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THE EARLY EDUCATION OF A NOBEL LAUREATE: HENRY DALE'S SCHOOLDAYS

by

E. M. TANSEY*

School of History, Queen Mary University of London, Mile End Road, London E1 4NS, UK

This paper examines the early schooling, in London and in Cambridge, of the later Nobel laureate and President of the Royal Society, the physiologist Sir Henry Dale (1875–1968). The influence of key teachers who directed the boy's interest towards science, and the impact of his schooling on his university education and later scientific career, are examined in particular. The significance of the zoologist Edward Butler of Tollington Park College, who taught Dale in his early teenage years, is highlighted.

Keywords: Sir Henry Dale; Leys School; Tollington Park College; Edward Butler; scientific education; Nobel laureate

INTRODUCTION

In a lecture inaugurating the Department of Biochemistry at the University of Newcastle in 1967, Sir Hans Krebs FRS, Nobel laureate in Physiology or Medicine in 1953, argued that 'scientists are not so much born as made by those who teach them.'[1] His examples all referred to undergraduate or graduate teaching, and his main contention was that all scientists of distinction (and 'despite some personal embarrassment' he used the Nobel prize as an indicator of such distinction) had been fortunate enough at some critical stage in their training to have come under the influence of an outstanding teacher. His own chemical/biochemical genealogy comprised seven Fellows of the Royal Society, starting with his teacher Otto Warburg (Nobel prize 1931, FRS 1934), Warburg's teacher Emil Fischer (Nobel prize 1902, FRS 1899) and a chain of chemists including August Kekulé (FRS 1875) and Justus Liebig (FRS 1840), reaching back to Claude Louis Berthollet (FRS 1789).[2]

Krebs's view was not, and is not, unique. Many successful scientists have created, as did Krebs, a scientific genealogy of eminent university teachers, with themselves as the endpoint.[3] A major study of the importance of mentors and role modes in science has emphasized that the effect can be either positive or negative.[4] There is some evidence that the chance of winning a Nobel prize is higher for those who trained under a Nobel laureate, although the fact that a Nobel prize winner is invited to make nominations for

*t.tansey@qmul.ac.uk

subsequent prizes may skew this association.[5] Other scientists, however, have decried the influence of all or parts of their formal education, the most famous example probably being the physicist Albert Einstein (Nobel prize 1921, FRS 1921), who commented, 'Education is what is left when you have forgotten everything you learned in school.'[6] Further, he believed it was 'nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of imagination', reflecting his own unhappy schooling experiences.[7] The subject of this paper, Henry Dale (Nobel prize 1936, FRS 1914), was also particularly critical of part of his education, later than that analysed here, believing that his time as a clinical student at St Bartholomew's Hospital 'delayed my scientific development'.[8] Evidence can indeed be mustered both in support of and against Krebs's viewpoint, and also for the importance of some form of self-education in promoting scientific creativity and professional achievement.[9]

Most examinations of the education of scientists have focused on university-level training.[10] This paper will examine an earlier stage: the school education of one of the most eminent scientists of the twentieth century, the physiologist Sir Henry Hallett Dale (1875–1968), for whom there is, as yet, no published biography.[11] Elected FRS in 1914, he served as Biological Secretary (1925–35) and President (1940–45) of the Royal Society, and shared the Nobel Prize in Physiology or Medicine in 1936 for his discoveries in chemical neurotransmission. This account will chart his early schooling and the role that chance played in it, explore the influences of particular teachers, and examine the impact of that schooling on his subsequent career.

Much of the material used here is derived from autobiographical information in the archives of the Royal Society, and Dale's biographical memoir by Wilhelm Feldberg, which relied uncritically on these archival sources for details of Dale's early life of which he had no personal knowledge.[12] The use and interpretation of such material can be problematic for later historians, especially when no corroborative sources exist.[13]

Family background

Henry Hallett Dale was born in 1875 at 5 Devonshire Street, North London, and spent much of his long life in London. His father, Charles James Dale, managed the London office of a Derbyshire stoneware firm, Bourne and Sons, and was largely credited with the introduction of 'Denby Chef Ware' for cooking purposes.[14] According to his son, and his obituarist, he was a noted amateur musician, playing the organ at his Wesleyan chapel and organizing a Finsbury Choral Association, which led to the establishment of a small College of Music in the neighbourhood, which he ran entirely as a hobby.[15] Dale's mother, Frances Ann Hallett, came from a Devonshire farming family, and probably met Charles Dale at a Methodist Chapel. They had seven children, Henry being the third child and third son of five boys and two girls. None of his siblings developed careers in science or medicine. The eldest son, Charles, died in early infancy, William became a glass manufacturer and Alec followed their father into Bourne and Sons; of his two sisters, Annie got married and Gertie remained at home to look after their parents.[16] Dale's youngest sibling, Benjamin, younger by 10 years, seems to have inherited their father's musical interests and abilities, and he became a fairly well known composer and Warden of the Royal Academy of Music.[17]

In his later reminiscences Dale recalled that his mother seemed to think him precocious, and her constant praising of him irritated both his elder and younger brothers, who used to tease

him that he would end up in an asylum. Despite his mother's apparent view of his abilities, his early education was, he described, 'remarkably casual and opportunist',[18] although he was even more scathing about Benjamin's education, which he considered 'conventional and inadequate'.[19] As a young child living on the Clerkenwell border of Islington, Dale attended a small private school close to the family home until, aged eight years in 1883 and then living in Crouch End, he was dispatched to another local establishment, Tollington Park College.[20] This was a private day school for about 200 boys, of which the proprietor and principal was William Brown.[21] Another new arrival in 1883 was Edward Albert Butler, a distinguished zoologist, who joined the school as Vice Principal.

Tollington Park College and Edward Butler

The school was physically small in 1883. Butler's later reminiscences recalled one very large room in which all six forms were taught simultaneously, with only a small annexe for specialized lessons or study.[22] Soon another room was built to hold the upper half of the school, an improvement no doubt, but still cramped, crowded accommodation. The strength of the school was reckoned to be mathematics, there being 'scarcely anything in the way of science teaching' when he arrived, Butler noted later. He quickly got zoology and chemistry teaching organized for the senior boys, and Tollington Park College soon acquired a reputation for the teaching of science which 'it has ever since maintained'.[23]

Described by Dale as a 'man of wide culture', Butler taught maths, Latin and sometimes English throughout the school, and chemistry and zoology to the older boys. By the age of 13 years, Dale had reached the sixth form, the most senior class, and was able to take Butler's zoology lessons. In that same year, 1888, Dale formed with his two brothers William, who was two years older, and Alec, two years younger, 'a, perhaps, rather priggish little "Society", in which we met and read papers, or lectures to one another'.[24] This Society did not last long, because in the autumn of that year William left school to work in the office of a music publisher, thus breaking up the schoolboys' little group. The notes of one of these lectures by Dale on the subject of Protozoa survive and make illustrative reading, reflecting not only the abilities and interests of the young boy but also something of the nature of the teaching he was receiving. In later life Dale himself thought the material of sufficient interest to warrant deposit in an archive, suggesting that it might be of interest to his grandchildren, 'or perhaps for some unfortunate friend, who might be called upon to fashion an obituary notice for me out of sparse materials.'[25] Perhaps he was, 60 years after the event, consciously or unconsciously, creating an account of himself as a precocious child? Eighteen pages of the incomplete manuscript exist, the first page is missing, figures are referred to but have not survived and the text terminates abruptly, suggesting a further missing section. It is neatly written, with very few corrections, describing in fluent detail the taxonomy of the phylum Protozoa. He uses some striking similes, noting for example that the chambered Foraminifera 'reminds one forcibly of onions strung on a string', while a description of the limestone deposits, such as the chalk Downs and the Alps, built of the calcareous shells of Foraminifera, brings forth the comment 'and if you don't think it one of the greatest marvels of the Universe, well I must confess, I wouldn't give much for you.'[26]

What were his sources for this essay? Writing in 1953, Dale acknowledged Butler's classes, which he described as short lectures illustrated by figures drawn on the

blackboard. The content, Dale believed, was largely drawn from 'Nicholson's *Textbook of zoology*', although he was uncertain that he possessed his own copy as early as 1888.[27] 'Nicholson's *Textbook*' refers to the work of Henry Alleyne Nicholson (1844–99; FRS 1897), a British zoologist who was a prolific writer of textbooks of zoology and palaeontology. His *Manual of zoology for the use of students* first appeared in 1870 and went through six further editions; his *Text-book of zoology for schools and colleges* went through five editions following its first appearance in 1871. Both books follow a similar style, organized in chapters devoted to separate phyla. The *Manual* is aimed at higher-level, probably university-level, students, and the seventh edition, which appeared in 1887 was substantially revised, as was necessary for 'dealing with a subject so progressive as Zoology' especially in light of the *Challenger* voyages, which had ended the previous year.[28] The *Textbook* covers the same range of material but in less detail, and includes broader contextual information, such as that of the shells of Foraminifora forming the chalk downs and the Alps. Thus it seems highly probable that Dale's essay was derived from Butler's lesson, which was in turn based on Nicholson's *Textbook*, with the teacher's additional asides and comments incorporated into the schoolboy's notes and the later essay. Dale later commented, 'I am conscious of owing to Edward Butler my first inclination to a special interest in natural science in general, and in its biological aspect in particular.'[29]

Butler, however, did more than direct an intelligent child's attention towards biological study, as Dale himself recorded: '[An] even more lasting bequest to me, from Butler's teaching, was a feeling for the use of the English language with precision and economy.'[30] Butler's own early zoological writings appeared in *Knowledge*, a monthly 'plainly worded—exactly described' illustrated magazine of science, and he expressed his intention in such writings to use 'ordinary language as far as possible'.[31] He impressed upon Dale the need for, and encouraged him to achieve, a style of unambiguous lucid writing. Dale's Personal Record and manuscript reminiscences in the Royal Society record several versions of his happy memories of being kept behind after the end of the school day to write and rewrite a piece of text until it finally received Butler's approval, '"Ah! Now you've got it. I can't misunderstand it and I can't improve it". And I would walk off home for a late tea with my young brain singing with the happiness of achievement.'[32]

That facility with language remained with Dale throughout his life. As a young physiologist, Dale's manuscripts to the *Journal of Physiology* were never subjected to the 'savage, though highly effective' editing of Professor J. N. Langley, the journal's owner and editor. Langley's robust editorial style frequently caused offence among the physiological community, and led to the establishment of the *Quarterly Journal of Experimental Physiology*.[33] Dale was even told by a colleague in later years that Langley cited one of Dale's papers as a model of how a paper should be written.[34] Sometimes, however, Dale's own readiness to rewrite or edit his colleagues' papers was not always appreciated. When Dale was president of the section of physiology and medicine at the British Association for the Advancement of Science's meeting in Toronto in 1924, he either lost or had stolen a favourite fountain pen. Two of his younger colleagues, Charles Lovatt Evans and J. H. Burn, laughingly gave thanks for its disappearance, apparently rejoicing that their boss's extensive editorial corrections would be curtailed for a while.[35] That said, throughout his life his junior colleagues would marvel at his ability to dictate, subclause by subclause, lengthy and complex correspondence.[36]

When he was 13 years old, Dale was entered for the public examinations of the College of Preceptors, an independent examination and accreditation board. This was routine for Tollington Park College. The whole of the fourth, fifth and sixth forms took the examinations every year, and there being no space large enough in the school to devote to the occasion, they all marched in line through Tollington Park to Holloway Hall 'mostly with looks of confidence on their faces'.[37] Dale's resultant certificate, of the 'second class, first division' shows 10 subjects examined, including English, French, Latin and Scripture, but no sciences.[38] Entered again the following year, in accordance with the school's usual practice, Dale achieved first class in the Honours Division and an additional special certificate, his 13 subjects including chemistry and zoology. He achieved the second highest marks in the country, and the school's proprietor, William Brown, keen to have the attention and publicity of producing the top student in the country, persuaded Dale's father to allow the boy to remain at school for a further year without charge, in an attempt to win first prize.[39] Describing the plan as 'fantastic' in later life, Dale did indeed enter the examinations for the third time in 1890, and this time his first-class marks in 13 subjects were the highest in the country.[40] He was also awarded a Certificate of Distinction of the London Society for the Extension of University Teaching, and received another prize, £20 donated by Barclays Bank, and a Junior Commercial Certificate, in an examination competition organized by the London Chamber of Commerce, which had initiated the examination to identify useful recruits for City offices.[41] The inclusion of 'Bookkeeping & accounts', 'Commercial history of the British Isles' and 'Arithmetic (including knowledge of foreign weights & measures, currency & exchange)' on Dale's certificate emphasize that intention. Thus by the summer of 1891, Dale's future in the commercial world seemed determined, and, more by default than by ambition, he seemed set on an office career either by following his father as had his elder brother, or by entering a City company.

Thus Henry Dale's early education hardly steered him towards a scientific career, although it did foster an interest in the natural sciences and a distinct aptitude for academic study and for passing examinations. The critical determinant of his future was the chance meeting of his father with Dr W. F. Moulton, which resulted in his attending the Leys School.

The Leys School, Cambridge, 1891–94

In 1891 Dale's father, an active Methodist, was a member of the Annual Wesleyan Methodist Conference, and there he met the eminent Biblical scholar Dr W. F. Moulton, who was also headmaster of the Leys School in Cambridge, a recently opened Methodist establishment. On hearing of the younger Dale's examination successes, and keen to attract bright youngsters to his school, Moulton arranged for the boy to sit, at very short notice, the Leys scholarship papers. Dale was recalled from his summer holidays in Devonshire and dispatched to Cambridge to take the examinations. These he passed with the highest marks and was consequently awarded one of three entrance scholarships. Plans for a business career were abandoned in favour of a return to full-time education.[42]

During the nineteenth century, attempts to rectify the educational deprivations of Nonconformists, denied the opportunities available to members of the Established Church, achieved increasing prominence.[43] Wesleyan Methodists first officially sanctioned

educational programmes at the 1833 Methodist Conference, after which they established Sunday Schools,[44] from which developed several primary schools and a few secondary schools. During the 1850s the passing of the Oxford, and then the Cambridge, University Acts permitted Nonconformists to become undergraduates, proceeding to the Bachelor's, but not to the Master's, degree. In 1871 the University Tests Act removed the theological requirements for admission to Fellowships, thus opening up the possibility of Oxford University and Cambridge University careers to Nonconformists.[45] It therefore became incumbent on Nonconformists to provide the requisite school education for their children to proceed to university.[46] To achieve this, the Wesleyan Methodists formed a syndicate, with W. F. Moulton as its Convenor, which recommended the establishment of their own public school, for which it initially acquired the Cambridge house of Professor Humphry (of the Cambridge Medical School).[47] When that school, the Leys School, opened in 1874, Moulton became its first headmaster and oversaw its gradual extension into adjacent properties.

The Leys School established a broader, more comprehensive scheme of education than was then current in most public schools, and it was particularly unusual in its promotion of science.[48] It emphasized practical teaching and in 1890 launched an appeal fund to build extensive new laboratories, '[T]he importance of this scheme and its probable bearing on the future of the school cannot be over-estimated.'[49] Its close proximity to the University and Colleges of Cambridge provided easy access to specialized teaching, and Old Leysians at the university often returned to assist with part-time teaching at the school. This arrangement frequently allowed the schoolboys to be in touch with the very latest developments and experiments then being taught to the undergraduates.[50]

Henry Dale at the Leys School, 1891–94

By the time that Dale took up his scholarship in 1891 and entered on the science side, the school was building new laboratory accommodation, which was completed in his final year. He was rapidly absorbed in school activities, and although later admitting to some difficulties in adapting to the unfamiliar life of a busy boarding school, described himself as a 'cheery youngster' looking with awe at senior boys such as Joseph Barcroft.[51] Within a few months he became a sub-prefect, and in early 1892, following one of the traditions of the school, he took and passed the London University Matriculation Examination followed by the BSc Intermediate Examination a little later, although he never took the final degree.[52] By now he was clearly joining in more school enterprises, particularly the Natural History and Science Society, which collected and classified a wide range of objects and maintained its own museum, of which Dale was appointed a curator, responsible for the astronomical and chemistry collection.[53] The society also encouraged members to give papers at its weekly meetings, and organized an impressive list of guest speakers, many from the local university.[54] School records show that Dale's interests were not restricted to science and that he participated in a wide variety of school activities: he was appointed a prefect in early 1893, played both rugby football and lacrosse for the school's second teams,[55] was a member of the Missionary Society and took part in various events organized by the Literary and Debating Society.[56]

Of Dale's academic studies at the Leys School we also have some account. His science teachers included the chemist C. W. Kimmins,[57] who gave him 'a good grounding in

inorganic, and the rudiments of organic, chemistry' and Alfred Hutchinson, a former pupil then completing the Natural Sciences Tripos at the university and teaching part time at the school.[58] It was through Hutchinson that Dale made 'precocious contact with what were then new developments in physiology', the lessons at the school closely following the university lectures. Hutchinson was working through the new, four-volume, edition of Michael Foster's *Textbook of physiology*, and he used it for his teaching, supplementing and updating the material with his own lecture notes. Thus, Dale recalled, 'We then learned from him about von Mehring and Minkowski's discovery of the relation of the pancreas to diabetes, Murray's successful trial, at Horsley's suggestion, of thyroid gland substances in myxoedema, and other such items which had not reached the 1891 [edition of] Foster'.[59] The excitement of this close contact with the frontiers of research was, Dale thought, 'largely responsible for the fact that Barcroft, Bainbridge and I, who left that school in successive years, each with a science scholarship to a Cambridge College, all found it natural to specialize in physiology'.[60]

The scientific provision of the school was greatly enhanced when the new laboratories were completed in 1893 (during Dale's final year at the school).[61] They were opened on a day of grand ceremony, the guest of honour being Lord Kelvin, accompanied by many Cambridge academic notables, including Foster,[62] who made a speech that was unfortunately not reported. The new facilities meant that the schoolboys were able to conduct several simple experiments, and Dale recalled muscle-nerve preparations from frogs and making simple histological and haematological preparations.[63]

Michael Foster held firm views on the value of teaching physiology 'as a wholly new field into which the natural mind may wander at will without any restrictions as to being qualified for entrance.' He advocated physiology for general attention, as an 'awakening study', but considered that as a distinct entity it was an unsuitable subject for school pupils and believed that demonstrations and practical exercises were the best educational methods.[64] This opinion was put into notable practice during Dale's period at the Leys School, when Foster, already a regular visitor to the school, gave a talk and demonstration on 'Nerves', assisted by Mr Anderson,[65] to the Natural History and Science Society on 25 November 1893—apparently the most successful and best-attended meeting of the Society on record. The school magazine, *The Leys Fortnightly*, reported the event in detail, which is worth repeating here:

> After describing the general features of nerves and the central nervous system, he demonstrated the result of electrically stimulating a nerve attached to a muscle and then that of stimulating the muscle itself after paralyzing the nerve endings by drugs. Next came a graphic demonstration of a frog's heart beating and the inhibitory and augmentory effects produced by the application of muscarin and belladonna. The lecturer then went on to describe the sensory nerves and the whole nervous reflex mechanism of the body, and showed how the action of efferent and afferent nerves could be distinguished by cutting all the nerve roots on one side of the spinal cord, and closed by saying how complex must be the mechanisms in the central nervous system compared with the somewhat simple ones of the nerves themselves, in which we can to some extent produce artificially the effects which are brought about in life.[66]

Although the *Fortnightly* article is anonymous, it is tempting to speculate that Dale, then the magazine's editor, was the author.[67] Irrespective of the report's authorship, the event is prescient—one of the most distinguished physiologists of the day demonstrating

experimental evidence of the function of the autonomic nervous system and the effects of various drugs on that system. In the audience was the schoolboy who, 40 years later, shared the Nobel prize for elucidating the chemical mechanisms of those actions.

Dale left the Leys School in 1894, to read Natural Sciences at Trinity College, Cambridge. His leaving prizes from the school included not only that for sixth-form science but also awards for translations and for articles in *The Leys Fortnightly*.[68] Several of his contemporaries also chose medical or scientific careers, further evidence of the school's academic strengths. Besides Joseph Barcroft, F. A. Bainbridge became Professor of Physiology at St Bartholomew's Hospital Medical School; C. F. Hadfield, also with Dale at Trinity, became an eminent anaesthetist at St Bartholomew's; and A. E. Barclay was an early exponent of radiology in Britain.[69]

Undoubtedly, the Leys School in Cambridge had a profound influence on the direction of Dale's further education, guiding him towards medical/scientific studies and equipping him with the knowledge and skills to undertake such work. The proximity of the school to the university, and its close links, especially with physiologists, meant that the students were exposed to the very latest ideas and exciting discoveries, so his decision to read Natural Sciences at Trinity College is hardly surprising. Indeed Dale's early exposure to advanced material at school jaded his appetite a little, and he remembered Foster's lectures at the university as being of familiar passages from his book 'rather monotonously recited by its author, with a steady rhythm of gesture for emphasis'.[70]

Considered in the light of the remarks that opened this paper, the evidence presented here goes a long way to support Krebs's view. It was clearly the advanced classes at the Leys School of Alfred Hutchinson, a Cambridge undergraduate also serving as an assistant master, that directed Dale towards university studies in physiology. However, Dale's education there might so easily not have happened: it had been the result of a chance meeting between his father and Dr Moulton, when Moulton was looking for bright young boys for his comparatively new school.[71] Dale's scholastic record, which seems not to have suggested further academic study to his father or his teachers, immediately impressed the young headmaster. But that scholastic record had been created at a modest North London school. Although the young Henry Dale undoubtedly had natural ability and intelligence, as demonstrated by his success in a broad range of school subjects, his intellect was stimulated and directed towards science by Edward Butler's teaching. Dale himself had no doubt: 'I am sure [Butler was] the best teacher I ever had, at any stage of my formal studies.'[72]

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Notes

1 H. Krebs, 'The making of a scientist', *Nature* **215**, 1441–1445 (1967), quotation on p. 1441.
2 *Ibid*.

3 See, for example, S. G. Waelsch, 'The development of scientific creativity', *Creativity Res. J.* **7**, 249–264 (1994); many of the introductory autobiographical papers in *Annual Reviews* (of Pharmacology, Neuroscience, Biochemistry, and so on) and republished in a series of volumes *The excitement and fascination of science: reflections by eminent scientists* (Annual Reviews Inc., Palo Alto, CA, 1978–1990) follow this format.

4 See D. K. Simonton, *Scientific genius: a psychology of science* (Cambridge University Press, 1988), especially ch. 5, 'Developmental antecedents', pp. 107–134.

5 H. Zuckerman, *Scientific elite: Nobel laureates in the United States* (Transaction Publishers Press, New Brunswick, NJ, 1996), especially ch. 4, 'Masters and apprentices in science', pp. 96–143.

6 A. Calaprice (ed.), *The ultimate quotable Einstein* (Princeton University Press, 2000), discusses the origin of this quotation on p. 473.

7 A. Einstein, 'Autobiographical note', in *Albert Einstein: philosopher-scientist* (ed. P. A. Schlipp), pp. 2–95 (Tudor Publishing Co., New York, 1949) [even pages in German, odd pages English translation], quotation on p. 16 (German) and p. 17 (English).

8 W. S. Feldberg, 'Henry Hallett Dale', *Biogr. Mems Fell. R. Soc*. **16**, 77–174 (1970), at p. 89.

9 See the examples given in D. K. Simonton, *Creativity in science: chance, logic, genius and zeitgeist* (Cambridge University Press, 2004), especially ch. 5, 'Creative scientists', pp. 99–136.

10 Sir Brian Pippard examined the influence of schoolmaster-Fellows in the middle of the nineteenth century, and regarded Queenwood College, Clifton College and Marlborough as particularly significant in promoting secondary science education; see B. Pippard, 'Schoolmaster-Fellows and the campaign for science education' *Notes Rec. R. Soc*. **56**, 63–81 (2002). A detailed study of science teaching at Clifton College (N. R. Ingram, 'All that you can't leave behind', *Notes Rec. R. Soc*. **57**, 177–184 (2003)) also emphasized the importance of inspirational school teaching.

11 See, for example, E. M. Tansey, 'The early scientific career of Sir Henry Dale FRS (1875–1968)' (PhD thesis, University of London, 1990).

12 See, for example, Dale's Personal Record at Royal Society HD 5.5, Dale's Autobiographical memoir, 1875–*ca*. 1920 [March 1958], and the note of B. J. Dale [1964], Royal Society HD143.2; Dale Reminiscences 1875–1904 at Royal Society HD143.3. See also W. S. Feldberg, *op. cit*. (note 8). Where possible, reference is made throughout this paper to the published account.

13 A useful discussion of this problem is R. Selya, 'Primary suspects: reflections on autobiography and life stories in the history of molecular biology', in *The history and poetics of scientific biography* (ed. T. Soderqvist), pp. 199–206 (Ashgate, Aldershot, 2007).

14 'Charles James Dale, aged 70', *Pottery Gazette*, 747–748 (1912). I thank Sir Arnold Burgen FRS for a copy of this obituary.

15 *Ibid*.; Sir Henry Dale: biographical notes on his brother Benjamin James Dale (1885–1943), Wellcome Library, Archives & Manuscripts PP/42/HHD/8.

16 Information from the late Lady Todd, Sir Henry Dale's daughter.

17 Details of Benjamin James Dale taken from *Who was Who* (1941–50), p. 282 (Adam & Charles Black, London, 1952); Dale, *op. cit*. (note 15), which includes obituary notices and assessments of Benjamin's musical achievements.

18 Feldberg, *op. cit*. (note 8), p. 80.

19 Dale had as a young man tried to get his 15-year-old brother Benjamin sent to the Leys School, with the hope of a subsequent university organ scholarship, but his father did not agree; Dale, *op. cit*. (note 15).

20 In contrast, his brother Benjamin was educated at the Stationers' Company School in Hornsey and the Oakfield School, Crouch End. These educational differences might reflect changes in family finances or location, rather than any profound thought given to his sons' different educational needs by Mr Dale.

21 'Reminiscences of Tollington Park College by E A Butler in 1915', from 'Tollington Schools of Muswell Hill' reproduced from the *Tollingtonian*, at http://tollington.com/tollingto_park_to_muswell_hill.htm (accessed 12 January 2011).
22 *Ibid*.
23 *Ibid*.
24 'Notes written by Sir Henry Dale in December 1953, accompanying notes from a lecture on Protozoa, written 1888', in Wellcome Library, Archives & Manuscripts PP/42/HHD/1.
25 *Ibid*. Dale's Royal Society obituarist, W. S. Feldberg, clearly did not have the problem of 'sparse materials' when writing Dale's biographical memoir (*op. cit*. (note 8)), which at 97 pages is one of the longest memoirs ever published by the Society.
26 Notebook, lecture on Protozoa by H. H. Dale, *op. cit*. (note 24).
27 Henry Alleyne Nicholson (1844–99) was Professor of Natural History at the University of St Andrews from 1875 to 1882, and then Regius Professor of Natural History in Aberdeen.
28 H. A. Nicholson, *A manual of zoology for the use of students*, 7th edn (Blackwood, London, 1887), quotation on p. v.
29 Feldberg, *op. cit*. (note 8), pp. 80–81, quotation from 'Autobiographical memoir [March 1958], and note of B J Dale [1964]', *op. cit*. (note 12), p. 7.
30 *Ibid*.
31 E. A. Butler, *Our household insects: an account of the insect pests found in dwelling houses* (Longmans, Green & Co., London, 1896), quotation on p. v.
32 Feldberg, *op. cit*. (note 8), p. 81.
33 D. Whitteridge, 'The origin of the *Quarterly Journal of Experimental Physiology*', *Q. J. Exp. Physiol.* **68**, 521–523 (1983), especially p. 521.
34 Feldberg, *op. cit*. (note 8), p. 81.
35 Autobiographical memoir [March 1958], *op. cit*. (note 12), p. 7. See also I. de Burgh Daly and R. A. Gregory, 'Charles Arthur Lovatt Evans', *Biogr. Mems Fell. R. Soc.* **16**, 233–252 (1970), and Edith Bülbring and J. M. Walker, 'Joshua Harold Burn', *Biogr. Mems Fell. R. Soc.* **30**, 44–89 (1984).
36 F. C. MacIntosh, *Vasodilator substances from the tissues* (Cambridge University Press, 1986), p. 185, a translated edition of J. H. Gaddum, *Gefässerweiternde stoffe der Gewebe* (Georg Thieme, Leipzig, 1936).
37 'Reminiscences', *op. cit*. (note 21).
38 All of Dale's certificates from the College of Preceptors are in the Royal Society at HD 142.2.
39 The boy who achieved the highest marks was W. W. Gibberd, later a classmate of Dale's at the Leys School, Cambridge, and his contemporary at Trinity College, Cambridge.
40 Dale's success in this examination was mirrored almost exactly in July 1901, when an earnest self-educated 20-year-old Scotsman, newly arrived in London, passed in 17 subjects and was equal first. However, that young man, Alexander (later Sir Alexander) Fleming, did not receive the award, which went to the unidentified 15-year-old with whom he had tied. See G. Macfarlane, *Alexander Fleming: the man and the myth* (Oxford Paperbacks, Oxford University Press, 1985), p. 24.
41 The certificates and their citations are in the Sir Henry Dale papers, Royal Society HD 142.3.
42 Dale was awarded an Entrance Scholarship worth about £50 per annum; see J. E. Mellor & W. H. Balgarnie, *Handbook and directory of the Leys School*, 10th edn (The Old Leysian Union, [Cambridge], 1925), p. 50.
43 The term Nonconformist is used in a general way to embrace the wide range of Protestant Dissenter constituencies; that is, those not belonging to the Established Churches of England, Wales or Scotland, and including Quakers, Baptists, Presbyterians and the several Methodist affiliations. However, the caution is remembered that 'it is a mistake to treat Protestant Nonconformity in England as though it were uniform', and the term Wesleyan Methodism is used quite specifically to refer only to that congregation; quotation from D. M. Thompson (ed.), *Nonconformity in the nineteenth century* (Routledge & Kegan Paul, London, 1972), p. 1.

44 See H. F. Mathews, *Methodism and the education of the people 1791–1851* (Epworth Press, London, 1949), especially ch. 4, 'The shaping of a Methodist education policy', pp. 109–142.

45 A useful summary of the religious tests at English Universities and the efforts to reduce and abolish them is S. J. Curtis, 'The modern universities and the ancient universities in the modern world', in *History of education in Great Britain*, pp. 421–466 (University Tutorial Press, London, 1968), especially pp. 448–457.

46 Mellor & Balgarnie, *op. cit*. (note 42), pp. 1–3. In his biography of Howard Florey, Macfarlane uses a quotation (originally C. Hill, *Reformation to industrial revolution* (The Pelican Social History of Britain, vol. 2) (Penguin Books, Harmondsworth, 1969), p. 251) that Nonconformists were fortunate not to have been exposed to the poor, stultified science teaching then available in universities, as they would have 'learnt to despise science', and points out that several prominent physiologists, for example Burdon Sanderson and Foster, also came from Nonconformist backgrounds; G. Macfarlane, *Howard Florey. the making of a great scientist* (Oxford University Press, 1979), p. 19.

47 William Fiddian Moulton (1835–98). His brother John Fletcher Moulton FRS (1844–1921), later Lord Moulton, was to cross Henry Dale's career path on several occasions. See H. F. Moulton, *The life of Lord Moulton* (Nisbet, London, 1922); E. M. Tansey, 'The Wellcome Physiological Research Laboratories 1894–1904: the Home Office, pharmaceutical firms and animal experiments', *Med. Hist.* **33**, 1–41 (1989).

48 The Leys School lists up to 1920 show 43 first-class honours degrees in science subjects, two in engineering, seven Fellows of the Royal College of Surgeons and one Fellow of the Royal College of Physicians, in contrast with 14 and 11 'Firsts' in classics and history, respectively; Mellor & Balgarnie, *op. cit*. (note 42), p. 137. The situation in other schools can be gauged from reports of the Association of Public School Science Masters, *The correlation of mathematical and science teaching* (George Bell & Sons, London, 1909), and Association of Public School Science Masters, *Registration of medical students* (George Bell & Sons, London, [n.d., but after 1912]), which appealed, well into the twentieth century, for organized, properly examined science teaching. Fellows of the Royal Society had been active in campaigns for science education at various periods during the nineteenth century; see, for example, M. Gowing, 'The Wilkins Lecture, 1976. Science, technology and education: England in 1870', *Notes Rec. R. Soc*. **32**, 71–90 (1977); Pippard, *op. cit*. (note 10).

49 Quotation from *The Leys Fortnightly*, vol. 15, pp. 321–322 (1890). The plans were for chemical, physical and biological laboratories (elementary and advanced), a lecture theatre and a set of smaller rooms. Details of these and other matters to do with the Leys School are taken from volumes of *The Leys Fortnightly*, volumes 15–20 (1890–95).

50 Mellor & Balgarnie, *op. cit*. (note 42), pp. 4–5.

51 Barcroft, later Sir Joseph Barcroft FRS, became Professor of Physiology at Cambridge. The quotation is from K. J. Franklin, *Joseph Barcroft, 1872–1945* (Blackwell, Oxford, 1953), p. 27.

52 The relevant certificates are in Sir Henry Dale papers, Royal Society HD 142.2.

53 Started in May 1878 by the science master, Mr A. H. S. Lucas, the society's museum collection was gradually divided and subdivided into specialist sections, each under a schoolboy curator. The society also had its own library, dark room and telescope. Mellor & Balgarnie, *op. cit*. (note 42), pp. 58–60.

54 Three or four lectures were given during term-time, at least one from an external speaker, such as the physiologist Dr Alexander Hill, Master of Downing College, who spoke on 'From eye to hand'. In later years Dale, too, was asked to address the school Science Society on the subject of 'Electric fishes', for which he approached several colleagues for the most up-to-date information, and promised the society 'a number of rather good lantern slides'; Royal Society HD 80.4, 'Leys School Science Society, 1952'.

55 Dale continued to play lacrosse while at Cambridge University, again playing for the second team; details taken from several reports in *The Leys Fortnightly* (1894–95).

56 One debate, 'That this house condemns Tit-Bits and its imitators', records: 'H H Dale thought that those who condemned Tit Bits looked at the question from a wrong standpoint. They looked at it from the viewpoint of educated gentlemen. They must also look at it from that of men who had no such privileges, and consequently could not appreciate good literature.' The motion was defeated. On a later occasion Dale spoke in opposition to the motion 'That in a schoolboy's life, the training of the body is of greater importance than the training of the mind', but supported a motion to abolish the House of Commons. He occasionally performed in the School's dramatic productions, playing minor roles such as the third daughter in Sheridan's 'The Critic'.

57 Kimmins was also Staff Lecturer in Chemistry for the Cambridge University Extension Scheme and based in Downing College. In C. W. Kimmins, *The chemistry of life and health* (Methuen & Co., London, 1892), p. v, he claims: 'The vast importance of the study of the Laws of Health is becoming so generally recognised that in future no System of Education will be considered complete which does not embrace this subject in its curriculum.' In later years he became the Chief Inspector of Science in Schools for the London County Council; see, for example, A. H. Radice, *Home and school* (with preface by C. W. Kimmins) (Partridge, London, 1926). He also developed a particular interest in psychology; see, for example, C. W. Kimmins, *Children's dreams. An unexplored land* (George Allen & Unwin, London, 1937).

58 Alfred Hutchinson was the first Leys schoolboy to achieve a university degree, and soon after Dale's arrival, on 24 November 1891, the school was granted a holiday when Joseph Barcroft became the second; details are taken from *The Leys Fortnightly*. Franklin, *op. cit*. (note 51), p. 26, reports the mistaken family belief that Barcroft was the first. When a Cambridge undergraduate, Dale too returned to the Leys as an assistant master. It is this capacity that his photograph is included in a centenary history of the school: D. Baker, *Partnership in excellence, a late Victorian educational venue: the Leys School,Cambridge 1875–1975* (The Leys School, Cambridge, 1975), photograph 43b between pp. 160 and 161.

59 Feldberg, *op. cit*. (note 8), p. 83.

60 *Ibid*., pp. 83–84. Joseph Barcroft agreed: he too acknowledged Kimmins's influence and noted that 'contact with the University no doubt helped'; in Franklin, *op. cit*. (note 51), pp. 26–27.

61 *The Leys Fortnightly*, vol. 18 (1893–94), pp. 28–33, carries a detailed description by A. Hutchinson of the new laboratories and their facilities, the biological laboratories containing physiological equipment and adequate lighting for microscope work, in addition to a wide range of reagents necessary for experiments and demonstrations in chemical physiology. See also the report in *The Times* of the opening of the new science building: 'Science in public schools', *The Times* (30 October), p. 8 (1893).

62 Michael Foster was then the Professor of Physiology at Cambridge University. See G. Geison, *Michael Foster and the Cambridge School of Physiology: the scientific enterprise in late Victorian society* (Princeton University Press, 1978).

63 Autobiographical memoir [March 1958], *op. cit*. (note 12).

64 'Dr. M. Foster on the teaching of physiology in schools', *Nature* **51**, 487–488 (1895); a footnote explains that Foster was asked by the Headmasters' Association for advice on the subject.

65 Hugh Ker Anderson, then a departmental demonstrator in the Physiological Laboratory, and later Master of Caius College.

66 Report of the Natural History and Science Society, 25 November 1893, in *The Leys Fortnightly*, vol. 18, p. 111 (1893–94).

67 Dale wrote a number of articles for the magazine, which are usually initialled. It has been possible, from later comment and correspondence in the magazine, to identify some of his anonymous contributions, but not to verify the authorship of the report of the Foster talk.

68 He won prizes for translating both German and Latin verse into English, and for two magazine articles, both of which had been published anonymously.

69 Other school fellows included J. H. Clapham, later Professor of Economic History at Cambridge and President of the British Academy when Dale was President of the Royal Society; and H. C. Gutteridge, Professor of International Law at Cambridge. Details are taken from Feldberg, *op. cit*. (note 8), p. 84, Franklin, *op. cit*. (note 51), pp. 27–28, and various university and college registers.

70 H. H. Dale, 'Sir Michael Foster, KCB, FRS. A Secretary of the Royal Society', *Notes Rec. R. Soc*. **19**, 10–32 (1964), quotation on pp. 25–26.

71 Dale frequently commented on the role of chance in his own and others' experimental work, remarking that some of his most notable scientific discoveries had come about as the result of unusual circumstances rather than careful planning. See H. H. Dale, 'Accident and opportunism in medical research', *Br. Med. J.* **ii**, 451 (1948), and E. M. Tansey, 'Henry Dale, histamine and anaphylaxis: reflections on the role of chance in the history of allergy', *Stud. Hist. Phil. Sci.* C **34**, 455–472 (2003).

72 Dale, 'Papers from a lecture on Protozoa' with a note on its origin written in December 1953, *op. cit*. (note 24). Dale and his brothers were all subscribers to their old teacher's major zoological work, E. A. Butler, *A biology of the British Hemiptera–Heteroptera* (H. F. & G. Witherby, London, 1923), and in 1927 Dale unveiled a portrait of Butler at an Old Boys' Day at the school, 'A short Tolly history—part one, 1879–1928' at http:www.tollington.com/short_tolly_history_pt1.htm (accessed 28 February 2011).