Part I

Genealogies of Science Policy Discourses

Chapter 1

Categorizing Science in Nineteenth and Early Twentieth-Century Britain

Robert Bud

Britain had no policy for science during the nineteenth and early twentieth centuries. Science was, however, called upon to address fears, problems, and incomplete narratives shared widely by government and people. Its study in schools and universities was a matter of perennial anxiety. Though the annual government grants given for research in the mid-nineteenth century were small, projects related to pressing government concerns received substantial support (Macleod 1971a, b). In the 1870s, the state funded the four-year round-the-world expedition by the naval vessel the *Challenger,* costing £100,000 ($500,000 or two million Reich Marks—hereafter RM). The mission to map and explore the deep sea and seabed was sustained both by the practical needs of laying an imperial telegraph network and by the scientific controversy over life and natural selection in such environments. The expedition resulted in fifty volumes of scientific reports, which set the stage for oceanography in the future (Burstyn 1972).

As the *Challenger* was finally returning to Britain in May 1876, London's South Kensington Museum was responding to a call for a boost to scientific culture in industry and education by opening an exhibition of "scientific apparatus" that had cost £15,000 ($75,000 or RM 300,000) to mount (Committee of Public Accounts 1878: ix; de Clerq 2003; Bud 2014b). Ranging from the Stephenson's pioneering Rocket locomotive to the Magdeburg hemispheres of von Guericke, this huge exhibition was visited by three hundred thousand people in just six months. The cost, hidden in the budget of the Science and

Art Department (responsible for technical education), was equivalent to the entire recurrent budget of Berlin's famous Physikalisch-Technische Reichsanstalt, founded a decade later in Charlottenburg (Pfetsch 1970: 575). Such major investments drew upon both the enthusiasm of a few influential intellectuals and civil servants and the wider engagement of military men, journalists, businessmen, and politicians. We need, therefore, to take seriously their commitment to the projects themselves, to the categories that made them possible—including, for instance, the inclusion of both "pure science" and "applied science" in the South Kensington exhibition—and to the concerns that underpinned them. Often seen as either so natural, or, alternatively, so misguided, as not to deserve historical attention, the use of these categories will be the concern of this chapter.

The classification of science into the categories of "applied" and "pure" (and closely related terms, such as "fundamental") became conventional from the late nineteenth century, and remained so for a hundred years. In his classic study, *The Organisation of Science in England,* D. S. L. Cardwell (1957: 1) suggested that it was "applied science" for which policy was made in the period of his interest from the mid-nineteenth century to the beginning of World War I. When he was writing, now six decades ago, Cardwell's priority was to look at policies, and less attention was paid to "pure" and "applied" science as concepts in themselves. In part, that was because these were still widely treated as realities, needing only precise definition. Furthermore, the context in which they were invoked was often the disconcertingly vague, and at that time often hard to recover, discourses between scientists and the general public, and the political rhetoric of competition and crisis.

Today, categories are no longer taken for granted, and historians have been enabled to deal with the public sphere more substantially by the availability of digitized newspapers. These are particularly interesting because the politically-aligned newspaper of the nineteenth century was closely interdependent with the political platform; speeches were widely reproduced verbatim in the national press and copied regionally; the texts of books and their reviews and advertisements were similarly already intermingled by canny publishers. Effectively, therefore, the discourses of news, marketing, and politics came to be interfused on the newspaper page.

The history of such concepts as "pure" and "applied" science is not just the history of specific phrases in the public sphere, but also of terms whose multiple meanings were reconfigured by new means of mass communication and discussion and of political debate.[1] I shall argue, first, that talk about science and its categories did work that went beyond the conventional categories of epistemology. Second, in the public sphere, "applied science" came to be the key category, not dependent on "pure science." Third, it was in the contexts particularly of educational debate that these categories first became significant.

The chapter begins with a focus on the development of language and the work it was expected to do. It deals with the nineteenth-century emergence of the concept of applied science to describe a form of knowledge particularly with an educational significance, and with the cognate terms "pure science" and "technology," whose meanings were also shaped in educational contexts. It then treats two periods: first, the two decades spanning the end of the nineteenth century and the first years of the twentieth century, and, second, the years from World War I to the end of World War II. These periods differed not only in the issues that dominated their concerns but also in the technology of media spaces: the earlier period was limited to the printed word; in the later period, the wireless became important. They shared characteristics too—above all, perhaps, the exposure to overseas influence. During each of these periods, interaction with Germany, France, and the United States was profoundly important. The shared use of the English language meant a close interpenetration of British and American discourses. Many British scientists, and indeed other professionals, had studied in Germany, and knowledge of French was a requirement for the educated person. So, Britain acted as a key node in the international circulation of concepts about the structure of science.

The Nineteenth Century: Emergence of Terminology and the Educational Context

The familiar terminology of pure and applied science cannot simply be read back in time, or even straightforwardly translated into an older classification system. We can see the tortured difficulties in producing a 1783 English edition of Torbern Bergman's *Essay on the Usefulness of Chemistry*. This was translated from Swedish into poor English ("lingua Franca") by the Austrian Franz Swediauer, and then rendered into good English by the renowned philosopher Jeremy Bentham. The result was that the German term "philosophische Chemie" came to be rendered as "pure chemistry" (rather than "philosophical chemistry," which might also have been acceptable). Perhaps surprisingly, the term "angewandte Chemie" became not "applied chemistry" but "(*chemia applicata*), mixt, particular or popular chemistry," which Bentham subsequently referred to simply as "popular chemistry" (Bergman 1779: 10, 12; 1783: 16, 20; Linder and Smeaton 1968). To Bentham therefore, writing in 1783, "applied chemistry" was not an option.[2]

Instead of simply inheriting old categories, the nineteenth century saw a reconstruction. The concept of "applied science" that emerged in the second half of the nineteenth century was a hybrid of three ancestors: "applied sciences" (quickly corrupted to applied science), "science applied to the arts," and "practical science." Let us look at each of these.

It was the Germanophile poet, polymath, and religious conservative Samuel Taylor Coleridge who introduced the term "applied sciences" to the English language at the beginning of the nineteenth century. In 1817, a time of social unrest and economic depression in the wake of the Napoleonic Wars, Coleridge sought to stabilize thought through an encyclopedia that would provide a rational structure for all knowledge in opposition to the alphabetically organized, and thus epistemologically haphazard, *Chambers Encyclopaedia* (Link 1948). In his proposal for the *Encyclopaedia Metropolitana,* Coleridge proposed a classification based on absolute truth value. This drew upon the differentiation of pure sciences and applied sciences developed in Germany and inspired by the work of Immanuel Kant. The first category, science based on the synthetic a priori, was necessarily and immutably "true" and therefore labeled as "pure" (see chapter 2). The second category, "mixed and applied sciences," more dependent also on empirical evidence, was necessarily contingent.[3] Here Coleridge drew upon the German term "angewandte Wissenschaft," which had been derived from Kant's "angewandte Vernunfterkenntnis" (Kant 1786: vi; Bud 2013a). As for Kant, the knowledge of this kind was less certain than its "pure" partner. Coleridge's structured encyclopedia, a form new to Britain, drew on a German tradition of Kantian compilers of knowledge, as exemplified for instance by Jena-based Carl Schmid, author of the 1810 *Allgemeine Encylopädie und Methodologie der Wissenschaften* ("Encyklopädie" 1895: 755; Snyder 1934: xxii). Although Coleridge argued with the publisher and eventually withdrew from the project, the encyclopedia nonetheless went ahead. It was completed over a period of twenty years and in twenty-eight volumes, thanks to a succession of three editors who shared both Coleridge's religious and philosophical position. A section of more than five thousand pages on "Mixed and Applied Sciences" subsumed subjects ranging from the fine and useful arts to medical sciences.

The articles in the encyclopedia were no-snippet length sound bites. Many were the length of entire books and were published separately. Charles Babbage's 1832 book *On the Economy of Machinery and Manufactures* was based on an entry he had contributed. This volume is itself credited by the Oxford English Dictionary as the first source of the phrase "applied science." The attribution of priority is incorrect, but it does highlight the influence of the work that Coleridge had instigated. The names of its structuring concepts were promoted through the advertisements for the work as a whole and the influence of its essays. A search of the numerous digitized newspapers of the nineteenth century makes it clear that the term "applied sciences" first appeared in the press during the 1820s (and until 1836 exclusively) within advertisements for the encyclopedia. And even in these advertisements, the plural form was sometimes corrupted to the singular “applied science.”

A complementary origin lay in the phrase “science applied to the arts,” which is an import from the French “science appliquée aux arts.” This term grew out of a formulation systematized by the Conservatoire National des Arts et Métiers, an institution in Paris that was redefined in 1819 as dedicated to teaching “l’application des sciences aux arts industriels.” In 1848, for example, the professors were charged with formulating a “système général pour l’enseignement des sciences appliquées aux arts industriels” (Marchand 2005). The author of this term seems to have been Charles Dupin, previously trained at the fabled Ecole Polytechnique. He had been influenced by the elite thinking during his youth, the practical achievements of French savants under the pressure of the revolutionary wars, and then by his explanation for the staggering British industrial achievements during the time the two countries had been at war (Dupin 1825; Alder 1997; Bret 2002; Christen and Vatin 2009; Bud 2014a).

Finally, there was also a long-established English term, “practical science,” that often connoted empirical science, related to—but not derivative from—so-called “abstract science.” In his studies on the history of brewing, James Sumner (2015) has highlighted the tensions between experts with a claim to “practical” expertise and those whose knowledge was more abstract or theoretical. The term had been used occasionally in the eighteenth century, but its use grew in the nineteenth, only giving way to “applied science” in the 1860s. Thus, in 1865, the University of Cambridge introduced a new course whose designation had changed from practical science in preliminary discussions to applied science in the published announcement.[4] These terms with rather different origins came to be used interchangeably, as they were hybridized to be useful in a new world.

Notwithstanding the efforts of Coleridge and his successors, the first occasion for the widespread journalistic use of the term “applied science” was coverage of the activities of the well-known and self-promoting chemist, J. F. W. Johnston and the campaign to cope with the elimination of tariffs on imported wheat. Applied science was proposed, for the first (but not the last) time as a substitute for “protection.” In the early 1840s, Johnston, professor at the new University of Durham, purveyor of soil analyses, and founder of the British Association, having originally espoused the term “science applied to the arts,” changed his linguistic allegiance. He argued that the model of “applied science” could be seen in the coherent body of techniques of navigation based on astronomy that had permitted sailors to sail the oceans. Across the country, the press, including the *Economist,* which led the campaign against tariff protection, endorsed Johnston's views that British agriculture could be saved through the careful assembly of techniques of soil analysis and "applied science" (Bud 2014a).

In the aftermath of the Great Exhibition of 1851, usages of "applied science" came to be even more common, but increasingly they were redirected to promoting the needs of educational innovation. While there were no clear definitions, there were illustrative stories that served as illuminating metaphors in making sense of the concept. The "romances" of the great inventors, James Watt and Robert Stephenson, both heroes of the nation as a whole and of specific regions, were incorporated within allegorical narratives about the nation's rise to greatness and the needs of its renewal. In 1867, the chemist George Gore was allowed two columns to lecture readers of the *Birmingham Post* on the importance of applied science to local industries, one quarter of which was devoted to the scientific heritage on which James Watt had drawn. In the region of North East England, centered on Newcastle-on-Tyne, Robert Stephenson, son of George and himself father of the railway system, was the scientific hero. The lives of both Watt and Stephenson could be read in terms of their arduous pursuit of a scientific education leading to brilliant achievements. These narratives communicated the truly local and national ancestry of applied science, belied any assertion it was an alien concept, and laid out a path for Britain's educational development in the future (Bud 2014a).

Just as Watt was destined, however unjustly, to be a hero of applied science, so Michael Faraday, perhaps equally unjustly, became the hero of that category's destined counterpart, "pure science." This, too, was a hybrid of native, imported, and pragmatic conceptions. There was a rich tradition of the practice of science for the sake of curiosity, sanctified by religion and validated by its interest and results. Often called "abstract science," it was, however, not sustained by a long domestic philosophical tradition. It is true that the term "pure science" is deeply rooted in the English language and appears in the writings of Samuel Johnson (1750) in the eighteenth century, but it was historically rarely used. It was to German sources that Coleridge had turned when he formulated his classification. Studying in Göttingen in the 1790s, Coleridge had been a pioneer in the English journey to German universities, which in the mid-nineteenth century became, for the British man of science, a rite of passage, and for the intending academic chemist, a professional necessity. From Germany, in particular, those students brought back cultures of pure science. According to Cantor's (1996: 174) biography *Faraday as a Discoverer,* the physicist John Tyndall—who had himself both studied in Germany and been inspired by another Germanophile, Thomas Carlyle—identified Michael Faraday as "the exemplary *pure scientist*" (italics in the original). Tyndall himself would become an influential and vocal spokesman for pure science.

The new classification system of different kinds of science did prove useful in laying out priorities for educational development (Bud and Roberts 1984). In 1868, the German-born ironmaster, engineer, and member of Parliament Bernhard Samuelson gave notice that he would move for a parliamentary committee on the "provisions for giving instruction in theoretical and applied science to the industrial classes."[5] Samuelson had chosen his terms with care: as he explained to the House of Commons, he had deliberately eschewed the use of the term "technical education" for fear that he would be blamed for trying to replace the factory education of the engineer. Such practical training was proudly kept sacrosanct in Britain, and Samuelson knew that he should not be seen to threaten it.[6] Instead he emphasized that he was seeking complementary schooling. He had drawn upon a phrase that had become acceptable and indeed fashionable to make a very particular point about the need for practical scientific education preliminary to industrial experience. Following the parliamentary committee, an even more extensive "Royal Commission on Scientific Education" was held, and that again raised popular interest and awareness.

One early outcome of the Samuelson committee was the consolidation of a variety of scientific schools into a new government school of science in the West London site of South Kensington, close to the former home of the Great Exhibition. Because it was government-funded, its curriculum and role would be elaborately planned and carefully scrutinized. Increasingly it was seen to teach a core curriculum of "pure science." Thereafter, the well-prepared student could develop a career in teaching or in industry deploying "applied science." Meanwhile, a remarkable amount of private money was going into developing a new generation of independent colleges both in London and the provinces, where they would be the bases of the new civic universities.

The growth of these colleges and the challenge of overseas developments spurred discussion on the role of study. A liberal education, dedicated to the development of the mind, had traditionally been based on the study of the classical languages and on mathematics. Beyond these means, the end was a training of the mind for social and material benefit (Rothblatt 1976). Now, the sciences could be introduced into the curriculum either as parts of liberal education or as specialized applications of it. Pure science could most easily be seen in terms of liberal education, and indeed be defined by it. This was the argument elaborated in Alexander Williamson's inaugural lecture at University College London under the title "Plea for Pure Science" (1870). He himself was no "absent-minded professor" and was known for his development of a boiler for generating high-pressure steam (Harris and Brock 1974). Yet, speaking in the wake of the Samuelson committee, Williamson had been provoked by the apparently overwhelming public enthusiasm for "applied science," as was the American physicist Henry Rowland (1883) a decade later in his own "Plea for Pure Science" (Hounshell 1980). Williamson argued for the special role of the university as a preparation for life. Through subsequent enquiries, pure science, as the professional education of teachers and as the universal basis of education for all technical professions, was confirmed as the principal focus of the curriculum.

Hybrid versions of these arguments would be debated. Thus, in 1873, Tyndall was the first to popularize a quip by his friend Louis Pasteur published two years earlier in obscure publications: "There exists no category of science to which the name applied science could rightfully be given. We have science and the applications of science, which are united together as the tree and its fruit" (Pasteur 1871, quoted in Tyndall 1873: 221).[7] Tyndall would incorporate this quotation in lecture after lecture, for instance again at the Royal Institution in January 1879.[8] A few months later, his close friend Thomas Huxley, a professor in South Kensington of the apparently useless subject of biology, expressed similar sentiments at the opening of the Mason College Birmingham. His famous oft-recited regret of the very coinage of the term "applied science" would itself be influential, and the boundary between pure and applied science proved to be an enduring issue (Gooday 2012). The attack had been on the category of "applied science" because the implication of arguments such as those of Samuelson was that this was the fundamental unit, from which the idea of "pure science" was derived as a residuum.

The variety of work that the very concept "applied science" could be expected to perform has been explored through a study of approximately one thousand articles employing the term recovered from digitized newspapers (Bud 2014a). These show that during the nineteenth century, the term was used in three ways: first, it could connote both machines themselves and knowledge about them; second, it expressed belief in a historical relationship between carefully nurtured scientific knowledge and practices that had already characterized great industrial breakthroughs in Britain and elsewhere; and, third, it expressed the expectation of the future potential of science to assure national and international wealth and prosperity. The relationship between a familiar past and a future made strange, on account both of the novelty of its gadgets and of change in the commercial world, was frequently described in terms of the progress of "applied science." Today, encountering the new social and political configurations brought about by social media, we can empathize with the need to make sense of the disorientation brought about by the telegraph, mass global travel, and other developments "in which the experience of the past is no longer a reliable guide" for the future (Kidd 1894: 6). The explanation given in this late nineteenth-century text would resonate in the next hundred years: "Since the beginning of the century, applied science has transformed the world" (Kidd 1894: 6).

From the middle of the century, users of the term "applied science" sought to link a selective rendering of the nation's past to fears about a future perceived as full of risk. European and American competition, both commercial and military, became the foci for national anxiety. In 1868, the educationist Matthew Arnold reported on "schools and universities on the continent." His influential report popularized the complaint that adherence to the "rule of thumb," having once been a British strength, was now a weakness in British instruction compared to continental trust in "science and systematic knowledge" (Arnold 1868: 211–212). Again and again, the deployment of "applied science" was prescribed as the remedy. The sense of threatening decline was widely translated into a problem of education, as other countries invested in forms of technical training unknown in Britain. That scientists of the late Victorian period proclaimed a sense of crisis to win economic and cultural resources was not itself evidence of the quantity or quality of the crisis invoked (Turner 1980). The language of threat and imminent decline was real, but the use of rhetoric needs to be considered separately from commercial, scientific, or economic competition. Historians of science have recognized the importance and complexity of calls for applied science in the public sphere context—in such works as Ronald Kline's study of speeches by engineering leaders who addressed their professional constituencies in these terms (Kline 1995).

We of course need to be cognizant of the vast influence of German, French, and American usages on talk about science in Britain. In 1957, the same year as the publication of D. S. L. Cardwell's *The Organisation of Science in England,* the distinguished American historian George Haines (1957) published his *German Influence on English Education and Science, 1800–1866.*[9] Haines saw the impact of the impressive rise of Germany as one of English "acculturation." Nonetheless, rather than merely expressing German "influence," the rise of the concept of applied science can be seen as a process of actively responding to German educational patterns within British culture. Nor was the relationship one way. Following the examples of the Kantians, in German, the use of the term "angewandte Wissenschaft" tended to be related to the contingent products of man (particularly law) than to more typically Anglophone connotations. However, in 1898, the German mathematician Felix Klein led the formation of a center at the University of Göttingen dealing with applied physics and mathematics, known as the Vereinigung für angewandte Physik und Mathematik (Schubring 1989). At the tenth anniversary celebration, the university's pro-rector defended the foreign origins of the idea and extolled the special role of Göttingen, which according to long tradition had many Anglo-American connections and was in the front line of exchange with the Anglo-American cultural sphere (*englisch-amerikanische Kulturwelt*) (Cramer 1908: 23).

The other English term that would be promoted together with new policies was “technology.” This, too, was an expression of German ancestry (Sebestik 1983) that had been popularized through an early nineteenth-century encyclopedia. The British newspaper archive shows a huge jump in usage from the 1822 publication of Crabbe’s *Universal Technological Dictionary.*[10] Again, in the 1850s, usage was eight times greater than in the previous decade. The predominant reason this time was the promotion of the term by the Scottish professor, George Wilson. Adopting the term “technology” from the work of the German chemical writer Knapp, he preferred it to “applied science” and used it to title his university chair at Edinburgh (Wilson 1855; Anderson 1992). This lapsed after his premature death in 1859, and the popularity of the term declined temporarily. It was revived, however, by a fundamentally new development early in the 1870s.

While the new colleges were teaching “applied science” to the middle classes at university level, from the time of the Samuelson committee, the long-established Society of Arts was discussing and then adopting vocational examinations for the working class. These were intended to build demand for an education equivalent to that of German trade schools. In 1873, seeking to emulate German technical education, the society launched a qualification system beginning with “cotton,” “paper,” “steel,” “silk,” and “carriages.” Building on scientific examinations administered by the government’s Science and Art Department, the new tests had two parts; the first evaluated technology, “that is to say the special application to each manufacture of the various branches of science that have to do with it” (Wilmot 1872: 9). A further part related to practical knowledge, and the candidate was expected to produce an attestation of skill from his employer. In 1880, the wealthy City of London Corporation and its long-established City Guilds took over responsibility for these examinations under the title “City and Guilds” and hired Rabbi Philip Magnus, who had previously studied in Berlin, to administer them. For the next fifty years, Magnus would be a doughty promoter of “technology” (Foden 1961, 1970). In 1883, twenty-five hundred students were in attendance, which rose by 1914 to fifty-five thousand students across the country (Foden 1961: xxii). Under the banners of “technical” or “technological,” teaching was organized at the municipal level by local education boards with increasing ambition—and massively increasing local and government funding.

The Saddle Time of Science Policy

At the heart of this chapter lie the transformational decades from 1899 to 1919, in which the agenda shifted from education to research. An “exemplary anecdote" or key story is the loss of the dye industry, which was based on England's William Perkin's discovery of the "first synthetic dye" half a century earlier, to the better organized, research-based German companies.[11] This was told and regretted at a major semicentenary commemoration of the discovery held in 1906 (Travis 2006). The frequent invocation of this story indicated the increasing determination that it not be repeated. Inherited concepts from the nineteenth century were redeployed to address the challenges of the twentieth. This has been widely seen by such historians as Peter Alter (1987) as the key period of development of twentieth-century science policy. Adapting a term from Reinhart Koselleck, this period could also be described as *Sattelzeit* (saddle-time).[12]

In this period, the emphasis switched from training to research, and new associations were drawn with rationalization for and the development of new technology (MacLeod 2007). The term "applied science" expressed therefore the relationship with other states, such as Germany and America, whose military and commercial success correlated with a national research base. In addition, it came to be used to make sense of the relationships between, and responsibilities of, an increasingly large plethora of organizations devoted both to education and research within Britain (Bud 2014a). It was, of course, used occasionally by academics and administrators, but this term was to be found more widely in popular newspapers, cartoons, and novels making sense of modernity. The term was also given meaning within exhibitions and in press talks about exhibitions. Thus the Science Museum in London, whose new building opened in 1928, was described at the time as "housing the products of science as applied to industry" and as "a temple of applied science." The museum context highlights the interrelationship between the telling of heroic and familiar stories and the terms in which they were told (Bud 2013b).

The numerous failures that preceded ultimate British victory in the Boer War (1899–1902) prompted a national movement for enhanced efficiency (Searle 1971). This period was one of rapid change across many sectors. Thus, building on previous discussions, educational provision was institutionally transformed and grew hugely. Secondary education was reorganized and systematized by the Education Act of 1902. At university level, the new civic universities, based in the industrial towns (as opposed to Oxford and Cambridge), prospered and multiplied. In just fourteen years, between 1900 and 1914, the number of science graduates in the country more than tripled from two thousand to seven thousand (Macleod 1971a, b).

The optimism of a progressive thinker was sympathetically expressed by John Masefield, who would later be the nation's official poet (poet laureate) for over forty years, in his novel *The Street of Today.* The hero pronounces early in the book his opinion that once the fighting man had been top dog; then the spiritual man "made it hot for all who wouldn't or couldn't believe. Now there comes the scientific man who wants to get the power to make it hot for those who won't or can't conform to the plain dictates of science" (Masefield 1911: 20–21). The book itself begins with the hero explaining Mendelism at a dinner party. Significant as Masefield was, the most articulate, influential, and best-remembered voice of science-talk of the generation was the novelist and futurologist, H. G. Wells. His vision of a samurai class of scientific experts and his ridicule of war inspired a generation of men and women proud to call themselves "Wellsians" (Crossley 2011). In this atmosphere, applied science came to be associated with rational public policy, rational business practice ("scientific management"), and the source of all new things.[13] It was also increasingly interpreted as the application of pure science, which rooted it in traditional values and culture just as it reached out to an unknown and, to many, a disturbing future. For many, this emphasis on linking the new gadgets and enduring culture distinguished "applied science" from "technology."

British elite engineering teaching, unlike the German, was not generally separated from the universities. "Civic universities" taught vocational subjects to large numbers of students, often by absorbing local colleges and by adopting strategies validated in the 1870s. At Glasgow, Sheffield, and elsewhere, such colleges became departments of, or prepared for degrees in, "applied science." The newly regrouped Royal Technical College was associated with the University of Glasgow from 1913 and offered degrees in "applied science," so named because twenty years earlier the university had acquired the right to offer such degrees.[14] At Sheffield, a new university struggling to prove its academic status as a full and integrated scholarly center, the former municipal technical school was incorporated as the "Department of Applied Science." So at these institutions, engineering training exemplified applied science.

Technology was used as a designation by two rather different kinds of institutions in the early twentieth century. On the one hand, in the municipally run and City and Guilds technical colleges, which were seen to offer intense training in practice and little of its conceptual basis, engineering was identified with "technology" following the nineteenth-century tradition. On the other hand, a few of the most esteemed universities also promoted their studies of engineering as technology rather than as "applied science," citing the *Technische Hochschulen* as well as British tradition. Manchester was confident enough of itself and sufficiently impressed by German models to link up with the Municipal Technical College as its "School of Technology." On the question of degree titles, it compromised by preparing students for the university's degrees in "technical science," which evoked the qualification in *technische Wissenschaft* chosen by the *Technische Hochschulen* in Germany (Short 1974;

Manegold 1989).[15] The university's industrial bent caused sufficient worry to the nation's Privy Council that in the 1904 charter of Manchester University, it was specified that the reorganized institution was entitled to offer degrees "provided that degrees representing proficiency in technical subjects shall not be conferred without proper security for testing the scientific or general knowledge underlying technical attainments."[16] Such a provision protected the university against the tendency "to degrade university teaching to technical teaching," in the words of Lord Balfour of Burleigh.[17] His contemporary, the German-educated Liberal Party politician R. B. Haldane, advocated the designation of applied science for the Imperial College he was promoting in London. He was, however, forced to give way. There, it was the local tradition of the City and Guilds, which Imperial College had incorporated, and the influence of its leader Philip Magnus that seem to have swung the decision to the federal name of "The Imperial College of Science and Technology."

As part of the modernization and efficiency agenda, the British government, challenged by the German formation of the Physikalisch-Technische Reichsanstalt, had established the (albeit less well-funded) National Physical Laboratory in 1899 (Moseley 1980). Such new institutions included committees of scientists now consulted on urgent government matters. In 1908, Haldane—inspired by the University of Göttingen, where he himself had studied and recently revisited—delegated Britain's development of aeronautics to a committee of distinguished physicists who were defined as "the experts," rather than to practical men who had actually flown (Gollin 1979). Most obviously during World War I, the government employed large numbers of scientists in research on military projects and to meet the needs of civilian industry. By the end of the war, the staff of the National Physical Laboratory numbered 532 (Fleming and Pearce 1922: 182). Alarmed by past German successes and anxious about the postwar world, the British government sought measures to promote "scientific education and industrial research."[18] Education, however, was beyond the remit of central government (Scotland had its own educational system), and what was founded in 1915 was the Department of Scientific and Industrial Research (DSIR). In the words of the first secretary, it had the remit "on the one hand, to encourage pure research, and on the other to organize applied research" (Heath 1919: 207). The former was largely delivered by support of graduate students (carefully not referred to as "education"); the latter, by subsidies for research in industry through matching funding conducted by industry associations. Although a wartime measure, this was planned as a preparation for competition in peacetime, when, as an MP pointed out in Parliament, "It will be more important for the child to know the date at which Oersted discovered the reaction between electricity and magnetism than even to know the date of the battle of Waterloo."[19]

In retrospect, the formation of DSIR provided a key reference point in the history of government policies toward science. As in earlier years, however, this occurred within a much wider discourse of applied science, which provided a framework for governmental initiative.

As Edgerton (2006) has pointed out, the department was neither the largest nor the only funder of science during the early postwar period. Within the military, large research groups had built up at centers such as Farnborough (aeronautics) and Porton Down (poison gas). Additionally, industrial research, particularly in the electrical and chemical industries, was funded massively by companies. Imperial Chemical Industries, founded in 1926, had an annual research budget of a million pounds, several times that of all the research associations put together (Varcoe 1981). The research that came out of such novel laboratories was often, though not necessarily justifiably, praised as the basis of the new products that civilian and military life were soon enjoying.[20]

By the end of that period I have suggested we see as a *Sattelzeit,* 1899–1919, the terms "pure science," "applied science," "technology," and "industrial research" had settled down with associations that would develop but be broadly familiar for the next half century. It is important to emphasize that the new connotations of research—abstruse, benevolent, or malevolent in outcome—did not replace older meanings but were rather overlaid upon the pedagogical associations that had dominated earlier discourse.

The Twentieth Century: From Education to Research

At the end of this transitional "saddle-time," the categories came to be useful in the new governmental adoption of policies for the support of scientific research. The first annual report of DSIR in September 1916 nodded awareness of the words of Huxley denouncing the differentiation between pure and applied science, but then emphasized its political reality: "The Council realise they have to deal with the practical business world, in whose eyes a real distinction seems to exist between pure and applied science."[21] The following year, a group of scientists responded to the new organization with their volume *Science and the Nation* (Seward 1917). As Gooday (2012) has shown, they could not agree on whether to advocate a vision of a pure science acting as the nerves animating a subsequently implemented applied science, or of science as a unitary category. It has been argued, however, that the scientists associated with the British Science Guild were emphasizing the prior importance of pure science to respond to the lay control of the DSIR (Hull 1999; Clarke 2010). This literature highlights the continuing ambivalence within the scientific community about the attraction of the distinction.

To some scientists, the category of pure science assured independence and a certain distance from the violent uses of science so recently suffered. Clarke (2010) has shown, however, that the term "fundamental research" was attractive to the DSIR as a category mediating between pure and applied. At the same time, she says, even this neologism was unstable. Sometimes it could represent the more general mission-oriented work carried out in industrial laboratories; at other times it was used as a synonym for pure science. Such an ambiguity could serve as useful flexibility. In 1922, learning of the plans for a large Imperial Exhibition, the DSIR contracted the Royal Society to plan a central exhibit on "pure science" that would complement the "applied science" on display in the Halls of Industry and Engineering. It would demonstrate the advances in pure science that necessarily underpinned its applications. In practice, however, the distinction proved hard to implement, particularly because it was felt that demonstrations would be needed to interest the public. The organizing committee shifted its approach to "fundamental science," and ultimately the exhibition included a display on the development of the radio valve as well as on more obviously "pure science" (Royal Society, British Empire Exhibition Committee, 1925).

Even as they were criticized, the distinct terms "pure" and "applied" maintained their appeal. In July 1931, the Marxist physicist J. D. Bernal (1931) reported on the recent congress of the history of science held in London's Science Museum:

> Everyone agreed that pure and applied science were interdependent. The English emphasized the growing appreciation of the debt of industry and public services while the Russians pointed out the converse. To them, the development of pure science is dependent on that of economics and technics both for the problems they present it with and for the means provided for their experimental study.

This review was published not in an academic journal but in the widely circulated magazine of politics and general affairs, the *Spectator*. The relations between the subcategories of science were matters of general discourse and often, for all Bernal's perhaps ironically emollient words, sharply divided. Cecil Desch, the professor of metallurgy in Sheffield's Department of Applied Science, perceived threats to support of curiosity-driven science latent in the words of the Russians. In a November 1931 speech titled "Pure and Applied Science," he urged his audience at the University of Cornell to appreciate both the value of disinterested research, expressed by the recent exhibition about Faraday, and its multiple and surprising applications in industry (Desch 1931). In September that year, London's huge Albert Hall had hosted a display celebrating a century of induction discovered by Michael Faraday, with his purely scientific discoveries at the center of widening circles of recent developments representing the application of his work (James 2008). In an age of electricity, development of new uses became the narratives of applied science, just as stories of Faraday renewed their status as the illustrative anecdotes of pure science.

The alternative term "technology" was also widely used as a synonym when talking about gadgets, but it did not have the same connotation of dependence on "pure science" and elite culture. For example, H. G. Wells, who acclaimed the American "technocratic" movement, rarely used the term "applied science." The same goes for reports of the DSIR, specialists in individual subjects, and engineers. "Applied science" was a collective term not needed when a discipline or specialty were being discussed. Nor was it liked by engineers. The distinguished electrical engineer and industrial research leader Arthur Fleming avoided it both in his account of industrial research and in his history of engineering (Fleming and Brockelhurst 1925). As a modernizing electrical engineer, Fleming was anxious in his public utterances to address the interests and traditions of his professional peers.

Widely used elsewhere in the public sphere, the categories of "pure science" and "applied science" were nonetheless used to make sense of a range of important issues beyond science. The times were defined as an age of "applied science." The terms captured the cultural preeminence of gadgets and the science on which they were said to be dependent, both in terms of research and the educationally acquired skills of their inventors. Two politicians who had matured before the war, R. B. Haldane and Arthur Balfour, continued to be influential commentators on science after 1918. Both were philosophers with deep personal commitments to the rootedness of actions and inventions in ideas. Both were concerned that British people were not sufficiently committed to the linkage between thinking and doing. In 1927, Balfour (1927) reflected, "In the fundamental discoveries of pure science, this country, I believe, has taken its full share. About applied science I am not so sure." It was a contribution to British science policy discourse that was very widely reported at the time and would be taken up time and time again in the years to come. R. B. Haldane's nephew, the physiologist J. B. S. Haldane, was also adept at linking the mundane and the fundamental. He began a 1929 lecture to the socialist Fabian Society with the words "Western civilisation rests on applied science" (Haldane 1929). Writers, journalists, broadcasters, politicians, and museum curators popularized the term in the public sphere. The historian Peter Bowler (2009) has shown how popular journalists expressed a profound and widely held faith that fundamental problems could be overcome through applied science.

The progress of modern medicine was frequently interpreted as evidence of the impact of applied science on the modern world. Its products in the interwar years, ranging from an understanding of vitamins A and D, to insulin, to the sulphonamide drugs, seemed to be offering a new kind of pharmacopeia and for the first time hope of rational chemotherapy. In London, the Wellcome Museum, funded by Sir Henry Wellcome, himself owner of a great pharmaceutical company, provided persuasive interpretations of the linkage of progress, science, health, and happiness (Arnold and Olsen 2003). Furthermore, the impact of applied science could be experienced in domestic life. The feminist writer Storm Jameson, writing in the *Daily Mail* in 1931, scorned those who romanticised the past and enjoined, "Make modern applied science lighten your work and enrich your leisure."[22]

Not just time was defined; so was space. In the currently peaceful world in which international travel and communication was increasingly common for private citizens, there was acute awareness of other countries. Was Britain falling behind Germany, France, or the United States? Talk about applied science provided ways of both bemoaning failure and celebrating success. International competition was exemplified by the weapons and progress of the recent war, and potentially the next war. Poison gas was the emblematic product of that interpretation, as gas warfare was still acutely recalled and its victims encountered daily. The influential *Daily Mirror* columnist Richard Jennings, reporting the 1922 British Association Meeting, asked, "Is scientific discovery destined to destroy mankind?" A few sentences later, he was talking about the applications of discovery because "it is applied science that matters to the average man."[23] To others, associated with the right wing of Oswald Mosley's "British Union of Fascists," the destructive quality of applied science was itself an attraction, offering a route to the development of yet more powerful weapons (Zander 2009). The *Daily Mail* newspaper, owned by Lord Rothermere, an admirer of Adolf Hitler (even though he feared Germany), was part of this movement but expressed its support in terms of "technology" rather than the more intellectualized "applied science." It was, however, the centralized new media of the age that were setting the pace in talk about science, providing privileged access with unprecedented reach.

Public broadcasting on the BBC had begun in 1922. By the late 1920s, the huge influence of the medium was being appreciated. The whole country had just one official channel to which to listen. There was a strict discipline in what could be broadcast under the Director-General Lord Reith, a Calvinist and himself under the eye of the government. Political controversy was excluded, as was trivia. Controversial talk about science, however, found a ready place, particularly from 1930, when the new head of talks, botanist and communist Mary Adams, took charge (Desmarais 2004; Jones 2012). Formerly an adult-education extramural lecturer in botany at Cambridge, Adams was keen to use the new medium to promote understanding of science within her BBC department of adult education. The number and range both of series and of voices, put together by Adams, were remarkable. Jones (2012: 930) has estimated at least forty broadcasts on science and society themes between 1930 and 1935.[24] Multipart series running at 7:30 in the evening included such topics as "Science and Religion" (twelve parts), "What Is Science?" (four parts), "Science and Civilisation" (six parts), "Scientific Research and Social Needs" (thirteen parts), and "Web of Thought and Action" (twelve parts). The points of view presented were diverse, but they all prioritized science and its connections to the world of today, in both its constructive and destructive aspects. Many of the talks were reproduced in the BBC's magazine the *Listener,* which was read by thirty-five thousand people by 1933, and were published in books, which attracted a further readership from enthusiasts. This represented by far the most intensive engagement with substantial issues of science in the public sphere in British experience.

The BBC expressed the diversity of meanings that science in general and applied science in particular had acquired over recent years. These meanings had been formed within diverse discourses about education and war, Britain's place in the world, and modernity, medicine, and agriculture. By the 1930s they were coming together. This convergence was promoted through such pioneering studies as Julian Huxley's *Scientific Research and Social Needs* (1934), first presented as a series on the wireless and then republished in the *Listener.* Godin (2006: 650) has credited to Huxley the formal "linear" taxonomy of research, formulated as a four-stage model from "background," to "basic," to "ad hoc research," to "development." We need to recall that this was, however, not framed within government; rather, the new discourse of science policy was expressed as part of a conversation in the public sphere. The book sold about two thousand copies but about thirty-five thousand people read the *Listener,* and radio audiences would have been in the hundreds of thousands. A review in the *Observer* newspaper pointed out how much more lively the broadcasts were than the printed page.[25] In his series of programs, Huxley reflected both on the general progression of ideas from pure to applied science, but also on the importance of influences flowing in the opposite direction. We need to recall here that his ideas were also discussed in the press. An 1936 article in the *Times* suggested Huxley's technical terms but concluded that for most people the distinction between "pure" and "applied science" would suffice: "However even if the distinction between pure and applied breaks down in theory, and should perhaps be replaced by some other terminology, such as basic and long-term research, on the one hand, as against ad hoc and development research on the other—it still remains convenient enough in most cases."[26]

The best known of 1930s reflections on policies for science today is J. D. Bernal's *Social Function of Science* (1939). This book is widely seen as the founding document of science studies. It was, however, also the culmination of a decade of talk about its topic. The assertion that science was indeed a "social function" had already concluded Huxley's book, which in turn rendered into print the sentiments of his 1933 radio series. Here the term clearly indicated the influence of Huxley's friend Bronislaw Malinowski. Pioneering structuralist anthropologist, coeditor with Huxley of the *Realist* magazine, and fellow broadcaster in the radio series on "Science and Civilisation," Malinowski was widely credited with promoting the concept of the social function among anthropologists of interwar Britain (Kuper 2014: 63).

Bernal's book expressed themes developed in the previous two decades not only among a small group of socialists but also among a greater circle of radio contributors on science. It also provided a pioneering and successful integration of polemical arguments for a new instauration of science with a rich panoply of quantitative data. Its own status as "science" and the ancestor of the "science of science" was expressed through its structure. The book was divided into two parts: "What science does" and "What science could do." Bernal called for a much more intensive commitment to investment in science even within a capitalist society, though he believed it was only in socialism that its full benefit could be exploited. He was known as a radical, but he used the traditional terms to frame his vision: applied science was referred to on nineteen occasions in the book, though he was concerned with pure or fundamental science. Bernal's contribution, forward-looking as it would appear, was also rooted in past British discourses of science as well as in Marxism.[27]

Envoi

Socialism, if not communism, and radical change did come to Britain at the end of World War II. In October 1943, a committee of parliamentarians and scientists produced a report on scientific research and universities after the war. It called for a vast expansion of industrial research but also emphasized that "applied science cannot live on the fundamental discoveries of past generations" (Parliamentary and Scientific Committee 1943: 3). Early in 1944, two meetings of influential scientists, social scientists, and science journalists were held at Nuffield College, Oxford (Ritschel 1995). Many of the participants were people who would be important in thinking about science in the postwar world, including Solly Zuckerman (the future long-term science advisor),

C. H. Waddington, C. P. Snow, Henry Tizard, John Cockroft, Harold Hartley, and two Hungarian economists who would become familiar as advisors to Harold Wilson in the 1960s, Tommy Balogh and Nicholas Kaldor, as well as such prewar leaders as Cecil Desch. In January and April, they conducted meetings leading to a "Statement of problems of scientific and industrial research," which was submitted to the chancellor of the exchequer (Nuffield College 1944). Four complementary perspectives were taken on science, from the points of view of industry's research needs, of the supply and needs of research workers, of society, and finally of education, where the conference was asked to reflect on the desirable relationship between pure and applied research.[28] A great expansion, including the formation of a further two dozen government-funded research associations, was called for. Despite the distinction of its authors and the wide-ranging scope of its concerns, this document, which was a manifesto for future science policies and whose authors included many people who would be influential for the next two decades, has been curiously overlooked. It also drew on twenty years of discussion about science expressed in the carefully summarized suggestions of recent years.[29] At its heart was a distinction between fundamental and applied research, the dependence of the latter upon the former, and an expression of their common needs:

> These considerations apply equally to what is called "fundamental" and to what is called "applied" research—by which we mean broadly speaking, on the one hand research carried on purely for the advancement of scientific knowledge, without direct reference to any practical outcome, and on the other research designed to achieve practical results either in industry or in any other field in which scientific discovery can be used to increase man's working mastery over the forces of nature. (Nuffield College 1944: 11)

It would be pleasant to end with the conclusion that "at last" science policy had been invented. Certainly the history of the field often takes as its founding moment the American "Bush report" of 1945, *Science, the Endless Frontier.* We know, nonetheless, that despite its fame, the National Science Foundation was not established for some years and had a more complex origin. Similarly, in Britain, while the Nuffield College paper highlights the widespread appeal of the call for more basic research to sustain applied research, most science expenditures were firmly under the control of major departments (particularly defense) for whom science was an instrumental tool. Even the appointment of a participant at the wartime Nuffield College meetings, the reforming conservative Quintin Hogg, as minister "for science and technology," did not happen until 1960, and his was more of a coordinative than a directive role. It could be said that many of the arguments of the early twentieth century did not achieve their goal until 2010, when scientific research, higher education, and industry policy were unified in one government department (the Department of Business).

We might conclude, nonetheless, that the categorizations of science, expressed as World War II was drawing to an end, were significant. They served as a passage point between a century and a half of wide-ranging discourse in the public sphere and the development of a postwar policy dialogue. Twentieth-century talk about research had drawn on contemporary concerns about war and rapid change and on nineteenth-century arguments about technical education, the privileging of practical training, and the arguments promoting applied science formulated in reaction. That discourse had been shaped by more than policy and politics. Broadcasting had proffered opportunities for coalescence of meanings from a variety of discourses. The challenge of disruptive technologies, which frightened as well as impressed, was managed by the language of applied science, which provided assurance that these awe-inspiring novelties were based on the enduring methods of science. When it might have seemed that culture and language would be torn apart, the enduring names of strong organizations provided closure of old debates. What was at stake in talk about "pure," "fundamental," and "applied science," and about "technology," was much more than either pure epistemology or the dynamics of innovation.

Robert Bud is the research keeper at the Science Museum in London. He has served at the museum as head of research (collections) and as keeper of science and medicine. He is a fellow of the Royal Historical Society, past winner of the Bunge Prize awarded by the German Chemical and Physical Societies, and holder of the Sarton Medal and Sarton Professorship at the University of Ghent. He has published extensively on the histories of applied science, chemistry, and biotechnology, including his books *The Uses of Life: A History of Biotechnology* (1993) and *Penicillin: Triumph and Tragedy* (2007).

Notes

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1. For more detailed explanation of the methodological approach chosen here, see Bud 2013a.
2. Linder and Smeaton (1968: 272) compared the original Swiedauer's translation and Bentham's—the first is the original, the second Swiedauer's lingua franca, and the third Bentham's: (1) "Wenn sie aber zum besondern, oder allgemeinen, Nutzen angewandt wird . . . so verdient sie den Nahmen der angewandten (Che-

mia applicata) eben wie die Mathematik in solchen Fällen diesen Zunahmen erhält." (2) "But when it is applied to a particular or general use . . . it merits the name of chemia applicata, just like mathematics obtains this name in such cases." (3) "But when it enters, more or less, into details, and applies itself to use . . . it may be termed [chemia applicata] mixt, particular, or popular chemistry, after the same manner that mathematics is denominated in the like cases."

3. The use of the word "mixed" was related to its use in the phrase "mixed mathematics," in which both axioms and material objects were invoked. See "mixed" in the *Oxford English Dictionary* (usage no. 5). *OED Online, June 2017, consulted November 13, 2017.*
4. University Library Cambridge, Guard Book, 28.5.1 ms ul, report revised by the Syndicate, 24 May 1865.
5. House of Commons Debate, vol. 191, "Motion for a Select Committee," 24 March 1868, cc160–86.
6. The issue of engineering education was a matter of heated dispute in the nineteenth century and of deep pride at the time, and has been widely written about since then (Buchanan 1989). For the related American disputes, see Calvert 1967.
7. The origins of this well-known quotation are complex. For instance, Hulin (1986) has highlighted the tension between Pasteur's Ecole Normale Superieur, dedicated to the training of future professors and teachers, and the Ecole Polytechnique, with its industrial bent, which Pasteur had addressed in a related way in 1868. Pasteur's challenge was also soon known in France. See, for instance, an essay by George Pouchet (son of Pasteur's old adversary Felix) (Pouchet 1872: 44–45; see also Fauque 2005).
8. "Tyndall on Illumination," New York Times, 16 February 1879.
9. The year 1957 is significant as the period of post-Sputnik introspecting in the West and the sense that where Germany had once outpaced Britain, now the Soviet Union was outpacing the United States.
10. In 1821, there are no uses in any newspaper; in 1822, only five; and in 1823, there are 142 uses. Data retrieved January 2016 from www.britishnewspaperarchive.co.uk.
11. William Perkin's discovery in 1856 of the coal-tar-based dye that he called "mauve" is generally regarded as the basis of the synthetic dye industry, which came to be dominated by German companies from the late 1860s.
12. In his description of the late eighteenth-century period he denotes as the *Sattelzeit,* Koselleck (2011: 10) explains, "While analogous developments can be discerned at the threshold of every epoch, a significant number of indicators do point to such an accelerated process of change in the political and social language of the period studied here. If so, then it is likely that the *modern world (Neuzeit)* was simultaneously experienced as a *new age (neue Zeit)*. Sudden changes permanently altered the once-familiar world, thus transforming the horizon of experience and with it the terminology (especially the central concepts) that had once been—reactively or proactively—tied to it." Similar phenomena could be observed in the period 1890–1919. The parallels are expressed in economic history

by the term Patrick Geddes (1915: 59) used for this period, "Second Industrial Revolution," coined as early as 1915.

13. "Business has been conducted too much in the spirit of an art, too little in that of applied science. The modern tendency is to introduce the exacter methods of science" (Hobson 1913: 198).
14. The Glasgow and West of Scotland Technical College, "Relations with the University of Glasgow," November 1909, in "Special Committee on Relations with the University. Minutes &c," 61/27/1, Strathclyde University Archives.
15. Curiously, German practice was changing in the other direction at this time, as *Technische Hochschulen* also started to offer doctorates. At the opening of the *Technische Hochschule* in Danzig in 1904, the Kaiser himself praised the ways in which such institutions combined "theoretische und angewandte Wissenschaft" and acted as scientific universities (Mangoldt 1904: 13).
16. "The Victoria University: Manchester Charter," *Manchester Guardian,* 29 May 1903.
17. National Archives, U.K. (NA), PC 8/605 pt 2, ff 89731 p. 30, Question from Lord Balfour to R. B. Haldane, Transcript of Shorthand Notes of Proceedings before the Committee of Council, on 18 December 1902.
18. "Mr. Pease informed the deputation that the particular problems to which they had drawn attention had been present [*sic*] to the Board of Education for some time past, and that a scheme had been elaborated under which substantial additional assistance would be given by the Government to scientific education and to industrial research." See "Report of meeting with Royal Society and Chemical Society." NA, ED 24/79, 6 May 1915. See also Addison to Pease; NA, ED 24/1581, 20 March 1915, in which the plans of the time are described as "Advanced Scientific Education and Research."
19. House of Commons Debate, vol. 71, Arthur Lynch, 13 May 1915, cc1930.
20. The modern literature on interwar industrial research is of considerable interest in highlighting the status and public relations value of such work and its problematic, if occasionally enormous, direct knowledge value to the companies. See three valuable studies of Du Pont (Hounshell and Smith 1988); Philips (De Vries and Boersma 2005) and Metropolitan Vickers (Niblett 1980).
21. "Science and Industry," *Manchester Guardian,* 1 September 1916.
22. Storm Jameson, "Get the Best out of Life," *Daily Mail,* 4 April 1931.
23. "Destructive Science," *Daily Mirror,* 9 September 1922.
24. Jones (2010: 66–67) has suggested that 10 percent of BBC output was comprised of talks, and 10 percent of these were on science, so that, by time, science talks were getting 1 percent of the schedule. With total BBC audiences of thirty million by the end of the decade, a 1 percent share for science came to several hundred thousand.
25. "Listeners' Science," *Observer,* 29 July 1934.
26. "Science," *Times,* 1 January 1936.
27. On Bernal and both his scientific circle and his relationship to socialism, see Werskey 1978.

28. Nuffield College, Wartime Research Committee and Social Reconstruction Survey, 12th Private Conference, "The Post-War Organisation of Scientific and Industrial Research: General Purpose of the Conference," 13 November 1943, MSS NCPC 7/2/2, Nuffield College Archives, Oxford University.
29. G.E.F, "Proposals for the Post-War Organisation of Scientific and Industrial Research," Nuffield College, Wartime Research Committee and Social Reconstruction Survey, 12th Private Conference 8-9 January 1944. Ff 7/2/27–7/2/32, Richard Gregory papers, SxMs 14/1, The Keep, Falmer.

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