FROM APPLIED MICROBIOLOGY TO BIOTECHNOLOGY: SCIENCE, MEDICINE AND INDUSTRIAL RENEWAL

by

ROBERT BUD*

Science Museum, London SW7 2DD, UK

In the late 1970s politicians and civil servants were acutely aware of the chronic decline of the manufacturing sector as a source of employment in Britain. At a time of fear of mass unemployment, sources of new work were urgently sought. Biotechnology had been promoted by visionaries since the early twentieth century. With oil prices soaring, its potential to produce substitutes for petroleum derivatives seemed newly attractive. At the beginning of 1976, John Bu’Lock at Manchester brought the attention of the new President of the Royal Society, Lord Todd, to the developments in enzyme and fermentation technologies. Both the Society and government began to take biotechnology seriously. In 1979 the Society organized a groundbreaking meeting, ‘New horizons in industrial microbiology’. In parallel, John Ashworth, the chief scientist of the government think-tank the Central Policy Review Staff, prompted by American developments in genetic engineering, its commercial exploitation and regional development, led thinking among government officials. The Spinks enquiry into biotechnology was consequently formed in 1979 as a collaborative enterprise of the Advisory Council for Applied Research and Development, the Advisory Board for the Research Councils and the Royal Society. The recommendations for far-reaching collaboration between research councils, government and industry were not fully implemented. However, even the limited implementation led to new models of science that would be significant in the emergence of a reconstruction of science.

BACKGROUND

The banking crisis of 2008 caused many to reflect on the revolution in the British economy that had occurred in the last decades of the twentieth century. Once fundamentally dependent for wealth and work on manufacturing, the country had changed radically. The proportion of employment represented by manufacturing fell from 36% in the 1960s to 31% in 1975, to 26% within a decade, and by a further 10% in the following 20 years.\(^1\) Much of this shift at 5% a decade happened silently, over a long period. However, in the years around 1980 the decline of traditional manufactures occasioned much debate and anxiety. That debate framed the process by which biotechnology became a national priority in Britain.

Even if, in Britain, the late 1970s would be most widely remembered by the ‘winter of discontent’ and subsequent massive inflation—reaching 30% at one point—the worst fears

*robert.bud@sciencemuseum.org.uk
of the Callaghan government, and, indeed, of the people, were of mass unemployment. Traditional manufacturing industries were losing their export markets to cheaper competition and, apparently, nothing was filling their place. The attempts of successive governments to pick winning projects within existing technological frames such as Concorde, Advanced Gas-Cooled Reactors or the System X telephone system had failed miserably. To many, it seemed that old industries should, instead, be replaced by new, just as, half a century earlier, textiles and coal had been replaced by chemicals and electricals. It was not just Labour Party ministers who feared the implications of a continuation of current trends. Lord Weinstock, chairman of GEC, famously complained to a Select Committee of the House of Lords that Britain would be reduced to supplying the Changing of the Guard and Beefeaters.

To avert the Weinstock catastrophe, it seemed necessary to build new industries based on information technology and biotechnology. In May 1978 the Cabinet Office arranged a special screening of a new BBC programme Now the chips are down, viewed by, among others, the Secretary to the Cabinet to ‘brief himself on the increasingly important “microprocessor revolution”’. The growing power of medicine offered the opportunity for rapidly growing markets as well as a challenge to the National Health Service. Where previously the nation had made and used machine tools, now Britain would make and use enzymes. In this transformation, it was widely expected, science would have a huge role. Government policy-makers worked with the Royal Society to help bind the triple helix of industry, government and science.

A will for transformation was shared by many countries around the hitherto industrialized world, exposed to new competitive forces and radically changing oil prices. We forget, perhaps, how sudden these changes were. In the period 1973–74, in the aftermath of the Yom Kippur War, the cost of petroleum doubled, and it doubled again in 1979–80 during the Iran–Iraq war. Moreover, Japan, which had been progressively becoming a more powerful threat to Western manufacturers, became an overwhelming challenge. In 1975 the USA experienced its last trade surplus of the twentieth century. By 1980 the GDP per capita of Japan reached almost the British level, having been only one-third of that of Britain in 1950.

In each region the challenge of industrial change was mediated in its own way. In Europe Commissioner Ralph Dahrendorff sponsored a report entitled Europe plus thirty, issued in 1974, which called for a major future-looking think-tank. This was indeed followed up by the creation of an internal, albeit small, group known as ‘FAST’, which followed the earlier creation of the Office of Technology Assessment in the USA. One of its first products was the tellingly entitled The Old World and the new technologies. In Germany the research ministry commissioned an investigation of the industrial potential of biotechnology from the chemical plant association Deutsche Gesellschaft für Chemisches Apparatewesen (DECHHEMA). Its 1974 report can be seen as the ancestor of all subsequent studies urging the centralized promotion of the new technological complex. This was, of course, not the only form of response, and, politically, such approaches based on planning and corporatism were confronted by the market-based visions of Ronald Reagan and Margaret Thatcher.

**BIOTECHNOLOGY: THE ENDURING DREAM**

Why biotechnology? We must, at one level, look to remarkable scientific advances of the time. However, these alone did not determine the path taken. Which advances would be
seen as critical, and which organizations would be involved, were influenced by past developments. Prophecies of the ‘age of biology’ that would succeed the ‘age of chemistry’, and of a ‘biological engineering’ that would be as important in the future as ‘chemical engineering’ in the present, had been made since the early twentieth century. So deeply entrenched and widely repeated was this prophecy right through the twentieth century that, instead of interpreting it as an empirical discovery on each occasion it was uttered, one can see it rather as a claim for a pre-existing cultural niche.

The word ‘biotechnology’ goes back to 1917. In Britain the early decades of the century had resounded to prophecies by Patrick Geddes, Julian Huxley and Lancelot Hogben, among others. The first was elderly by the 1920s, but the latter two were members of the group of Young Turks of the Royal Society in the early 1930s, described as the ‘visible college’ by historian Gary Werskey. They were heard by such established members of the Society as Harold Hartley, who would go on to be a campaigner for the biological era into his nineties. Other well-known prophets were to be heard in Hungary, Germany and the USA, where Lewis Mumford preached. In 1970 Desmond King-Hele, the physicist and historian, in his paperback *The end of the twentieth century?*, reflected, ‘We have come to accept the marvels of technology, based on great advances in physics. Now the rapid advance of biology is beginning to generate marvels of what might be called bio-technology—the manipulation of living things’.

In part, the prophets were inspired by the achievements in microbiology of the late nineteenth and early twentieth centuries. Louis Pasteur had been among the most famous of recent scientists, and it seemed that his followers and contemporaries might achieve even greater things. In Britain Joseph Lister became a hero, promoted as Pasteur’s British counterpart, and the Lister Institute was a smaller British equivalent of the Pasteur Institute. This medical glory seemed about to be matched by industrial achievement. During World War I, Chaim Weizmann had famously led a team that made vitally needed acetone for explosives through the fermentation of starch. His assistants A. C. Thaysen, L. D. Galloway and T. K. Walker went on to create distinguished teams of industrial microbiology in government (Chemical Research Laboratory), the West Indies and Manchester University.

However, the Weizmann school failed to nucleate a crystallization of industrial microbiology. Neither Weizmann nor his erstwhile assistants, nor even their protégés, were ever elected to the Royal Society. It was in Delft, in the school of A. J. Kluyver, who was elected a Foreign Member of the Royal Society in 1952, in Prague through Konrad Bernhauer, in Japan through the work of Sakaguchi, and in the USA at Pfizer and in a Department of Agriculture team that during the interwar years a powerful tradition of highly respected, theoretically based, technologically sophisticated industrial microbiology was developed. Famously, it was the Americans rather than the more medically and chemically oriented British team who developed the deep-fermentation process for penicillin manufacture during World War II. Such, nonetheless, was the credit that accrued to microbiology from one of the greatest breakthroughs in the history of applied science that even in Britain the development of antibiotic manufacture seemed sufficient to justify the expectation of an age of biology.

Indicative of the new status of microbes were the awards made to those who studied them. In 1945 Marjory Stephenson, author of the frequently republished classic *Bacterial metabolism*, became one of the first two female Fellows of the Royal Society. A year later, Paul Fildes was awarded a knighthood to reflect his wartime establishment of the
Microbiological Research Establishment (MRE) at Porton Down. In the face of feared German advances, Fildes had been recruited at the onset of war to establish a centre of biological warfare. At Porton Down he built a large and congenial institute whose culture, halfway between the military and the civilian, would be a remarkably creative host for distinguished scientists to work with the world’s best equipment. Until the explosion of Britain’s hydrogen bomb in 1957 the MRE was seen as being a potential source of super-weapons. Thereafter it was constantly reviewed for civilianization. Its distinguished Biological Research Advisory Board ensured that almost all its work was published in the public domain. Both Fildes himself and his successor, David Henderson, were elected to the Royal Society. The MRE became known for its work with pathogens, with continuous fermentation and with the production of enzymes such as asparaginase extracted from microbial cells.

The success of the MRE in continuous fermentation became the reference point for a huge wave of new fermentation endeavours from the 1950s to the 1970s. At a time when world protein shortage seemed at the heart of the problem of starvation, and animal feed was expensive, new foods for humans and animals could be made by growing microbes on petroleum products, using models of continuous fermentation. This would make better use of the complex chemicals in oil than just burning them. The term ‘single-cell protein’ was coined by Nevin Scrimshaw at Massachusetts Institute of Technology, but it was British firms—BP, Shell and ICI—that seemed to be in the lead in Western countries. Shell’s research led by Lord Rothschild dropped out first, but BP’s Toprina product, made in a huge plant in Sardinia, and ICI’s Pruteen seemed the way of the future in the mid 1970s. Quorn, made initially by ICI on the Pruteen pilot plant, is the survivor from this era.

Meanwhile, alcohol made by fermenting carbohydrates of various kinds seemed to be the solution to the shortage of cheap oil. Continuous fermentation, again drawing on the experience of the MRE, seemed to be the route to both gasohol and to a more efficient production of beverages such as beer. Immobilized enzymes were another solution to the challenge of alcohol conversion, and enzyme production seemed again on the critical path to a new industrial era. Mass production of a novel sweetener, high-fructose corn syrup, by the enzymatic conversion of glucose to fructose, replacing sugar in soft drinks, seemed to portend a new age of enzymes.

The achievements in biofuels, novel foods and enzyme technologies would perhaps be forgotten as prices of fuel and food fell in the 1980s. The products of fermentation technology had, however, seemed both real and important, even revolutionary, in 1980. They were also familiar, producing large quantities and potentially employing numerous people. The technology was quite new and boasted a respectable provenance, rooted in familiar large corporations such as BP, ICI and the chemical engineers APV, and in the great Porton research institute. Such were the developments that inspired the 1974 German report on biotechnology.

**BIOTECHNOLOGY AND THE ROYAL SOCIETY**

At the same time, it might rather be thought that the truly significant developments of the time were the product of the science of molecular genetics. Certainly to many, even at the time, they were indeed, and particularly to scientists at the Laboratory of Molecular Biology (LMB) at Cambridge, a part of the Medical Research Council (MRC). At a time
of national champions, this was Britain’s ‘national champion’ in the emergence of molecular biology. Its Nobel Prize count was unparalleled. Seven laureates would attend the Science Museum exhibition opening celebrating the laboratory’s 40th anniversary in March 1988. In commercial development, however, in 1980, the LMB did not seem to be world-leading when compared with American competitors.

The development of genetic engineering in California had already spawned a rhetoric of benefits in the USA and the creation of small but very ambitious research organizations on the west and east coasts. Cetus, Genentech, Biogen and Genex were the first. The rhetoric of benefits was developed in response to the threats of tight control from Congress. In hearing after hearing, the potential good that should be taken into account before mitigating remote chances of harm was outlined by promoters such as Joshua Lederberg. Such benefits as personalized protein engineering (called by Lederberg ‘euphenic engineering’) might have been speculative but they became increasingly ‘real’.

The early emergence of interferon, human insulin, human growth hormone and, soon, monoclonal antibodies attracted huge funds to the new biotechnology companies in Massachusetts but especially in California. This was a model of the conduct of science that seemed to emulate the chip development of a previous decade that had led to the growth of Silicon Valley, the new minicomputer and emerging microcomputer industry. Here was a model of regional and indeed national regeneration that the rest of the world, and specifically Britain, might envy.

All these ideas came together first in Britain, not in Cambridge or Porton Down, but instead at the University of Manchester where a chemist, John Bu’Lock, was inspired by the potential of microbiology. In honour of his hero, he got his laboratory funded as the ‘Weizmann Laboratory’. From 1973, Bu’Lock held meetings in an octagonal room, from which the Octagon papers were published. He was in close touch with colleagues across Europe and indeed Australia. By 1976 his network was strong among microbiologists and had issued a series of Octagon papers, each coming out of an international workshop. The first three topics indicate what the issues were seen to be: ‘Projects and prospects in industrial fermentation’, ‘Large-scale fermentations for organic solvents’ and ‘Cellulosic substrates’.

Like Weizmann himself, Bu’Lock was no member of the scientific elite but did have the benefit of good connections. In 1975 his doctoral supervisor at Cambridge, Lord Todd, became President of the Royal Society. In January 1976 Bu’Lock wrote a four-page letter to his former supervisor suggesting that government understanding of the ‘potential of biotechnology’ was sorely needed. Until the Labour victory in 1964, Todd had been chairman of the Advisory Council on Scientific Policy (ACSP) and clearly now felt that the Royal Society should return to its traditional role at the heart of British science policy. It is nonetheless ironic that this protagonist of the place of the Royal Society in policy and of the importance of biotechnology was also a man who had firmly traditional views on the independence of science. He had resigned from the ACSP in 1964 to avoid a clash with Patrick Blackett, the new government’s Chief Science Adviser, in a more dirigiste political climate. Now, in the era of the Rothschild report, he found himself once more at the centre of science policy.

In the late 1970s, scientific advice to the British government was formally the responsibility not of any one chief scientist, a post that had recently been abolished. Instead, individual departments had their own chief scientist. Within days Todd had forwarded Bu’Lock’s plea to the chief scientist at the Department of Industry, Sir Ieuan
Maddock, himself an FRS since 1967. Maddock wrote back again within a few days, recalling the enthusiasm of Harold Hartley and suggesting that the Royal Society should convene a group to explore the issues.  

It was possibly directly out of this correspondence that a discussion meeting to explore the potential of industrial microbiology under the aegis of the society was organized by two former colleagues at the LMB, Sydney Brenner and Brian Hartley. Brenner was about to be the director of the laboratory and, at that time, was endeavouring both to understand the molecular biology of the nematode worm and to recover the finances of the LMB.  

Hartley, by contrast, had moved on to Imperial College, London, and, enthused by the challenge of enzymes, was increasingly drawn to the problem of the economic fermentation of ethanol and the production of proteins. He would be a founder of the early biotechnology company Biogen in 1978. They were joined by Peter Rodgers of ICI, who was working on such projects at Billingham as Pruteen and the microbially produced plastic PHB (polyhydroxybutyrate). These three, with their associations with LMB, Imperial College and ICI, lay at the centre of British biotechnology. Their meeting, which typically for the time took about three years to organize, was held in June 1979.

The year 1979 was a critical moment—far more significant in the history of British industrial biotechnology than 1976, when the idea of a conference had first been proposed. Fuel prices were rising rapidly and the potential of gasohol seemed higher than ever. American biotechnology companies such as Genentech and Biogen, although still small but growing rapidly, were now becoming known in Europe. The Wall Street bubble was still in the future. Indeed, a young new Washington-based stockbroker, Nelson Schneider, seeking to find out more about the potential of the new technology, was advised by Wally Gilbert, CEO of Biogen, to attend the British meeting to find out more about the technology. So impressed was he that on his return he wrote a paper for the clients of his firm, E. F. Hutton, and in August he presented his findings to an investment meeting that would overflow and whose enthusiasm would launch the biotechnology revolution.

The Royal Society meeting had been introduced by Brian Hartley, who reflected on the unique qualities of that moment when rapid technological change had coincided with a collapse in commercial certitudes and with a change in the political climate. Margaret Thatcher had been elected just a few weeks earlier. Now he pointed to the emphasis on enterprise and innovation as the key to industrial regeneration. The mood of the meeting proved to be rather less gung-ho, concluding tentatively, as the official report recorded, ‘on a note of cautious optimism, with the hope that some of the recent successes that had been presented during the meeting would encourage more support for research into industrial microbiology.’ The reason for such caution was, in part, uncertainty about the views of the newly elected Thatcher government. It perhaps reflected, too, the determination not to take for granted the parallel initiative in which many of the key stakeholders in this meeting were also involved.

THE ORIGINS OF THE SPINKS ENQUIRY

Back in 1976, the British government itself had been forced to engage with the potential of biotechnology. The Convention of 1972 outlawing biological warfare had come into force in 1975. Seeking economies, the Ministry of Defence proposed to shut down the MRE.
Such a decision was not straightforward, even from a strictly administrative point of view, because the laboratory already provided services to the MRC and to the Department of Health. The issue was therefore put on the table of the newly appointed head of science within the Cabinet Office’s think-tank, the Central Policy Review Staff. John Ashworth was just 38 years old and his rank of Under-Secretary was not comparable with that of the former post of chief scientist. Ashworth was, however, in a strategic position at the heart of government, and as a trained biochemist himself he was attracted to the challenge of recommending a course of action on the MRE. He quickly found, just as Bu’Lock was complaining at the same time: there was no government policy at all for the emerging field of biotechnology.

Ashworth was interested in the potential of intervening at such a level. In 1980 he reflected on the challenge of averting the mistakes of the past when winning solutions had been chosen by ministers. This had failed, but he felt that government did have to act. ‘One way of out of this dilemma’, he wrote in a letter to Geoffrey Cooper of the Chloride Group, ‘might be to identify technologies (rather than the products or processes which embody that technology) where the UK ought to regain or maintain a presence. I think the concept of Government support for and encouragement of “enabling” or “heartland” technologies would be attractive.’ Ashworth was particularly attuned to biotechnology’s potential as a source of development because of his own long-standing professional links to the USA. He had spent time in San Diego, California, whose City Council had made a decision in 1965 to invest determinedly in the new molecular biology in the hope of sustaining an economy hitherto dominated by the Navy. The Salk Institute, founded in the 1960s, had been followed by the major medical research centre, the Burnham Institute, founded in 1976. One of the first biotechnology companies, Hybritech, which developed a monoclonal antibody test for hepatitis B, was formed there in September 1978 and would spawn many descendants.

At the same time as Hybritech was being formed in California, Ashworth was leading a campaign to promote awareness of biotechnology in Britain. In December 1978 The Economist published a widely cited article entitled ‘Industry starts to do biology with its eyes open’ that Ashworth had himself drafted. Now pressure was exercised by the scientific community acting in unusual concert. Within government the voice of science was the centrally funded research councils collectively represented by the Advisory Board for the Research Councils (ABRC). Outside government, and of course completely independent, was the Royal Society. Between was the recently founded Advisory Council for Applied Research and Development (ACARD), established partly in response to pressure from the Royal Society’s past President Alan Hodgkin as a means of providing independent advice to ministers.

Through ACARD, Ashworth managed to bring together all the organs of British science in a concerted and apparently independent manner. In the summer of 1978 ACARD was completing three reports—‘Technology change and employment’, ‘Application of solid state technologies’ and ‘Innovation’. Now it was looking for new topics to explore, although there was a certain amount of competition with the Royal Society. In June the Society had hosted a small meeting to discuss its own role in matters of ‘scientific and national significance’. Alf Spinks, ACARD’s deputy chairman and research director of ICI, took part together with a select small group of Britain’s leading scientists. Biotechnology was raised as a matter for the Society to investigate. So when, a month later, there was a discussion at ACARD, the preference was to leave this to the Society.
In September, however, Spinks was told that Ashworth was nonetheless pressing that ACARD should take on biotechnology itself. Ashworth was given leave to approach the ABRC to sound them out on whether they would collaborate on an enquiry and report to ministers. On 13 December Shirley Williams, Secretary of State for Education and responsible for the research councils, told Parliament, in a written answer, that she had approved the establishment of a joint committee to investigate the potential of biotechnology.

In listing the partners, Shirley Williams mentioned only the ABRC and ACARD. It had, however, been unthinkable to exclude the Royal Society, which had already taken a lead in the area and was led by such a senior figure in science policy as Lord Todd. Moreover, the distinguished members of the committee would probably be Fellows. Even before the parliamentary announcement there had been a formal exchange of letters between Spinks (for ACARD) and Lord Todd. In a manner useful to the historian, although possibly redundant for the recipient, Spinks specified why this moment was the one in which long-held dreams of the age of biology would come to pass. Immobilized enzymes, large-scale fermentation technologies, recombinant DNA and the potential of biofuels were listed.

The topics listed by Spinks echoed the interests of his company, ICI. Indeed, the committee and its environment were dominated by ICI. The chief scientist at the Department of Industry was Duncan Davies, who, as a career ICI man and then General Manager of R&D there from 1969 to 1977, had worked under Spinks. The committee that met on 6 February 1979 had six members. It included Spinks and Ashworth, who had been progenitors of the idea, and Professor A. W. Johnson, a natural products chemist who had worked closely with Spinks at ICI in the late 1930s, had taken a doctorate under Lord Todd and was now President of the Chemical Society. Above all he was a member of the National Research and Development Corporation, an organization he would represent time and time again in the discussions. Brian Hartley, a progenitor of the conference being organized by the Royal Society, was also an active partner in the pioneering international biotechnology company Biogen. John Davidson was Professor of Chemical Engineering at Cambridge. The vice-chairman was the distinguished animal virologist William Henderson, who had been Secretary of the Agricultural Research Council since 1972. At the very first meeting he welcomed the opportunity to counter the caution induced by concerns about the safety of genetically modified organisms. ‘I am a benefits man—not a hazards man’, were almost his first words to the group. To this small core group would be added by invitation Austin Bide, the chairman of Glaxo, and Arnold Burgen, a doctor and pharmacologist who was the director of the National Institute of Medical Research.

**The report**

The first to speak at the first meeting after the introductions was Brian Hartley. In his comments he emphasized the speed of developments, the impact of changes in oil prices and the implications of the ‘revolution in genetic manipulation’, to which Spinks responded ‘but also fermentation, enzymes, biomass, etc.’. The official minutes summed up the decision to focus on the use of genetic manipulation, fermentation techniques, enzymes and biomass. This list of course reiterated the concerns that Spinks had tabulated in his original letter to Lord Todd. It was also a set that underpinned the definition of biotechnology given in the introduction of the final report, ‘The application of biological organisms, systems or processes to manufacturing and service industries’.
Although the list was apparently comprehensive, a second look reveals the absence of agriculture. In retrospect this may seem surprising. At that moment, however, the very productivity of agriculture had created huge fiscal problems for the European Economic Community, and specifically for Britain as a net contributor to its budget. Europe was suffering from massive overproduction of agricultural products and a market in which costs to the consumer bore only an indirect relation to costs of production. An interpretation of biotechnology as a means of aggravating this already difficult position would not have been politically astute. Indeed, it would have been dysfunctional, because the enquiry was primarily intended, as Spinks emphasized in introducing the first meeting, to produce a report for ministers.\textsuperscript{32}

Hartley complained, to the eighth meeting in July 1979, about the lack of exciting new ideas in either written or oral testimony.\textsuperscript{33} The report, however, through its sponsorship by three key and clearly separate organizations of British science and the weight of evidence drawn from distinguished witnesses as well as its own eminent authors, did have considerable weight. It put in brief sentences in a way and form accessible to ministers the thoughts of leading members of the scientific community. The emphasis was on the need for closer collaboration between government departments, scientists, research laboratories and industry. The report gave authority to recommendations that otherwise might have been dismissed as journalistic or old-fashioned government interventionism at a time of political revolution.

The response to the Spinks report was prepared almost immediately. It was presented by a group of cabinet office officials that was chaired by Duncan Davies of the Department of Industry and included John Ashworth in his role as chief scientist of the Central Policy Review Staff. Despite their proximity to the authoring team, the dynamic political situation of the time made it impossible for these civil servants to frame a clear and specific way forward on the basis of the report. So when a necessarily vague response was published it was met with predictable anger from both industry and academics. This rebuff served to put further pressure on the government, so that the 1981 White Paper that followed was rather more positive than the initial response had suggested. Nonetheless, Sheffield’s Professor M. W. Fowler commented sardonically on the large amounts of biomass that the white paper consumed rather than its positive contribution!\textsuperscript{34} More directly, the science policy analyst Margaret Sharp commented that the White Paper ‘brought fury’.\textsuperscript{35}

In the background to the response to the report was a precipitate crisis. The 18 months from the election of Mrs Thatcher to the end of 1981 proved to be some of the most traumatic that British industry had ever experienced. In that short time, manufacturing output declined by almost 20\% in value. The response of the new government was, in general, to trust the market. Yet the recommendation to support a British company that would commercialize molecular biology gave authority to the National Enterprise Board to support, in November 1980, the formation of ‘Celltech’ in order to exploit advances made at LMB.\textsuperscript{36} The kind of thinking that the report had legitimated was expressed by Mrs Thatcher herself in 1984 at the Conservative Party meeting shortly after the explosion in her Brighton hotel.

In the 1940s, when I took a science degree, the new emerging industries were plastics, man-made fibres and television. Later it will be satellites, computers and telecommunications, and now it is biotechnology and information technology; and today our universities and science parks are identifying the needs of tomorrow.\textsuperscript{37}
Both the MRC and the Science and Engineering Research Council (SERC) would establish substantial biotechnology research programmes.\textsuperscript{38} Moreover, the Department of Trade and Industry (DTI) came to be a major sponsor of the new industry. Under its minister, Patrick Jenkin, who had worked for the Distillers Company, the DTI established a biotechnology directorate in November 1981. A year later this announced a £16 million programme and by the end of the decade claimed to be spending £50 million a year on related programmes. Scientists were beginning to span the academic and industrial spheres, even if with less dispatch in the UK—either than in the USA, or than the promoters had hoped. By 1985, 40 small biotechnology companies had been established in the UK, more, suggested Edward Yoxen, than in the rest of Europe together.\textsuperscript{39} The Spinks report would itself be hugely influential, for instance on the Organization for Economic Co-operation and Development (OECD) report written by three British scientists—Alan Bull, Geoffrey Holt and Malcolm Lilly—whose definition of biotechnology would follow that of the Spinks committee.\textsuperscript{40}

Eight years after publication of the Spinks report, the Royal Society organized a symposium to review the developments since then. An important paper was contributed by the science-policy analyst Margaret Sharp, now Baroness Sharp.\textsuperscript{41} She pointed out that the key proposal for strong centralized coordination of biotechnology had been frustrated not just by the government’s aversion to central control: the research councils had also found it impossible to work together. She told a story of John Ashworth and Alf Spinks pushing hard for the establishment of a powerful coordinating body but also of their frustration by the MRC. Sharp argued that the MRC Secretary, Sir James Gowans, saw in the recommendations for coordination the extension of the Rothschild customer–contractor relationship and the loss of the independence of scientists.

Gowans’s concern about the threatening loss of independence that would come with central coordination and industrial advisers sitting on the coordinating committee echoed enduring issues for scientists and the Royal Society. It was this sort of issue that had induced Lord Todd to resign his role in the ACSP two decades earlier. It was perhaps ironic that it was under his presidency that the Royal Society sponsored a report that others saw as so threatening. However, I have tried here to emphasize the sense of peril that underpinned the recommendations of the Spinks committee. If biotechnology was a cuckoo in the nest of science, it had not arrived by accident.

\textbf{EPILOGUE}

It is probably fair to say that although the science developed faster than anyone had expected, the technology and industry progressed more slowly than was hoped or expected. Many of the industrial changes anticipated in the Spinks report in the utilization of biomass were rendered uneconomic by cheaper fuel and food. In general the application of the advances of genetics proved hard to commercialize in medicine. It was instead in agriculture, that, surprisingly, the most dramatic changes were encountered, as genetically modified soy, maize and cotton became a global challenge.

The mere mention of genetically modified organisms reminds us how, in the subsequent 20 years, the environment of science changed completely. Analysts saw the emergence of new models of science in which science, industry and government were more than ever intertwined, and the general public was engaged with co-constructing attitudes to science.
rather than merely understanding more. The phrases ‘triple helix’ and ‘mode 2’ have become methods of describing a form of scientific organization far more visibly integrated into general policy-making than had hitherto been expected. Today, as the shape of the economy is once again being debated, as the scales of medicine and agriculture are each of concern, and as potential impact is proposed as a major factor in the evaluation of proposals, the changes proposed by the Spinks committee continue to be relevant.

ACKNOWLEDGEMENTS

I am grateful to Sir John Ashworth, Professor Brian Hartley and Dr Peter Warren for kindly talking to me about their experiences as promoters and members of the Spinks committee process, and for the comments of Sir Geoffrey Allen, formerly Secretary of SERC, and of Sir James Gowans, formerly Secretary of the MRC. Dr Peter Collins of the Royal Society kindly shared his own research and made available files of the Royal Society. I am grateful also to the Cabinet Office, which made available files not yet in the public domain. An earlier version of this paper was presented to the Egenis group at the University of Exeter and I am grateful for the comments of the audiences there and at the Royal Society meeting where the draft of this paper was presented.

NOTES


4 B. G. Jamieson to R. Prime, 14 May 1978, CAB 134/1697, National Archives.


11 Bu’Lock to Todd, 19 January 1976; see also Ieuan Maddock to Todd, 27 January 1976. Box 112, Todd papers, Acc 703, Churchill Archives Centre, Churchill College. I am grateful to Dr Peter Collins for highlighting this correspondence to me.

On the enthusiasm of Harold Hartley going back to the 1930s, see Bud, *op. cit.* (note 1).


I am grateful to Mr Nelson Schneider for sharing his memories with me.


John Hunt to Prime Minister, 18 November 1976, Prem 16/2228, National Archives.

John Ashworth to Geoffrey Cooper, Chloride Group, 26 March 1980. I am grateful for Cabinet Office access to this still-unopened file.


I am grateful to Sir John Ashworth for his advice that he had drafted this article. John Ashworth to Robert Bud, 19 February 2010.

John Hunt to Prime Minister, 10 August 1979, CAB 184, National Archives.


B. G. Jamison to Spinks, 28 September 1978, CAB 184/421, National Archives.

HC Deb 13 December 1978 vol. 960, cc252W.

Spinks to Todd, 23 November 1978, Biotechnology Joint W-P Correspondence, 1/79–4/81, file 401050.Z401, Royal Society Archives.


Peter Warren, handwritten notes of the first meeting, 6 February 1979, 1/79–4/81, file 401050.Z401, Royal Society Archives.


40 The OECD definition went as follows: ‘Biotechnology is the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services.’ See Alan T. Bull, Geoffrey Holt and Malcolm D. Lilly, Biotechnology: international trends and perspectives (OECD, Paris, 1982).

41 Sharp, op. cit. (note 35).