Policy Study No 105

Science Fiction

– and the *true* way to save British science

Terence Kealey

CENTRE FOR POLICY STUDIES

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Preface

BRITAIN'S SCIENTISTS ARE ANGRY. They believe that:-

i) their science is in decline;
ii) this decline will harm the economy; and
iii) this decline has been caused by the Government's meanness. They have, therefore, campaigned against the Government's policies.

This paper demonstrates, on the contrary, that:-

i) Britain's science thrives;
ii) academic science depends on economic growth, rather than the other way around; and
iii) British scientific institutions could ease their problems by adopting the principles of a free market.

1
Save British Science

During the mid-1980s Britain's scientists exploded with anger. They believed that a mean government was destroying their science and their universities. Their professional journals published articles with titles such as: 'Britain over the hill' *(Nature)*; 'Sorry, science has been cancelled' *(New Scientist)*; and 'Bye-bye Britain' *(British Medical Journal)*. Meanwhile, distinguished scientists made frightening public statements. Sir George Porter, the President of the Royal Society, claimed that 'the morale of the scientific community has fallen to its lowest point this century'; Sir David Phillips FRS, the Chairman of the Advisory Board of the Research Councils, maintained that 'a British scientist can hardly travel anywhere without being subjected to pity by others'; while Professor Robin Weiss, the Director of the Institute of Cancer Research, explained that 'we were able to respond to the AIDS challenge only because of the excellent groundwork laid in the UK. But the erosion of our science has been so bad that the next virus along will beat us'.

Early in 1986, 1500 scientists, many of whom had been instrumental in Oxford University's rejection of Mrs Thatcher's honorary degree, launched the pressure group Save British Science (SBS). Its spokesman, Professor Dennis Noble FRS, summarised its concerns when he wrote in *The Independent* 'that when he asks his colleagues in almost every discipline . . . the talk is less about how to save the situation, but whether it is possible to do so'. The newspapers, television and radio joined in the scare, and soon all well informed people knew that the Government had apparently neglected science shamefully. The case against Whitehall was summarised in *The Daily Telegraph* of 15 June 1987 in an article entitled 'Swansong for British science' and subtitled 'Technology correspondent Roger Highfield finds that the future is far blacker than many had thought'.

Highfield published five graphs which are reproduced overleaf: graphs 1 and 3* show that the quality of British science

* Many of the graphs stop at 1982, as does some of the data produced in this pamphlet. Many of the national and international bodies which publish these facts take years over their collection.

has apparently collapsed, graph 2 shows that the quantity has fallen, graph 4 reflects the brain drain, and graph 5 shows that British science is underfunded.

Slightly earlier in the year, on 19 February 1987, the House of Lords Select Committee on Science & Technology had reviewed the same evidence and had also concluded that not only was British science in decline, but that the decline had been caused by government underfunding.

Moreover, the Select Committee considered that the economic consequences were serious; British industry would never revive until British university science had revived first.

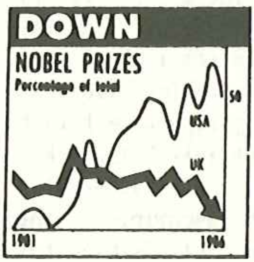
Let us, therefore, consider these three questions:-

i) is British science in decline?

ii) if so, has this been caused by the Government's meanness? and

iii) if so, is industrial revival dependent upon an academic one?

1



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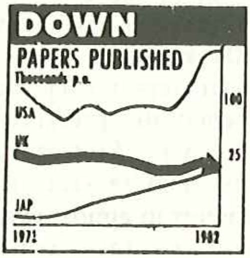

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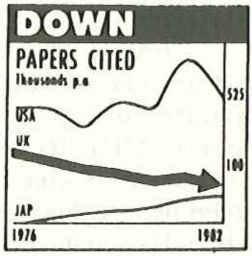

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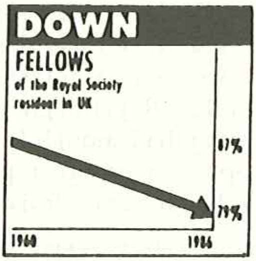

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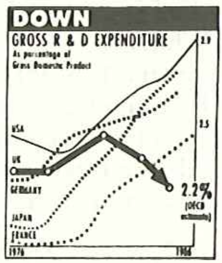

2

The state of British science

It is, curiously, hard to avoid the conclusion that British science is thriving. Possibly North America beats us, but we do better than Germany, France or Japan. The two indices that matter are the quantity and quality of the national scientific output.

Quantity

Over three hundred thousand scientific papers are published globally every year. In 1986, the Advisory Board for the Research Councils (ABRC) and the Economic and Social Research Council (ESRC) commissioned the Royal Society Policy Studies Unit to chronicle those three hundred thousand papers and to determine their national origins (*Evaluation of National Performance in Basic Research*, ABRC Science Policy Studies No. 1 1986). Table 2.1 summarises the data for 1982, the last year analysed in the ABRC report.

TABLE 2.1

International comparison of scientific papers published for 1982

Country	Total number of papers published	Population in millions	Number of papers published per million population
Canada	11,700	24.4	483
USA	106,900	229.8	465
UK	23,900	56.0	432
Germany	17,900	61.7	295
France	14,600	54.0	279
Japan	21,200	117.7	174

The data for the number of papers came from the ABRC Science Policy Studies No. 1. Population data for 1981 came from the OECD Economic Surveys 1983-1984, (OECD, 1984). The number of papers published per million are the author's calculations.

Table 2.1 shows that we are a major science nation. We nearly equal the productivity of the USA or Canada, and we are much more prolific than our European or Asian competitors. It will be seen, therefore, that Highfield's graph 2 (page 6) which indicated: i) that Japan is about to overtake us in numbers of papers published per year, and ii) that we publish a quarter of the papers that the USA does, is misleadingly depressing because it omits a *per capita* comparison.

Numbers of researchers

It is often said that the universities and the numbers of researchers they support are shrinking. Professor Malcolm Bradbury, the Professor of American Studies at the University of East Anglia, wrote during 1988 in *Unsent Letters* (Deutsch):-

> Our present political masters regard British universities in much the same way as Henry VIII regarded the monasteries. My own university, for example, far from looking for new people, is paying distinguished colleagues considerable sums to depart.

Table 2.2 shows the actual *expansion* of universities.

TABLE 2.2
Numbers of full-time academic staff

Academic year	Total full-time staff	Full-time staff wholly university financed	Full-time staff not wholly university financed
1976-77	40,246	32,738	7,508
1981-82	43,924	33,735	10,189
1982-83	43,080	31,642	11,441
1983-84	43,149	31,096	12,053
1984-85	44,210	31,043	13,167
1985-86	45,743	31,412	14,331
1986-87	47,038	31,432	15,606

This data comes from *University Statistics 1986-87*, published by the University Grants Committee. It does not distinguish between numbers of scientists, social scientists and those in the humanities, but most of those in column 3 are in the sciences.

The total numbers of full time staff (column 1) registered a small decline during 1982-83, although that has long been made good. Column 2 shows that the numbers of 'full-time staff wholly university financed' (in practice this largely means university lecturers and professors) declined during 1981-82, and that this figure has since stabilised at approximately 31,000. However, column 3, 'full-time staff not wholly university financed', has expanded steadily. This category largely consists of senior research fellows, post-doctoral researchers and research associates. These are generally young people employed on three or five year contracts, whose salaries are paid by the research councils, the medical charities or industry – the university staff who actually do most of the research, because the lecturers and professors also have to teach undergraduates and administer their institutions.

Not included in column 3 are the postgraduate students. These undertake most of the rest of British academic research. Their numbers rose by 34% between 1981-82 and 1986-87.

Interpreted, these figures mean that the number of permanent university staff (who are generally university lecturers and professors with tenure and whose responsibilities are divided between teaching, research and administration) fell by 5% between 1981 and 1983 as a consequence of the Government's 1981 cut in the University Grants Committee budget, but that the numbers of actual researchers in British universities increased by no less than 50% between 1981-82 and 1986-87, having doubled since 1976-77.

Over the very period, therefore, that British researchers were claiming that their numbers were shrinking, they were in fact expanding dramatically. But that expansion was not balanced: it was driven by the increased funding for science which was coming from the charities, industry and government agencies. These bodies were paying the salaries of postgraduate students, post-doctoral fellows and research assistants – but were not endowing permanent lectureships or professorships. Young scientists were, therefore, being trained for academic careers in increasing numbers at the very time that the sum total of permanent academic jobs had stabilised after a fall.

Many young scientists, once trained, found jobs in industry; which could only benefit the nation. But for those who desperately wanted academic jobs, the log-jam was heartbreaking. As early as 1970, the year when the Robbins expansion halted, the Committee of Vice Chancellors and Principals (CVCP) had warned of the approaching career crisis for young scientists, but no actual steps were taken to integrate research funding in order to provide balanced career prospects. During the 1980s, when the crisis finally broke, the universities then aggravated the problem by blaming the Government for its neglect of science – when the real difficulty lay in the expansion of funding for the training of researchers. The 5% cut in permanent jobs did not help, of course, although the Government believed it was justified. But the career problems spawned by the 5% cut were dwarfed by those spawned by the 100% expansion over ten years of the numbers of scientists in training*.

The responsibility for the career structures of young scientists lies firmly with the universities. These are the organisations which administer the research grants and employ the scientists in training. The universities, therefore, must encourage the external granting agencies (i.e. the medical charities and industry) to fund permanent jobs in proportion to the total research money they donate to the universities.

The external agencies have, in the past, been reluctant to fund permanent jobs because of the risks of tenure and stagnation. But the regular review of permanent staff, as I show below, will reduce the dangers. The external granting agencies should, of course, retain certain *ex officio* places on the reviewing and appointing committees.

Quality of science

All scientific work is based upon previously published papers – 'If I have seen further, it is because I have stood on the shoulders of giants' (Isaac Newton). The value of any particular paper may be judged, in part, by the number of times it is subsequently cited. Citation, of course, is not an infallible guide to the quality of any particular paper: some papers are cited in disapproval, some scientists tend to cite themselves, some scientists confine

* The 5% 1981-2 fall in full-time staff who were wholly university-financed must be put into the context of the 630% increase of the last 50 years. Figures are: 5,000 in 1938-39, 11,000 in 1954-55 and 16,000 in 1962-63.

themselves to papers written in their own language. Moreover, important papers may well be overlooked by an unprepared scientific community, as were Mendel's papers on genetics. But despite these reservations, we can reasonably draw some conclusions from the grand totals of citations of papers published every year.

In recent issues of *Current contents,* the science journal, Dr Eugene Garfield has identified the 100 most cited papers recently published in the life, chemical and physical sciences. Table 2.3 overleaf summarises his findings, and it suggests that British science is far from backward. At the very highest levels of science, the ones which matter most, we produce an impressively high number of papers which command attention.

The brain drain

The publicity over the brain drain has been intense and vitriolic. Article after article, television programme after television programme, has chronicled the irreversible loss of British talent. The philosophers Professor Bernard Williams, Provost of Kings College, Cambridge, and Dr Steven Lukes, Fellow of Balliol College, Oxford, in particular, generated great publicity over their own departures, although just why they were leaving was left unclear. Each enjoyed a tenured, important, well-paid job, and each was well buffered from any putative government cuts by the nature of their research (philosophers need little more than pencils and paper). Bernard Williams told the *Observer* (18 January 1987) that he found Mrs Thatcher's Government too right wing, and that Cambridge was becoming too middle class for him – though, one may then ask, why did he leave for America, the land of unregenerate capitalism where students have to pay university fees?

Williams and Lukes apart, during 1986 three representative academic bodies commissioned studies on the drain. The Royal Society, the Economic and Social Research Council and the British Academy investigated the loss in science, social science and the humanities respectively. But, curiously, the drain proved difficult to measure. Individuals do of course emigrate to America. But an embarrassing number of foreigners travel in the other direction. Finally, both the Economic and Social Research Council and the British Academy concluded that they could find no drain of brains in either social science or the humanities – but they chose not to publish their findings. That might have been unfashionable. There is academic freedom for you!

The Royal Society, however, did publish its findings (Policy Study No. 1, 1987, Science and Engineering Policy Studies Unit), which were a great disappointment to the *bien pensants*. Between 1975 and 1985, 931 university scientists emigrated, while 685 immigrated. The net emigration of 246 scientists over a decade can hardly make headlines. The Royal Society, however, was worried about the high quality of the 246. For example, as Highfield's graph 4 (page 6) indicates, in 1961 some 16% of all Fellows of the Royal Society lived abroad at the time of their election, whereas by 1985 that figure had risen to 24%.

TABLE 2.3

National origins of the 300 most cited papers published during 1983 or 1984:-

Country	100 life science papers (1984)	100 chemical science papers (1983)	100 physical science papers (1984)	Total citations
USA	79	66	74	219
UK	13	8	9	30
Germany	1	11	14	26
France	5	5	8	18
Switzerland	5	6	5*	11
Canada	6	4	1	11
Japan	4	1	3	8
Australia	4	1	0	5
Israel	2	2	1	5
Holland	0	2	3	5
Italy	0	0	5	5
USSR	0	1	3	4
Spain	0	0	4	4
Belgium	3	0	0	3

The data came from *Current Contents* of 24 November 1986 (physical sciences), 8 December 1986 (life sciences) and 22 December 1986 (chemical sciences) (* Papers from CERN, an international body based in Switzerland, have not been included.) The total number of papers exceeds 300, because some come from more than one country, and so are counted two or more times. This data has since been updated in *Current Contents* of 28 November 1988, 12 December 1988 and 6 February 1989. This shows that we remain second only to the USA as the national origin of the most cited life science papers for 1986. For 1985 chemical science papers we remained third, after the USA and Germany. But for physical sciences in 1986, we actually climbed up into second place. Not too much should be made of this numbers game with citations, of course – but they scarcely suggest a dying British science.

Had some thousands of scientists been leaving, the cause might well have been an overall underfunding of British university research. When only a select few depart, however, then the fault probably lies in the employment and research policies of British universities. So it transpires: American universities tailor themselves to the needs of the élite, while their British counterparts concern themselves more with the mediocre.

In America, academic stars are paid several times more than their middle rank colleagues. In Britain, all professors* have until recently been paid very similar salaries. Not surprisingly, therefore, some brilliant British researchers have emigrated just to triple their salaries.

In America, research funds are concentrated on productive scientists. In Britain, until recently, the University Grants Committee spread its research money across all academics near-equally. Not surprisingly, again, some brilliant British researchers have emigrated to triple their research funds.

In America, tenure is granted late in an academic's career, and even then it does not always guarantee a salary for life. In Britain, tenure has until recently meant a job for life, and has been granted early. This has invariably tied resources to the mediocre, who cannot be sacked, at the expense of the good, who are therefore starved of money. Not surprisingly, once

* The Government has recently imposed reform on British universities. These issues will be explored further in Chapter 7.

again, some brilliant British researchers have emigrated to increase their share of the available resources.

In conclusion, let it be repeated that the brain drain is small, and is almost entirely a consequence of the universities' own misplaced egalitarianism and restrictive practices. What is surprising is why the brain drain should suddenly have been discovered in the mid-1980s. Once indeed, there was a real brain drain. The National Science Foundation recently reported that in 1968 alone, during Mr Harold (now Lord) Wilson's administration, 491 British scientists emigrated permanently to the USA. That later declined, and in 1979 Mrs Thatcher inherited on annual US-bound permanent emigration rate of 254. In 1985, the last year of the National Science Foundation survey, that figure had risen to 255. It seems a little unfair to judge Mrs Thatcher harshly over an annual rate of increase of 0.05%.

3

Funding of British research

Table 3.1 below compares the total research and development (R & D) budgets of the major science nations.

TABLE 3.1
International comparisons of Research and Development for 1985

Country	% of GDP spent on all R & D
USA	2.8
Germany	2.7
Japan	2.6
UK	2.3
France	2.3
Italy	1.1

The figures come from the OECD science and technology indicators as quoted in the *Annual Review of Government Funded R & D*, 1988, HMSO.

At first sight, this table seems to show that all is reasonably well with British science funding: we spend less than most of our major trading partners, but the differences look small. This analysis, however, would be simplistic. Research and Development might be either defence or civil and, as Table 3.2 shows, there are major national differences in the defence research budgets.

TABLE 3.2

International comparisons of defence research budgets

Country	% of GDP spent on defence research for 1985	% of total R&D budget spent on defence for 1983
USA	.88	28
UK	.60	29
France	.45	21
Germany	.13	4.3
Italy	.06	–
Japan	.01	.05*

Source: OECD, quoted in *Annual Review of Government Funded R&D 1988*, HMSO. * Japan's figures are for 1981. The percentage of total R&D budget spent on defence for 1983 are the author's calculations.

It will be noted that we British spend a higher percentage of our total R&D budget on defence than any of our major trading partners (we tend to win more wars, too). This expenditure is no longer fashionable – but nor was it so during the 1930s; and our unpreparedness in 1939 nearly cost us our freedom. We live in a very dangerous world, still.

Regardless of strategic considerations it has been suggested that the Government should shift some of its resources from defence into civil research; but the two budgets are not readily interchangeable. Defence research is customer-led, not curiosity-led, ie: there is not one national research budget from which 29% is arbitrarily assigned to defence. The Ministry of Defence commissions research from its own budget to further its own ends. If the Ministry of Defence were to spend less on R&D, civil research would not necessarily be boosted. That would have to be a quite different political decision. Defence research will not be considered further in this pamphlet, but let its critics be appeased: much defence research transcends the warlike. Charles Darwin's trip on HMS *Beagle*, for example, was funded by the Admiralty, and many of the 20th century's advances in aircraft technology, rockets and electronics were propelled by strategic considerations.

Table 3.3 catalogues the civil R & D budgets for the major science nations:

TABLE 3.3

Total civil R & D as a percentage of GDP (ie: industrial and academic research combined)

Japan	2.5 (1983)
W. Germany	2.5 (1985)
USA	1.9 (1985)
France	1.8 (1984)
UK	1.7 (1985)

Source: *Annual Review of Government Funded R & D*, 1987, HMSO.

These figures look bad, which is why Save British Science quote them frequently (see Highfield's graph 5, on page 6) but they cannot be easily interpreted because civil research comprises two very different categories. There is academic or university research and there is industrial or commercial research. This latter generally takes place within the laboratories of companies themselves. For example IBM discovered ceramic high temperature superproductivity in its Zurich laboratories, and the Bell Telephone Research Laboratories discovered the transistor in its American laboratories.

Tables 3.4 and 3.5 show that Britain's shortfall lies in industrially funded research, not in government funded university research. (The figures do not add up to those in Table 3.3, because the figures for government funding of industrial research through such schemes as Alvey and Esprit are not included.)

TABLE 3.4

Percentage of GDP spent on civil R & D by industry for 1983

Japan	1.6*
W. Germany	1.5
USA	1.3
France	0.9
UK	0.9

Source: *Annual Review of Government funded R & D, 1985*, HMSO.
* Japan's data is for 1982.

TABLE 3.5

Government expenditure on academic science in 1982

Country	Percentage of GDP
W. Germany	0.49
France	0.44
UK	0.38
USA	0.31
Japan	0.25

Source: *International Comparison of Governmental Funding of Academic and Academically Related Research*, ABRC Science Policy Studies, No. 2, 1986.

The ABRC published the data for Table 3.5 in 1986, and it is hard to understand why Save British Science, which was founded the same year, thought that the figures proved that British science was underfunded by the Government. Table 3.5 relates to 1982. The ABRC has yet to update these figures but, should anyone suppose that the situation has markedly deteriorated since, it must be noted that the Government increased academic funding by £95 million this year – a considerable percentage increase.

In conclusion, therefore, the British Government's support for university science is about the international average; and its support for defence research is above average. Its support for industrial research is also creditable. Britain's problem lies in inadequate industrially-funded research, which will be discussed in Chapter 7.

Non-governmental support for university science

It is not necessarily the function of government to pay for research through taxation; but it is the Government's function, one it shares with other responsible institutions and individuals, to ensure that sufficient national research is done. No one really knows how much research is sufficient, as will be discussed in Chapter 3, but let it be noted here that there are at least three major sources of non-governmental funding for British academic research: the medical charities, industry, and the universities' own endowments.

Medical charities

These fall into two major categories; those like the Wellcome or Nuffield Foundations which were endowed by individuals, and those like the cancer charities, the British Heart Foundation or the British Diabetic Association which rely on donations from the public. Collectively, their support for British medical research is magnificent, and for 1987-88 amounted to £128 million. This nearly equals that of the Government's Medical Research Council, which will be £146 million for 1988-89.

TABLE 3.6
The research funding of the major medical charities 1987–1988

	£million
Imperial Cancer Research Fund	38.8
Wellcome Trust	27.8
Cancer Research Campaign	24.6
British Heart Foundation	11.8
Arthritis and Rheumatism Council	7.0
Ludwig Foundation	5.0
National Foundation for Crippling Disease	3.0
Muscular Dystrophy Foundation	2.0
Multiple Sclerosis Society	1.8
Tenovus	1.4
Cystic Fibrosis Research Trust	1.26
British Diabetic Association	1.2

Data collated by the Association of Medical Charities

Britain's medical and biological research dependence on the charities has been criticised by Professor Dennis Noble and others as representing an abdication by the Government of its proper responsibilities. But charitable research is democratic, not bureaucratic, discretionary, not rigid; and reflects the concerns and the generosity of the British people. Furthermore, it is not narrow. The charities have consistently demonstrated superb scientific judgement in the breadth and depth of the research they support. For example, James Watson was supported by an arthritis charity, albeit an American one, while he helped to discover the structure of DNA. Moreover the charities, as they grow, shoulder ever more responsibility for their researchers' careers. The British Heart Foundation supports 21 professors, while the Wellcome Trust's support for career programmes are legendary.

Curiously, the pattern of the charities' financial support has proved superior to that of the Government. Professor Dennis Noble has suggested that charitable support is less dependable than the Government's, because the charities have to rely on regular donations. But, in practice, it is government support which has fluctuated in fits and starts, while charitable money has grown steadily – exactly the pattern best suited to scientific research. Last year it increased by no less than 23%. Table 3.7 illustrates the income of the Cystic Fibrosis Research Trust, for example.

TABLE 3.7
Research expenditure by the Cystic Fibrosis Research Trust

1965	£20,000
1970	£50,000
1975	£120,000
1980	£450,000
1987	£1,260,000

Over the last ten years, of course, all charities have done well. The reductions in direct taxation, the stimulation of the economy, and the increasing emphasis on personal rather than public morality, have all boosted charitable donations; but the medical charities have done especially well, to the benefit of scientific research.

The other two major sources for non-governmental funding for academic research – industry and the universities' own endowments – are discussed below, in Chapter 7.

4

Government-funded university science – a good economic investment?

Save British Science, the pressure group, maintains that government-funded university science is crucial to economic growth. The House of Lords (*Select Committee Report*, 19 February 1987) agrees. The Lords argue that no revival of British industry will occur until the Government spends more money on university science. Are these organisations right? Their intellectual chronology is persuasive: the universities make fundamental advances; industrial scientists develop these, and economic growth then ensues. For example, as Professor Sir George Porter, the President of the Royal Society, posited in his 1988 Dimbleby Lecture, Faraday discovered electromagnetic induction while working at the Royal Institution. This then led to the commercial generation of electricity and so prompted industrial growth.

Actually, Sir George Porter's example was poor advocacy for government funding of university science because the Royal Institution was then, as now, a private body, funded to promote economically and socially useful science. The real lesson of Faraday's experiment was very different, namely that basic scientists should not be over-directed in their research: it was not until Faraday was freed from committee control that he was able to pursue electromagnetic induction. (Will Sir David Phillips and the ABRC repeat this mistake with their IRCs? See Chapter 7).

Notwithstanding Sir George's particular example, is he right? Is industrial growth dependent on university science? The evidence points the other way. It appears that university science is dependent on economic growth, but it also appears that industry can thrive in the absence of university science.

Let us review the model: i) university science makes discoveries, ii) these are converted into technology, and iii) industry then creates wealth.

We must test first the last link of the chain: do developments in technology underlie the creation of wealth? Historically, the answer is clear. As neolithic man progressed, he moved through ages named for technology; the stone, bronze and iron ages. It was the wealth created by these technologies that spawned the classical civilisations. Similarly, the wealth we now enjoy is the product of the technological developments of the 18th and 19th centuries – developments so dramatic that we refer to them as the Agricultural and Industrial Revolutions.

The dependence of wealth on technology has been quantified: Robert Solow won the Nobel Prize in Economics in 1987 for his studies on the factors that underlay the doubling in gross output per hour of work that the USA enjoyed between 1909 and 1949 ('Technical change and the aggregate production function' Rev. Econ. Statist., 1957; 39:312-320). Of all the factors that might have been responsible, such as the capital-output rates, the rate of savings or the rate of growth in the work force, Solow showed that seven-eighths of the economic growth was attributable to 'technical change in the broadest sense'. This includes the better education of the workforce. Only one-eighth was attributable to increased capital injection which will, after a certain point, yield only diminishing returns. Technological growth undoubtedly underpins economic growth. But what is the relationship between technological growth and academic science? If this question is answered chronologically, it appears that technological developments have owed little to academic science; whereas academic science owes everything to the wealth created by technology.

The neolithic technical advances such as the control of fire or the harnessing of wind and water power through mills and sails all predated the development of universities and their science. The culmination of early technology, the classical civilisations, then fostered the first scientists. But they, for their part, produced little new technology.

A similar pattern was repeated during the first half of this millennium. Europe grew increasingly rich during the medieval period as it continued to develop its agricultural and commercial technology, and only then did it flower in the Renaissance of Galileo, Vesalius and Newton – from whose science, however, little further technology flowed.

The Agricultural and Industrial Revolutions repeated the pattern yet again. They occurred during the 18th and 19th centuries, when England had only two universities, Oxford and Cambridge, then notoriously stuporous. Edward Gibbon, writing in his *Autobiography* of his undergraduate months at Magdalen College, described his tutors as 'monks . . . easy men, who supinely enjoyed the gifts of the founder'. Of his own tutor, Gibbon wrote that he 'well remembered he had a salary to receive, and only forgot he had a duty to perform'. Gibbon described his fourteen months at Oxford as 'the most idle and unprofitable of my whole life'.*

It was only after the industrialists had created their wealth that the English universities were revitalised. Consider, for example, the dates of some of the major events of the Industrial Revolution: Darby's discovery of coked iron-smelting, 1709; the invention of the flying shuttle, 1738; the development of the spinning jenny, 1767; Crompton's invention of the mule, 1770; the building of Ironbridge, 1777. Now consider the foundation dates of England's great civic universities: Manchester, 1851; Newcastle upon Tyne, 1852; Birmingham, 1900; Liverpool, 1903; Leeds, 1904; Sheffield, 1905.**

The history of other countries is similar. Japan has grown spectacularly in the near-absence of basic university science. It is only now, when its country is rich, that the Japanese government has started to spend money on university science, and it still spends less than ours (see Table 3.5). The history of the USA is also similar. As Highfield's graphs show (page 6), America's domination of science is recent – post-war in fact. Allan Bloom wrote in *The Closing of the American Mind*, 'if all of America's universities had been closed in 1930, the loss to international research and scholarship would have been negligible'. Yet, by 1930, America had long overtaken us in GDP *per capita*.

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* The Scottish universities never quite plumbed the depths of Oxford and Cambridge, and they played some part in technological development. James Watt, for example, was for a time a technician at Glasgow University. But even the academic Scots' contributions to the Industrial Revolution were small compared with those of the industrialists themselves.

** These are the dates of the Royal Charters. Many of these universities developed from earlier institutions, but even these post-date the great developments of the Industrial Revolution.

It appears, therefore, that technological growth precedes academic science. But whence does technology come? It comes from the workshops of capitalists. Here is a dramatic example of early industrial science:-

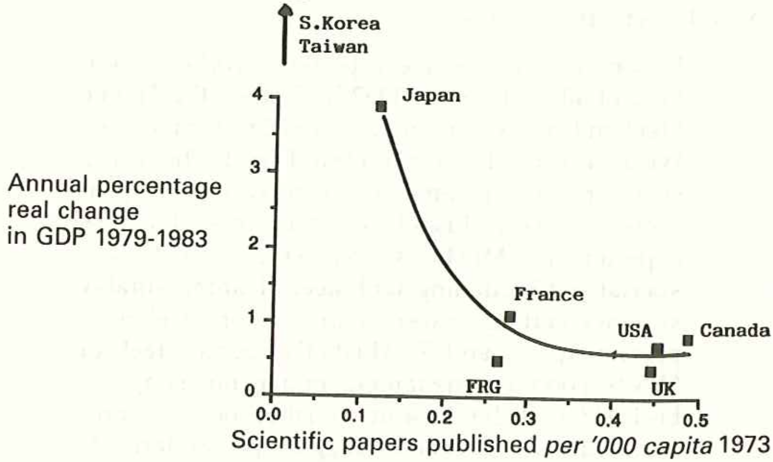
> Robert Mushet became a pioneer worker in the field of alloy steels. In 1862 he formed the Titanic Steel and Iron Company . . . and the Titanic Steel Works was established in Dean Forest. This was a small crucible steel-making plant where, in great secrecy, Robert Mushet carried out his alloy steel experiments. Mushet's greatest success was a special self-hardening tool steel of immeasurably superior cutting power to the carbon steel used previously . . . and R. Mushet's Special Steel, or "RMS" soon became famous in machine shops on both sides of the Atlantic. Mushet took the most extraordinary cloak-and-dagger precautions to keep his RMS formula secret. The ingredients were always referred to by cyphers and were ordered through intermediaries. The mixing of the ingredients was carried out in the seclusion of the Forest by Mushet himself and a few trusted men. (L.T.C. Rolt, *Victorian Engineering,* Allen Lane, Penguin Press, 1970).

Not all industrial research was necessarily so conspiratorial. But Mushet was typical of the early entrepreneurs. They did their own experiments, developed their own technology and created their own wealth. It was that wealth which then funded, amongst other developments, the subsequent growth in universities and their science.

But is modern technology different? Thirty years ago C.P. Snow suggested that we were now living through a second industrial revolution, one in which technological change had become so sophisticated that it could grow only through intellectual advance – an advance that had to come from the universities. Let us, therefore, ask the question: does current economic growth depend on academic science?

FIGURE 4.1

The correlation between the annual real change in GDP and the numbers of scientific papers published.



Economic data came from *OECD Economic Outlook: Historical statistics 1960-1983* (OECD, 1985). The horizontal axis was calculated by the author from population data provided by OECD Economic Surveys 1983-84, (OECD, 1984) and the publication counts were provided by the ABRC Science Policy Studies No.1 (ABRC, 1986).

Figure 4.1 shows that there is no positive correlation between scientific output and the growth of national wealth. We British publish lots of papers but our economy does not grow as fast as other countries who publish less. A similar result emerges if scientific output is measured by quality, not quantity: a graph comparing national citations with economic growth would show a similar shape to Figure 4.1.*

The distribution of Nobel Prizes confirms these findings. Since their inception in 1901, 363 Nobel Prizes have been awarded in science, and their national allocation has been: USA, 132; UK, 62; Germany, 50; France, 22 etc. Since 1901, our GDP *per capita* has collapsed from being the world's highest to its miserable position today.

* Figure 4.1 does not prove that science is actually bad for growth. The economies of the Far Eastern countries use low-cost labour and borrow our technology freely. As they grow (see Chapter 5), they will wish to invest in more science.

It appears, therefore, that the traditional relationship still holds: namely, that technological developments are industry-led, not curiosity-led, and that the wealth they create then supports, *inter alia*, academic science. But academic science cannot, itself, promote economic growth if industry is weak. This was recognised by Sir George Porter who wrote in *The Independent* of 23 March 1987:-

> In those industries where countries like Japan and Germany are so successful, it is usually because they make better products. And they make better products because they do more research and development *in the industry itself* (his italics).

As Chapter 3 (see Table 3.4) discussed, it is Britain's shortfall in industrial research which has underlain our poor economic growth.

Has university science, therefore, no role in the creation of wealth? It must have: the great English civic universities were largely founded by private industrialists and these men were not particularly sentimental. Nor are modern-day Japanese industrialists, but they have imitated Britain's 19th century entrepreneurs: Jeremy Bray MP, the Labour Party spokesman for science, pointed out in *The Independent* of 19 April 1988, that Japanese companies have largely compensated for the lack of government-funded university science by building their own in-house near-universities.

So why have industrialists founded universities? As Corelli Barnett stated in *Audit of War*, one of the reasons was that the industrialists wished to train man-power. They wanted educated employees who could then invigorate their own in-house, industrially-related research and development. And the sort of education the industrialists wanted for their employees soon grew beyond the training resources of individual companies – hence the collaborative foundation of British universities.

The universities may have been founded as teaching institutions, but they soon developed their own separate ethos – one that elevated scholarship over utility. Two influential books, in particular, both reflected and guided the British academic rejection of industry and its needs. Newman's *Idea of a University* published in 1852 claimed that an education could be obtained only by study for its own sake. Newman believed that the study of useful science could do no more than mechanically train a rude brain. Bruce Truscot's *Red Brick University* published in 1951 maintained that research was more important than teaching.

These attitudes are not shared internationally. The French, for example, direct their best young people to the *Grandes Ecoles*. These élite institutions teach the applied sciences: management, politics, economics and engineering. They do foster research and scholarship, but only as an adjunct to teaching. Of course, the French do have universities as well as the *Grandes Ecoles*, and they are similar to our own: but their entrance requirements are markedly inferior to those of the *Grandes Ecoles*.

Germany, too, runs two parallel systems of higher education, and their *Technische Hochschulen* not only provide a university education which is firmly geared to the needs of industry, but they also compete successfully with the conventional universities for the best students, the best dons, the best scholarship and the best research.

America once eschewed research and scholarship. Frances Trollope's *Domestic Manners of the Americans* (1832) describes a nation obsessed solely by making money. Since then America has embraced Newman and Truscot. Is this wise? While its research has flourished, American productive industry has been collapsing in the face of foreign imports. This collapse has included precisely those hi-tech industries which scientists were meant to be invigorating. Since 1980, foreign sales in machine tools have risen from 27% to 45%, and in computers from 7% to 25%. Perhaps America, flushed with imperial pride, will dissipate its wealth in science, art and global peacekeeping. Will it follow Britain down the anti-enterprise road of old, with its conservatives despising industry for snobbish reasons and its socialists despising industry for ideological ones?

The most frightening example of a country failing to find economic growth through science is Russia. The Soviet Union spends no less than 3.73% of its GDP on research, a huge proportion (see table 3.1). Admittedly much of that is spent on defence, but the Russian experience should nonetheless chill British universities, because one of the reasons Robbins justified the massive expansion of British universities was that the Russians were expanding theirs so as to ensure economic growth.

Academic research is of less economic value than academic teaching: the two were weighed against each other by J. Langridge *et al* of Manchester University, England, in *Wealth from Knowledge: a study of innovation in industry* (1972), Wiley, New York. They studied the origins of 84 technical innovations in industry and they found that 'although scientific discoveries occasionally lead to new technology, this is rare'. Generally 'technology builds on technology'. They concluded, however, that:-

> the most important benefit . . . of basic research is . . . the output of highly qualified men and women educated in science and its methods. This is because discoveries and techniques cross international boundaries more easily than men.

Let it be noted that Solow, too, noted that the better education of the workforce in technology was a major factor in industrial growth. We can, therefore, begin to answer a near-imponderable question – 'how much university science does a medium-sized nation need?' – by summarising the above. Industrial wealth creation depends on the industrial development of technology. This, in turn, depends on a nation's output of trained scientists whom industry can then employ. Government, therefore, should spend as much on science as is necessary to retain the right number of university scientists: and that number is defined as that which is sufficient to teach enough graduates to supply industry. There is no point in teaching any *more* than industry needs; India, for example, educates many more technologists than its industries will employ – which has not led that country to great wealth.

* * * *

Good university science teachers must be retained, but they will not be kept unless their research is well-supported. This is for two reasons: first, it is widely understood that the exposure of students to research is an integral part of their training in science. Secondly, dons like doing research. That is why they became dons. But, economically, their research is of less value than their teaching.

Economically, a medium-sized country like Britain need not be self-sufficient in all basic science. There will inevitably be areas of science in which it will not lead, because no medium-sized country can possibly hope to generate all the 'scientific discoveries that occasionally lead to new technology'. That does not matter. It does, however, matter to a medium-sized country that its applied science should be healthy. The discoveries of basic science are freely available through international scientific publications, and it is important that a nation's industrial scientists should exploit the world's basic science. Switzerland provides a good model: it is a small country which generates very little of the globally available basic science, but it houses three of the world's richest, most successful and most innovative drug companies, Roche, Sandoz and Ciba Geigy, whose applied scientists generate great wealth for their country.

It is an irony that the British Government's support for science correlates historically with our economic decline. There was no such government support during our centuries of international dominance, the 18th and the 19th. But the forerunners of the MRC, SERC and UGC were founded in 1913, during the first World War* and 1919 respectively. Those years marked our apogee of imperial and commercial greatness but, as government support for science increased over the successive decades, so did our relative prosperity decline.

But science cannot be blamed for that: the main reasons for government support have always been strategic, not economic. The military implications of the tank, aircraft, radar, the Bomb and Sputnik, to name a few technological advances, scared successive governments into supporting British science and technology. Even the MRC was founded in part because of the horror expressed by recruiting sergeants during the Crimean and Boer wars over the poor physique of the potential cannon fodder.

The economic justification for government funding of science was always *post hoc* and opportunistic – and often not very sound. The only time that government support can be justified economically is when an economy is growing well (see Chapter 8), and so might outstrip its supply of technologists. And perhaps we are even now entering such a phase.

* The SERC press office could not give me a more accurate date.

5

Which way is British science going – and why?

Everybody is very worried that British science is in decline. Is it? Consider Table 5.1.

Table 5.1
Percentage changes in the number of scientific papers published annually, and of national citations

Country	Percentage change in the number of papers over the decade 1973-1983	The numbers of papers published *per 000 capita* in 1982	Percentage change in the number of citations over 1976-82
Canada	- 0.73%	483	- 2.4 %
France	- 2.76%	279	+ 7.85%
FRG	+ 8.20%	294	+13.2 %
Japan	+52.15%	174	+48.8 %
UK	- 7.95%	432	- 5.2 %
USA	+ 4.9 %	465	+ 3.9 %

This data was calculated by the author from scientific data published in ABRC Policy Studies No. 1, (ABRC, 1986) and from population data published in OECD Economics Surveys 1983-1984, (OECD, 1984).

This shows that Britain does indeed suffer the greatest relative rate of decline of all the major science nations, as determined by both the total number of scientific papers (a 7.95% fall between 1973-1983) and the total number of citations (a 5.2% fall between 1976-1982). Canada and France also declined a little, but the USA and West Germany both grew. Japan exploded. Furthermore, Britain's share of Nobel Laureates is falling. The figures are: 1901-1930, 15.6%; 1931-1955, 20.3%; 1956-1965, 22.6%; 1966-1975, 22.0%; and 1976-1986, 13.6%. Note, however, that we start from a spectacularly high base. In 1982 we published nearly as many papers *per capita* as the USA or Canada, and many more than France, West Germany or Japan; while we were second only to the USA in citations *per capita*, and had 5 1/2 times more than Japan. We have also won more Nobel Prizes than anyone else per capita. These rough figures do not justify complacency, but nor do the percentage changes justify undue gloom.

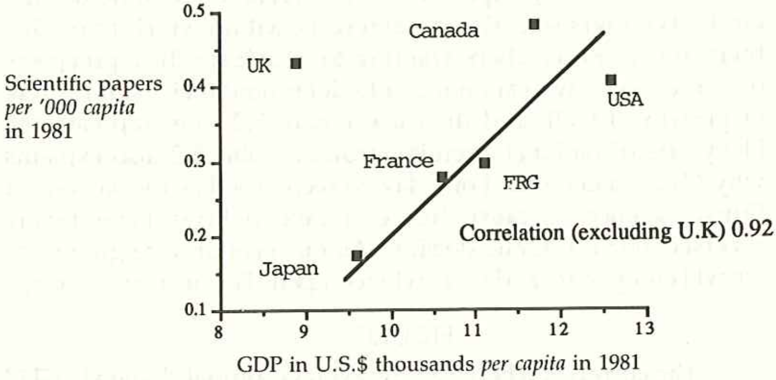
Why are we in decline? The less important explanation is political – there is less money coming from Whitehall. Post-war, successive British governments performed an experiment. They had been told by Robbins and other technocrats that, notwithstanding the evidence of Chapter 4, industrial growth could be stimulated by academic science. So all governments, between 1945 and 1970, increased their expenditure on the universities and their science massively. Some years saw real annual increases in the science vote of 13%. But where was the growth? That quarter-century witnessed an appalling British decline in relative terms. Industrial expansion is never led by academia, it is led by industry, and post-war governments watched with chagrin how foreign entrepreneurs made money from British discoveries. Finally, in 1971, echoing Tony Crosland on local government, Mrs Shirley Williams announced that 'for the scientists the party is over'. The Government's attempt at stimulating the economy through academic science had failed, and successive administrations committed themselves to little more than level-pegging.

Britain, however, was not unique. Most other governments cut back on universities and research during the 1970s, as they too concluded that increased investment would no longer be profitable; and as Table 3.5 shows, British academic science remains well-funded when judged internationally as a percentage of GDP. The real reason for Britain's scientific decline is economic. As discussed in Chapter 4, academic science depends on the wealth that industry creates. Consider Figure 5.1.

Excluding Britain, it can be seen that there is a good correlation (0.92) between a nation's GDP and its scientific output.

Figure 5.1

The correlation between national GDP and the numbers of national scientific papers.



Economic and population data came from OECD Economic Surveys 1983-1984 (OECD, 1984). The vertical axis represents the author's calculations from scientific data published in ABRC Science Policy Studies No.1 (1986).

But, as Figure 5.1 shows, we produce much more science for our GDP than might otherwise be expected. We enjoy so much science because we are still living off the capital of our imperial greatness, embodied for example by the great civic Victorian universities. None of our major trading partners have such capital: the Germans and the French lost theirs during the world wars, and neither the USA nor Canada nor Japan produced much science one hundred years ago. But, as we spend our Victorian capital, so we fall inexorably to the level of science that our current earnings will support. Britain's scientific decline is a long term phenomenon, which has been caused by our long term economic decline – and which long pre-dates Mrs Thatcher's administration (see Table 5.1).

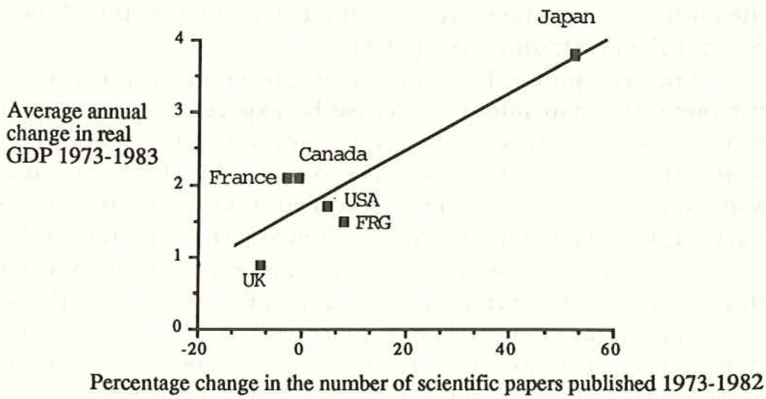
And yet, as Figure 5.2* shows, there is a direct correlation between the rate of growth of naional GDP and the rate of

* Figure 5.2 would have been more authoritative had the ABRC analysed the scientific growth of more countries. The slope relies too much on one point, Japan. But anecdotal evidence from South Korea, Taiwan and Turkey confirms its message.

growth of national academic science: the faster a nation's economy grows, the faster does its science *(we know from Figure 4.1 that the reverse is not true)*. This is a crucially important figure because it not only explains Britain's relative scientific decline but it also offers scientists a framework within which to predict their future. Researchers wanting to anticipate their prospects over the next few years need only determine their nation's rate of growth of GDP and then use Figure 5.2 to extrapolate the likely rate of national scientific growth. Table 5.2 also explains why Mrs. Thatcher will one day be recognised as the saviour of British science, because her economic policies have finally reversed our economic decline. As our economy re-grows, so we will enjoy more and more science again. The future is hopeful.

FIGURE 5.2

The correlation between the average annual change in GDP and the change in numbers of papers published over the decade 1973-1982.



The economic data was calculated from OECD *Economic Outlook: Historical Statistics, 1960-1983* (OECD, 1985). Figures adjusted so as to represent 'real' changes. The scientific data was calculated from Table 4.1 of ABRC Science Policy Studies No. 1 (ABRC, 1986).

6

Government-funded university science – a good cultural investment?

It appears now to be axiomatic that government-funded science is of cultural importance. Professor Dennis Noble's article on Save British Science, for example, in *The Independent* of 13 January 1987 was entitled 'Britain's culture in crisis' while Professor Colin Blakemore's address to the Oxford summer 1987 meeting of the Physiological Society explained how its members embodied culture – a culture imperilled by the philistines of Mrs Thatcher's Government.

But can anything funded by a democratic government be culturally significant? Democratic governments have to work consensually. They may, therefore, be good at organising the transmission of orthodox culture – but close examination generally reveals that orthodox culture will transmit itself irrespective of governments (for example, there are cantons in Switzerland which have no laws imposing compulsory secondary education, but which enjoy higher school attendance than many countries which bristle with anti-truancy legislation). Cultural innovation, however – the development of new thoughts – is so rarely consensual that it is probably a necessary, if not a sufficient, definition of an important cultural innovation that it outrages orthodoxy. That precludes the active support of representative government, and may indeed promote its active opposition, as is illustrated by the history of science itself. Science was most vulnerable, but also most important, when it challenged the culture of received wisdom and revealed truth. Anaxagoras, for example, who proposed that the sun was not a god, but only a rock, albeit one bigger than the Peloponnese, almost suffered Socrates's fate for his heresy. Pericles was just able to safeguard Anaxagoras's passage to Lampascus where he died in 428 BC, but not even Pericles could protect him within Athens itself. Two thousand years later, Galileo outraged Christendom with heliocentricity, and it was only when he was shown the instruments of torture by Pope Urban VIII that he was persuaded of the intellectual force of orthodox teaching. At about the same time, certain Englishmen were beginning to study the 'new philosophy' of Copernicus, Vesalius and Descartes, but they met secretly as the 'Invisible College' (Robert Boyle) to avoid the repressions of the Puritans. Only after the Restoration could they meet openly as the Royal Society. But the ridicule that men like Charles Lyell and Charles Darwin were to suffer from the likes of Bishop Ussher and Bishop Wilberforce was to last for two centuries more. Even within the twentieth century, tyrants like Stalin and Hitler unleashed creatures like Lysenko and repressed 'Jewish science' in the defence of intellectual orthodoxy.

But these battles now seem distant. The methods of science – its experimentation, reason and logic – have triumphed throughout the civilised world. Its pragmatic culture is dominant and pervades all thought. If all governments everywhere were to stop funding research the cultural consequences would be trivial.

It is a paradoxical consequence of science's triumphs that there are few famous living scientists, even though 90% of all the scientists who have ever lived are still alive today. A recent *Times* survey showed that the only scientists most people could name were dead: Einstein, Darwin and Newton. Once, all Europe followed the struggles of Galileo or Darwin, but now that science has become orthodox, its practitioners can be taken for granted.

Ironically, it is only now that science is no longer vulnerable that government support for research has emerged. For example, the MRC was founded in 1913 as the Medical Research Committee, the SERC was founded during the First World War as the Department of Scientific and Industrial Research, and the UGC was founded in 1919. But governments support less science than is generally believed. One company alone, IBM, spent $3975 million on research and development in 1986, the year that two of its Zurich researchers discovered ceramic superconductivity. In that same year, Britain's entire Research Council budget, for all academic science, was £540 million.

University science, too, can be autonomous. America's greatest science universities, MIT, Harvard, Yale, Princeton, Stanford and Caltech, are all private foundations. Although they do tender for US Government research grants, much of their money is raised privately. Stanford, for example, raised $80 million last year through gifts and endowments.

Do these observations argue against British government support for science? Most people would not think so, nor would I. The transmission of culture remains an important activity, and the British traditionally entrust many important cultural activities to central government. Despite the vast evidence which shows governmental agencies to be less efficient than private ones, they are still seen to be more accountable. But the degree of governmental support of science, for cultural reasons, must be imponderable.

The best non-economic, if not cultural, case for the Government's continued funding of basic science remains our ignorance of the world and its threats. Where would we have been in 1940 without the physicists who cobbled together radar in the face of the *Luftwaffe*? Our future problems are unpredictable. Who would have guessed in 1982 when, at the urgings of Lords Buxton and Shackleton, Mrs Thatcher safeguarded the British Antarctic Survey, that the British taxpayer was financing the most vital environmental observation of the 1980s – the gap in the ozone layer, discovered in 1984? Are we a better nation for the discovery of this gap? Are the French a better nation for discovering the AIDS virus? The fruits of these discoveries will in any case be internationally available. And, science being globally competitive, these discoveries would have soon been made elsewhere – after all, neither NASA nor Gallo were too far behind Farman or Montagnier.

No one can really say how much money should be spent on non-economic, pure research ; and your opinion, reader, is as good as mine. It comes down, surely, to the estimate which each of us makes about the proper place of national pride, of patriotism, common sense and generosity.

7

Save British science by abolishing the UGC/UFC research budget

Are British universities, and the way they run their science, perfect? Or could they be reformed?

One clue lies in the first sentence of an article Owen Hickey wrote on the brain drain, such as it is, in *The Times* on 9 January, 1987:-

> There is an international market in academic talent, and a good thing too for humane scholarship and scientific research.

This might appear to be an unexceptionable, even obvious statement, but it is not a true one. In practice, this market is largely American, and so the statement should be amended to read:-

> There is an American market in academic talent, and a good thing too for American humane scholarship and scientific research.

A comparable British statement would read:-

> There is no British market in academic talent, because British universities adopt egalitarian and restrictive practices, and then they blame the Government for the damage to British humane scholarship and scientific research.

There are four major areas where British academic practice deviates from the principles of the free market: tenure, fixed salary scales, the sources of university funding, and the dual funding of British research.

1. Tenure

The term 'tenure' means, in practice, an academic job for life regardless of continued academic merit. It is the academics' greatest perk, and they have fought, and will fight, in its defence. The universities have always reserved the residual right to dismiss academics for 'good cause', but this has, in practice, been reserved for acts of moral depravity or gross dereliction of duty. Good cause notwithstanding, some universities have in the past ignored blatant breaches of contract, because of the strength of the ethos of tenure; but discipline is now tightening as fiscal pressures grow. This, indeed, was one of the Government's justifications for its 1981 cuts. Nevertheless, the universities continue to refuse to judge dons as scholars or researchers.

The universities defend tenure as a bulwark of academic freedom. This freedom is, of course, important; but for experimental scientists, at least, it is largely fictitious. Experiments cost money, which is raised by short-term grants of three or five years. These grants are, rightly, peer-reviewed, but that flagrantly breaches academic freedom. And all dons' academic freedom is restricted by the peer-review that learned journals and publishers impose upon submitted work.

Initial appointments and promotion are also peer-reviewed; which means that in practice academic freedom is restricted to lecturers who conceive of unpopular ideas after they have been appointed, who do not wish to publish those ideas, who do not aspire to promotion or even the friendship of their colleagues, and who need no research money. For the vast majority of dons, academic freedom is a chimera.

In the name of this chimera, the universities have done great damage to themselves. Because of tenure, the system is clogged by hundreds, if not thousands, of lecturers who do less work than they might or who are not very able. Dons generally receive tenure during their late 20s or early 30s on appointment to a lectureship. That is far too young to be given a job for life. But when it is remembered that thousands of dons were appointed during the 1960s, when the universities were expanding so fast that there was a shortage of able candidates, it will be realised that there are too many lecturers currently in post who would not be short-listed for a job today. These lecturers damage the universities twice over, because not only do they not do their own work properly, but they also block the career prospects of young academics.

The Government has now formally abolished tenure for new academic appointments (*Education Reform Act 1988*), but little will change in practice since the Government has not imposed formal, regular judgement of dons as teachers and researchers. This is because no formal scheme of quantifying dons' research or teaching could succeed; the judgements would be too arbitrary, too subjective or too absurdly bureaucratic to enjoy widespread support or consent. The majority of dons do good work, and their re-employment every ten years or so should be self-evident upon formal review. But how can that minority of dons who appear to a review committee to be unsatisfactory be identified according to criteria seen to be just?

Fortunately, absolute rules can be avoided in favour of a more subtle and more practical system of judgement: the free market. Dons who appear on review of their research and teaching to be poor should have to re-apply for their own job against open competition. Thus the university will be able to avoid bureaucratic judgements, and will be able to rely on relative judgements. These, too, are difficult, but they will increase the likelihood that a university has the best person available in each job. The universities have long accepted the principle of relative judgements: all initial appointments to tenured jobs are already made against open competition. Indeed, the history of Oxford and Cambridge shows that it was Jowett's introduction of open competition to appointments that revitalised them. In the wake of Jowett, the Oxford and Cambridge colleges even introduced regular review of their fellows. Their dons generally have to be re-elected every five years. But, although custom varies from college to college, this practice has largely degenerated into ritual. There are few Oxbridge fellows who live in fear of not being re-elected. We must now revive and extend Jowett's reforms.

Academics who fail to be re-appointed should be well compensated. This would not only be compassionate, it would also deter the universities from failing to re-appoint staff for trivial reasons. Dons should also be able to appeal against compulsory re-application. Initial appeals should be made to those fellow academics best able to judge the nature of arcane or complex scholarship. Final appeal should be made to non-academics, for a curious reason: it has been suggested that tenure protects dons against wicked governments. That is, of course, nonsense. British universities are autonomous. Tenure, in fact, protects academics from their professors. So, academics who believe that their compulsory re-application for their own jobs might be ideologically motivated should be able to argue their case before a disinterested tribunal.

There will always be, of course, yet another level of appeal: the free market. Because abolishing tenure will increase the turnover of academic staff, it will increase the number of vacancies enormously. Aggrieved academics will always be able to re-apply elsewhere.

Ten-yearly review of university staff might appear to be the harbinger of innumerable committees, but academic careers tend to be punctuated by regular review anyway. Dons apply for promotion from lecturer to senior lecturer to reader to professor, and science dons are reviewed even more frequently as they apply for grants or seek to publish. The extra administrative load of ten-yearly review would be small, and would be more than offset by the rejuvenation which it would promote.

Tenure evolved almost by accident. The medieval Oxford and Cambridge colleges, upon which the later universities were modelled, were very small. Their governing bodies rarely exceeded ten or twenty fellows, and they comprised unmarried clergymen who lived in college. Such institutions, which were really extended families, soon learned the importance of tolerance, from which tenure flowed. But such corporate immobility hardly mattered because most fellows were only waiting for a vacant living. They would teach for a few years until their seniority earned them the next rectory in the college's giving. Then they could leave and marry.

Tenure, which evolved to meet the needs of a small group of transient medieval celibates, was hardly likely to prove appropriate to large, modern, research-minded universities: and so it has proved. Tenure has been retained because universities are self-governing bodies, and so the dons have awarded themselves jobs for life. All closed corporations try to do this. It will be remembered that Arthur Scargill led his men on strike to defend the miners' hopes of jobs for life.

Although tenure was never justified academically, the universities in the past were at least private, self-financing bodies and so had the right to autonomy. Now that they are largely dependent on the state, they should be run more efficiently.

2. Fixed salary scales

British scientists have, until recently, been paid on fixed scales determined solely by rank, age and length of service. (British professors have always been able to negotiate their own salaries, but only within such narrow bands as to render the negotiations virtually meaningless). In America, there is a free market in salaries. An assistant professor at, say, Alcorn State University, Mississippi, will earn $20,500 p.a. (rather less than a British university lecturer on £18,210) while an academic star like Bernard Williams – egalitarian protests notwithstanding – may well be on $100,000 or more.

There are two powerful reasons for introducing flexible salaries into British universities: the brain drain and competition from industry. The brain drain affects only a tiny élite. It makes obvious sense to pay that élite more to keep it here. The overall costs to the universities will be small. Competition from industry is a greater problem. The universities, by virtue of their low, fixed salaries, are locking themselves into an academic slum. In many modern disciplines such as electronics, the universities are increasingly appointing second-raters, or leaving vacancies unfilled. Many of the best potential academics have been lured by industry's higher salaries. It makes obvious sense to pay computer experts and the like more money. The universities have already accepted the principle of differential salaries: academic clinicians are remunerated at NHS rates, and Oxbridge dons are better paid than their *arriviste* colleagues. This flexibility should now extend to all dons, even those unblessed by medical qualifications or fellowships of ancient colleges.

The classicists and others in the humanities will of course be upset because their market value is small, but differential salaries may eventually benefit them too. They are also now immured in the shabby-genteel academic slum where tenure is traded against poor salaries. But the best of our youth is not going to be attracted by such a package.

Academic salaries must be raised for the long-term health of the universities; but how? Collective action will not work, not only because government money will not be forthcoming, but also because the academics will be inhibited by their professed egalitarianism and by their sense of responsibility. But serious bargaining by individual dons over their individual salaries will press the universities into finding good money for good academics of all disciplines. And if that results in smaller but better universities, so much the better. And if that forces the universities to struggle to find more money, better still. The American experience is particularly encouraging: academic salaries were once low there too but, in the biological sciences at least, they soon rose following the expansion of the National Institutes of Health (NIH). The NIH, initially, could not attract academics except by offering them higher salaries, and soon all the universities were raising salaries to keep, or attract, their stars.

Higher academic salaries would enable us to match the mobility of the Americans. Their professors move in and out of government or industry at various stages of their careers. This strengthens both society and the universities. But British universities are static, because no one in the outside world can afford to go back as a don.

The Government has now enabled the universities to offer different salaries to different professors. This theoretical dispensation should be taken up vigorously by the universities and should be extended to all academics, not just professors.

3. The sources of university funding

Although our universities are constitutionally autonomous, they are no longer independent. The extent to which they have betrayed their traditions is not generally recognised. For centuries, in contradistinction to the *dirigiste* Europeans, our universities maintained their independence from the state, and this was widely recognised as a glory of British culture. Our tradition of academic freedom sprang from the genuine fiscal autonomy of the universities. The Americans have remained true to this inheritance, and the majority of their best universities such as Harvard, Yale, Princeton, Stanford and Caltech are private.

The price of freedom, however, has been eternal fund-raising. But, whereas the Americans have continued to massage their alumni and to celebrate their donors, the British have sunk into the arms of the state. By 1982, 79% of British universities' funds came from Whitehall. This dependence has been disastrous. It has locked individual universities into national, bureaucratic scales of payment, employment and research which has inhibited the flexible use of resources. Strangely, the universities have resisted the Government's attempts to wean them to financial independence. In 1980 the Government announced that all new foreign students would pay full fees. Previously they had been subsidised like British students. The difference is significant: in 1986-87, for example, home undergraduates paid £536 p.a. in fees and home postgraduates £1,680. But foreign art students paid £3,480, foreign science students £4,570 and foreign clinical students £8,450. Upon the Government's 1980 announcement, the universities erupted with dire warnings. Vice-Chancellors and eminent professors broke into savage print in the letters' pages of the newspapers. So, too, did masters of Oxbridge colleges, although few of them had regularly subsidised their own foreign students' college fees. In the event, as Table 7.1 shows, the fall in foreign students' numbers was small and transient. But the increase in income has been large and permanent (Table 7.2). Even more important, the universities have now wrested back from the Government a little extra piece of autonomy – or, rather, have had it thrust upon them.

Thus a new awareness has developed, and fund raising has gathered pace. For example, the UGC cuts of 1981 which hit Salford, Aston and Bradford universities particularly hard, and which were widely condemned as destructive, have actually revitalised those universities. Under the leadership of inspired Vice-Chancellors, they have raised millions of pounds from industry, encouraged voluntary retirement by less-useful staff – and have emerged fitter and leaner.

We have a long way to go before we rival the Americans. Stanford alone raised $80 million through donations and endowments in 1988, but the spirit in our universities is changing. Even Oxford has now launched an appeal for £200 million. The Government could help by making all such donations tax-deductible, as they are in America. Furthermore, about one tenth of the universities' research income is provided by industry (£32 million in 1983 for example, out of a total of £305 million) and as Save British Science has suggested, this would be stimulated if industry could offset that against tax.

TABLE 7.1
New foreign students paying full fees to British universities

Year	Undergraduates	Postgraduates	Total
1975	6,340	10,424	16,764
1976	6,817	10,767	17,584
1977	7,096	10,837	17,933
1978	7,898	11,145	19,043
1979	6,525	10,576	17,101
1980	5,039	9,132	14,171
1981	4,874	8,749	13,623
1982	5,090	8,994	14,084
1983	5,528	9,655	15,183
1984	5,915	10,370	16,825
1985	7,401	11,915	19,315
1986	7,935	12,670	20,605
1987	7,996	11,976	19,972

Source: *University Statistics*, published annually by the UGC. EEC students are excluded because they pay subsidised fees.

TABLE 7.2
The British universities' revenue from foreign students' fees

Year	£millions
1975-76	9
1976-77	13
1977-78	25
1978-79	28
1979-80	35
1980-81	54
1981-82	71
1982-83	82
1983-84	92
1984-85	104
1985-86	125
1986-87	142

Source: *University Statistics*, published annually by the UGC.

4. Dual Funding

This represents, perhaps, the greatest waste of money in British university science. It is based on the idea that, in addition to teaching, all university academics should spend a proportion of their time on scholarship or research. Of course they should! But not all do. Yet in Britain they are all paid as if they do. Sir Christopher Ball, the Chairman of the National Advisory Body for Public Sector Education, has calculated that this one practice alone wastes £300 million a year. Remember that Save British Science has been campaigning for just £100 million more a year.

British academic science enjoys 'dual funding'. During 1986, for example, the University Grant Committee (UGC)* spent £670 million on research, and the Research Councils spent £540 million. The UGC pays for the infrastructure of university research: the maintenance of university research laboratories, the costs of small projects, and that proportion of university lecturers' time which is spent on research or scholarship, rather than on teaching. That is arbitrarily fixed at about 40%.

The Research Councils fund the additional costs of particular research projects: they pay for the specific chemicals, equipment or manpower which lecturers might need to do a piece of work. The Councils also maintain a number of separate institutions devoted purely to research.

Research Council money

There is little structurally wrong with the Research Councils' grants to the universities. These are distributed collectively, after peer review, to the best applicants. The grants are generally held for only three or five years. In consequence, very little money is wasted. But the Research Councils spend much of their money (two thirds in the case of the MRC and SERC) on their own permanent establishments, and these suffer from the problems of permanence. Jobs are offered to good young scientists, not all of whom fulfil their early promise. Although some Research Council establishments such as the MRC Cambridge Laboratory for Molecular Biology are superb, a disproportionate number of important British discoveries come from the universities, (see Professor Petersen's letter in *Nature,* 12 March 1987). This is sometimes blamed on the relative isolation of many Research

* To be renamed the Universities' Funding Council

Council establishments.That is probably less important than the fact that the Research Councils have to support their own scientists indefinitely, while they can restrict their university research grants to dons who are productive.

The Research Councils are, however, slightly more flexible in their employment policies than the universities, and they will on occasion close unproductive establishments and even make people redundant. But the relative productivity of the Councils' grants to the universities and their support for their own establishments should be subject to the free market. Research Council employees should compete with the university dons for research funding. Research Council establishments, furthermore, should be linked with neighbouring universities, and academics should be free to move between them. Thus any lecturer should be able to undertake research almost full-time, while Research Council employees who fail to win grants should teach. Teaching, as well as research, will improve because the pool of potential teachers would be expanded.

Save British Science emerged from the frustration of university academics whose 'alpha' grant applications were rejected by the Research Councils for lack of funds. It is awful to consider that the £100 million shortfall in alpha funding might have arisen from the rigidity of the Research Councils' intramural funding policies.

UGC money

The UGC spends its money much less happily than the Research Councils: until recently, equally to all intents and purposes. This was because the infrastructural support for research was spread between the universities according to formulae weighted towards student and staff numbers, and all academic staff were paid as if they were spending 40% of their time on worthwhile research. But no one actually monitored the research of individual universities or dons, because that would have interfered with academic freedom. Alas, equal spending means wasted spending, because some universities and some dons are much better than others.

The government cuts of 1981 forced the UGC to acknowledge these obvious facts, and they have since undertaken 'selectivity exercises'. The UGC has graded departments, faculties and universities according to the amount of outside grants they win and the numbers of papers they publish. And it has then given the better universities more money than the bad ones. Apart from confirming that some universities really are much better than others (for example, the fifteen least good British universities, which consist of 33% of the total of forty five, win only 10% of the research grants, a disproportion which cannot be accounted for solely by size), the selectivity exercises have proved unhelpful.

First, the numbers of papers that a department publishes, or the money it raises in grants, are very crude measures of quality. Distributing the money to universities compounds the error. Research is done by individuals, not universities. It was the ABRC itself which concluded 'that there is lack of purposeful direction, nationally, in the redeployment of the university research effort' (*Strategy for the Science Base*, 1987). Money, therefore, should be focused exclusively on good scientists. It should not be distributed by UGC bureaucrats, working to misleading guidelines, to university bureaucrats.

Instead, the UGC science research budget should simply be transferred *in toto* to the Research Councils*. Individual research grants should be doubled to encompass the maintenance and secretarial cost of laboratories. Thus infrastructural support will be concentrated solely on good researchers.

Freedom from teaching, furthermore, should be reserved for good researchers: all university lecturers should be contracted, like polytechnic teachers, to full-time teaching. Only those scientists who won outside grants should then be free to negotiate a reduction in teaching with their university by drawing a percentage of their salary from their grants. Similar schemes already obtain in some American universities. Some of their professors, for example, are paid only in term-time for their teaching. Their vacation pay, if any, is drawn from research grants.

Universities may wish to employ certain individuals as

* This paper does not concern itself with the Economic and Social Research Council, whose usefulness is controversial (Porters, R., *Eur. Econ. Rev.*, 1987,31; 1329-40)

full-time scholars or researchers, or they may wish to endow them with exceptional facilities. They should of course be free to do so, but only with their own non-UGC money.

This paper has not concerned itself with the humanities; but there is no reason why the scheme I propose could not be extended to them. 40% of lecturers' time is meant to be spent on scholarship; let that time be monitored by a humanities' Research Council, which would fund lecturers with a proven track record of scholarship, in lieu of teaching.

The scheme should also be extended to the polytechnics. At present many of their abler researchers are partially excluded from research because dual funding does not extend to them, and there is no mechanism for reducing their teaching.

One drawback to this scheme is that it will, effectively, rob the charities of the hidden subsidies that they have received. Unlike industry, they have not had to pay the infrastructural costs of the university research which they have funded. The Government should now, I believe, increase its expenditure on science (see Chapter 8) but I believe it should not necessarily do so by giving more money to the Research Councils. Rather, it might match every pound spent by the medical charities in British universities with a further pound to pay for infrastructural costs. This should stimulate further charitable donations, and promote plurality in science funding. The more bodies which consider research projects, the less likely it will be that good ideas are lost.

The remuneration of Ph.D students illustrates the value of plurality in science funding. The quality of young scientists is the best guarantor of science's future health. But the Research Councils have tried to accommodate quantity too. Good graduates can now earn at least £10,000 in their first year of employment in the City or industry, but the Research Councils are offering only £2,975 to Ph.D students. That increases the quantity of students but what about their quality? The Wellcome Trust and the Cystic Fibrosis Research Trust, to name two charities, decided recently to offer £4,000 p.a. to their Ph.D students – and they have reported success in their saving some of the brightest young men and women from the toils of the City.

* * * *

The ABRC recently rejected the suggestion that the UGC research budget should be abolished, because it feared that a restriction of non-accountable, free-floating money would inhibit 'initial and innovative investigations. . . from which future growth points will emerge'. This is a romantic view of science. Initial and innovative investigations generally emerge from the curiosity of active researchers whose dynamism will have ensured that they already hold grants. It was notable that the ABRC offered no example of university lecturers, having mouldered unproductively for years, suddenly erupting into UGC-funded creativity.

The ABRC, instead, has foisted yet another bureaucratic distortion on science: the Interdisciplinary Research Centres (IRCs). These centres will contain scientists from different fields and different universities working together on closely related problems. There is nothing, of course, wrong with such centres in principle, but they should arise organically. They cannot be imposed by central *diktat*. As presently envisaged, the Research Councils will either decide they want an IRC in, say, neuropharmacology, and then ask universities to form consortia and bid for them, or groups of universities will be asked to suggest something for which they would like an IRC.

The IRCs would 'require more positive management than is generally the norm for university research at present' *(Strategy for the Science Base)*. They would have directors and a secretariat. This is, in fact, the central imposition of Big Science on British research. Yet the ABRC itself has acknowledged that, whereas most British science since the war has been excellent, the shortfall has come in Big Science. Paragraphs 2.27, 2.28, 2.29 and 2.30 of *Strategy for the Science Base* chronicle the poor value for money we have obtained from particle physics, CERN, astronomy and oceanography.

The IRCs will be an expensive failure. Good science flows, not from centrally set-up committees, but from individual scientists. If such individuals, either alone or in partnership, do such good work that they need huge, IRC-like resources, then the Research Councils should provide them. But the imposition by *fiat* of centralised IRCs will not necessarily conjure up good scientists to work in them on experiments that appeal to a committee in London. Inspiration comes from the people at the bench, and it ought to be they whom the Research Councils should be encouraging to become their own directors, and on whom the Council should be spending the appropriate amount of money.

British science, at present, resembles the British economy of the 1960s and 1970s, when bureaucrats tried to plan and manage through pay pauses, Neddys and income policies – to say nothing of appeasing the block votes of trade unions committed to collective bargaining and the closed shop. If only individual scientists could be left alone, they would manage their own resources much better.

8
Conclusion

It will be seen that the state of British science is more complex than the scientists' pressure groups would have us believe. We are told that the universities are shrinking, whereas they are in fact expanding. We are told that there is a brain drain, but it is in fact a very small one: caused by the restrictive practices of the universities themselves and by the egalitarianism of the UGC. We are told that British science is underfunded, when international comparisons are far from unfavourable – except that the British universities' vigour for fund raising falls short of that of the Americans. We are told that academic science spawns economic growth, whereas the exact opposite appears to be true. And we are told that contemporary scientists embody culture, but we are not told that this is the culture of the trade union movement.

The academic pressure groups have long oversimplified their case. For example, the universities constantly claim that they ought to expand, but that the lack of government money stops them from educating more undergraduates. Actually, 15% of all undergraduates are already admitted with less than three grade Cs at A level. Privately, many dons concede that few such poorly prepared students would benefit from a British university education as generally understood.

The public oversimplifications, however, cause damage. In *The Times* of 11 April 1987, Sir Karl Popper denounced the 'high priests of the so-called media' who exaggerate society's problems. He wrote:-

> as a consequence there are many believers, especially young people, who are made deeply unhappy by the incessant propaganda, who really believe that they are living in a bad, unjust world, and who are keenly suffering as a result of this universal belief.

Most British scientists are deeply unhappy. The propaganda of Save British Science and the leaders of their profession have led them to believe – an all too common belief – that British science has been destroyed by a wicked Government. The price of the nonsense is heavy. The Cabinet's Chief Scientific Adviser warned recently that schoolchildren were no longer choosing science. These children need saving from Save British Science. Ironically, 1989 would be an excellent year to take up science. By the mid 1990s, all those 1960s' university lecturers will be retiring, creating thousands of vacancies. Furthermore, the remarkable expansion of the British economy will create even more research jobs in industry, and consequent investment in science.

It has been forgotten during the current furore that government science policy since the war has been bipartisan. Both parties, when in power, have made the same experiment: between 1945 and 1970 they expanded science in the hope that it would stimulate the economy. And they also hoped that the expansion of the universities would make Britain a gentler, more cultured place. Both hopes were, of course, dashed. Indeed, the universities' student unions positively nurtured riots, direct action and drug-taking. So both parties back-peddled. Let us remember that it was Mrs Shirley Williams, in 1971, who first warned the scientists that 'their party was over'.

The scientists never accepted the Government's right to subordinate science funding to what the Government believed was the national interest. Indeed the academic community actually opposed the Government in its attempt to reverse our long-term national decline. By 1981, the Government had correctly diagnosed that many of Britain's economic ills were caused by restrictions of the free market: collective bargaining, incomes policies, restrictive practices, jobs-for-life and, of course, an over-dependence on the State. In 1981, therefore, the Government cut the UGC budget by 5%. For two reasons : first, resources needed to be concentrated on the creation of wealth, and second, the universities needed to be reformed. The Government correctly assumed that only fiscal pressures would stimulate reform. But, other than the TUC, the NUM and the steelworkers, no organisations were more wedded than the universities to collective bargaining, restrictive practices, jobs-for-life and dependence on the State. So 364 economists belittled the Government's policies, Oxford University rejected Mrs Thatcher's honorary degree and the researchers produced Save British Science.

But there is a further price to be paid: because the scientists denied the Government the right to cut their funding when the economy was in decline, they cannot use the Government's own arguments to claim more money when the economy is recovering. Yet times are now improving, and there is a good case for expanding science funding.

The arguments presented above do not show that academic science is of no economic benefit: they merely suggest that it is the child, not the parent, of economic growth. Nevertheless, the example of the Victorian entrepreneurs who founded universities, of the present-day Japanese entrepreneurs who run in-house near-universities and of our own cultural history should convince us that academic science is to be greatly valued. It does make long-term economic sense for the Government to help anticipate the future scientific hunger of industry.

Unfortunately, the scientists' pressure groups have not been arguing this case; our future prosperity might have been endangered by their refusal to talk to the Government on its own terms. Fortunately, the Government's own key indicators led it earlier this year to increase science funding by £95 million. Its economic successes will ensure our scientific future.

The Government, rightly, sees its economic role as in the main catalytic. In her speech to the Royal Society of 27 September 1988, the Prime Minister adumbrated future government policy; as industry regains its entrepreneurial confidence it will increasingly be expected to shoulder its own responsibilities for research. University scholarship, in contrast, will be relieved of the commercial pressures embodied by such industrial corporation schemes as Alvey, Esprit and Case – and will more and more revert to pure research. Thus the Government's economic successes will return universities to the proper, unalloyed search for truth.

It is a remarkable fact that the Governments of Harold Macmillan, Harold Wilson and Edward Heath all enjoyed considerable academic support. All three men, for example, were awarded honorary degrees by Oxford University. Yet their Governments were disastrous for Britain (and so for the universities themselves). Mrs Thatcher's Government, on the other hand, which has finally reversed our long decline, which has restored some of the universities' autonomy, which has presided over a doubling of the number of university researchers, and which is now pleading to return the universities to their proper role, is actually hated by the universities themselves. It almost makes one question the value of higher education.

9

Recommendations

The recommendations made here can be summarised:-

1 Ten yearly review of permanent academic staff: those who appear to be unsatisfactory should be obliged to re-apply for their own jobs against open competition.

2 Salary scales: all academic staff, of whatever grade, should be free to negotiate their salary with their employer.

3 Charitable donations to the universities, and industrial support for research, should be tax-deductible.

4 The Government should meet every pound raised by the research charities with a further pound.

5 The UGC/UFC research budget should be transferred to the Research Councils.

6 UGC-funded permanent academic staff should be contracted to full-time teaching, and should be relieved of teaching only by drawing a percentage of their salaries from outside grants.

7 Research Council staff should have to apply for their intramural research funds in open competition with university academics.

8 Research Council establishments should be formally linked with neighbouring universities, and staff should be able to move freely between them.

9 External granting agencies should endow a number of permanent academic jobs commensurate with the number of short-term grants which they fund.