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The First World War, Academic Science, and the "Two Cultures": Educational Reforms at the University of Cambridge

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SHORTLY AFTER THE FIRST WORLD WAR, William J. Pope, professor of chemistry at the University of Cambridge, wrote to Ernest Rutherford to encourage him to return to Cambridge to succeed his former teacher J.J. Thomson, the recently appointed master of Trinity, as Cavendish professor of experimental physics. "Our classical friends have lost status during the last few years," Pope confided to Rutherford, who was then professor of physics at Manchester, "and all now realise that the future of the University is in the hands of the experimental science people."[1] For Rutherford, who did accept the offer and went on to make the Cavendish Laboratory the Mecca of nuclear physics, Pope's confidential letter probably played only a minor role. But for historians of science and universities, Pope's statement raises a number of intriguing questions about the effect of the First World War on academic science and its relationship with the humanities. Was Pope's allusion to the conflict during the war between science and the humanities, for example, an antecedent of the clashes between the "two cultures", the term popularised by C.P. Snow in the 1950s which still reverberates today?[2] If so, in what ways does this modify our evaluation of the role of the First World War in the shaping of science and higher education in the twentieth century?

Several recent scholarly works have examined the effect of the First World War on science and higher education in Europe, the United States and Japan.[3] There are also accounts of scientific developments at Cambridge in the early years of this century, especially in physics, physiol-

[1] William J. Pope to Ernest Rutherford, 11 March, 1919, in Papers of Ernest Rutherford, Cambridge University Library.

[2] Snow, C.P., *The Two Cultures and a Second Look* (Cambridge: Cambridge University Press, 1984; first edn 1959). For a controversial look at current American debate, see Gross, Paul R. and Levitt, Norman, *Higher Superstition: The Academic Left and its Quarrels with Science* (Baltimore: Johns Hopkins University Press, 1994), esp. pp. 7–9, 241–244.

[3] For a general survey, see Rudy, Willis, *Total War and Twentieth-Century Higher Education: Universities of the Western World in the First and Second World Wars* (Rutherford: Fairleigh Dickinson University Press, 1991). On the effect on American universities, see Geiger, Roger L., *To Advance Knowledge: The Growth of American Research Universities, 1900–1940* (New York: Oxford University Press, 1986). On the Japanese experience, see Bartholomew, James R., *The Formation of Science in Japan: Building a Research Tradition* (New Haven: Yale University Press, 1989), Ch. 7.

ogy and biochemistry.[4] However, the effect of the war on science in general and academic science at Cambridge in particular is not very clear. Most of the literature on the First World War by historians of science has focused on scientific internationalism.[5] Few case studies explore the shift of national science and education policy during and after the war.[6] Fewer still examine in detail the intricate connections between the war and the rise of science in modern universities which Pope's statement suggested. The vast literature on Cambridge science—mostly biographical—largely concentrates on either the nineteenth century or the period between the two world wars.[7] Although these works provide invaluable background and perspective, they are necessarily incomplete, leaving, for example, the changing relations between the "two cultures" unaccounted for.

The restructuring of the University of Cambridge during the First World War can be seen both as the culmination of a long struggle for reform and as the crucial event that shaped the institutional context of science between the wars. The university continued to enjoy, with the University of Oxford, a special status as an ancient and national university. However, this institutional transformation was not an isolated incidence but rather part of a powerful movement for reform in British science and universities during and after the First World War. Three major changes affected scientific and educational practices at Cambridge. These included the abolition of the compulsory examination in Greek, the introduction of the degree of Doctor of Philosophy—the PhD—and the establishment of governmental financial support.

Cambridge and the Scientists' Campaign during the First World War

Although most historians of science regard the Second World War as the turning point in the maturing of the partnership between science and government, especially in the United States, the First World War proved

[4] See, e.g., Hendry, John (ed.), *Cambridge Physics in the Thirties* (Bristol: Adam Hilger, 1984); Crowther, J.G., *The Cavendish Laboratory 1874–1974* (New York: Science History Publications, 1974); Geison, Gerald, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late Victorian Society* (Princeton: Princeton University Press, 1978); and Needham, Joseph and Baldwin, Ernest (eds), *Hopkins and Biochemistry, 1867–1947* (Cambridge: W. Heffer, 1949).

[5] See, e.g., Kevles, Daniel, " 'Into Hostile Political Camps': The Reorganization of International Science in World War I", *Isis*, LXII (Spring 1971), pp. 47–60; Badash, Lawrence, "British and American Views of the German Menace in World War I", *Notes and Records of the Royal Society of London*, XXXIII (1979), pp. 91–121; Forman, Paul, "Scientific Internationalism and the Weimar Physicists: The Ideology and its Manipulation in Germany after World War I", *Isis*, LXIV (1973), pp. 151–180.

[6] But see Roy MacLeod on British science and technology, e.g., "The Chemists go to War: The Mobilization of Civilian Chemists and the British War Effort, 1914–1918", *Annals of Science*, L (1993), pp. 455–481.

[7] For a review of recent examples, see Seidel, Robert W., "Nuclear Physics under Rutherford at Cambridge", *Historical Studies in the Physical and Biological Sciences*, XVII (1986), pp. 175–181; and Williamson, Rajkumari (ed.), *The Making of Physicists* (Bristol: Adam Hilger, 1987).

more catalytic for most other countries. Barely a few weeks after the outbreak of conflict in 1914, the journal *Nature* concluded that "this war, in contradiction to all previous wars, is a war in which pure and applied science plays a conspicuous part". Claiming that "the first duty of all men of science" during wartime was to serve the War Office "unreservedly", it called on scientists to organise themselves for work on military technology.[8] Others agreed, calling the war a contest "of engineers and chemists quite as much as of soldiers".[9] Anti-submarine and chemical gas warfare provided the best known, although not the earliest, indication of the vital importance of science to national defence. The shortage of critical chemical materials, which Britain had imported from Germany, sounded the alarm before the advent of the U-boat and the poisonous cloud. In particular, the crisis in the British textile industry, which had depended on Germany for about 80 per cent of its dyestuffs, threatened an important part of the national economy and consequently affected the government's efforts to mobilise for war.[10]

Tracing the difficulties of the chemical and textile industries to a national indifference to science and science education, British scientists waged a powerful campaign to promote science in the country's educational, industrial and governmental systems. While such complaints about the lack of attention and support were, of course, not new—struggles for recognition of the scientific profession started in the nineteenth century, if not earlier—the war offered the advocates of science an unprecedented opportunity to make their case. It provided a sense of urgency in general and a medium for displaying the utility of science in particular, both of which were exploited to good effect.[11]

Scientists at Cambridge, many of them prominent figures in the British scientific establishment, participated in the movement to enhance the position of science—when they were not busy working on various war-related projects. They wrote articles for *Nature*, sent indignant letters to *The Times* and other newspapers, and held well-publicised conferences on the subject. For example, Lord Rayleigh, the former Cavendish professor of experimental physics and the chancellor of the University of Cambridge, lent his considerable weight to the campaign on behalf of science. In 1916, he and Sir Arthur Shipley, a zoologist and vice-chancellor of Cambridge, joined a group of prominent scientific spokesmen to issue a "Memorandum on the Neglect of Science".[12] The memorandum concluded that the

[8] "Science and the State", *Nature*, XCII (29 October, 1914), pp. 221–222.

[9] Fleming, J.A., "Science in the War and After the War", *Nature*, XCVI (14 October, 1915), pp. 180–185.

[10] "The War—and After", *Nature*, XCIV (10 September, 1914), pp. 29–30; and Gardner, Walter M., "The Manufacture of Dyestuffs in Britain", *ibid.* (21 January, 1915), pp. 555–557.

[11] See Turner, Frank M., "Public Science in Britain, 1880–1919", *Isis*, LXXVI (1980), pp. 589–608, esp. 603–607.

[12] See Poole, J.B. and Andrews, Kay (eds), *The Government of Science in Britain* (London: Weidenfield & Nicolson, 1972), pp. 72–78.

examinations for entrance into the Universities of Oxford and Cambridge, and for appointment into the civil service and army, should be reformed to give more weight to science. Only then, they argued, would the public change its "indifferent" and even "contemptuous" attitude towards the natural sciences. The group later held a widely publicised national conference on the "Neglect of Science", which Rayleigh chaired and used as a forum to deplore the ignorance of science shown "by all classes of society".[13] Although some recent scholarly studies suggest that the British government had a long tradition of relying on technology in its military strategy, the perception that science and technology were being neglected was nevertheless prevalent.[14]

This advocacy of science set the tone of the reform across the country, and at the University of Cambridge in particular. Given its illustrious tradition of scientific accomplishments, why did its practitioners perceive a "neglect of science"? Individually, and by the standard of the time, the successors of Isaac Newton and James Maxwell such as James Larmor and J.J. Thomson enjoyed great national and international scientific prestige as well as ample financial support for their scientific research. The difficulty was more institutional. During the first two decades of the twentieth century, laboratories became more expensive to equip and operate and often required team-work with great demand for assistants and technicians. At the same time, science became specialised and required a new educational system with its own curriculum and degrees to aid in the selection and training of students. Scientists felt that the traditional university and college structure failed to accommodate these rising needs, and their calls for reform mounted. By the beginning of the war, the matter became a rallying cry for the restructuring of the entire educational system.

From the Chemical Industry to Science Education

At the national level, scientists at Cambridge and spokesmen for science from elsewhere first took up the issue of the chemical industry. They made effective use of the media, especially of *Nature*, in an effort to increase public appreciation of their profession. The poor performance of the British chemical industry in utilising science and technology was contrasted with the excellent German system. However, they claimed, the fault did not lie with the British scientists. Many members of the public, including some members of parliament, acknowledged that their "men of science" were as good as, if not better than, their German counterparts. The scientific work of young British chemists "stands second to none", according to an article

[13] *Ibid*, p.77; "Science in Education and the Civil Services", *Nature*, XCVII (11 May, 1916), pp. 230–231.

[14] See, e.g., Edgerton, David, *England and the Aeroplane: An Essay on a Militant and Technological Nation* (Basingstoke: Macmillan Press, 1992), and "The Prophet Militant and Industrial", *Twentieth Century British History*, II (1991), pp. 360–379.

in *Nature*.[15] Rather, many blamed the ignorance of science in the British government, industry and education for the crisis in the chemical industry. On 6 May, 1915, for example, a high-level delegation of scientific societies, led by the Royal Society, met members of the Board of Education and Board of Trade to urge the government to help forge closer ties between industrialists and scientists and to strengthen science education.[16] In addition, scientists implored the government to formulate a strong science and technology policy to accomplish these goals.[17]

In response, in 1915 the government created, using subsidies, a chemical company, British Dyes Limited, to salvage the crumbling textile industry. However, the lack of technical experts among the company's leaders infuriated many scientists.[18] One governmental official explained that scientific expertise might make a scientist unduly influential on the board. This entrenched belief that experts should properly be "on tap" but not "on top", and the old-fashioned gesture towards "fair play", were immediately denounced by scientists as not only an example of mediocre policy but outright dangerous—only the enemy would find "gratifying and useful" this system of appointment on ignorance rather than on competence.[19] It was charged that "the British custom of entrusting the management of large concerns to financiers, commercial magnates and 'men of affairs' has done much to retard the scientific development of our industries".[20]

Pope, a major participant in the research on gas warfare in Britain and president of the Chemical Society by the end of the war, also used British Dyes Limited as an example of the shortcomings of the British way of organising science. He was especially critical of the hierarchical and inefficient science policy establishment. One had to climb a vertical maze of gradually "higher, and even less learned, authorities [to get to] the real, but sublimely ignorant, fountain head" to get anything done, he complained in 1915.[21] In another popular speech criticising "appointment by ignorance", Pope charged that "the exclusively British method of making the specialist entirely subservient to the administrator" was responsible for "the horrors" in the early phase of the war.[22] In a third article, he went even further and

[15] "Duty-free Alcohol for Scientific Purpose", *Nature*, XCV (4 March, 1915), pp. 11–12. The parliamentary discussion of the government's proposal for a new science and technology agency was reported in "An Advisory Council on Industrial Research", *ibid.* (20 May, 1915), pp. 321–327.

[16] "The Government and Chemical Research", *ibid.* (13 May, 1915), pp. 295–296.

[17] Gardner, W.M., "The Manufacture of Dyestuffs in Britain", *op. cit.*

[18] Ross, Ronald, "Organization of Science", *Nature*, XCIV (3 December, 1914), pp. 366–367; and "Attempts to Manufacture Scientific Discovery" (7 January, 1915), pp. 512–513. See also J. F. Thorp's letter to *The Times*, 2 February, 1915, reported in *ibid.* (4 February, 1915), p. 622.

[19] "Science and Industry", *Nature*, XCV (18 March, 1915), pp. 57–59.

[20] Gardner, W.M., "The Manufacture of Dyestuffs in Britain", *op. cit.*

[21] Pope, W.J., "The Shortage of Dyestuffs," *Nature*, XCVII (20 April, 1916), pp. 163–164.

[22] "Notes", *Nature*, C (11 October, 1917), pp. 110–111; "Professor Pope Protests", *The Cambridge Magazine*, VII (13 October, 1917), p. 6.

declared that "the war is directly traceable to the contempt with which experimental science has been systematically treated by the more influential circles of the British community". Such "contempt" for science made the Germans believe that Britain could not establish a successful chemical industry and "war seemed hence a safe proposition".[23]

Despite this controversial beginning, the government's wartime initiatives in science and industrial policy did mark a new departure from the traditional policy of *laissez-faire*. British Dyes did much to help the recovery of the British textile industry. Likewise, the government moved to strengthen its role in science and education. Soon after the visit of the delegation of scientific societies led by the Royal Society, the Board of Education proposed a "Scheme for the organization and development of scientific and industrial research" which indicated the government's willingness to encourage and finance scientific activity. The government first established an Advisory Council for Scientific Research, and in 1918 transformed it into the Department of Scientific and Industrial Research (DSIR), which provided grants for university research with industrial relevance.[24]

The government's actions were designed to boost applied research rather than basic research, which was understandable both in terms of the necessities of wartime and the traditional governmental policy of using public funds for practical purposes. Yet, in a debate foreshadowing later debates in Britain and the United States, scientists pointed to the potential danger of upsetting the balance between basic and applied research. Lest the emphasis on applied science—which they themselves were helping to promote—persisted and dominated British science policy after the war, they made a special point, whenever appropriate, of mentioning the vital role of "pure science".

In 1917, a group of eminent Cambridge professors and alumni published *Science and the Nation* to enlighten the lay public on the importance of science. Edited by A.C. Seward, professor of botany, master of Downing College and formerly vice-chancellor, the book's contributors included Pope, the physicist W.H. Bragg and the biochemist F. Gowland Hopkins. They attempted to illustrate that pure science was not merely "a purely academic subject", but was the source of many practical applications that brought national strength and prosperity. Chemical products, X-rays, wireless telegraphy, bacteriology and other examples crowded the pages to prove the point. In many ways, the tenor of the collection anticipated that of Vannevar Bush in *Science: The Endless Frontier* in the American context

[23] Quoted in Morton, Jocelyn, *Three Generations in a Family Textile Firm* (London: Routledge and Kegan Paul, 1971), p. 217.

[24] Part of the White Paper is in Poole, J.B. and Andrews, K. (eds), *The Government of Science in Britain op. cit.*, pp. 65–68. See also MacLeod, Roy M. and Andrews, E. Kay, "The Origins of the D.S.I.R.: Reflections on Ideas and Men, 1915–1916", *Public Administration*, XLVII (Spring 1970), pp. 23–48.

of the Second World War, although it was not an official report and did not set out an explicit national science policy.[25]

The interesting parallel between British and American science did not end there. Again, anticipating the American response to the challenge of the Soviet sputnik four decades later, many British scientists advocated science education as the key to improving national strength during the crisis precipitated by the First World War. Pope, for example, believed that "if it were generally demanded that no person should be regarded as reasonably educated who had not mastered the rudimentary principles of natural science and scientific method", some of the most acute initial difficulties of the British chemical industry could have been avoided.[26] Lord Rayleigh, in his campaign against the "neglect of science", also pointed to the need for educational reform, with more emphasis required for science in the curriculum.[27] Lord Moulton, head of the explosives supplies department of the War Office during the war, and a Cambridge alumnus (senior wrangler, 1868), supported the call for educational reform. In his introduction to *Science and the Nation*, he asked the public to "change radically our conception of national education". Traditional education was dominated by "ancient languages and humanities" that had "no practical value". Instead, he urged that students be trained in scientific methods. A scientific education indeed became the major item on the agenda of the campaign to end the neglect of science.[28]

But what would make a scientific education? The question was dealt with officially in 1916 when the prime minister appointed a "Committee on the Position of Natural Science in the Educational System of Great Britain". J.J. Thomson, then president of the Royal Society and Cavendish professor, was appointed chairman of the committee. As it turned out, many of the recommendations of the Thomson committee's report, which was published in 1918, became the battle-cries of reformers in science education, at the University of Cambridge and elsewhere. The report included a proposal to abolish compulsory Greek in the examinations for a degree in Cambridge and Oxford, condemning it as "a real and irritating hindrance to the study of science".[29] It supported the introduction of the PhD degree as vital to progress in modern science and scholarship. Of most significance, the report urged that the government provide financial aid to universities, for

[25] Seward, A.C. (ed.), *Science and the Nation: Essays by Cambridge Graduates* (Cambridge: Cambridge University Press, 1917).

[26] "Notes", *Nature*, C (11 October, 1917), pp. 110–111.

[27] "Science in Education and the Civil Services", *ibid.*, XCVII (11 May, 1916), pp. 230–231.

[28] Seward, A.C. (ed.), *Science and the Nation*, *op. cit.*, pp. xviii–xix. See also Moulton, Lord, *Science and War: The Rede Lecture 1919* (Cambridge: Cambridge University Press, 1919); T.M., "Moulton, John Fletcher", in *The Dictionary of National Biography 1912–1921* (London: Oxford University Press, 1927), pp. 392–394.

[29] Committee on the Position of Natural Science in the Educational System in Great Britain, *Natural Science in Education* (London: HMSO, 1918), p. 183. H.G. Wells also blamed the "Greek shibboleth" for the rift between science and the humanities: see Cardwell, D.S.L., *The Organization of Science in England* (London: Heinemann, 1972), pp. 223–224.

their scientific research and facilities.[30] Scientific reformers and their allies at Cambridge took up these three issues one by one.

The Abolition of Compulsory Greek

When Pope wrote to Rutherford about the loss of status of his "classical friends", he probably had in mind a recent vote in its governing body, the university senate—which then comprised all MAs of the university—to abolish compulsory Greek as part of the degree examination.[31] Perhaps more than anything else, the "Greek question" had long been a rallying point for reform, and not for scientists alone. The war provided the final push.

Several forces in the reform movement had been at work to abolish compulsory Greek. The strongest came from those who advocated more modern languages and more science. As early as 1912, commentaries began to appear in the newly established liberal weekly, *The Cambridge Magazine*, attacking what was perceived as the hegemony of the classics. One critic of the domination of classics observed bitterly that some Cambridge colleges "gave as much scholarship money for Classics as for Natural Sciences, History, and Modern Languages put together".[32] The neglect of modern languages such as German, and even English, was described as "a serious national danger" and the abolition of compulsory Greek in "Little Go"—the examination for a non-honours "pass" degree—was seen as a key to changing the situation.[33] One commentator felt that the classics-dominated education at Oxford and Cambridge was outdated and impractical. It led to "neither bread-winning nor Empire-building".[34] Many schoolmasters complained that the emphasis on Greek and Latin at Oxford and Cambridge dictated a rigid curriculum for pre-university education. The onset of war brought home the need for foreign languages and the irrelevance of the classics as officials sought to meet the demand for interpreters in German and French.

As the Thomson committee's report indicated, scientists regarded the requirement for a classical language as an obstacle to scientific training and research. The days when Latin was the international language of science were long gone and scientists felt it was a waste of time to study and pass examinations in classics. The requirement for Greek embodied, to them, the domination of the classics over other more recent learning. The attack

[30] *Natural Science in Education, op. cit.*, pp. 199–208.

[31] "University and Educational Intelligence", *Nature*, CII (23 January, 1919), p. 417.

[32] Compton, R.H., "Commercial Classics", *The Cambridge Magazine*, VI (27 January, 1917), p. 243.

[33] D.T.B.W., "The Neglect of German", *The Cambridge Magazine*, I (27 April, 1912), pp. 257–258; Benson, A.C., "A School of English", *ibid.*, III (6 December, 1913), pp. 225–226; "The Recognition of English", *ibid.*, VI (3 March, 1917), pp. 397–398.

[34] Kekewich, Sir George, "Classics and the University Curriculum", *ibid*, I (25 May, 1912), p. 369.

on Greek became both programmatic and symbolic, drawing support from outside the university, and in one important instance even from abroad. In 1908, Andrew Carnegie, the American industrialist and philanthropist whose support was much sought after in both the United States and Britain, cited compulsory Greek as among his reasons to refuse a request for funds from Chancellor Rayleigh on behalf of Cambridge. Both Oxford and Cambridge, Carnegie lamented, "committed the offence of requiring scientific students to waste time studying a dead language, an insult to Science, which has been the Cinderella of the family of knowledge quite long enough". Echoing many other advocates of science he added: "It is to science that we have chiefly to look for the future progress of Man."[35]

Although many realised, from the start of the campaign, that science was "the cuckoo likely to thrust Greek out of the nest", repeated efforts in this direction before the war had failed.[36] Only the enhanced public image of scientists during the war made it possible to overthrow the traditionally powerful forces in support of the classics. Sir Joseph Larmor, the mathematical physicist who occupied Newton's chair, and member of parliament for the university which was then independently represented, warned in 1916 that "if the university does not prepare for taking action [to abolish compulsory Greek] as soon as the war is over there is great danger that the matter may be taken out of their hands"—perhaps by a Royal Commission.[37] In early 1917, a memorandum was signed by some 200 members of the university senate urging its executive body, the council, to act fast on the "Greek question". In a strong show of solidarity, professors of science and medicine, such as Thomson, Pope, F.G. Hopkins (biochemistry), J.N. Langley (physiology), A.S. Eddington (astronomy) and Clifford Allbutt (medicine), comprised about two thirds of the 25 professorial signatories. They insisted that "in the altered circumstances of the nation . . . Greek must be made optional".[38]

Under pressure, the conservative council released a report one year later that recommended the abolition of compulsory Greek. But it replaced Greek with compulsory natural science![39] In the ensuing debate on the report in the senate, a sharp exchange took place between advocates and opponents of compulsory Greek. William Ridgeway, the arch-conservative professor of archaeology who also held a readership in classics, led the

[35] Andrew Carnegie to Lord Rayleigh, 2 September, 1908, as printed in Robert John Strutt, *Life of John William Strutt, Third Baron Rayleigh* (Madison: University of Wisconsin Press, 1968, 2nd edn), pp. 324–325.

[36] *Cambridge Review*, XL (14 March, 1919), pp. 257–258.

[37] Transcripts of Cambridge senate meeting of 13 May, 1916, reported in "[Senate] Discussion of Reports", *Cambridge University Reporter*, 23 May, 1916, p. 789. Also see "Compulsory Greek?", *The Cambridge Magazine*, V (27 May, 1916), pp. 493–494.

[38] "The Greek Question: An Imposing Memorial", *The Cambridge Magazine*, VI (3 March, 1917), p. 386.

[39] "Academia", *ibid.*, VII (20 April, 1918), p. 612; "Hard Options", *ibid.* (11 May, 1918), pp. 684–686.

offensive on behalf of the classics. "The attack on Greek," he declared, "is simply an attack upon the Humanities generally." He believed humanities and classics were "the best training for the mind". The scientists' education was, according to him, too narrow. They had done "so little" during the war; they had even "caused shortage of beef" because some of them "did not know difference between 'dead weight' and 'live weight' ". Therefore, Ridgeway concluded, "the scientific people of this country ought not to carry very much weight" in educational policy-making.[40] "A kind of anti-Greek bacillus" may have attacked the scientists, diagnosed Peter Giles, the master of Emmanuel and a scholar of comparative philology.[41]

E.W. Hobson, the Sadlerian professor of pure mathematics, tried to justify the decision to make science compulsory. He referred to the "discussion in the last few years on the danger resulting from insufficient attention to natural science". Moreover, he argued, the real parallel was between on the one hand natural science, and on the other all languages put together, including Greek and Latin.[42]

Interestingly, not many scientists came to the defence of compulsory science. Many advocates of reform thought it would be a "disastrous policy" to replace one tyranny with another, whether the tyranny were Greek or science. This sentiment against coercion was probably shared by a majority of the scientists, despite their natural desire to see science given more weight in the curriculum at Cambridge University. The measure dissatisfied them also because they had not been consulted on the matter.[43] Two votes in the senate in 1919 abolished compulsory Greek by 161 votes to 15, and vetoed compulsory science by 119 votes to 50.[44] The final scheme made both Greek and science optional; Latin was later put on the same footing as Greek.[45]

One goal of many scientists in their wartime campaign was now achieved. The campaigners for science had effectively taken advantage of the call for a utilitarian education. By building an effective coalition with the modern linguists, scientists flexed their muscles to defeat the classicists in the battle over compulsory Greek.

The Introduction of the Degree of Doctor of Philosophy

Another goal of the scientist-reformers at Cambridge during the war was to introduce the degree of Doctor of Philosophy. As a research degree, the

[40] Transcripts of Cambridge senate meeting of 25 April, 1918, reported in "Discussions of Reports", *Cambridge University Reporter*, 7 May, 1918, pp. 649–650. Ridgeway was also an ardent anti-feminist: see "Notes and Comments", *The Cambridge Magazine*, III (7 March, 1914), p. 433; "Salvage", *ibid.*, VI (17 February, 1917), pp. 322–323; and "Miss Harrison's reply to Professor Ridgeway," *ibid.* (24 February, 1917), p. 367.

[41] Transcripts of Cambridge senate meeting of 25 April, 1918, *op. cit.*, p. 653.

[42] *Ibid.*, p. 654.

[43] "The Opportunity of Science", *The Cambridge Magazine*, VIII (1 March, 1919), p. 449.

[44] "Discussion of Reports", *Cambridge University Reporter*, 21 October, 1919, p. 165; *The Cambridge Review*, XL (23 May, 1919), p. 318.

[45] Cambridge University, *The Student's Handbook to the University and Colleges of Cambridge 1922* (Cambridge: Cambridge University Press, 1922), pp. 303–307.

PhD was widely expected to encourage the creative spirit of science and other modern subjects such as modern languages and the rising social sciences. Rutherford, for example, thought highly of the PhD and played an active role in its acceptance at Manchester. Shortly before returning to Cambridge, he extolled the new degree as "a real and very great departure in English education—the greatest revolution . . . of modern times".[46] On this prediction, he was to be adequately vindicated.

The movement towards research degrees at the University of Cambridge actually began at least as early as 1879, when a degree of Doctor of Science was created.[47] In 1895, the university passed another milestone when a new regulation permitted graduates from other "recognised universities" to earn a Cambridge BA through research alone. Critics of the change feared that the scheme would attract only "degree-hunters" to Cambridge.[48] But scientific men such as J.J. Thomson strongly supported the research BA. In later years, he was proud to point out that it was under this new scheme that Rutherford came to the Cavendish from New Zealand in 1895.[49]

The establishment of the DSc and research BA mitigated the agitation for more research degrees until 1913-14 when proposals were made for a lower doctorate, such as the PhD.[50] This measure was defeated but the war breathed new life into the ferment for more research degrees. In 1916, the general board of studies, responsible for university teaching and research, proposed the enactment of degrees of bachelor of literature and of science by research.[51] Although the scheme met with much approval during a senate discussion on the subject, critics viewed it as a temporary solution. J.J. Thomson, for example, suggested instead that a doctorate be awarded to a student who had completed six terms in residence and "a satisfactory piece of research". Among his arguments for the PhD, Thomson took special note of the diplomatic implications since the degree would help to attract students from neutral countries, in particular the United States, who traditionally went to Germany to study for the PhD.[52] Thus, national security and international prestige were factors in British debates over educational and science policy during the First World War, just as they were in the United States in the aftermath of the sputnik crisis in the 1950s.

Strong opposition to the proposal came from a strange alliance of two former rivals on the "Greek question", Hobson and Ridgeway. As repre-

[46] "Conference of Universities", *Nature*, CI (16 May, 1918), p. 208.

[47] Simpson, Renate, *How the PhD Came to Britain: A Century of Struggle for Postgraduate Education* (London: Society for Research into Higher Education, 1983), p. 62.

[48] *Ibid.*, p. 64.

[49] Thomson, J.J., *Recollections and Reflections* (New York: Macmillian Company, 1937), pp. 136–137.

[50] Sartain, W.J., "The University and Research. II: The Establishment of the PhD Degree", *The Cambridge Review*, LXXVI (30 April, 1955), p. 482.

[51] Cambridge General Board of Studies, "Report of the General Board of Studies on Degrees for Research", *Cambridge University Reporter*, 6 October, 1916, pp. 50–51.

[52] "Discussion of a Report", *ibid.*, 14 November, 1916, p. 219.

sentatives of mathematics and classics, the two traditionally dominant fields of study at Cambridge, they balked at the proposed PhD for fear that it would lower the standard of the existing doctorates and be stigmatised as "inferior". They also turned around the nationalism implicit in Thomson's argument in their counterattack. Hobson claimed that the PhD "was a piece of goods made in Germany", and Thomson's proposal was "a piece of window dressing quite unworthy of the dignity of the university".[53] As a compromise, the general board of studies established research master's degrees, but not the PhD. In its report, the board insisted that the high standard of the existing doctors of letters and of science offered "a great incentive to research", which might be lessened were a lower doctorate instituted.[54]

Although this policy of stalling prevailed during the war, Cambridge felt increasingly isolated on the matter. Great pressure came from Oxford and many other British universities which adopted or planned to adopt the PhD degree during the war. Finally, the Foreign Office intervened to express its desire that the University of Cambridge institute "a two year doctorate for American graduates" to overcome the competition from Germany.[55] Once again, education and science were called on to enhance national security and prestige long before the Cold War made them central parts of national strategy.

Finally, the university appointed a committee to investigate the matter anew. Less conservative than the general board of studies, the committee, after an extensive inquiry, recommended the introduction of the PhD degree at Cambridge. On 22 February, 1919, the senate voted 84 to 26 to approve the proposal.[56] *The Cambridge Review* commented afterwards that "at a time like this, when Cambridge science has attracted national attention . . . it is fitting that the basis of the highest type of University study should be broadened".[57]

The creation of the PhD at Cambridge marked, in a significant way, the modernisation of the university in the emerging era of "big science". It not only provided a universally recognised academic qualification but also an important means of training future scientists. Both factors helped to accelerate the professionalisation of science.

The new degree's significance for science in Cambridge can be seen from the following statistics. According to topics of their dissertations in 1921, two out of the first four PhDs at Cambridge were in science. Subsequently, the proportion continued to be high: 8 out of 10 for 1922, 22 out of 26 for 1923, 29 out of 35 for 1924, and 30 out of 37 for 1925.[58] Remarkably, the

[53] *Ibid.*, pp. 220–221.
[54] "Discussion of a Report", *ibid.*, 12 December, 1916, pp. 316–317.
[55] Simpson, R., *How the PhD Came to Britain*, *op. cit.*, pp. 144–145.
[56] *Ibid.*, pp. 146–147; "University and Educational Intelligence", *Nature*, CII (27 February, 1919), p. 515.
[57] *Cambridge Review*, XL (28 February, 1919), p. 230.
[58] Personal files of Professor Lawrence Badash. See also "University and Educational Intelligence", *Nature*, CXXI (2 June, 1928), p. 878.

degree did not attract only foreign students. Between 1920 and 1946, Cambridge awarded 1,104 PhDs, of which 757—i.e., more than two thirds—went to British students.[59] In 1926, an American, Katherine B. Blodgett, who conducted her research for two years in the Cavendish Laboratory, became the first Cambridge woman to be awarded the degree.[60] Thanks to another hard-won reform and with strong support from scientists such as Rutherford, Pope and Hopkins, women at Cambridge gained the right to receive titular degrees such as the PhD in the 1920s, although they were still denied membership of the university.[61]

Years later Rutherford had a chance to praise the educational reforms at Cambridge, especially the introduction of the PhD. "Every man who obtains his PhD in science in this University [Cambridge]," he claimed, "has not only done a solid and substantial piece of work but in nine [out] of ten [cases] has contributed something material to the advancement of knowledge." Nearly two decades of experience at Cambridge, directing dozens of PhD candidates and producing among them many Nobel laureates, surely qualified Rutherford to make this claim. Nor did he conceal his satisfaction when observing that, out of the 365 research students registered in 1935, 250 were "on the science side".[62]

The Establishment of Governmental Support

The last, and perhaps the most important, reform affecting science at Cambridge was the introduction of governmental financial aid. The Thomson committee's report of 1918 recommended that public financial support be provided for universities, especially for the conduct of scientific research. The recommendation was tempered with the caution that the freedom and independence of universities should be left intact. But autonomy led Cambridge into crisis in 1919. The shortage of students during the war had reduced income from fees, and the all-important support of the colleges had fallen away. The university faced severe financial difficulty as it emerged from the war. The financially independent colleges were notoriously reluctant to put their revenues at the disposal of the university. Over the period from 1880 to 1914, they had in fact been persuaded to give substantial support, despite increasing problems in managing their endowments which were exclusively invested in land. However, this source of income for the university now dwindled under the effect of inflation and a

[59] Simpson, R., *How the PhD Came to Britain*, *op. cit.*, p. 162.

[60] See Yost, Edna, *American Women of Science* (Philadelphia: J.B. Lippincott, 1943).

[61] "University and Educational Intelligence", *Nature*, CXI (10 March, 1923), p. 345. On scientists' support for women at Cambridge, see "Degree for Women", *The Cambridge Magazine*, VII (20 April, 1918), p. 616; "This is Not the Time", *ibid.* (11 May, 1918), p. 704; Howarth, T.E.B., *Cambridge Between Two Wars* (London: Collins, 1978), p. 40.

[62] The University Bureau of the British Empire, *Report of Proceedings of the Fifth Quinquennial Congress of the Universities of the British Empire* (London: G. Bell, 1936), pp. 54–55.

resurgence of the traditional dispute about whether university professors were needed at all. Busy college tutors and lecturers, especially in the humanities, viewed them as drones, well paid to give lectures which nobody attended or to undertake research which nobody cared about.[63]

The demobilisation and subsequent large increase in enrolment further strained the limited existing resources. The number of matriculating students increased by one third after the war, from 1,178 in 1913-14 to 1,833 in 1918-19.[64] Students reading science probably increased the most; the number of physics undergraduates, for example, doubled after the war.[65] Rutherford, as director of the Cavendish, faced a serious problem of congestion in the laboratory. "We had a busy time," he wrote to his friend B.B. Boltwood of Yale shortly after he arrived at Cambridge in 1919. Nearly 700 undergraduate and postgraduate students and naval officers studied in the laboratory.[66] The rapid growth in branches of scientific research also generated the need for an expanded budget.

The fiscal woes of the University of Cambridge had mounted by early 1919, when *Nature* reported that the university in general, and "its scientific departments in particular, [were] in a grave position financially".[67] At least £32,000 was needed just to carry on scientific research on the prewar scale. Monetary problems had also made the university vulnerable to "raids" on its faculty by industry. The latter gained a new interest in academic scientists and engineers as a result of their prominence during the war. To match some of the offers from industrial firms, and retain its best scientists, Cambridge had to find additional funds.

This dire situation called for prompt action. In March 1919, the university sent a delegation consisting of Larmor, Pope, Steward and several heads of colleges to meet H.A.L. Fisher, president of the Board of Education. They discussed the financial problems of Cambridge and reached the consensus that the government had to help. Fisher proved very sympathetic to the needs of Cambridge. In shaping the Education Act of 1918, he had promoted public financial support for elementary education. He was also working hard to bring into being the University Grants Committee, which was to become the channel through which all British universities received their money from the government. Scientists took advantage of the importance of science during the war in order to launch both the University Grants Committee and the principle of governmental

[63] See Brooke, Christopher N.L., *A History of the University of Cambridge. IV: 1870–1990* (Cambridge: Cambridge University Press, 1993), pp. 78–80.

[64] See Cambridge University, *The Historical Register of the University of Cambridge: Supplement, 1911–1920* (Cambridge: Cambridge University Press, 1922), p. 198.

[65] Wood, Alexander, *The Cavendish Laboratory* (Cambridge: Cambridge University Press, 1946), p. 48.

[66] Badash, Lawrence (ed.), *Rutherford and Boltwood: Letters on Radioactivities* (New Haven and London: Yale University Press, 1969), p. 322.

[67] "The Financial Position of Cambridge University", *Nature*, CIII (22 May, 1919), p. 229.

support for universities.[68] Although both Oxford and Cambridge had absented themselves from the initial scheme, Fisher was convinced as early as 1917 that the two universities could not continue to discharge their functions or to cope with the developing requirements of "applied science" without help from the state.[69] Perhaps the visit of this Cambridge delegation, and especially the plea from the scientific men, further convinced him of this. Years later Fisher described the government's response to the two ancient universities' pleas for help:

> Austen Chamberlain was fortunately Chancellor of Exchequer. He was himself an alumnus of Cambridge and son of the founder of Birmingham University. Few words were necessary to convince such a man of the needs of the two universities. After twenty minutes I left the Treasury Chambers with an assurance of a certain grant of £30,000 a year for each university pending the report of the Royal Commission, which we agreed between us must necessarily be set up.[70]

In a letter to the vice-chancellors of Oxford and Cambridge, Fisher explained that "a comprehensive inquiry" into the resources and their distribution in the two universities and their colleges was essential if the government was to provide them with public funds.[71]

The proposal for governmental subsidies did not stir as much opposition at Cambridge as might have been expected. This was in contrast to the situation in 1913, when the medical board at Cambridge had, for the first time in the university's history, decided to apply for support from the Board of Education. The proposal met much opposition in a spirited debate in the senate. While the medical and biochemical professors Allbutt and Hopkins justified the measure as necessary to maintain the high quality of medical research at Cambridge, Ridgeway opposed it as opening the gate for harmful governmental control. Other members of the senate, including J.J. Thomson, expressed concern about the accompanying government inspection.[72]

Many apparently changed their attitudes during the war. For example, in his report for the government in 1918, Thomson recommended government grants to universities for scientific research, provided that their freedom and independence were not encroached upon.[73] When the senate debated this issue of much larger and broader public financial support in 1919, both Pope and Thomson spoke strongly in support of the measure. Other

[68] Hutchinson, Eric, "The Origins of the University Grants Committee", *Minerva,* XIII (Winter 1975), pp. 583–620, esp. pp. 592–596, 602–604. For a comparison with the American system, see Greenberg, D.S., "Academic Finance: British System Smoothly Functions in 50th Year", *Science,* CLXIX (14 August, 1970), pp. 658–660.

[69] Fisher, H.A.L., *An Unfinished Autobiography* (London: Oxford University Press, 1940), p. 115.

[70] *Ibid.*, pp. 115–116.

[71] The letter, dated 16 April, 1919, is cited in Hutchinson, E., "The Origins of the University Grants Committee", *op. cit.*, p. 609.

[72] Transcripts of Cambridge senate meeting on 23 October, 1913, reported in "Discussion of a Report", *Cambridge University Reporter,* 4 November, 1913, pp. 205–207.

[73] *See Natural Science in Education, op. cit.*, pp. 206–208.

influential members of the university followed. Opposition did come from a few in the senate during the debate. Ridgeway again attempted to turn the tide of change. He complained that governmental grants would be "the uncomfortable corollary of state control".[74] But on 31 May, 1919, when the matter was submitted to a vote, it passed without opposition.[75] Possibly the doubters thought they were just asking for an "emergency grant", or perhaps they were soothed by Fisher's statement that the government was "not competent" to interfere with the autonomy of universities.[76]

But the government tried to do so anyway, if in a different guise. The Royal Commission on Oxford and Cambridge Universities was established in 1919, for the purpose stated in Fisher's letter. In Rutherford's words, it was to examine "the dark corners" of the two ancient institutions.[77] Apparently the commission did much more than that: as a result of its investigation, it recommended that Oxford and Cambridge be given government grants. It justified this recommendation by citing the scientific contributions made by their "scientific men" during the war and the importance of science for industry. Reflecting the campaign for science during the war, especially as expressed in *Science and the Nation*, the commission recognised basic research as "the surest means by which the nation can ultimately command the resources of nature".[78] Its report also praised the science schools at Cambridge as having acquired "a unique position in the history of science".[79] In fact, science at Cambridge was receiving so much attention that the commission worried it might become a "science university", at the expense of the humanities.[80]

Both universities at first received an *ad hoc* grant of £30,000 each from the Board of Education in 1919-20, as stipulated by Fisher. The size of these grants grew rather rapidly. The amount for Cambridge tripled in seven years, reaching £93,500 by 1926-27; it comprised almost half the university's income and strengthened its power *vis-à-vis* its constituent colleges.[81] (The Royal Commission had specifically recommended against public grants being made to the colleges.[82]) A pension plan was created for university teachers, whose salaries were also subsidised by the state grant.[83] With this governmental support, laboratories and libraries became better maintained, and research and graduate teaching improved.

[74] "Cambridge and the Royal Commission", *Nature*, CX (25 November, 1922), pp. 689–690.
[75] See "The Financial Position of Cambridge University", *Nature*, CIII (22 May, 1919), p. 229; "University and Educational Intelligence", *ibid.* (5 June, 1919), p. 278.
[76] Howarth, T.E.B., *Cambridge Between Two Wars*, *op. cit.*, p. 84.
[77] Rutherford to Boltwood, 19 August, 1920, in Badash, L. (ed.), *Rutherford and Boltwood*, *op, cit.*, p. 330.
[78] Royal Commission on Oxford and Cambridge Universities, *Report* (London: HMSO, 1922), p. 45.
[79] *Ibid.*, p. 118.
[80] *Ibid.*, p. 45.
[81] See Cambridge University, *The Cambridge University Calendar for the Year 1928–29* (Cambridge: Cambridge University Press, 1928), p. 137.
[82] Royal Commission, *Report, op, cit.*, pp. 55–56.
[83] *Ibid.*, pp. 190–195.

The Cambridge commissioners in 1925 also proposed new statutes for the university, which obtained royal approval in 1926. As a result, the university, rather than the individual colleges, controlled all formal teaching.[84] The new statutes codified many of the measures of reform contemplated during the war.[85] A faculty system was established to organise teaching and research in various fields. Each faculty had its own governing board which, unlike the previous special boards, was now partly elective. Thus democratic elements in the government of the university were notably strengthened.[86]

While much of the Royal Commission's report was clear and progressive, its recommendations on women at Cambridge were rather ambiguous and conservative. Although the commission recommended that £4,000 a year be given the university for ten years to benefit its women's colleges and that women be granted membership of the university, it also urged—over the objections of two commissioners, Blanche Athena Clough, principal of Newnham, one of the two women's colleges of Cambridge, and William Graham, a member of parliament—that "Cambridge remain mainly and predominantly a 'men's University' " by limiting the number of women graduates to 500. Bowing to the conservative non-resident alumni who consistently voted to deny women membership of the university, the commission further stipulated that women should have only limited representation in university government and should not be allowed to hold the office of chancellor, vice-chancellor or proctor.

Adopting this half-hearted reform, Cambridge became one of the last British academic institutions to give women equal status. Yet, by suggesting that a new "house of residents" replace the senate as the governing body of Cambridge, thus removing the power of the non-residents, the Royal Commission also paved the way for the eventual achievement of equal rights for women at the University of Cambridge in the 1940s and 1950s.[87]

On balance, there is no doubt that the centralised and yet more democratic university system helped to improve teaching and research in science, in particular by placing the limited experimental facilities into more efficient use. The government's financial support also alleviated some of the urgent needs of Cambridge's scientific departments. More significantly, ties

[84] See "The New Statutes of the University of Cambridge", *Nature*, CXVI (7 November, 1925), pp. 694–695. On university and college teaching under the old system, see Cambridge University, *The Student's Handbook*, *op. cit.*, pp. 295–296; and Howarth, T.E.B., *Cambridge Between Two Wars*, *op. cit.*, p. 86.

[85] See, e.g., memorandum to heads of colleges from the vice-chancellor of Cambridge, 6 November, 1918, in Papers of J.J. Thomson, Cambridge University Library.

[86] Royal Commission, *Report*, *op*, *cit.*, pp. 82–94. See also Godwin, Sir Harry, *Cambridge and Clare* (Cambridge: Cambridge University Press, 1985), pp. 183–184; and Mann, F.G., "The Place of Chemistry. II: At Cambridge", *Proceedings of the Chemical Society* (London), July 1957, p. 193.

[87] Royal Commission, Report, *op. cit.*, pp. 172–175; Brooke, C.N.L., *A History of the University of Cambridge*, *op. cit.*, pp. 363–364; Perrone, Fernanda, "Women Academics in England, 1870–1930", *History of the Universities*, XII (1993), pp. 339–367.

with the government, which were vital for "big science" to be done at Cambridge, were finally solidified by the state's financial contribution. The war emphasised the interdependence of the needs of science and government.

Scientific Research at Cambridge Following the War

Hard as it is to document a causal relationship, the reforms did contribute much to the outstanding performance of science at Cambridge in the years between the two world wars. New fields and new scientists arrived at Cambridge in the 1920s. The replacement of Thomson by Rutherford was more than symbolic for physics. Several features of "big science" emerged or were reinforced in the Cavendish Laboratory at this time: team research, numerous publications, organised research programmes, an international orientation, and a sense of competition were brought in by Rutherford, who had already practised this style of science at McGill.[88] Thanks to the campaign for science and to the measures of reform, many research workers in the laboratory were now working for the PhD and some of them had received grants from the Department of Scientific and Industrial Research. With few exceptions they clustered around Rutherford's specialty of nuclear physics.[89] An assistant directorship of research was created for the first time at the university in 1924, for James Chadwick to help Rutherford organise research at the Cavendish Laboratory. The following year, Peter Kapitza became assistant director of magnetic research.[90] These appointments signified a new level of organisation and management of scientific research. The war brought science at Cambridge from the "sealing wax and string" tradition into the era of "big science". High productivity followed as the Cavendish produced more than 50 scientific papers in the single year of 1927-28.[91]

Other fields of science also bloomed at Cambridge in the 1920s. Theoretical physics centred around Rutherford's son-in-law, Ralph Fowler. He occupied an office at the Cavendish and established a valuable link between physics and mathematics in the university. A new generation of Cambridge theoretical physicists obtained their PhDs under his supervision, P.A.M. Dirac and Nevill Mott, two Nobel laureates, being the most

[88] Badash, Lawrence, "The Origins of Big Science: Rutherford at McGill", in Bunge, Mario and Shea, William R. (eds), *Rutherford and Physics at the Turn of the Century* (London: Dawson/New York: Science History Publications, 1979).

[89] For a survey of research at the Cavendish in the 1920s and early 1930s, see Badash, Lawrence, "Nuclear Physics in Rutherford's Laboratory Before the Discovery of Neutron", *American Journal of Physics*, LI (October 1983), pp. 884–889.

[90] See Cambridge University, *The Cambridge University Calendar for the Year 1928–29, op. cit.*, pp. 41–42.

[91] Wood, Alexander, *The Cavendish Laboratory* (Cambridge: Cambridge University Press, 1946), p. 46.

prominent; Mott later became director of the Cavendish.[92] The astronomer Arthur Eddington led a government sponsored expedition that confirmed one of Albert Einstein's predictions on relativity.[93]

Chemistry also prospered at Cambridge in the postwar period. Pope's wartime campaign for stronger ties between academic science and industry paid off handsomely. The very large grant of £210,000 to his chemistry department at Cambridge from a consortium of British oil companies and industrialists provided perhaps the most direct evidence of the new appreciation of scientific research. The money enabled Pope to found a new chair of physical chemistry and a new chemistry building in 1920. The donors' clear intention was that the chemistry of mineral oil be investigated.[94] Thomas M. Lowry, a former colleague of Pope's, was appointed to the chair; among the students in the new field was C.P. Snow.[95]

Engineering also benefited from the war. As the connection between science and industry, it emerged from its prewar obscurity to become one of the most important fields of study at Cambridge. In 1918, there were only 37 students in a department depleted by war. That number increased tenfold in 1919, when 283 full-time students and 95 naval officers attended classes and laboratories. Two years later, the number of students had risen to 808. C.E. Inglis succeeded Bertram Hopkinson as professor, and a separate board of engineering studies was established in 1919. In the same year, a new Francis Mond chair of aeronautical engineering was founded by an endowment from Emile Mond; it went to B.M. Jones. Several new lectureships were created, which increased the teaching staff in engineering to 48 by 1920. Another magnificent endowment by D.J. Tata, head of the Indian engineering firm and a Cambridge alumnus, made possible the construction of a new engineering building.[96] As with Pope's oil industrialists, Mond and Tata expressed their appreciation of the contribution of scientific and engineering research to industrial progress. They viewed science and technology as of "ever increasing national importance" and paid particular tribute to Cambridge for "the concentration at the University of distinguished representatives of the Sciences".[97]

[92] See Mott, Nevill, "Theory and Experiment at the Cavendish circa 1932", in Hendry, John (ed.), *Cambridge Physics in the Thirties* (Bristol: Adam Hilger, 1984), 125–132. See also Badash, L. "Rutherford and Theoretical Physics", in Kargon, Robert and Achinstein, Peter (eds), *Kelvin's Baltimore Lectures and Theoretical Physics* (Cambridge, Mass.: MIT Press, 1987), pp. 349–374.

[93] See Douglas, A. Vibert, *The Life of Arthur Stanley Eddington* (New York: Thomas Nelson, 1956), Chs 6, 7.

[94] "University and Educational Intelligence", *Nature*, CIII (5 June, 1919), 278. Even during the war, Pope began to court receptive chemical industrialists by, e.g., sending them his DSc students. See Morton, J., *Three Generations in a Family Textile Firm, op. cit.*, p. 219; "Academia", *The Cambridge Magazine*, VI (5 May, 1917), p. 555.

[95] J. Pope, W.J., "Thomas Martin Lowry", *Obituary Notice of the Royal Society* (London), II (1938), pp. 287–293.

[96] See Hilken, T.J.N., *Engineering at Cambridge University 1783–1965* (Cambridge: Cambridge University Press, 1967), Ch. 6.

[97] Tata's donation letter is printed in *ibid.*, pp. 156–157; part of Mond's letter is on p. 158.

The war modernised Cambridge in another respect. The veteran act after the war, like the American GI bill after the Second World War, enabled demobilised solders to enrol at Oxford and Cambridge, radically expanding and altering these universities' traditional student bodies. Having realised the futility of their classical education in contrast with the rising power of science during the war, many older students now turned to scientific and engineering subjects. In the case of Cambridge, the number of students of science and engineering increased greatly.

Conclusions

Thus, the First World War wrought radical changes at the University of Cambridge in more than one way. The accompanying institutional reforms led to a considerable consolidation of the position of science in modern higher education. The diminished influence of the classics, the introduction of the PhD degree, the beginning of large-scale state financial aid for research, and the weakening of the traditional power of the colleges prepared the stage for the startling developments in science at Cambridge in the interwar years. Most significantly, the recognition of the importance of science and technology for national prestige, for defence and in producing industrial strength, all helped to advance science at the University of Cambridge in the first decade after the war. In retrospect, while some changes may have been less rapid than expected, Pope in his letter to Rutherford in 1919 evidently did not misread the trend of British science and education in the aftermath of the First World War.

This examination also calls into question some of the most prevalent ideas about modern science and its relations with the humanities. Contrary to the conventional view of "two cultures", neither camp was immoveable and during the war the frontier between them constantly shifted. Alliances were formed across the boundary between the sciences and the humanities, as was evident in the debates over educational reforms at Cambridge. Polarisation did not appear to centre on the objects of study, whether the study of nature for the scientific subjects or the study of man for the humanities. Rather, it seems to have consisted of a challenge of the modern, more utilitarian fields of studies against the traditional fields like classics which had established a stronghold at universities such as Oxford and Cambridge. Thus mathematicians, in a field with traditions established as early as the classics, resisted the efforts of the natural scientists and modern linguists to introduce the research degree of Doctor of Philosophy—while on the other hand, modern linguists joined natural scientists in overturning the requirement for compulsory Greek.

While the increasingly utilitarian tendency of higher education following the First World War largely vindicated William J. Pope's hegemonic claim for science, the humanists' concerns about the technological dominance of universities were not to be easily brushed aside. The revolt against science in the 1960s was only one indication of a growing wariness about the dominance of science and technology both within and outside the universities. The end of the Cold War in the late 1980s brought another reassessment of the place of science in society. In many ways, harmony between the "two cultures" in higher education today is as elusive as it was at the University of Cambridge in the era of the First World War.