the Celt engages in a war of reason *v.* sentiment, sentiment almost invariably proves the winner" (Westaway 1936, p. 923).

school entrance examination. The evidence is that both father and daughter found these sessions stimulating and enjoyable, Katherine describing them in later years as the highlight of her week (Kitchener 1981).[47] They were also undoubtedly successful, as Katherine found the mathematics component of the examination "too easy for words." Nevertheless, Westaway made it plain in his writings that he believed the average mathematical ability of girls was lower than that of boys and that their interest in mathematics was less. He even went so far as to suggest that the majority of girls did not need to study mathematics beyond the age of thirteen.

He was also a language purist, urging teachers to avoid the word "scientist" while admitting that the more correct term *sciencer* (analogous to astronomer), did not trip easily off the tongue,[48] and urged teachers to insist on the indicative mood when pupils wrote up their laboratory notes. As an inspector, he was highly regarded by his colleagues, while those he inspected found him astute in his judgement, constructive in his comments, and unfailingly courteous in his dealings with people. He was unusually, perhaps, a welcome guest in many school staff rooms.

What, other than the deployment of science in war, prompted Westaway to place science "in the dock" and invite his readers to judge its guilt? Of what crime did science stand accused? Any answer to this later question must, in part, be conjectural but the "verdict" delivered by Westaway at the end of *Science in the Dock*, and the text itself, provide important clues. Reviewing, from the perspective of 1942, the position of science in relation to war, civilisation, education and religion in a rather muddled manner, Westaway ultimately leaves the verdict for the reader to decide. However, he suggests that a Scottish jury would bring in a verdict of "not proven" and that almost any jury would append to its verdict "the rider that science seems to be rather indifferent to the results of its work on the happiness of humanity." In addition, the jury would not improbably express the opinion that "not a few of the men who devote their lives to unearthing the secrets of nature really think less of the welfare of mankind than of their own enregistration on the roll of personal fame" (Westaway 1942a, p. 128).

Throughout his life, Westaway had tried to bridge the gap between science and the humanities and, as noted above, he held firmly to the view that scientific knowledge should be directed towards the greater good of the human race. The collapse of humane values represented by the Second World War and its associated technology of destruction were thus a challenge to the ideas which Westaway had espoused and promised for many years. The publication of *Science in the Dock* in 1942 can be seen both as a personal exploration of the issues surrounding the social relations of science in the strained circumstances of a nation at war and as an attempt to reassert the importance of science as a humane endeavour. It can also be seen as an attempt by Westaway to expose the consequences of the early

[47] For further information on Katherine Westaway, see Hunt (2004) and Godber & Hutchins (1982).

[48] Here he followed Gregory, *Nature's* editor. *Nature* did not use the word scientist until the 1940s.

specialisation that marked English secondary education and to emphasise the need for breadth and balance. From the perspective of the early twenty-first century, however, one is also left to wonder about Westaway's attempt to reconcile his personal beliefs about science and the Christian faith. Again, conjecture is inevitable, but his books on the aims and methods of science and theology suggests strongly that he accepted the notions of a first cause and a directing agency behind the natural phenomena that scientists made it their business to explore (Westaway 1920, chapter 12).

Frederick William Westaway died from bladder cancer on 25 February 1946 at the age of 81. His personal papers have not survived. Unlike many of his colleagues in the inspectorate, he was never accorded an honour; nor did he have an entry in *Who's Who*; and the teaching press ignored his passing. His one and only obituary notice in the *Bedfordshire Times* simply recorded that his "kind and scholarly face will be missed."[49]

Westaway's legacy

Westaway was but one of an army of HMIs whose support, criticisms and writings have contributed to science teaching over the past 150 years in ways that deserve fuller investigation by historians of education. We hope that this essay will encourage others to investigate the role of inspectors in encouraging and promoting science education.[50] In this essay we have highlighted the career of just one HMI whose contribution seems to have been of exceptional importance. Westaway was a somewhat unusual recruit to the Inspectorate for most were Oxbridge graduates.[51] However, the range of his reading and expertise put him among the best graduates from Cambridge's mathematical and natural science tripos – the graduates he himself believed were the very best qualified to be excellent science and mathematics teachers. As Eric Holmyard commented, after reading Westaway's writings, a

[49] At the time of his death the Westaways and their daughter were living in de Parys Road, Bedford, adjacent to Bedford School. At Probate in Oxford, 26 April 1946, his estate was valued at £4,604 (about £138,000 in today's buying power) and willed solely to his daughter, presumably because of his wife's incapacity. Mary Westaway died on 9 March 1947. All three Westaways are buried in the churchyard of All Saints, Renhold, where the family evidently worshipped.

[50] However, HMI reports of science lessons can be disappointing as source material. HMI visits were infrequent and often focused on different aspects of a school's work, making comparisons difficult. For a guide, see Morton (1997).

[51] E.g. Charles Thomas Whitmell (1849-1920), BSc (London), NST (Cambridge), taught Chemistry, Physics at Tonbridge School before joining the inspectorate in 1879 serving in Cardiff (1879-87) and at Leeds until retirement in 1910; Frederic W. H. Myers (1843-1901) became an HMI in 1872 after teaching classics at Cambridge; Francis Bernard Stead (1873-1954), a close friend of Westaway's, who had worked at Plymouth's Marine Biology Association before joining the inspectorate; Thomas W. Danby (1840-1924), NST (Cambridge) and assisted the chemist George Liveing before becoming chief inspector of schools for south-east England. For some amusing reminiscences of inspection in the second half of the nineteenth century, see Sneyd-Kinnersley, E. M. (1908).

harassed schoolmaster will, after all, appreciate the usually dreaded, attentions of an HMI (Holmyard 1929).

But what, it might be asked, is the relevance of Westaway's writing to school science teaching today, given the profound changes in the social context of both science and religion?[52] Part of the answer lies in the fact that many of the issues that Westaway addressed have arguably become more, rather than less, important and that some of his arguments, lucidly and eloquently developed and expressed, continue to offer a challenge to the contemporary mind. Beyond this, some of Westaway's writing about science and education sets a standard that others might seek to follow, notwithstanding the changes that have taken place in the last half century in our understanding of the history and philosophy of science. Ultimately, however, reading Westaway forces the reader to ask questions about the educational function of science, questions that seem to be urgently in need of answers as school science education is increasingly cast in an instrumental mode, serving economic rather than humane ends.

At a time when serious doubts are again being expressed about whether practical work and experimentation should play an essential (but expensive) role in schools, Westaway's arguments are well worth reading again.[53] We can also take to heart Westaway's expectation (and challenge) that:

> When a boy leaves school, he should have been so taught and be so informed that he is able to take an intelligent interest in all scientific, technical, and industrial developments. He should be able to turn up technical reports, and obtain at least an intelligent general grasp of their contents. He should be able to discuss in a council chamber the pros and cons of proposed new applications to industrial processes. In short, the former secondary school boy should be the disseminator of new knowledge and the intelligent adviser of the community (Westaway 1929, pp. 385-386).

Because of the way that the sociology of science has transformed approaches to the history and philosophy of science since the 1960s, Westaway's *Scientific Method* is now only of historical interest. Similarly, his pioneering *Endless Quest* has been superseded by a more nuanced and critical approach to the history of science – though it has to be said that no historian has been able to provide a better encyclopaedic and illustrated guide for teachers on how scientific achievements were brought about. Its message, taken from Westaway's grasp of philosophy, that despite the "passing of dogmatism" there is no reason to suppose "that what is mathematically describable is ultimately real, and the only reality", is one that all teachers should reflect upon. Finally, despite world-wide cultural differences and national varieties of syllabuses and curricula, his *Science Teaching* and *Craftsmanship in the Teaching*

[52] For Westaway's continuing relevance in an American context, see Keller & Keller (2005).and the electronic blog at http://www.smartscience.net. See also Matthews (1998).

[53] See, for example, Taber (2011).The issue is also highlighted by the REACH legislation on the safety of chemicals.

of Mathematics remain inspirational and illuminating reading for both novices and experienced teachers.

Acknowledgements:

We are grateful to Nicola Aldridge for information about the Westaway family; and to Dr M. P. Price, Librarian of the Mathematical Association Library at the University of Leicester, for comment on Westaway's mathematics.

Bibliography

Anon (11 October 1894). *Bristol Mercury*.

Anon (1920). Review of Westaway (1919). *Nature*, 105, 5

Anon (1920). Review of Westaway (1932). *Nature,* 105, 607-608

Anon (1931). Review of Westaway (1931a). *Nature*, 128, 950

Anon (1933). Review of Westaway (1927). *School Science Review*, June 1927, VIII, 289

Anon (1935). Review of Westaway (1934). *The School Science Review* (1935), XVI, 135

Anon (1938). Review of Westaway (1938b). *Nature* (1938), 141, 766-767

Anon (1959). Obituary of W. C. Fletcher. *Mathematical Gazette*, 42, 85-87

Barker, Sir Ernest (11 August 1937). *The Times.* Quoted by Westaway (1938a), p. xi

Beatley, R. (1933). Review of Westaway (1931a). *American Mathematical Monthly*. 40, 548-553

Bowler, P. J. (2001). *Reconciling Science and Religion. The Debate in Early Twentieth-century Britain.* Chicago: Chicago University Press

Brock, W. H. (Ed.) (1967). *The Atomic Debates.* Leicester: University of Leicester Press

Brock, W. H. (Ed.) (1973; reprint 2012). *H. E. Armstrong and the Teaching of Science.* Cambridge: Cambridge University Press

Brock, W. H. (1996). *Science for All.* Aldershot: Variorum, Ashgate Publishing

Butterworth, H. (1982). The Science & Art Department examinations: origins and achievements. In MacLeod (1982)

Conant, J. B. (1947). *On Understanding Science*. New Haven, CT: Yale University Press

Conant, J. B. (1957). *Harvard Case Histories in Experimental Science*, 2 vols. Cambridge, MA: Harvard University Press.

Dewey, J. (1900). *The School and Society.* Chicago: University of Chicago Press

Dewey, J. (1902). *The Child and the Curriculum.* Chicago: University of Chicago Press

Dewey, J. (1916). *Democracy and Education.* London: Macmillan

Dingle, H. (1935). Review of Westaway (1934). *Nature*, 135, 938

Dobbs, W. J. (1929). Review of Westaway (1928b). *Mathematical Gazette*, 14, 471

Donnelly, J. F. (2002). The 'humanist' critique of the place of science in the curriculum in the nineteenth century and its continuing legacy. *History of Education*, 31 (6), 535-555.

Donnelly, J. F. (2004). Humanizing science education. *Science Education*, 88 (5), 762-784.

Donnelly, J. F. & Ryder, J. (2011). The pursuit of humanity: curriculum change in English school science. *History of Education*, 40 (3), 291-313.

Finch, R. & Kimmins, C. W. (1932). *The Teaching of English and Handwriting.* Glasgow & Bombay: Blackie

Fletcher, W. C. (1924). English and mathematics. *Mathematical Gazette*, 37, 37-49

Fowles, G. (1937). *Lecture Experiments in Chemistry.* London: Bell & Sons

Godber, J. & Hutchins, I. (Eds.) (1982). *A Century of Challenge: Bedford High School, 1882 to 1982.* Bedford: priv. printed

Gordon, P. (1978). The writings of Edmund Holmes: a reassessment and bibliography. *History of Education* (1978), 12, pp. 5-24

Gosden P H. J. H. (1966). *The Development of Educational Administration in England and Wales.* Oxford: Basil Blackwell

Gregory, R. (1916). *Discovery, or, The Spirit and Service of Science.* London: Macmillan

Holmes, E. (1911). *What Is and What Might Be: A Study of Education in General and Elementary Education in Particular*. London: Constable; 2nd ed. 1928, with many impressions

Holton, G. (1952). *Introduction to Concepts and Theories of Physical Science.* Cambridge, MA: Addison-Wesley

Holmyard, E. J. (1929). Review of Westaway (1929). *Nature* 124, 436-437

Hudson, R. & Walmsley, J. (2005). The English Patient: English grammar and teaching in the twentieth century. *Journal of Linguistics,* 41, 593-622

Hunt, F. (2004). Kathleen Mary Westaway. *OxfordDNB*

Huxley, T. H. (1868), A Liberal Education and Where to Find It. In Huxley, T. H. (1905). *Science & Education Essays* (pp. 76-110). London: Macmillan

J. A. H. (1912). Review of Westaway (1912). *Nature*, 90, 277-278

Jenkins, E. W. (1973). The Thomson Committee and the Board of Education 1916-22, *British Journal of Educational Studies*, XXI, 76-87

Jenkins, E. W. (1979). *From Armstrong to Nuffield.* London: John Murray

Jenkins, E. W. (2001). Who were They? F. W. Westaway (1863-1946). *School Science Review*, 83 (September 2001), 91-94

Keller H. E. & Keller, E. E. (2005). Making real virtual labs. *The Science Education Review*, 4, 2-11; and the electronic blog at http://www.smartscience.net

Kitchener, D. (1981). *Kate Westaway, 1893-1973: A Memoir.* Bedford: priv. printed

Mach, E. (1893). *The Science of Mechanics. A Critical and Historical Account of its Development.* London: Watts

MacLeod, R. (Ed.) (1982). *Days of Judgement.* Driffield: Nafferton Books

Matthews, M. R. (1998). Opportunities lost: the pendulum in the USA National Science Educations Standards. *Journal of Science Education and Technology*, 7, 203-214

Mayer, A-K. (1997). Moralizing science: the uses of science's past in national education in the 1920s, *BJHS*, 30, 51-70

Mayer, A-K. (2004). Fatal mutilations: educationism and the British background to the 1931 International Congress for the History of Science and Technology, *History of Science*, 40, 445-472

Morton, A. (1997). *Education and the State from 1833.* Kew, Richmond: PRO Publications.

Price, M. H. (1994). *Mathematics for the Multitude? A History of the Mathematical Association.* Leicester: The Mathematical Association

Remsen, I. (1886). *An Introduction to the Study of Chemistry.* London: Macmillan

Roscoe, H. E. (1866; new ed. 1886). London: Macmillan

Sampson, G. (1921). *English for the English. A Chapter on National Education.* Cambridge: Cambridge University Press

Sarton, G. (1921). Review of Westaway (1920). *Isis*, 4, 119-120

Schwab, J. J. (1982). *Science, Curriculum and Liberal Education.* Selected essays edited by Ian Westbury & Neil J. Wilkof. Chicago: University of Chicago Press

Shute, C. (1998). *Edmund Holmes and the Tragedy of Education*. Nottingham: Educational Heretics

Sneyd-Kinnersley, E. M. (1908). *Some Passages in the Life of One of H. M. Inspectors of Schools* (reprint 1913). London: Macmillan

Sonnenschein, E. A. (1914). Review of Westaway (1914). *Classical Review*, 28, 213-214

Stead, F. B. (1918). *Natural Science in Education: Being the Report of the Committee on the Position of Natural Science in the Educational System of Great Britain* (1918). London: HMSO

Taber, K. S. (2011). Goodbye school science experiments? *Education in Chemistry*, 48 (June), 128; available at www.talkchemistry.org

Vlaeminke, M. (2000). *The English Higher Grade Schools: A Lost Opportunity.* London: Woburn Press

Weaire, D. & S. O'Connor (1987). Unfulfilled renown: Thomas Preston (1860-1900) and the anomalous Zeeman effect. *Annals of Science*, 44, 617-644

Westaway, F. W. (1912). *Scientific Method. Its Philosophy and Practice*. Glasgow and Bombay: Blackie. 439pp.

Westaway, F. W. (1914). *Quantity and Accent in the Pronunciation of Latin.* Cambridge: Cambridge University Press. Reprinted 1923; 2nd revised ed., 1930

Westaway, F. W. (1919). *Scientific Method.* 2nd ed. Glasgow & London: Blackie

Westaway, F. W. (1920). *Science and Theology: Their Common Aims and Methods.* Glasgow & London: Blackie. 346pp.

Westaway, F. W. (1924). *Scientific Method.* 3rd ed. Glasgow & Bombay: Blackie

Westaway, F. W. (1926). *The Writing of Clear English.* Glasgow & London: Blackie

Westaway, F. W. (1928a). G*eometry for Preparatory Schools.* Glasgow & London: Blackie. 201pp.

Westaway, F. W. (1928b). *Lower and Middle Form Geometry.* Glasgow & London: Blackie. 260pp.

Westaway, F. W. (1929). *Science Teaching.* Glasgow & London: Blackie. 442pp.

Westaway, F. W. (1931a). *Craftsmanship in the Teaching of Elementary Mathematics.* Glasgow & London: Blackie. Reprinted 1934 and 1937. 665pp.

Westaway, F. W. (1931b). *Scientific Method.* 4th ed., "revised and enlarged, present-day methods critically considered". Glasgow & Bombay: Blackie

Westaway, F. W. (1932). *Science and Theology.* 2nd ed. Glasgow & London: Blackie. Reprint 1934

Westaway, F. W. (1933a), The pronunciation of Latin, *Greece & Rome*, 2, 139-143.

Westaway, F. W. (1933b). *The Teaching of English Grammar. Function versus Form.* Glasgow and London: Blackie

Westaway, F. W. (1934). *The Endless Quest: Three Thousand Years of Science.* Glasgow & London: Blackie. 1080pp. 2nd ed. 1935 with minor corrections only; reprint 1936. Chinese translations 1937 and 1966, Czech in 1937

Westaway, F. W. (1936). *The Endless Quest*. 2nd ed. reprint. London & Glasgow: Blackie

Westaway, F. W. (1937a). *Scientific Method.* 5th ed. Glasgow & London: Blackie

Westaway, F. W. (1937b). The teaching of general science. *School Science Review*, XVIII, 310-311

Westaway, F. W. (1938a). *Obsessions and Convictions of the Human Intellect.* Glasgow and London: Blackie. 528pp.

Westaway, F. W. (1938b). *Man's Search after Truth.* Glasgow and London: Blackie. 528pp.

Westaway, F. W. (1939). *Appreciation of Beauty.* Glasgow and London: Blackie. 223pp.

Westaway, F. W. (1942a). *Science in the Dock: Guilty or Not Guilty?* London: Science Book Club. 133pp. Reprint 1944.

Westaway, F. W. (1942b). *Science Teaching.* Reprint. Glasgow: Blackie

Westaway, K. M. (1917). *The Original Element of Plautus.* Cambridge: Cambridge University Press

Westaway, K. M. (1922). *The Educational Theory of Plutarch.* London: University of London Press

Westaway, K. M. (Ed.) (1924). *Selections from Plautus.* Cambridge: Cambridge University Press

.

[12,131 words]