Civil research and development. Volume I, Report / Select Committee on Science and Technology.

HOUSE OF LORDS

SESSION 1986–87
1st REPORT

SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY

CIVIL RESEARCH AND DEVELOPMENT

VOLUME I — REPORT

Ordered to be printed 26 November 1986

LONDON
HER MAJESTY'S STATIONERY OFFICE
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ORAL EVIDENCE

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WRITTEN EVIDENCE

* Also gave Oral Evidence (see Volume II)

FIRST REPORT

26 NOVEMBER 1986

By the Select Committee appointed to consider Science and Technology

ORDERED TO REPORT:

CIVIL R & D

CHAPTER 1 INTRODUCTION

Terms of Reference

1.1 The Committee have conducted an enquiry into the policy and practice of public support for civil science and technology in the United Kingdom.

1.2 The Committee appointed as their specialist advisers Sir John Charnley, formerly Controller of R & D Establishments and Research, Ministry of Defence, and Professor Roger Williams, Professor of Government and Science Policy, University of Manchester. The Committee record warm thanks for the expert advice and unstinting support which they have received. They also express gratitude to the many witnesses, listed in Appendix 2, who gave evidence.

Science and Government

1.3 It is five years since the Committee looked into the broad question of Science and Government and particularly the provision of scientific advice to government. That report[1] spelt out the vital contribution of science and technology to national prosperity and the quality of life. It urged Ministers and policy-making civil servants to recognise the importance of science and technology, to seek out advice from the best available sources and then to listen to it.

1.4 The Committee suggested a number of ways in which the machinery of government could be improved to achieve this. The report argued in favour of a minister to speak for science and technology in Cabinet but rejected a separate Ministry of Science and Technology; it identified a vacuum at the centre of scientific and technological endeavour, to remedy which a Council of Science and Technology was recommended; and it recommended a Government Chief Scientist and staff in the Cabinet Office. But the report was not dogmatic about the details. The Committee saw that there is never any "correct" machinery of government; this is bound to be influenced by the needs and personalities of the day. But the objective was clear. "What above all is needed is a strengthening of the scientific dimension in Government as a whole".

1.5 Some of the Committee's recommendations were adopted in substance. Others were not. One development, which is important because of its potential to bring about further change, was the introduction of an Annual Review of Government-funded R & D. This sets out systematically facts about public funding of civil science and technology on which decisions about future policy can be based. By taking a horizontal look at spending across the whole of Government in addition to the normal vertical look, Department by Department, it helps rational decisions about priorities and focusses attention on overall levels of spending. Without it, the present enquiry would have been almost impossible.

A fresh start

1.6 During the last five years however, the general state of science and technology in the United Kingdom has not improved. In some areas it has even become worse. This is the unavoidable conclusion to be drawn from the evidence of nearly all witnesses outside Government Departments. In spite of the valiant efforts of individuals to make the present system work, and in spite of a few success stories in branches of science and technology, the overall picture conveys an impression of turmoil and frustration.

[1] 1st Report, Session 1981-82, HL 20

1.7 Morale is low in the scientific community, as the Save British Science campaign (P226) testifies. Because of rapid growth in the cost of science and constraints on funds, a gap is growing between the potential of science and the resources available to scientists. The academic community, subjected to financial restraints and stagnant recruitment, is held back from breaking new ground or enthusing its pupils. A brain drain among the best graduates is again evident. The Research Councils are having to turn down many alpha research projects and reduce their own activity. The Advisory Board for the Research Councils (ABRC) have forecast that a continuation of present policies will reduce their real resources from the Science Vote by at least 10 per cent during the 1980s.

1.8 In industry pessimism is common also. The manufacturing base has shrunk alarmingly. Investment performance in R & D is poor by comparison with the United Kingdom's major competitors—a situation on which the Committee have already commented in a report on Engineering R & D.[1] British GDP per capita is now substantially below that of its industrial competitors. For the first time, in 1983, Britain went into deficit in its trade in manufactures. The spirit of pessimism is well expressed in the report of the House of Lords Select Committee on Overseas Trade[2] which said in 1985 that the national attitude towards trade and manufacturing "needs to change—and change radically—if we are to avoid a major social and economic crisis in our nation's affairs."

1.9 This pessimism need not continue, and it must not be allowed to. The Committee's message is twofold. First, long-term recovery requires success in science and technology; it is impossible otherwise. Within the limits of the country's resources, support for science and technology, and especially those areas offering the prospects of increased national wealth, must be generous. Secondly, the Government have the responsibility of all governments, namely leadership. It must be seen to lead the country to new heights in science and technology. The Committee's message about the scientific dimension may be similar to that in 1981, but it is now more urgent. The country needs a fresh start and the optimism to make its talents work.

1.10 The problem is not a new one. "Expenditure by the Government in scientific research and science institutions, on which its industrial prosperity so largely depend, is wholly inadequate in view of the present state of international competition" complained the Royal Society Yearbook in 1903. The solution is unlikely to be a new one. But the Committee's recommendations, which are given in Chapter 6 of this report, should help.

1.11 The key issue is one of attitudes: the determination to make the United Kingdom industrially successful, combined with new hope for those engaged in science and technology. These can revive both morale and the economy. Cosmetic adjustments to the *status quo* will not be enough. The Government has to show that it means business and create a new climate of optimism in which its example generates confidence in others.

[1] 2nd Report, Session 1982-83, HL 89
[2] Session 1984-85, HL 238, para.7

CHAPTER 2 THE OBJECTIVES OF PUBLICLY FUNDED CIVIL R & D

2.1 This chapter is concerned with the reasons why the taxpayer supports science and technology. The discussion requires distinctions to be drawn between broad categories of R & D activity and the Committee have adopted the following definitions:

> *basic (pure or fundamental) research*—research undertaken primarily to acquire new knowledge and with no specific applications in mind;
>
> *strategic research*—research undertaken with eventual practical applications in mind even though these cannot be clearly specified;
>
> *applied research*—research directed primarily towards specific practical aims or objectives;
>
> *development*—systematic work drawing on existing knowledge to produce new products, processes, etc.

These categories are essentially those adopted in the Annual Review of Government Funded R & D 1986 except that in that document strategic research is regarded as falling within the applied research category. The categories are not, of course, clear-cut. It is commonly stated that research spans a spectrum but this is perhaps a misleading concept in suggesting that any research project can be assigned to a particular point in the spectrum. The position is more complicated; a research project may involve elements from all the categories in changing proportions as the work progresses. The categories are necessary to facilitate discussion but the difficulties of definition must be kept in mind.

Objectives of Research

Basic Research

2.2 Basic research accounted, in 1985/86, for nearly 40 per cent of the total Government spend on civil R & D.[1] The arguments for basic research were succintly put by The Royal Society in its evidence (p 218):

> "Basic research, as a quest for understanding the natural world, is an essential part of cultural development, and every civilised country should accept some commitment to its furtherance. Research, as carried out in universities, is an important factor in maintaining the standards of teaching and the production of skilled manpower. The knowledge obtained by basic research provides a source for industrial development and exploitation of new products and processes and for solving industrial problems."

2.3 This assessment of the importance of basic research was echoed in much other evidence. The Science and Engineering Research Council (SERC), for example, described basic research as an activity "which most advanced countries accept as part of the proper fabric of university life, not least because of its close links with teaching" and which "also provides the essential background of knowledge from which practical benefits of many kinds are derived, even though that was not its original purpose" (p99).

2.4 The views described above are those of scientists but evidence on the importance of basic research has come also from industry. For example, in stressing the need to preserve the health of the university system, Dr Roberts of GEC commented (Q 682): "the ultimate economic benefit is there for anyone who cares to see it in the sense that the economic health of the country is totally determined by the quality of the people who are going to work in manufacturing industry, and the quality of the people will be determined by the quality of the education and the stimulation that they get... in universities... schools... and polytechnics ..."; and "... retaining the United Kingdom universities as vigorous seats of learning and education is fundamental to the economic health of the country." A similar point was made by representatives of the private research organisations. Mr Flanagan stated (Q 989): "the prime objective of a university is to produce educated and trained manpower and basic research which it conducts maintains the teachers at the top of their subjects. That is an important reason for basic research as well as its contribution to knowledge."

[1] Annual Review of Government Funded R & D 1986, Table A.23

2.5 Research contributes to the quality of teaching, and hence to the production of educated and trained people. Involvement in research is important for the acquisition of skills in high technology. These benefits of research would perhaps generally be accepted with little question. A sharper consideration in relation to the question of the resources that should be devoted to research is the nature of the connection between research and direct economic returns deriving from the exploitation of research findings. Many examples can be given of basic research, undertaken in the quest for knowledge, that has led to the creation of major industries and very large economic benefits.[1] Evidence from industrial witnesses has asserted the connection between research and wealth creation. For example, BP stated (P49) that "Basic research is essential to the chain of discovery and development which leads ultimately to wealth creation and should not be compromised"; and the Association of the British Pharmaceutical Industry stated that "the success of the pharmaceutical industry in the United Kingdom is heavily dependent on the strength of academic science in the fields of medicine, biochemistry and biotechnology" (P9).

2.6 It is, however, another matter to establish a general connection between expenditure on basic research and economic benefits. In spite of many studies that have been carried out by economists, a quantitative link has not been clearly established. A recent report by the US Office of Technology Assessment[2] found that while "Economists have shown a strong positive correlation between R & D spending and economic growth .... They have *not* been able to show comparable returns, and at times been unable to show *any* returns, on Federal R & D expenditures, except for some applied research programmes ..." The report noted the limitations of economic methods in this field, especially for basic research where the principal benefit—"new and often unexpected knowledge"—cannot be assigned a direct economic value. The relationship between research and economic benefit was described as "long-term, indirect and unpredictable", depending on various factors outside the research process. Thus: "A highly successful basic research effort may never generate technological innovation or economic pay-off if other factors in the economy are not conducive to technological change."

2.7 The unpredictability of the returns from basic research was noted by the Natural Environment Research Council (NERC): "Basic research... is, by definition, of unspecifiable value to society before it is undertaken. Investment in basic research is an act of faith based on long experience that the creation of knowledge, when handled wisely, has been beneficial" (p224). The harsh financial climate has brought that faith into question and has focussed attention on how the contribution made by research to economic objectives might be more reliably ensured. Within industry, while there is wide acceptance of the importance of university research and teaching, and concern about the impact of cuts in university funding, there is also support for the view that the balance of university research should move towards the strategic and applied end of the spectrum.[3]

2.8 It was widely accepted in evidence that basic research must continue to be funded mainly from the public purse. As one witness stated: "Industry by and large will be hesitant to invest heavily in (long-term research) as they wish to see a reasonable return on investment in the short-term" (P171). The point was also made that companies considered that they already supported basic research in universities and research councils through the taxes they paid. These views are endorsed by a Working Party of the Advisory Board for Research Councils (ABRC) (the "Mathias" report)[4] which concluded that "Much fundamental research is to be seen as a public responsibility for which no significant substitution of private funds is possible. The civil science budget therefore needs to be maintained, and if possible enhanced, in real terms if the fundamental science base of the country is to be sustained". The Government in its Green Paper on Higher Education,[5] has also said "with regret, that no substantial part of established public funding responsibilities (for higher education) can be shed".

Strategic Research

2.9 Nearly one quarter of publicly funded Civil R & D in 1985/86 was strategic research.[6] Of that research, nearly 60 per cent was supported by university and research council funds provided

[1] The Society for General Microbiology gave, as varied examples of basic research which was later seen to have "enormous potential for commercial development," research into the genetic code, the recent development of monoclonal antibodies, the discovery of penicillin and J J Thomson's research into the nature of the electron. (P245)

[2] Research Funding as an Investment: Can We Measure the Returns? A Technical Memorandum (Washington, DC: US Congress Office of Technology Assessment, OTA-TM-SET36, April 1986), p24.

[3] See paragraphs 5.34–5.36.

[4] Report of the working party on the private sector funding of scientific research, ABRC, May 1986.

[5] Cmnd 9542, paragraph 9.4

[6] Annual Review of Government Funded R & D 1986, Table A.23

through the Department of Education and Science (DES), the rest being funded by other departments. Most government departments need to carry out research, largely strategic and applied, in support of their policies. A common criticism in evidence was that under financial pressure departments had neglected longer term needs and that this had imposed an added burden of strategic research on the research councils.

2.10 Over 35 per cent of the Science Budget in 1985/86 was in fact used to support strategic research and only about 50 per cent was used for basic research. In commenting on this the ABRC stated:[1]

> "The distribution between basic and strategic research is however not particularly helpful for making policy. It erroneously suggests that a clear boundary can be drawn between purely 'curiosity-oriented' and 'relevant' research. It also encourages the idea that curiosity-oriented, as opposed to more relevant research, is a luxury which the country cannot necessarily afford. But most branches of physics and chemistry are of strategic importance in relation to the engineering and chemical industries; and almost all fields of biology from molecular genetics to mathematical ecology are potential contributors to medicine, agriculture, food processing and environmental management. Science is now so pervasive and the applications of science so widespread that most basic science is relevant to the practical needs of society."

2.11 However true that may be, the statement suggests that much of the strategic research undertaken by universities and research council institutes lies towards the basic end of the research spectrum. Such work is likely to be of a kind where the benefits from eventual application are uncertain, and probably long-term, and which will not therefore attract substantial funding from industry. The arguments for support from public funds will be essentially those that apply for basic research. The same arguments will apply to strategic research commissioned by departments which is undertaken to meet policy needs without reference to any potential for commercial exploitation. A good example is research sponsored by the Department of the Environment (DoE) to support the development of environmental policies.

2.12 Other strategic research is directed specifically to foreseen future needs of industry: the emphasis is on the investigation of possibilities for eventual application and exploitation rather than the acquisition of knowledge. The need for this research is obvious; less obvious is the case for providing support from public funds. Evidence received by the Committee recognised the necessity in present circumstances of such support. For example, Professor Ashworth commented (Q 1158): "it is inevitable that Government must support this kind of research if only because industry will not . . ." The considerations that arise are similar to those for applied research and are discussed further in the following paragraphs.

Applied Research and Development

2.13 In 1985/86 nearly 40 per cent of government funded civil R & D was in the applied research and development categories. About one third of these funds was dispensed by the Department of Trade and Industry (DTI), mainly to encourage and support R & D within industry. At the start of the enquiry the former Chief Scientific Adviser, Sir Robin Nicholson, expressed the hope that the Committee "would look at the interface between the public support and the private support of R & D because much of the public support is geared very much to what is happening in the private sector" (Q 1).

2.14 It is generally accepted that most R & D to promote industrial innovation should be funded by industry; the expenditure should reflect commercial judgements on market possibilities and other factors that only industry is in a position to make. However, as stated by DTI (p 56), there are circumstances "where defects in the market mechanism may mean that DTI support for industrial technology can secure net economic benefit to the nation." A similar position was taken by the Confederation of British Industry (CBI) (p 203) and other witnesses.[2] Another reason for using public funds to support R & D in private manufacturing industry is that this is done in main competitor countries, reflecting the importance of industrial performance to economic growth and national prosperity. The support given in the United Kingdom in this field is not high compared

[1] Science and Public Expenditure 1985: a report to the Secretary of State for Education and Science from the Advisory Board for the Research Councils

[2] See for example pp 120, 219, 284, P144

with that in other countries (p187). Indeed, GEC stated that "United Kingdom industry must compete with firms world-wide which receive more favourable financial support from their governments" (p282).

2.15 British industry stands as much in need of support as industry in competitor countries. Concern about lack of R & D by British industry was strongly expressed in the evidence.[1] The Chancellor of the Exchequer stated in September 1986[2] that British industry was still taking too short-term a view over investment, research, training and pay, that non-government civil R & D spending as a share of GDP was running about 50 per cent higher in the USA, West Germany and Japan than in Britain, that in this country industry had traditionally looked to the Government to carry out a large R & D programme, and that this had inevitably produced research that was less relevant to industry's competitive needs. Changes in the financial world, including the trend to institutional ownership of British industry, have contributed to short-term thinking.[3] The need to promote and support industrial R & D must clearly be seen as an important element of the case for public funding of civil R & D.

[1] See for example QQ 39, 220, 221, 1007
[2] Chancellor's speech to the Scottish CBI on 4 September, 1986
[3] Speech by D A Walker, Executive Director, Bank of England to the Glasgow Finance and Investment Seminar, 24 October 1985

CHAPTER 3 PRESENT POLICY AND PRACTICE

3.1 This chapter briefly describes the present arrangements relating to Government support for R & D but it is useful first to draw attention to various developments that have occurred during the Committee's enquiry.

3.2 The Committee began their enquiry in January 1986. Since then some action has been taken by the Government and a number of influential and highly relevant reports and articles have been published. Indeed, the Committee have sometimes felt that they have been operating on a moving staircase. The Committee have taken account of these developments, and references to them will be found throughout the report. They are listed in the following paragraphs.

Action by the Government

3.3 Action taken by the Government included:

a) The establishment of an Office of Science and Technology Assessment in the Cabinet Office (July 1986).

b) The Government Response to the House of Commons Education, Science and Arts Committee Report on "The Future of the Science Budget" (Cmnd 9849, July 1986).

c) Autumn Statement: new money for science and the universities

Reports by Official Bodies

3.4 Reports published by official bodies included:

a) Report of the Working Party on the private sector funding of Scientific Research ("Mathias Report"—ABRC May 1986).

b) The report of the Advisory Council for Applied Research and Development (ACARD) on Exploitable Areas of Science (including a prefatory letter from the Prime Minister) (May 1986).

c) The ACARD report "Software: A vital key to UK competitiveness" (June 1986).

d) Science and Public Expenditure 1986: a report to the Secretary of State for Education and Science from the ABRC (July 1986).

e) "An International Comparison of Government Funding of Academic and Academically Related Research", commissioned by the ABRC. (October 1986).

f) "The Evaluation of National Performance in Basic Research" A study by the Royal Society Policy Studies Unit on behalf of the ABRC and the Economic and Social Research Council (ESRC). (ABRC Policy Studies No 1, October 1986).

g) Publication of Corporate Plans by SERC, NERC, MRC, AFRC and ESRC (1986).

Action/Reports by Other Bodies

3.5 Action and reports by other bodies included:

a) Save British Science Campaign (Manifesto in January 1986).

b) "Crisis in Research" by the Office of Health Economics April 1986.

c) Report of the Council for Science and Society on "UK Military R & D" (July 1986).

d) Paper by Kaldor, Sharp and Walker on "Industrial competitiveness and Britain's Defence", published in Lloyds Bank Review, October 1986.

e) Proceedings of the British Association for the Advancement of Science, 1986.

f) Report of the IT86 committee chaired by Sir Austin Bide on "Information Technology: A plan for concerted action".

The arrangements for Government funded R & D

3.6 Government financed R & D falls into two distinct categories:

(a) research undertaken to advance knowledge, to maintain a fundamental capacity for research and to support higher education, which is the responsibility of the scientific community. The Secretary of State for Education and Science makes resources for this research available directly to the universities, research councils and other bodies;

(b) other R & D supported by Government Departments, each in its own area, in accordance with the customer/contractor principle, on the scale and pattern which it judges to be most appropriate to the formulation and pursuit of its policies, whether relating, for example, to defence, industry, agriculture or environment, and the solution of specific needs and objectives, short or long-term.

It should be noted that while the two categories are distinct in terms of motivation and funding, there may well be substantial overlap in terms of scientific content.

Research Supported by the Department of Education and Science (DES)

The Science Budget

3.7 The Secretary of State for Education and Science is responsible for about one-half of the Government's annual expenditure on civil R & D (p 80). One of the two main components of this DES expenditure is the Science Budget which is disbursed almost entirely as grants-in-aid to the five Research Councils. Small grants are paid to the British Museum (Natural History), the Royal Society and the Fellowship of Engineering (p 85). The Research Councils collectively receive over 80 per cent of their income from the Science Budget, the remainder coming from various sources, in particular from Government Departments for commissioned research. Research Council income arising from sources other than the Science Budget is substantial only for the Agricultural and Food Research Council (AFRC) and NERC.[1]

3.8 The fundamental responsibilities of the Councils (p 81) are the advancement of knowledge, the maintenance of the national research capability, postgraduate training and the achievement of practical benefits. The funds received through the Science Budget are used to support research in the institutes and laboratories that are within, or funded by, the Councils and to support research and teaching in the universities through research grants and postgraduate awards. In 1985-86 about 26 per cent of the Science Budget was used for research grants, 13 per cent for postgraduate awards and 34 per cent for the support of institutes and research units[2] (p 86).

3.9 The emphasis on the advancement of knowledge as the essential purpose of research funded through the Science Budget—which is closely linked with research funded by universities in the dual support system (see paragraph 3.12)—has fostered the view that such research is entirely basic in character and generally remote from practical applications and benefit. Certainly support of the science base is seen by the Research Councils as a prime responsibility. However, that the Councils recognise wider responsibilities is clear from a statement made by the ABRC:[3]

"It is the responsibility of the Research Councils

(i) to undertake and support research of high quality in the areas for which they have responsibility;

(ii) to decide at any time the balance between fundamental research which extends the frontiers of knowledge and research for which an application is already seen;

(iii) to preserve the capability to respond to new creative ideas, particularly those leading to new technologies and to new lines of research; and to arrange priorities accordingly."

In fact, according to the Annual Review of Government Funded R & D 1986,[4] over 35 per cent of the Science Budget in 1985-86 was allocated to strategic research and nearly 12 per cent to applied research.

The Advisory Board for the Research Councils

3.10 The ABRC was set up in 1972, replacing the Council for Scientific Policy following the recommendations of the Dainton Committee.[5] Its membership includes eminent academic scientists and senior representation from industry and government. The Board's main function is to advise the Secretary of State for Education and Science on the resources needed for science and on

[1] pp 86,87
[2] The balance of about 26% covered international subscriptions (12%), capital (8%) and administration (6%)
[3] The Science Budget: a forward look 1982. A report to the Secretary of State for Education and Science from the Advisory Board for the Research Councils
[4] Table A.23
[5] The Future of the Research Councils System. A report of a CSP Working Group. Cmnd 4814

the division between the Councils of the monies made available. On the latter aspect at least it appears that that advice is invariably accepted. The ABRC also acts for the Councils collectively in presenting the case to Government for the support of science. Thus, although the Board is by name an advisory body, it stands to some extent in a line relationship with the Councils and appears to exercise quasi-executive powers.

3.11 This function is consistent with the thinking of the Dainton Committee which recommended that "the activities of the Research Councils should be co-ordinated and administered by a Board"[1] and that the Board "would determine broad problems of science policy ... and any readjustment of the internal boundaries between Research Councils, and would allocate resources to the individual Research Councils. It would also be able to add to and subtract from the number of Research Councils, in response, for example, to the growth of new disciplines ...".[2]

3.12 In fact it appears that the precise powers and standing of the ABRC in relation to the Councils (which are Chartered bodies) are not clearly defined. When the resources made available for science were perceived to be adequate the system appeared to work harmoniously. However, during a time of increasing financial constraint, when harsh decisions on priorities have had to be taken, strains in the system have become apparent.

UGC funding: the dual support system

3.13 Research in universities is financed partly by Research Council grants and funds from other external sources, including charitable trusts and foundations, but the main support comes from general university funds, these deriving from University Grants Committee (UGC) block grants and tuition fees. The support from general funds and that from the Research Councils together constitute the dual support system. The essence of that system is that (p 80) "the input from general funds should provide the basic 'floor' of research capability in university departments, enabling speculative ideas to be generated and developed to the stage at which specific funding can be sought." That capability includes the provision of "well-found" laboratories in departments, suitably equipped for the research. Because of financial pressures over recent years, the dual support system has been under increasing strain.

3.14 These financial pressures led in 1985/86 to the UGC's selectivity exercise. Selectivity in the allocation of funds to universities was made necessary by the fact that there is "no longer ... enough money to produce 'well-found' laboratories everywhere" or "to produce the research floor in every department of every university"(Q1366). The Green Paper on Higher Education[3] too noted that "Greater concentration and selectivity may mean that some departments or even whole universities will lose research funding from the UGC". Selectivity constitutes a radical change in the approach to university financing. It depends on difficult judgements on the relative merits of departments in different universities in terms of the quality of their research. Inevitably the introduction of the system has caused some dissatisfaction and complaint[4].

3.15 The UGC block grant is applied to both teaching and research needs and it is for each university to allocate the funds it receives according to its own priorities, but the UGC is also now interesting itself in this allocation. Any assessment of expenditure on research from university general funds can only be approximate since it must depend, among other things, on apportionment of the time of academics between research and teaching. At present the assessment is based on a formula derived in part from a survey of the use of academic staff time conducted in 1969-70 (p 81). The validity of the formula is doubtful (Q 730) and the DES has commissioned a study to provide a more reliable picture (Q 266).

Report to the House of Commons on the Science Budget

3.16 The report of the House of Commons Education, Science and Arts Committee on "The Future of the Science Budget" was published in July 1985.[5] The Commons Committee found that while it remained Government policy to maintain the level of the science vote in real terms in order to protect basic science—"level funding"—that objective was not in practice being achieved. In the first place, maintaining the science vote dealt only with part of the system for supporting basic

[1] Cmnd 4814, paragraph 47
[2] Cmnd 4814, paragraph 49
[3] The Development of Higher Education into the 1990s, Cmnd 9524, paragraph 5.7. HMSO
[4] See paragraphs 6.98, 6.99
[5] First Report from the House of Commons Education, Science and Arts Committee Session 1984-85

research; it took no account of the vital role of UGC funds in providing the research floor in universities to sustain the superstructure financed by the research councils. It was "extremely difficult to protect the research base in universities when the UGC grant funding is cut".[1] Evidence to the Commons Committee from Sir David Phillips, Chairman of the ABRC, referred to estimates by the Board that the cuts in university funding had resulted in a decrease of at least 11% in university support of science since 1981.[2] In the second place, as other evidence to that Committee made clear, maintaining the science vote did not maintain the level of funds that could be devoted by the research councils to the support of science; in those terms level funding amounted to (downward) "sloping funding".[3]

3.17 In inviting evidence the present Committee drew attention to the fact that the Commons enquiry had recently considered the Science Budget and that they therefore proposed to focus on strategic and applied research. The Committee recognised however that they would be bound to go over some of the same ground.

R & D Supported by Other Departments

3.18 Many Departments and government agencies have significant R & D programmes in support of their policies and responsibilities. Together these programmes (excluding that of MoD) accounted, in 1985-86, for about 45 per cent of the total Government spend on civil R & D. Nearly three quarters of this work was in the applied R & D category; over 20 per cent was strategic and less than 5 per cent basic research.[4]

3.19 Those Departments that have a significant interest in R & D have Chief Scientists with supporting staffs who are responsible for advising their Ministers on the research needed for policy purposes.[5] They are also generally responsible for the formulation of research proposals and the negotiation and control of research contracts on behalf of customer divisions within the Departments, or of external bodies for which the Departments act as proxies.

Department of Trade and Industry

3.20 About 15 per cent of civil R & D expenditure is the responsibility of the Secretary of State for Trade and Industry (p 56). It provides partial support for innovation in industry. The support is provided in the form of grants and contracts to assist specific activities or to spread awareness of new technology.

3.21 Following a policy review in 1985, support for individual project activities was reduced. Increased funds were allocated to the spreading of awareness through collaborative longer term, applied research, advisory services and schemes for improving best practice and key skills. Over the period 1984-1989, single company project support is set to fall by 50 per cent while support for collaborative projects and for non-project activities is planned to double (pp 57, 77).

3.22 In 1972 Research Requirements Boards were set up to operate in accordance with the Rothschild principle and act as proxy customers for the applied research of the Department. The Boards approved projects and provided funds for "contractors" from industry, research councils and research associations, as well as the Department's own R & D establishments. In 1985 a new structure was introduced by which a single, high level, Technology Requirements Board supported by 16 advisory committees provides advice to Ministers and the Departments' sponsoring divisions on all aspects of science and technology policy including advice on priorities between sectors and technologies (pp 74, 77, 79).

Ministry of Defence

3.23 The overriding aim of the Procurement Executive (PE) of the Ministry of Defence is "the procurement of equipment of the right performance and quality to meet the needs of the Armed Forces at the best possible price."[6] Over 80 per cent of the £8.25 billion equipment budget is spent

[1] First Report from the House of Commons Education, Science and Arts Committee, Session 1984–85, para 40
[2] ibid, Q 23
[3] ibid, para 42
[4] Annual Review 1986, Table A.23
[5] 9 Government Departments have Chief Scientists or equivalent - the titles used vary. These are the Ministry of Agriculture, Fisheries and Food, the Ministry of Defence, the Departments of Energy, the Environment, Health and Social Security, Trade and Industry, and Transport, the Scottish Home and Health Department and the Northern Ireland Office
[6] Statement on the Defence Estimates 1986, Vol 1, page 46

with British suppliers in companies ranging from large national organisations to very small firms employing only a handful of people. Some 225,000 people are employed directly, 170,000 indirectly, and a further 120,000 if exports of defence equipment are included.[1] MoD is British industry's largest single customer.

3.24 The work falls under three main headings: the development and production of equipment, wherever possible through competitive processes; research activities in both the public and private sectors; and the promotion of exports of British defence equipment. There is an underlying commitment to international collaboration.

3.25 The defence R & D programme, about £1.9 billion on development and about £400m on research (QQ 1315-6), amounts to over 50 per cent of the Government spend on R & D in 1985/86. This absorbs a higher proportion of GDP than in any other commercial competitor country except the USA.[2] It has been estimated that over 25 per cent of the skilled scientific and technical effort of the United Kingdom is associated with the procurement of military equipment.[3]

3.26 As a secondary policy objective, MoD has been pressed to increase the contribution made to the economy more generally by the heavy investment in defence and two new initiatives were taken late in 1985. The first was the launch of the joint MoD/Research Council grant scheme aimed at increasing MoD spend in the universities from £10 million to £20 million per annum. In partnership with the Research Councils MoD identifies proposals from universities with a defence interest and contributes to the funding. The second was the formation, by a group of financial institutions supported by industrial subscriptions, of Defence Technology Enterprises. DTE has privileged access to MoD scientists for the specific purpose of identifying and exploiting spin-off opportunities in the defence research establishments. DTE has a "ferret" in each of the main establishments with access to both classified and unclassified work to spot potential civil applications (Q 1339). In the first twelve months 450 items have been identified for circulation to its 150 associate members, many of them small companies. When an item is selected by a company DTE is prepared to assist, if necessary, with the raising of finance for exploitation.

Other Departments

3.27 The remaining Departments and government agencies have smaller R & D programmes in support of their policies and responsibilities. Together these programmes accounted, in 1985-86, for almost 30 per cent of the total Government spend on civil R & D, the largest being the Department of Energy with 8 per cent and the Ministry of Agriculture, Fisheries and Food (MAFF) with 6 per cent.[4] About 45 per cent of the work is aimed at the improvement of technology.[5]

The Central Structure for R & D

3.28 As indicated in paragraph 3.6, responsibility for R & D is shared between many Departments. No Minister has responsibility for science and technology issues across the board. The Committee understand that there is a Cabinet Committee on science and technology and it is presumably largely within this forum that the increased Ministerial consideration of these issues to which Sir Robin Nicholson referred (Q 9) is taking place. The Annual Review of Government Funded R & D provides a focus for this consideration. At official level there are the Committee of Chief Scientists, chaired by the Chief Scientific Adviser in the Cabinet Office, and the Committee of Chief Scientists and Permanent Secretaries under the chairmanship of the Secretary of the Cabinet, although it appears that the latter committee has met only very infrequently (QQ 925-930).

The Advisory Council for Applied Research and Development (ACARD)

3.29 ACARD advises the Government on applied research, design and development and the application of research and technology, together with the co-ordination of these activities with basic research. The members of ACARD are mainly senior industrialists and academics; the Chairman of ABRC and the Chief Scientific Adviser are also members. The Chairman of the Council is a

[1] Statement on the Defence Estimates 1986, Vol I, p46
[2] Annual Review of Government Funded R & D 1986, Table F1a
[3] Kaldor, Sharp and Walker, Industrial Competitiveness and Britain's Defence, Lloyds Bank Review, Oct 1986
[4] Annual Review of Government Funded R & D 1986, Table A.3
[5] ibid, Table A.11

leading industrialist. Its secretariat is provided by the Cabinet Office. The Council reports to the Prime Minister.

3.30 ACARD is expected to collaborate with the ABRC. One aspect of the collaboration is the preparation jointly by the two Chairmen of "state of the nation" reports on science and technology to the Government. One such report has so far been issued, in 1983 (Q 1180).[1]

THE CUSTOMER/CONTRACTOR PRINCIPLE

3.31 Under the customer/contractor principle, as set out in the Rothschild report[2] and subsequently implemented by the then Government in 1972,[3] Departments are placed in the position of customers for the research they need: "the customer says what he wants; the contractor does it (if he can); and the customer pays." Substantial proportions of the funds previously received by the AFRC (then the Agricultural Research Council—ARC), MRC and NERC from the Science Budget were allocated instead to the Departments concerned with research undertaken by the Councils. (For the MRC these arrangements were subsequently reversed; see p 361, QQ 893-4).

3.32 The customer/contractor principle was to apply only to applied R & D; it was recognised that "basic research .... has no analogous customer/contractor basis." No provision was made for strategic research. However, the Rothschild report recognised that applied R & D laboratories generally needed to engage in some research not directly concerned with commissioned programmes. The report recommended an average surcharge of 10 per cent on R & D contracts to meet the need for "general research" which Lord Rothschild defined as being done

> "(a) to engage in basic research in a field relevant to the applied tasks of the laboratory, but which is not being done elsewhere, for example, at a university;
>
> (b) to test out new, way out and unprogrammed ideas of the scientists, engineers and mathematicians themselves;
>
> (c) to maintain expertise, for example, to recruit and keep a spectroscopist who will not join the laboratory unless he can spend part of his time on his own research;
>
> (d) to facilitate the transition from academic life to that in an applied R & D organisation."[4]

3.33 The report distinguished between the role of the Chief Scientist, who would be part of the customer organisation and would advise the customer on research needs, and the Controller R & D who would be "the chief executive of the research function." As the customer/contractor principle has been implemented, it appears that in all Departments except MoD (see Q 1334) both functions are carried out by the Chief Scientist.

3.34 On the question of the transferred funds, the 1972 White Paper stated that "No conditions will be placed on the use of the money transferred to customer Departments, but the expectation is that it will be spent to commission applied research work from the Research Councils." Evidence from one witness suggested that continuation of funding at the same level was regarded by some of those affected as a commitment rather than an expectation (Q 559). In fact the reductions in the funding of commissioned research brought about by the financial constraints on Departments have created serious problems for the Research Councils concerned (see for example QQ 348, 628; pp 138, 250). The 1972 White Paper accepted that Departments would need to appoint Chief Scientists and central scientific staffs. On the 10 per cent surcharge the White Paper stated: "The Government accepts the proposal in principle, but the degree to which this provision is needed will vary .... Departments will make appropriate arrangements in agreement with the Treasury." However, it appears that this qualified undertaking has seldom been implemented (see for example QQ 87, 88, 624; p 248).

3.35 The Government reviewed the changes that flowed from the Rothschild report in 1979.[5] It concluded that while it was too early to make a firm judgement, these changes appeared to have

[1] The second report was published on 12 December 1986
[2] Cmnd 4814
[3] Cmnd 5046,
[4] A Framework for Government R & D, Cmnd 4814, 1971, para 15
[5] Cmnd 7499.

strengthened the Government's R & D machinery. It was noted that if too high a proportion of the income of a Research Council were to come from commissioned research, the viability of the Council as an independent research organisation would begin to be called in question. On the general research surcharge the review commented that "experience has borne out the view taken in Cmnd 5046 (the 1972 White Paper) that contractors would vary in the degree to which they found such a surcharge useful in maintaining a general research capability for meeting future needs .... Thus the Research Assocations routinely add to their contracts with the Department of Industry a surcharge (which is subject to technical approval and a limit of 10 per cent) whereas NERC—another contractor used by the Department of Industry—has not been able to negotiate a surcharge." It was accepted in the review that the new system of commissioning had led to additional administrative costs but it was stated that it was not possible to determine the level of these costs.

3.36 A less encouraging view of the operation of the new system was given in a later (1983) report, resulting from a study undertaken by Sir Ronald Mason for the ABRC.[1] The report concluded that the new commissioning arrangements had not provided "the dynamic for change" that had been intended; there was no evidence that they had affected significantly the appreciation by the Councils of Departmental requirements. The report was critical of the strength of the scientific advice within customer Departments, which, it argued, needed to be increased if the customer/contractor principle was to operate as the Rothschild report had intended. The report was also critical of the bureaucracy of the new arrangements, which often involved ultimate customers, government departments or proxy customers, Research Council headquarters and research institutes or units. Finally, the report concluded that the customer/contractor principle, together with the effects of cash limits on departmental budgets, had led to undue emphasis on short-term, applied objectives, so that strategic research, "which should be integral to commissions"[2] was not adequately covered. Taken with the failure to implement the general research surcharge, the review considered that this had led to strategic research "being increasingly supported from the science vote, with a consequent reduction in funds available for basic studies."

3.37 The subject of strategic research and the Rothschild system has been considered by the Committee in previous enquiries. In particular, in their Report on Marine Science and Technology.[3] The Committee reached a conclusion similar to that of the Mason report, that the level of departmental funding of strategic research in marine science and technology was inadequate. The Committee recommended that pending a review of the Rothschild principle a sum equivalent to the 10 per cent surcharge on contracts for marine research should be returned from departmental funds to the science vote. This sum would be at the disposal of the Research Councils (through the proposed Marine Board) but would be regarded as earmarked against departmental R & D requirements. The Government[4] has deferred a response to these recommendations pending the publication of the present report.

[1] A Study of Commissioned Research, Advisory Board for the Research Councils, November 1983
[2] ibid, para 23
[3] 2nd Report, House of Lords Select Committee on Science and Technology, Session 1985-86
[4] Cmnd 9861, para 5.2

CHAPTER 4 INTERNATIONAL COMPARISONS

4.1 Many witnesses who contributed to the enquiry expressed concern about the level of public funding of R & D in the United Kingdom compared with that in competitor countries. This chapter briefly presents some comparative data on R & D funding in different countries.

4.2 Information on R & D funding in the United Kingdom compared with that of other countries is given in the Annual Review of Government Funded R & D 1986, first on a European Community (EC) basis and then on the wider basis of the Organisation for Economic Co-operation and Development (OECD). Salient points are presented below.

4.3 Expressed as a proportion of total government R & D funding by EC countries in 1984 (that is, including defence R & D), the Federal Republic of Germany (FRG) and France spent nearly 30 per cent, the United Kingdom nearly 25 per cent and Italy about 11 per cent. There are considerable difficulties in assessing the extent to which expenditure on defence R & D contributes to civil R & D objectives. However, for the reasons discussed in Chapter 6 the Committee consider that that contribution may be relatively small. If defence expenditure is excluded these proportions become FRG 34 per cent, France 26 per cent, United Kingdom 16 per cent and Italy 13 per cent. That is, United Kingdom government spend on civil R & D was comparable to that of Italy, less than half that of the FRG and about 60 per cent that of France. The figures illustrate the effect on such comparisons of the relatively high ratio of defence to civil government R & D expenditure in the United Kingdom.

4.4 Expressed as a percentage of GDP, total government R & D expenditure in the United Kingdom in 1984 was second only to that of France. If defence R & D is excluded, however, the figures for the FRG, France and the Netherlands (all about 1 per cent) were substantially greater than those of the United Kingdom and Italy (about 0.7 per cent) and Belgium (about 0.6 per cent). Another basis for comparison is to express government R & D expenditures in *per capita* terms. In those terms, again for 1984 and excluding defence R & D, the United Kingdom spend was about half that of the FRG, about 60 per cent that of France and the Netherlands and a little above that of Italy and Belgium.

4.5 The Annual Review provides a breakdown of government R & D expenditure by EC countries into different areas of research.[1] As the Review indicates, there are inherent difficulties of classification in such a breakdown and the figures must be treated with caution. Under the category "Industrial production and technology" the United Kingdom spend in 1984 was about half that of the FRG and France and less than that of Italy. Under the category "Research financed from general university funds", expenditures by the United Kingdom and France were virtually the same in 1984, the FRG spend being over 2½ times greater. Another category is "Non-oriented research", this being principally research in the fields of mathematics and the natural sciences. These two categories together would appear to give some measure of the resources devoted to basic research. On that basis the spends of the FRG and France in this area in 1984 were, respectively, nearly 2½ times and 1½ times that of the United Kingdom.

4.6 Somewhat different figures for basic research are suggested by a recent study commissioned by the ABRC and undertaken by the Science Policy Research Unit.[2] The study examined government support for basic research in six countries, including the United Kingdom. The report of the study states "it is difficult to avoid the conclusion that the United Kingdom spends less on academic and academically related research than its two closest European competitors, France and Germany". The data presented (for 1982) show related expenditure in the FRG and France as being, respectively, 1.7 and 1.3 times that of the United Kingdom. The differences between these figures and those given above presumably reflect, at least in part, differences in classification.

4.7 The OECD data given in the Annual Review[3] cover the USA and Japan as well as the major European States and also take account of R & D expenditure by private industry. The data (for 1983) indicate that in terms of total civil R & D expenditure (public and private) as a percentage of GDP the United Kingdom (1.6) was below France (1.7), the FRG (2.5), Japan (2.5) and the USA (1.9). As was noted by the DTI in their Science and Technology Report for 1984-85, "Of the five

[1] Table E1
[2] B R Martin, J Irvine, "An international comparison of government funding of academic and academically related research", Science Policy Research Unit, University of Sussex
[3] Table F3

leading industrial nations, the United Kingdom now devotes the smallest share of its gross domestic product to civil R & D. This disadvantage in quantity is not offset by any generally greater effectiveness of R & D in Britain." In absolute terms, because the United Kingdom GDP is lower than those of these other countries, the relative position of the United Kingdom is significantly worse than the above figures suggest.

CHAPTER 5 REVIEW OF THE EVIDENCE

5.1 This chapter reviews the evidence submitted to the Committee. The volume of that evidence in itself testifies to widespread concern about the state of science and technology in Britain.

5.2 The first question posed by the Committee in inviting evidence was: how far ought public support for science and technology to be an objective of national policy? Most witnesses who responded to this question took it as asking simply whether science and technology should be supported from public funds. There was virtually unanimous agreement that such support was vital and several witnesses saw the need as self-evident. For example, the Institution of Production Engineers felt "most strongly that public support for science and technology must be a major objective of our national policy" (P172). Other witnesses stated: "Civil R & D should be a *top* public priority, unless one envisages the future of the United Kingdom as an agricultural and tourist island" (P121); "Science and Technology policy is crucial to the future survival of the country as a competitive and culturally vital nation" (P206); and ".... public support for civil science and technology should receive as high priority in relation to national policy as defence research and development" (P240). These witnesses were from the academic world but similar views were expressed by witnesses from industry. For example: "The effective use of technology is critical to the creation of wealth in the United Kingdom.... United Kingdom R & D must be on a comparable footing to that of its competitors... all of which benefit from public support...." (P144); "Support for science and technology is vital to industrial, and hence to national, prosperity" (P49); and "It is surely self-evident that all science depends to a large degree on public support and that, for science to flourish, such support must be an objective of national policy" (P140).

The Organisation of Civil Research and Development

Central Structure

5.3 If the support of science and technology is regarded, in itself, as an objective of national policy, then it could be argued that there should be a clearer focus than exists at present within government for its responsibilities in this field. This organisational aspect of the question was scarcely touched upon in written evidence but was explored by the Committee with many of the witnesses who gave oral evidence.

5.4 The Secretary of State for Education and Science commented that the question of a Minister for Science had come up "again and again and again" (Q 1630) He argued against this: a separate Minister for Science, "if one of those Ministers without portfolio,... would have little impact in the Whitehall machine... If he were given control of the various science budgets in the various departments... it would not in my judgement constitute a very powerful voice round the Cabinet table... When there are major scientific matters coming forward, they come through me; if they bear in a significant way upon the industrial side of our country, they might come through the Secretary of State for Trade and Industry, but between us we would do it... I do not think that diversity weakens the thrust at the centre" (Q1631). Mr Baker also pointed to the Prime Minister's responsibility in the field of science and to her "great interest in the overall role of science in society" (Q 1633).

5.5 Sir Robin Nicholson referred to the pervasiveness of science in arguing that "it is hard to make the support of science and technology an objective... It is not in my view the end product. The end product is an effective industry, good education or good communications" (Q 2). He accepted that responsibilities for R & D were fragmented and that overview and co-ordination were needed but he believed that this was happening: "collective discussion among Ministers concerning R & D and science and technology... has increased markedly during the period I have been in Cabinet Office and is still increasing" (Q 9). In Sir Robin's view the problem would not be solved by changing the organisation; the solution was to use "the existing organisation and the existing mechanisms much more effectively than is done now" (Q 11). Similar views were expressed by the Chairmen of the ABRC, ACARD and the UGC in their evidence (QQ 54, 1183, 1414). Sir Peter Swinnerton-Dyer commented: "I can think of no organisational changes which I would regard as crucial. To set up a Ministry of Science would not be advantageous if the Minister of Science was at the bottom of the pecking order, and for a long time the Department of Education and Science has been pretty close to the bottom of the pecking order".

5.6 A contrary view was taken by other witnesses. In his evidence Sir John Kingman expounded his previously stated view that Britain urgently needed a Ministry of Science and Technology to

achieve a coherent policy for the public support of science, and that this could not be realised simply through better communications within the existing system: "the issue is not communication but power".[1] Sir John argued that the Ministry should be "fairly small" and "professional"; it would have responsibilities for "policy making over a broad field of both pure and applied science" and would be "able to advise the Government as a whole about the balance, the nature of their R & D programmes" (QQ 103, 104). The Ministry would exercise "the present function of the research councils collectively; that is to say, supporting research in research establishments, and in universities, and thereby being responsible for the science base, and interacting with those departments which were running their own applied research programme" (Q 122). Sir John attached much importance both to there being "at least one minister who raises scientific issues at Cabinet level when necessary" and to "the effective presence of science at the top layer of officials in Whitehall" (Q 106).

5.7 Other witnesses agreed on the need for a Minister, if not a Ministry, for Science. Sir Douglas Hague commented: "... there is a lot to be said for a Minister for Science, but he should not have a large, or even a significant, bureaucracy to run. He should have some clout, he should have money, but he should be backed up by very good analytical thinking" (Q 470). Professor Ashworth wished to see a Minister for Science, or perhaps a central committee chaired by the Prime Minister on the Japanese model (QQ 1123, 1124). The Royal Society was at first reluctant to express an opinion on the shape of the required central structure (Q 534) but later proposed, in supplementary evidence, that a National Science Advisory Council should be formed. The Society considered that the Council "would need to be chaired by a senior non-departmental Minister, preferably the Prime Minister" (P221). The Chairman of the SERC said: "I do not think there is anywhere in Government where a view is taken across the whole field" (Q 292). He expressed "sympathy with the view that some Minister, perhaps a Minister for Science, should look at the whole programme across the board". This view was shared by Dr Roberts of GEC (Q 723). Dr Rudge of the Association of Independent Research and Technology Organisations (AIRTO) said "I think you need a complete national system; the top has to be as high as you can go. A committee with the Prime Minister chairing it would give it real emphasis" (Q 1033). The committee "would have to set up a structure which would carry out policy objectives" (Q 1034). Sir James Gowans, Secretary of the MRC, accepted the need for "some mechanism through which decisions on national priorities for science" could be reached but felt unable to express a view on the form that that mechanism should take (Q 885). He considered, however, that the ABRC should be in a position to advise Government as a whole, rather than DES only (Q 881).

5.8 A comprehensive plan for changes in the overall management of Government funded research was put forward by Mr Fish, Chairman of the NERC (p245), who considered that "There are grounds for basic reorganisation of the system" (Q 635). Under the "Fish" plan, the ABRC would become the National Science Council (NSC) which would advise a Minister of Science (a designated DES Minister) on policy, manage the research councils (see paragraph 5.13) and co-ordinate publicly funded basic research. ACARD would be replaced by a National Committee for Research and Development (NCRD) under the Chief Scientific Adviser in the Cabinet Office. The NCRD would review national needs for R & D and provide advice to government on the level and balance of public expenditure on R & D (p247, Q 641).

5.9 The Secretary of State for Trade and Industry said that he and his colleagues were more actively involved than in the past in the co-ordination of government funded R & D (Q 1568). On the role of ACARD he stated: "... I think it is right that there should be one body that looks at the Government's priorities across the whole field, and that I think probably should report to the Prime Minister, as it does at present" (Q 1586). Other witnesses commented on the roles of ABRC and ACARD in providing the advice required by government in the formulation of science and technology policies. The Royal Society, in presenting its case for a National Science Advisory Council, argued that the policy needs within government called for "an altogether broader concept than ACARD and ABRC together embrace" (P221). The Committee of Vice-Chancellors and Principals described the distinction between the roles of ABRC and ACARD as "artificial" and urged that the Select Committee's earlier proposals for the creation of a Council on Science and Technology[2] should be re-examined (P81).

[1] Science and the Public Purse: 1985 *Government and Opposition* Leonard Schapiro public lecture, given by Sir John Kingman at the London School of Economics, 7 November 1985. (See Q 105)

[2] 1st Report, Session 1981-82, HL 20, paragraph IV.15

5.10 An important aspect of ACARD's work is that it comments on the annual review of Government funded R & D (Q 1167). As the present Chief Scientific Adviser stated: "The Annual Review is becoming a very significant part of the process of managing science and technology" (Q 1237). ACARD's advice is not published and Sir Francis Tombs argued that this was "a source of considerable strength"; he attributed the "considerable effect" of ACARD's advice on government thinking partly to the fact that it was confidential (Q 1169). Sir Francis said that, in contrast to ABRC, "ACARD is not a departmental organisation; it is not part of a spending department and therefore it can take a much more detached view" (Q 1181). Several witnesses expressed doubts about ACARD's effectiveness (QQ 146, 147, 872, 1373). One witness commented: "I have a feeling that ACARD is too much seen as a subsidiary of the Cabinet Office. It is a little too close to Government and I do not think it has the required independence" (Q 702). In responding to this criticism, Sir Francis pointed out that some ACARD reports were "quite critical of Government as well as of industry" (Q 1172).

ABRC and the Research Councils

5.11 There was criticism of the ABRC in evidence to the Committee. Sir John Kingman stated bluntly: "I think ABRC is a profoundly unsatisfactory body" (Q 131). "It is a body of very distinguished people who get together regularly. They have implicitly on the agenda the whole health of science and technology in the United Kingdom, but in practice their discussions are about whether a few million should be taken off one research council and given to another" (Q 136) Sir John noted: "There is a tendency for the ABRC to try and become a single research council, to try and manage the research programmes. This has to be resisted....." (Q 139).

5.12 This tendency is clearly of concern to some heads of research councils. Professor Mitchell said: "We are worried by the way it (the ABRC) is operating... it is doing jobs which we should be doing" (Q 282); and, "when our grant is announced it is our job statutorily to manage it..." (Q 289). Professor Jinks commented: "We have tended to become supplicants who make our case to the ABRC..." (Q 376). Sir James Gowans referred to the ABRC tendency "to intrude sometimes into the management of the research councils" (Q 881). Sir Douglas Hague saw a need for the ABRC to "clarify its own objectives and strategy" (p191) and to adopt a different role in its relations with the councils (Q 468). He and other witnesses were critical of the size of the ABRC (QQ 452, 378, 442). However, the Royal Society offered a defence of the ABRC: "The research councils want the ABRC as a buffer between them and government... but... they want steel on one side, relative to government, and jelly on the other side relative to research councils" (Q 521).

5.13 Other witnesses regarded the increasing management role of the ABRC as desirable, indeed inevitable. The Secretary of State for Education and Science said: "I wholeheartedly support the more active role that the ABRC has adopted in recent years" (Q 1648). Mr Fish saw the issue in terms of a need to secure proper management discipline and accountability in the operation of the research councils: "without such a co-ordinating force it is inevitable that the optimum results of collaboration, avoidance of boundary problems and of flexibility in the realignment of resources to needs and available funds, will not be achieved". He considered that "the ABRC should be drawn into the effective management structure by turning it into an executive body" (p246) which would control the existing councils as research directorates (p247). A similar emphasis was placed on management by Professor Ashworth; he argued that strong management was essential at a time of contraction (Q 1118) and thought that "we could, with benefit, move towards having a single research council on this (the US National Science Foundation) model" (p422). Sir Robin Nicholson thought that the present research council system was "not conducive to the best possible use of the science budget" and that a single council, replacing the ABRC, would reduce bureaucracy and make it easier to deal with emerging areas of science which often appeared at the boundaries of research council interests (Q 14). This view was supported by another witness (P265).[1]

5.14 However, the main weight of evidence was against the idea of a single research council. Sir John Mason thought that the creation of a single council "would be a terrible upheaval" and would not solve the boundary problems (Q 521). He wondered whether "the disturbance it would cause is worth it" (Q 556) and whether, if the ABRC became an executive body, Ministers would

[1] Professor M B Wilkins, University of Glasgow

still require an advisory body to assist them (Q 542). The same point was made by other witnesses (QQ 97, 939). Sir James Gowans was against radical reorganisation (Q 881) and the AFRC thought that a single research council would offer "no significant advantage over the *status quo*" (p137). Sir Douglas Hague argued that a single council would give less openness in the system and would actually hold back the looked-for developments in management (p190, Q 467). Other witnesses stressed that the interface problems would not be solved by a single council; a sub-structure of boards and committees would still be needed (QQ 397, 704). One view [1] was that a single council would be "administratively, cumbersome and inefficient" (P21). Another witness[2] saw "positive advantages in having separate research councils looking at the needs of the scientific community from slightly different points of view" (P281).

5.15 There was substantial agreement in the evidence that the present research council system was broadly satisfactory but that more needed to be done to tackle boundary problems and the problems of funding multi-disciplinary subjects.[3] The Royal Aeronautical Society appeared to speak for many in stating: "There is a danger of concentrating too much on the organisational structure of Research Management. A number of different arrangements of Research Councils would be satisfactory provided sufficient funds are available. It is no solution to current problems to 'move the furniture about' instead of providing more funds" (P218). Some witnesses were concerned with problems arising between particular research councils (PP59, 62, 215).

5.16 Some witnesses proposed general changes in the basis for the division of responsibilities between research councils (PP18,86). Two specific proposals for change in the structure were put forward. First, there was concern about the position of engineering in the present system. International Computers Ltd commented that the councils were still "'science-oriented': engineering remains a poor relation within SERC, when it could be persuasively argued that IT, currently an element under the Engineering Board, justifies a Board, or even a Research Council, in its own right" (P144). Ferranti plc (P115) and the Institution of Production Engineers (P173) considered that a separate Engineering Council was needed. The Institution of Electronic and Radio Engineers saw merit in this proposal (P171). British Aerospace thought that "the SERC would benefit from being split into a science group and an engineering group" (P23). Arguments against the separation of engineering and science were presented by the Chairman of the SERC (Q 302) and were supported by the Fellowship of Engineering (Q 331). Professor Ashworth said that he had changed his view on this issue: he was now in favour of separation on the grounds that "science and engineering are profoundly different activities in the way in which they call on central management" (Q 1148, p423).

5.17 The second proposal reflected concern about the increasing importance of biological research. The AFRC proposed, as a "limited realignment" of the boundaries between the research councils, the creation of a Biological Resources Research Council (p138, QQ 380-384). The pros and cons of such a development were set out more fully by Sir David Smith (P242). The Royal Society acknowledged that it now saw less merit in the proposal than formerly (Q 547) and Dr Holdgate questioned whether the change would be beneficial (Q 395). The Institute of Biology thought that any change to the research council system should be "progressive and non-disruptive" but saw advantage in establishing a Biological Resources Council (P148). Another view was that this would be a retrogressive step, which would improve collaboration in some areas but introduce new barriers in others (PP21, 109).

Other organisational issues

5.18 The Committee sought evidence on the organisation of research and development in research council institutes, higher education, and government, industrial and other research establishments, and on the links between them. There was wide agreement on the importance of close links between research council institutes and higher education institutions (HEIs).[4] Several witnesses stressed the benefits to research of establishing research institutes or units within universities so that their work would be exposed to "the intellectual turmoil which is rightly characteristic of a university" (Q 15). Sir David Phillips said that it was "almost... an item of (ABRC) policy" that

[1] Professor R.C. Floud, Chairman, Birkbeck College Research Committee, University of London
[2] University of Oxford
[3] PP15, 28, 43, 78, 81, 84, 185, 222, 259, 261, 262, 268, 269, 281, 284, 286, 287
[4] QQ 17, 72, 385; PP18, 67, 82, 109, 148, 282

"institutes should be located in close relationship with universities" (Q 72). There was some criticism of the policies of NERC and AFRC in this regard (Q 15, P282). The sharing of resources between research council institutes and universities, both facilities and personnel, was suggested as one means of strengthening links (PP18, 67).

5.19 Another theme was the need to establish centres of excellence. IBM UK Ltd commented: "There is insufficient emphasis on centres of excellence in research" (P138). Other witnesses agreed that centres of excellence should be encouraged, though with the proviso that there should not be too great a concentration of expertise in too few centres (PP211, 287). Support for the centres of excellence concept came also from the Fellowship of Engineering (p119). The University of Oxford referred to the need to develop interdisciplinary centres in universities (P282).

5.20 The need to strengthen the links between academic research and industry was widely recognised in the evidence.[1] The Royal Society of Chemistry referred to the "very great increase in recent years" in collaborative work between HEIs and industrial groups but was concerned that this should not go too far and force HEI work "almost entirely into the applied mould" (P222). Sir Robin Nicholson thought that the links between universities and industry should be "markedly increased" and that there could be "quite a substantial shift in balance without... any danger of universities becoming subjugated to industry" (Q 18). The Secretary of State for Education and Science argued strongly that universities were not yet doing enough to establish links with industry: "I have said constantly that universities must open their doors more to businessmen... but I do not think that until the last few years there has been very much welcome of businessmen into the ivory towers .." (Q 1637). However, he thought that the previous Colleges of Advanced Technology had "responded in a vigorous and positive way" (Q 1639). The position of HEIs in the public sector was described by the National Advisory Body: ".. the development of a research ethos concentrating on applied activity makes a close relationship with industry important" (P200). Some polytechnics, and the Committee of Directors of Polytechnics, saw scope for strengthening relations with industry through the exchange of staff (PP78, 211, 215). There was support for expansion of the Teaching Company Scheme and of CASE[2] awards.[3] Two witnesses referred particularly to the part that HEIs could play in assisting small firms which lacked R & D facilities (PP22, 268). One witness commended for consideration the setting-up of joint university-industrial units on the model of the Engineering Research Centres established by the National Science Foundation in the USA: the aim was to develop fundamental knowledge in areas critical to industrial competitiveness (P282).

5.21 The evidence from some witnesses suggested disquiet about the role of government research establishments (GREs). The Fellowship of Engineering considered that GREs were justified "only if there is a need to undertake a strong national effort which cannot reliably be carried out elsewhere, or where there is a need to serve direct Government customers. There is a feeling that some GREs which should be concerned with applied research are not sufficiently in touch with their customers in the way that their European and American equivalents are" (p121). Similar views were expressed by other witnesses (Q 1030, P169). In oral evidence, representatives of the Fellowship of Engineering stressed the importance of achieving much greater mobility of scientific staff (Q 336) and the need to ensure that "manpower is working on the right problems and the results are being transferred very efficiently into users and products" (Q 339). The problem of long-established centres becoming "out of tune with the world" was mentioned also by Sir Douglas Hague (Q 457).

The Funding of Civil Research and Developmemt

5.22 It is not surprising that the evidence should have revealed wide concern about present levels of public funding of R & D.[4] The Save British Science movement, and the evidence from that organisation (P226), testify to the concern in the academic world. Many witnesses referred to the low morale within the scientific community, brought about by the lack of funds to support promising research and by what they see as a failure to value the contribution made by scientific research to society. Professor Wilkins of the University of Glasgow stated: "The number of alpha projects not being funded at present is quite unacceptable in a country concerned about its future as a leading industrial nation" (P265). These concerns were strengthened by awareness of the poor

[1] pp 102, 122, 204; PP56, 67, 78, 148, 173, 198, 211, 215, 216, 287
[2] Co-operative Awards in Science and Engineering
[3] p122; PP78, 174, 211, 268
[4] p537; PP16, 17, 20, 49, 66, 82, 149, 191, 206, 215, 217, 246, 262, 267, 282, 283, 284, 286

comparative position of the United Kingdom in relation to leading competitor countries in the public support of R & D. Sir David Phillips said: "I think the straight comparison which comes out of the Annual Review of Government R & D with, say, Germany, is very illuminating and frightening" (Q 79). Similar views were expressed by witnesses from the private sector. British Aerospace stated: "Overall levels of funding require to be increased, in order for the United Kingdom to stay competitive" (P23). Dr Rudge of AIRTO said: "The current level of civil R & D in the United Kingdom is disastrous as far as the future of United Kingdom industry is concerned (p390).

The dual support system

5.23 There was much support in the evidence for the dual support system, although many witnesses considered that because of financial pressures that system had been substantially eroded[1]—to the point of collapse in the view of two witnesses (PP20, 261). Sir Robin Nicholson commented that while he regarded some form of dual funding as imperative he was "not sure that the division of resources between the two areas of the dual support system is ideal" (Q16). A similar point was raised in evidence from the Fellowship of Engineering (p122). Ferranti plc thought that consideration should be given to channelling more money for university research through the research councils rather than through the UGC (P116). Sir Peter Swinnerton-Dyer saw the problem as entirely one of funding: "The problem is not the balance of channels; it is that there is not enough money going through any of the channels" (Q1364).

5.24 Several other aspects of the public funding of R & D in universities were raised in evidence. There was concern about inadequate provision for equipment in universities.[2] Professor Mitchell said that the "shortage is absolutely frightening—it builds up to £100 million or so of neglect over the years" (Q299). Two witnesses suggested that the cost of supplies for research had increased excessively and that this represented a substantial drain on R & D resources (PP149, 217). Another area of concern was the "refusal of many industries and government agencies to pay the full costs of the research they fund in universities... In accordance with UGC guidelines, universities request a minimum of 40 per cent of the direct costs of research to cover overheads from bodies other than research councils and United Kingdom charities but are very often unsuccessful. Government departments, in particular, usually provide only in the region of 20 per cent overheads" (P282). Other witnesses supported this complaint (PP225, 285).

Support from industry for research in HEIs

5.25 The Secretary of State for Education and Science pointed out that universities' research income from United Kingdom industry, though increasing rapidly, still amounted to "only just over 2 per cent of their total income" and that this did not "bear comparison with leading universities in America or in Germany" (Q1671). In fact the evidence indicated a wide appreciation of the scope for increased funding from industry and a general willingness to seek it.[3] Some anxiety was expressed—and not only by witnesses from HEIs—that industry support was linked to projects thought likely to yield early commercial benefits and that too great an emphasis on such work would be potentially damaging to the science base (PP142, 261, 266). The point was also made that increasing the use by industry of the scientific expertise in HEIs called for awareness of the possibilities in industry as well as in the institutions. The Royal Society commented that "much of United Kingdom industry fails to understand and make use of the potential of the universities" (p221). The University of Oxford stated that "some industrial firms are not aware of the potential for collaboration; others, especially hi-tech companies, find present university facilities, hit by the cuts in equipment grant, inadequate" (P283). Several witnesses urged that the possibility of tax incentives to encourage industry investment in HEI research should be explored.[4]

Public support for R & D in industry

5.26 Concern about the poor investment in R & D by British industry was strongly expressed in evidence (QQ 39, 220-1, 321, 1007; p390). The Secretary of State for Trade and Industry thought that recent OECD figures for industry-funded R & D in the United Kingdom and competitor countries gave cause for "considerable concern". However, he saw it as "central to the Government's philosophy that the motivation for spending more on R & D must come from industry itself" (Q1569). He accepted "that in the long-term most British companies, certainly of any size,

[1] Q70; p497; PP73, 82, 224, 255, 268, 282
[2] Q299; PP223, 224, 263, 266, 267, 282, 283
[3] p221; PP82, 215, 216, 262, 266, 283, 285, 286
[4] PP16, 18, 83, 156, 216

and some small ones too, must spend perhaps a bigger proportion of their income on R & D than they have in the past if they are going to stay in the first league or, indeed, even not in the first league, with the rapid changes in technology that are going on all over the world" (Q 1581).

5.27 Several witnesses commented on the scale and targeting of government support for industrial R & D. The Secretary of State for Trade and Industry thought that the support given to British companies in the development of advanced projects was "reasonably comparable" to that given to firms in other Member States of the European Community by their governments (Q 1578). Sir John Collyear, Chairman of the DTI Technology Requirements Board, said that his Board wished "to see United Kingdom industry receive at least equal treatment to other governments' treatments in competitive situations" but pointed to the difficulties of making true international comparisons in this area (Q 1068). Some evidence from industry presented a different view. GEC stated that "United Kingdom industry must compete with firms world-wide which receive more favourable financial support from their governments" (p282). The GEC witnesses contrasted the United Kingdom unfavourably with France and West Germany in terms of the size of the grants available and the difficulty of securing them (Q 701). The Electronic Components Industry Federation stated: "In 1984 British Government support for investment in micro-electronics was only 40 per cent of that given by the German Government, and barely one-fifth of French Government support" (P110). The Federation also referred to the inadequate size of grants in this field.

5.28 DTI evidence described a recent change in the Department's policy for the support of industrial R & D (p57). Under the new policy "a greater proportion of the DTI support would be made available to collaborative research, advisory services and schemes for encouraging best practice, and less support would be given to projects in individual companies..." (Q 166). Mr Roith, Chief Engineer and Scientist of the DTI, explained that the change was expected to give better value for money given the limitations imposed by the size of the vote (QQ 170, 171). He admitted that if the vote were larger it could be spent effectively (Q 173). Sir John Collyear underlined the case for support of collaborative programmes but acknowledged the difficulties of achieving the best balance in support policy with a limited budget (Q1085-1088). Dr Rudge of AIRTO also accepted the need to support collaborative industrial research (Q 1017). However he commented "...the current change in policy is to me indescribable. To spend £100 million on an awareness programme, £60 million on collaborative research and £70 million on single project type research seems to me to be an extraordinary balance, looking at the problem in hand" (Q 1010). The UEI company commented that while industry was exhorted to plan ahead, DTI policy "has fluctuated in both principle and practice both in respect of defining the types of project it aims to support and to the extent of this support" (P196).

5.29 *Additionality* Several witnesses criticised the principle of "additionality" as applied to the award of grants. DTI explained that "One is continually looking at what additionality the Government spend does bring, or is in fact a company only going to do a fixed amount of research, and if the Government pays for it, then the company reduces its own contribution" (Q 174). The Secretary of State for Trade and Industry thought that the principle had been operated in "a very relaxed way" for small firms so that the extent to which a grant could accelerate a project and improve market prospects could be taken into account (Q 1064). However one witness from a small company said: "I made the serious error the first time of answering the question, 'If you were not to be successful in this grant, would you pursue your idea', 'yes'. Of course, anybody who has got any go in them at all would do this and say so... but that was something I should not have said" (Q 1478). Another witness thought that additionality should be scrapped "because it favours struggling companies" (Q 1485). UEI plc thought it was now widely accepted in industry that the concept "had become debased to the level of accounting ingenuity" and should be replaced by other criteria (P196). The Chemical Industries Association Ltd referred to difficulties associated with additionality and urged that the requirment should be changed to make it "more flexible and less of an obstacle to applicants" (P76).

5.30 *Financing of long-term R & D* The problems faced by British industry in financing long-term R & D were stressed by several witnesses. The representatives of the TUC referred to the risks posed to firms through undertaking long-term projects (Q 1502) and to the failure of financial institutions to appreciate the need for technological research (Q 1511, p541). They commented: "... it is fairly clear that money is looking for short-term results and if they cannot be demonstrated the money is not forthcoming" (Q 1508). Sir John Collyear and Dr Hilsum of GEC referred to other aspects of the financial system which acted to the detriment of long-term thinking (QQ 690, 694, 701, 1074-1077; p283). The Secretary of State for Trade and Industry said that financial institutions claimed that they were alive to the importance of R & D, and that it was clear that some

companies had "a very considerable communications problem: they do not allow the City to know what their long-term aims are and what their research is for and how much they are spending and why" (Q 1579).

5.31 *Disclosure of R & D expenditure* There was general agreement that companies should disclose their R & D expenditure in their accounts. The Secretary of State for Trade and Industry was "strongly in favour" of this practice. He hoped that industry would voluntarily agree to a revised accounting standard rather than it becoming necessary to impose disclosure by legislation. However he added: "I cannot say that I rule out for all time the mandatory requirement" (Q 1579). The Fellowship of Engineering was in favour of disclosure although it foresaw possible problems in the definition of R & D (QQ 328-330). A similar point was made by the GEC (Q 692). Sir John Collyear was in favour of making disclosure a listing requirement and considered that the problem of definition could be overcome (Q 1078-9). Dr Rudge said that AIRTO recommended "as an immediate step" legislation to require companies to declare their R & D spends in their annual reports. He believed this would have a significant impact and would also "give government more chance of monitoring the R & D spend" (QQ 996-7).

5.32 *Tax incentives* On the question of tax incentives to encourage investment in R & D by industry, the Secretary of State for Trade and Industry said that there was already favourable tax treatment for R & D although he acknowledged that some countries, including Australia, were giving tax concessions which appeared more favourable than those in the United Kingdom (Q 1569). Sir John Collyear said that the Technology Requirements Board was looking at experience in other countries where tax credits had been instituted; he referred to the advantages to industry of such a scheme (QQ 1069-1074). Support for tax incentives for industrial R & D was expressed by the Fellowship of Engineering (QQ 322-4) and the TUC (Q 1514). British Aerospace thought that "government actions in creating an improved climate of taxation, grants and other indirect policies" to stimulate R & D investment by industry would be a "most important factor" if industry was to remain competitive (P23).

5.33 *Public purchasing* Some witnesses referred to the power of public purchasing as a means of promoting R & D in industry. The Fellowship of Engineering stated: "The use of public purchasing policy as a stimulus to technological innovation has been badly neglected in the United Kingdom" (p120). Sir Alan Muir Wood, speaking for the Fellowship, said: "What we are looking for here, I think, is a much better demonstration of, if you like, the informed customer, what the Treasury has called in another context the enlightened purchaser, somebody who really understands the benefit to UK Ltd from a particular purchasing policy rather than looking too nervously at the immediate short-term interests of the organisation" (Q 332). Evidence from representatives of smaller companies gave examples of the ways in which government could assist them through purchasing policies (QQ 1458, 1486). The Secretary of State for Trade and Industry accepted the importance of public purchasing in helping suppliers to become more competitive. He said: "What we want to do with public purchases in this field is to specify requirements in performance terms rather than detailed designs . . .; to get the private sector to undertake a greater share of the R & D that supports public purchasing; to discuss longer-term needs with suppliers; to set out product needs for the future and be more demanding in doing so, and to be ready to be the first to use innovatory products" (Q 1614). With regard to the Public Purchasing Initiative (p576) as applied within DTI, the Secretary of State agreed that "the profile has not been very high" (QQ 1618, 1619).

The balance of R & D funding

5.34 Many witnesses wished to see changes in the balance of R & D funding. Mr Michael Clark of the Plessey Company argued forcefully that "profound and radical changes are needed, if we are to stop putting our human and financial resources into the delights of international pure science . . . and instead seek a new-found enthusiasm for the tangible products of industrial technology . . ." (p337). He proposed that the support of basic research should be halved and that of applied research doubled (p338). Similar, if less extreme, views were expressed by other industrial witnesses. ICL called for the establishment of selective national research strategies both at the long-term (10-20 years) and medium term (5-10 years) levels, and for a clearer set of strategic directions to be given for basic research in academic institutions (PP144, 145). IBM United Kingdom Ltd said that R & D funding required "some redirection into applied research to provide a firmer bedrock for the British economy" and that "funding for basic research should be concentrated on those disciplines that underpin strategic commercial interests . . ." (P139). Ferranti plc stated that the majority of its developments had depended on basic and applied research in other countries and questioned the need for basic research in Britain, especially if that research was exploited more successfully by foreign companies. The company urged the need to review expendi-

ture on basic and strategic research (P115). The Society of British Aerospace Companies stated: "...it would be prudent to select research priorities for their potential of technology advancement and economic return. Emphasis should be placed on the production end of technology, rather than on science..." (P248). Dr Rudge of AIRTO commented: "We believe that too high a proportion of the national basic research effort is directed toward scientific work which offers little or no potential for commercial exploitation in the foreseeable future... We are not pressuring universities to do short-term development work, but there are different kinds of basic research" (Q 990) Other witnesses stressed the need for a change in priorities, with much greater emphasis on development and the application of technology to encourage and support manufacturing industry on which Britain's future depended (PP111, 196, 240, 254).

5.35 These views were not confined to industrial witnesses. Professor Hartley of Imperial College stated: "... we can no longer afford our traditional level of basic research. It is not just lack of money; the pool of best brains is large but finite. Unless more are now harnessed more directly to problems that create wealth we will compromise the economic base for our future science" (P122). The Institution of Electrical Engineers considered that the funding of basic research should be concentrated on areas "where there is a history of excellence, a potential for success and an expectation of commercial exploitation" (P166). The Institution thought "it should be recognised that the future for big, long-term science projects will increasingly be in international co-operative enterprises" (P168). The Committee of Directors of Polytechnics called for "a transfer of resources from prestigious projects to the applied technological areas on which the economy of the country depends" (P79). A similar view was expressed by other witnesses from polytechnics (PP215, 254). The need for greater emphasis on strategic research was supported in other evidence (PP76, 220, 249).

5.36 The arrangements for supporting strategic research were examined in evidence from Glyn Ford MEP. He considered that the most important gap in Britain's R & D structure was "the lack of any coherent policy for the conduct of strategic research" (P117). He proposed the establishment of a Strategic Research Executive within the Cabinet Office which would have a budget to fund strategic research.

The evaluation of research

5.37 Several witnesses stressed the need for greater attention to be paid to the evaluation of research. Professor Smellie of the University of Glasgow felt "very strongly that organisations providing funding for research should pay more attention to progress and final reports" which should be "subject to the same peer review as when awards are being made" (P241). The Royal Society of Edinburgh considered that "there is a need, at least in some Research Councils, to attempt to measure more effectively the value and success of research projects" (P224). The evaluation of R & D was discussed at some length in evidence from the Policy Research in Engineering, Science and Technology (PREST) unit in the University of Manchester. The PREST evidence concluded: "... a new approach to evaluation of R & D is needed, one where it is the rule rather than the exception. If the system is to learn from past experience a far better 'management information system' is necessary. Evaluation is not without cost and a commitment of up to one per cent of the cost of a programme is often cited as the level necessary for a serious approach to evaluation" (P281). Professor Ashworth expressed a similar view: "... I would have thought that if you were not spending about one per cent of the total budget on evaluation, you should be worried. I do not suppose that we are spending anything like that " (Q 1164).

European Community (EC) funding of R & D

5.38 The funding of research by the European Community was widely welcomed in the evidence. However, many witnesses complained about the procedures involved in seeking EC support for research proposals, which they regarded as excessively bureaucratic.[1] One witness commented that these procedures "can cause considerable delays" and that one of the most serious difficulties was that "grants are often not formally awarded until after the starting date" (P261). Several witnesses made the point that the need to collaborate with institutions in other countries meant that substantial costs were incurred simply in preparing proposals.[2] Another area of concern was the difficulty encountered by some organisations in seeking funds to match the 50 per cent contribution from the EC, a difficulty compounded by the short time allowed to respond to announcements on EC projects (PP137, 198).

[1] PP28, 62, 83, 215, 261, 264, 266, 283, 285, 287
[2] PP79, 84, 262, 283

5.39 It was suggested in evidence that many university departments were ill-informed about possibilities for EC funding (PP241, 263). One witness proposed that the office of the UK Permanent Representative to the Community should circulate all universities "with full and intelligible details of the EEC research grants available, the office responsible for advertising those grants and the appropriate way to obtain further information and to make applications" (P287). Another view was that "A small group skilled in progressing EC funding applications is needed to assist organisations seeking research funds from this source" (P161). It was suggested that in other European countries there was a closer relationship between universities and civil servants in seeking EC funding than existed in Britain (P60).

5.40 A different view of British participation in EC research programmes was given by other witnesses. Sir Robin Nicholson stated: "the signs are good and suggest that the "juste retour" of about 20 per cent of Community expenditures is being achieved and in some cases will be exceeded. The Commission have told us that research submissions from the United Kingdom are in general of a high quality" (P205). This assessment was confirmed by representatives of the Commission of the European Communities in discussion with Members of the Committee. It was stated that the Commission strove to achieve scientific excellence and disowned the concept of "juste retour": the value of research to Member States was to be measured not only in money but in access to the results. The Commission acknowledged that there were shortcomings in the procedures for dealing with research proposals and contracts, which they were seeking to improve. They noted that the main problem was the dissemination of information. They were trying to deal with this by improved documentation but they stressed that the efforts made in this area by Member States were equally important.

5.41 There was some criticism in evidence of the Treasury policy relating to United Kingdom participation in EC R & D programmes. The Committee of Vice-Chancellors and Principals stated: "We also believe it to be unfortunate that individual Departmental budgets are reduced to accommodate the cost of relevant EC initiatives. This policy blunts the incentive to maximise funding from European research programmes" (P83). A similar point was made by other witnesses (PP151, 215). Mr Barnes of MoD said that there had been little collaboration with research under Commission auspices "because it became obvious that if money were to be forthcoming into one of our establishments from the Commission, there would be concomitant reduction in the funding coming from HMG. We decided that we would prefer to be masters of our own house" (Q 1312). Supplementary evidence from the Treasury described the relevant public expenditure control mechanisms and stated that it was not the Government's intention that a research establishment should receive no net benefit from EC funding because of an equivalent cut in its own funding (P256).

International collaboration

5.42 The scope, indeed the necessity, for increased international collaboration in R & D, in both the EC and wider contexts, was recognised in the evidence. Miss Ros Herman, a science journalist, referred to the "low importance" that scientists attached to the "admittedly rather vague geopolitical entity" of Europe. She thought this might be due to the reluctance of the scientific community to "single out a particular set of collaborators" among its many international contacts and commented: " This is fine while science is pursued for motives wholly or mainly connected with intellectual curiosity, and when funding is available from national sources. In an increasing number of areas of science, however, one or both of these conditions remains unfulfilled" (P127). The Royal Society stated that "the need for a well-developed United Kingdom policy for international science will grow, and an increasingly important aspect of improved machinery at the centre of Government will be the balance of United Kingdom support for national and internationally-based activities" (p222).

5.43 The scope for increased collaboration within the EC on environmental research was referred to by NERC (QQ 601-4). Industrial witnesses commented on the collaborative research inititatives under ESPRIT and other EC programmes and under EUREKA.[1] On ESPRIT (and Alvey) ICL observed: "These programmes are largely concerned with applied (pre-competitive) research, and as such provide useful foundations. At product development levels, where spend is an order of magnitude greater, HMG support for industry is tending to reduce" (P145). Dr Roberts of GEC was concerned that vigorous support of these programmes, which he favoured,

[1] See footnotes, p58

would leave insufficient funds available to promote and assist purely United Kingdom initiatives, for which, he argued, a case still remained (Q 684).

THE CUSTOMER/CONTRACTOR PRINCIPLE

5.44 As would perhaps be expected, government departments were generally content with the operation of the customer/contractor principle.[1] As stated by the Ministry of Agriculture, Fisheries and Food, the principle was "the most effective way of ensuring value for money as both a direct and proxy customer for R & D" (P195). The DTI acknowledged that "The research establishments are carrying out more applied research than pre-Rothschild" and that "there is a potential danger that the strategic research would fall away as resources and priority are given to applied research". The Department indicated that further attention was to be given to this problem (p60). The AFRC commented: "A strength of the principle is that it has sharpened scientists' perception of the need to direct their work towards clear objectives and to be accountable for their use of resources". However, the Council noted that commissioning operated in parallel to funding through the Science Budget and that this had "considerably complicated research management" (p141). NERC stressed the problems posed by "the general lack of long-term programmes" of commissioned work and supported the findings of the Mason report that the customer/contractor principle had led to inadequate support being given to strategic research (p252).

5.45 Many other witnesses were broadly in favour of the customer/contractor principle, if often with some reservations.[2] One of the main reservations was that the principle favoured short-term work and had led to a reduction in strategic research. The UKAEA considered that the most important benefit from application of the customer/contractor principle was that it helped "to clarify the objectives of applied R & D work. Without this discipline R & D may follow avenues that are interesting (perhaps because challenging), whilst losing sight of the environment in which the ideas will have to be applied" (p319). However, the Authority recognised as one potential disadvantage, that "some customers' time horizons will tend towards the short-term..." (p320). Other issues raised in evidence were the ability of the customer to foresee and define his research needs and the relationship between the customer and the contractor. BP commented: "R & D is not in the usual sense, definable. Indeed, if it were, it would not be R & D. The customer/contractor principle may therefore degenerate into dictation of work programmes or, under a more friendly regime, into a cosy, but not very productive, relationship" (P51). The absurdity of the position that could arise where a customer department lacked the expertise to define its research needs was illustrated by Sir James Gowans' comments on the early application of the principle to the MRC: "I really thought people had gone mad" (Q 893). The importance of "a strong relationship between groups engaged in the research and the people who will benefit from the results of that work" was stressed by Mr Fairclough, the Chief Scientific Adviser. However, he added: "I did not wish to imply that the recipients of the research should control the money associated with the research programme. I am not at all sure that is always appropriate..." (QQ 1293-4).

5.46 There was concern also in the evidence about the "Rothschild 10 per cent". Sir David Phillips noted that this recommendation "was never implemented and of course it made a great deal of difference to how well the system did or did not work" (QQ 87-8). Sir John Mason stated: "The ten per cent research surcharge was never implemented and I think that is terribly important because I am worried about the balance between *ad hoc* research and development in relation to basic science" (Q 562). This view was shared by other witnesses (p390; P247).

5.47 Many witnesses were opposed to the customer/contractor principle, some strongly so.[3] While recognising that the principle had led to a strengthening of the scientific dimension within government departments, Dr Jeffers, Director of the Institute of Terrestrial Ecology, concluded that "after a trial of some 13 years... the Rothschild principle has failed to generate the kind of applied science that this country needs, and has, at the same time, helped to reduce the fundamental and strategic science which is a necessary precursor to applied science" (P180). He saw as one weakness of the system the bureaucracies it had created: "We have now reached the ridiculous position in which we actually spend more time talking about the research we might do, and in accounting for the way in which research resources are used, than in actually doing the research itself". He observed: "The commissioning of research has not greatly changed the direction of

[1] QQ 234-7, 414-423, 1334; pp 84, 160; PP97, 105, 107, 195, 211, 236
[2] pp 341, 390; PP23, 43, 51, 65, 116, 134, 145, 155, 156, 202, 216, 264, 270
[3] pp 123, 283; PP44, 83, 123, 130, 149, 153, 192, 223, 241, 262, 267, 287

much of our research, but it has greatly delayed the actual doing of the research" (P178). The Institute of Biology thought that the system had "done little more than place another tier of administrators between bench scientists and their sources of funds" and recommended "its abolition and replacement by a simpler consultative procedure" (P149). The Fellowship of Engineering commented: "The customer/contractor principle was an attempt to force the real world into a pattern which would be easier to administer but it did not happen that way. Any research worker knows that the difficulty of identifying a customer is exceeded only by the difficulty of persuading him to define his requirements (p123).

Defence R & D

5.48 The high and increasing proportion of publicly funded R & D devoted to defence was questioned by several witnesses, notably by Sir John Kingman who commented: "... the defence of this country will collapse, not necessarily for military reasons but for economic and political reasons" (Q 153). Sir Robin Nicholson said: "It is rather facile to believe that the science budget is 'too small' because the defence budget is 'too large'. The science budget is so small in relation to public expenditure as a whole that I do not think one can relate those two" (Q 47). A similar point was made in evidence by Dr Gummett and Mr Weston: " We must avoid the assumption... that resources released from defence R & D would be transferred into civil R & D" (P272). Sir Robin Nicholson acknowledged that defence and civil R & D could interact in their demand for scarce manpower: MoD was so dominant in some areas that its demands might lead to shortages of skilled manpower for civil R & D (Q 47). This point was raised by the TUC who expressed deep concern about "the desperate manpower shortage in certain high-tech skills" and said that "a lot of people in electronics are working in the defence sector" (Q 1548). The Gummett and Weston memorandum commented that the employment of scarce specialists on defence work might not be "an ultimate 'loss' to the civil sector, provided that the work done on MoD funds could be made available for civil purposes" (P275). IBM United Kingdom Ltd said that "there is military/commercial overlap in the basic research area but this is not significant in applied research and development. The commercial benefit is certainly out of proportion to the extent to which British talent is concentrated in military related research and development activities" (P139). Mr Barnes, Deputy Controller R & D Establishments, MoD, said: "I do not think... that we are pre-empting a disproportinate amount of the resources (of skilled manpower) in an area where there is recognised nationally to be a shortage" (Q 1344).

5.49 There were varied opinions on the extent to which defence R & D contributes to civil objectives. Some witnesses considered the contribution to be limited, or even negative:[1] others thought that it was significant or substantial.[2] The Fellowship of Engineering stated: "If the post-war period from 1945 to the present is viewed as a whole, there is no doubt that defence and defence-related R & D has weakened civil research initiative, especially in industry, and that this has had a harmful effect on product innovation and industrial competitiveness" (p133). However, the Fellowship also commented: "It is interesting to note that the enthusiastic claims for spin-off come from Fellows with a close involvement in defence contracting. Those not so closely involved in the 'system' see far fewer examples..." (p124). The MoD commitment to maximising spin-off was clearly expressed by Mr Barnes: "... there is an imperative here to ensure as far as we possibly can that science and technology that is in some way paid for and generated by the Ministry of Defence can be used to maximum possible benefit to the United Kingdom economy" (Q 1332). An impressive list of defence R & D projects that have led to, or give promise of, commercial exploitation was supplied by MoD (pp 464, 469-477). There was support from industry that spin-off is substantial. The Society of British Aerospace Companies Ltd said: "There is a fundamental interdependence between civil and military R & D in aerospace. Aerospace industries everywhere depend on the basic research and expertise generated by the demands of defence procurement and the use of expensive facilities as a platform to secure civil business" (P248). Dr Roberts of GEC referred to evidence that "over many years... MoD stimulated research has been increasing the United Kingdom's capability in certain areas of science, technology and engineering." He said: "The idea that somehow we have defence-oriented companies that do only R & D for defence and do not exploit it, well, as one of the biggest companies in the area, that is a situation I do not recognise" (Q 727). A similar view was expressed by Professor Gosling of Plessey: "I cannot think of a major area of military research which has not generated a very great deal of spin-off" (Q 845).

5.50 The industry views referred to above were challenged by the TUC. Mr Tuchfeld commented: "Twenty years ago they (GEC and Plessey) were well-known high street names and where do

[1] P133; PP45, 65, 155, 157, 163, 171, 172, 223
[2] PP24, 166, 174, 186, 217, 219, 248, 257

we see them now? Both companies opted for the soft option of public funding of military expenditure, and the Maddock report[1] is highly sceptical of there being any spin-off" (Q 1555). Referring to the Maddock report, Mr Webb said: "what he was saying in effect was that the whole style of a company, that is company ethics and ways of working, was not geared up to innovation in the defence sector, and they painted themselves into a corner by relying on defence contracts and had not got the necessary marketing skills to get into the commercial market and compete with the Japanese, who do not do very much on defence" (Q 1548). The TUC considered that the Government should "encourage and prod" the defence contractors by requiring them to assess the potential civil applications of defence projects for which they tendered and by indicating that this would be an important criterion in the award of contracts (Q 1551).

5.51 The need to take all possible steps to increase spin-off from defence R & D was recognised in the evidence. Sir John Kingman said: "... if you accept... that we are going to spend 55 per cent of our public R & D budget on defence, then a lot more can be done to ensure that the country as a whole benefits from that in a non-defence way" (Q 154). In welcoming the Defence Technology Enterprises (DTE) initiative, Sir Robin Nicholson said: "I do not think it is enough" (Q 44). The MoD said of the DTE: "It is an important instrument; it is not the only one" (Q 1339) and acknowledged that "The chances of DTE uncovering what one might call a large number of ripe plums, bits of technology that can be put straight on the market—a sword turned into a ploughshare overnight—are probably rather small. Almost certainly they would see something that has civil exploitation and it would need to be developed" (Q 1340). This statement might be seen as a response to a criticism made by the CBI who stated: "The predication behind Defence Technology Enterprises was that there were nuggets of technology within the Government's own research establishments which could be lifted out as a package and transferred into industry. That is the sort of thing that very rarely happens" (Q 514). The Defence Manufacturers Association concluded that DTE activities were still not well known among its members and should be better publicised (P93). Mr Barnes stressed the importance of the secondment of staff between MoD establishments and industry: he thought "there is no doubt... that the most effective way to transfer technology is to move people from one place to another" (Q 1339).

5.52 The Royal Society considered that there was "too little transfer between defence and civil science" and that access to MoD facilities "would greatly benefit civil science and technology". The Society believed that the security risks associated with defence work were "overstated and are often no different in kind from those affecting research in other politically-sensitive areas" (p223). Sir David Phillips indicated that the joint use of facilities had presented difficulties but was still under discussion with MoD (Q 93). On the security question, Mr Brett commented, for the TUC: "... my members tell me there is too much secrecy, unnecessarily, about what defence work might have a spin-off" (Q 1555). Other witnesses saw security considerations as a significant barrier to spin-off (PP153, 270).

5.53 Another issue that emerged in the evidence was the extent to which spin-off might be increased by the greater involvement of small firms in defence contracts. Dr Rudge of AIRTO thought that "spin-off could be greatly improved if MoD R & D contracts were spread more equally to the smaller industrial companies and research organisations (as is the practice in the USA for example) (p391). He said that when defence contracts were placed with large companies "the research and expertise which develops... tends to reside within the defence company. There is relatively little flow even to another branch of the same organisation", whereas, in smaller organisations, "the same people are generally involved in doing the military work and the civil work" (Q 1044). A different view was presented by Dr Roberts of GEC who said: "... we regard a major part of our business as being in ensuring that all this technological capability that we create, a lot of which is initially created to meet a particular defence objective, is applied laterally throughout the company" (Q 727). The CBI stated that, in America, the Department of Defense placed many contracts with small companies, so increasing spin-off, whereas in the United Kingdom, "much of our defence expenditure is placed with the large monolithic companies". The CBI commented: "At present most of the policies which are being carried out, ostensibly to aid the spin-off from defence into civilian use, seem to be policies that will act in the opposite direction" (Q 514). Mr Barnes of MoD observed that although there was no directive about the amount of defence business that should go to small firms, the position in the United Kingdom in that respect seemed to compare well with that in the USA. He said that MoD was looking into ways of increasing the spend with small firms (Q 1331).

[1] Civil Exploitation of Defence Technology: Report to Electronics EDC, NEDO, 1983

5.54 A related question that arose in evidence was the extent to which technology derived from defence contracts remained locked up in large companies rather than being released to small companies who would exploit it. The Defence Manufacturers Association found that about 20 per cent of their members who were consulted on the point believed that there were such unexploited opportunities. The Association concluded that "it would be worth considering ways in which the dissemination of this expertise may be encouraged" (P93). The Royal Institution of Naval Architects stated: "There is no machinery to benefit the smaller companies and, of course, a reluctance to share information generated by a particular company for military purposes if a civil fallout is in any way likely to be profitable" (P221). The Chemical Industries Association Ltd made a similar point (P76).

Manpower and Training

5.55 The Committee invited evidence on the availability of qualified manpower to exploit any increased funding of R & D and much concern was expressed on this aspect. Professor Irvine of the University of Manchester said that "the pool of qualified, skilled manpower trained to undertake science and engineering research and capable of exploiting the new technologies... is grossly inadequate for the needs of the country" (P177). British Aerospace considered that "adequately trained manpower will continue to be an important limiting factor in United Kingdom performance" (P23). The Institution of Chemical Engineers stated: "If nothing is done to enhance the recruitment of first class engineers into either an academic career or a short term research appointment in universities, there will be such a dearth of this talent within the next ten years that effective precompetitive research could not be undertaken in many fields..." (P156). Similar anxieties were expressed by other witnesses.[1]

5.56 Of particular concern to some witnesses was the question of science teaching in schools. ICI commented: " Unless something is done very soon the research funding problem will solve itself in a disastrous way—there will be so few good young scientists coming forward that even with the limited funding, we shall be able to support them all!" (P143) The Institute of Physics referred to a letter from the President of the Institute to the then Secretary of State for Education and Science which expressed "grave and growing concern about the state of physics education in our schools and institutions of higher education" and noted that "Physics is fundamental to the nation's wealth producing industries..." (P155). Sir David Phillips agreed that the situation was alarming (Q 98). Professor Irvine stated: "A higher percentage of pupils in English schools give up the study of mathematics and physics at an earlier age than in any comparable industrial nation. A contributory factor must be that more than eighty per cent of our school pupils will never be exposed to a graduate physics teacher" (P177). For the TUC, Ms Warwick saw it as a "fundamental problem" that schools were not producing students with "sufficient interest in science and technology to go on to higher education and then into a career or making a contribution to our research and development" (Q 1560). The Secretary of State for Education and Science acknowledged the importance of the problem: "if we do not increase the impact of the take-up of science in schools and get children interested—girls as well as boys—in science, there will be, however much money one puts into the science base, a constant degeneration in future years". He saw the present shortage of mathematics and physics teachers as "an emergency" and described the various measures the Government was taking to tackle the problem (Q 1680).

[1] PP44, 111, 143, 169, 171, 218

CHAPTER 6 OPINION OF THE COMMITTEE

Introduction

6.1 Two conclusions about the support of civil science and technology emerge unmistakeably from the evidence. First, the advance of science and technology must be a central objective of government policy. The Government has, in the words of Sir David Phillips, a general responsibility to support science and technology because this is fundamental to the social and economic well-being of the country (Q 52). The Committee strongly agree.

6.2 Secondly the overwhelming weight of opinion from almost every sector of the research community and from the private sector is that R & D in many fields is underfunded, and in some cases seriously underfunded. It may be objected that much of this opinion is based on self-interest or sectional concern. But the Committee are persuaded that the case has been made out. This is a prime cause of the low morale which is evident in the scientific community.

6.3 These two views should not be taken together to mean that the underfunding is wholly the responsibility of the Government. This is not true. A large share of the responsibility rests with industry, who have failed to invest enough in R & D and to appreciate its importance. Other sections of society, particularly the City and institutional shareholders, have to accept some responsibility. The Committee are concerned at the comparative failure of British industry to undertake and to finance R & D, and its disposition to rely on publicly funded work. They are aware that the Government shares their concern, and they make some proposals below to try to deal with this intractable problem.

6.4 But this report is about public support for civil science and technology. If in a new climate of optimism morale is going to revive, within the timescale which the problem requires, the public sector has a lot to do. This is where the report concentrates.

6.5 During the course of the enquiry, steps have been taken to strengthen the Cabinet's scientific Secretariat and, as the Committee are led to believe, the Cabinet structure itself. The Committee naturally welcome those developments, though the conventions of secrecy about Cabinet Committees are not helpful when there is a need to project the public image of science and technology and no one is allowed to admit that any ministerial machinery for science and technology policy consideration exists. The Committee are convinced that more than this is required. Recognition of the vital role of science and technology in the life of the nation should be public and visible. Recommendations below cover this point.

6.6 The Committee have found, in their evidence, a strong belief that the share of the R & D expenditure devoted to defence (over 50 per cent) is too high. It is not for the Committee in this enquiry to advise the House on the size of the Defence R & D budget. All they can do is to draw the House's attention to some of the consequences of the preponderant role of the defence sector on civil R & D resources and manpower, which are discussed below.

6.7 As far as international comparisons are concerned, there are risks because conditions and classifications differ greatly. The Committee have studied the policy making procedures of the United Kingdom's principal competitors and some of their achievements. It is not sensible to copy systems appropriate to different political and social environments and cultures; we must build on what we have. But it is worth considering their policies. According to many sets of R & D criteria, the United Kingdom comes low in the batting order of comparisons with our competitors, and when defence is taken out of account—as it must be—the gap between the United Kingdom and the other main industrial countries in expenditure on civil R & D is too wide.

6.8 It is difficult to prove that there is a direct relationship between the health of the economy, or of sections of it, and the levels of expenditure on R & D. Indeed the Treasury informed the Committee that there was none (Q 737, p311). Nevertheless, the Committee find it hard to accept such a negative view, when all our industrial competitors take the opposite one, and when they have all increased, and the majority are still increasing, their expenditure, while the United Kingdom has contracted its expenditure and plans to continue to do so.

6.9 The Committee understand the constraints inherent in the present economic situation of the country. They accept that in the area of science and technology we cannot try to cover everything; that there is always room for better management of existing resources; that higher education is not exempt from cuts in expenditure; and that there is a strong need for greater efforts in the private

sector. But all this said, the actual consequences of present policies, as responsibly revealed in the evidence, cause the Committee deep concern.

6.10 The Committee's attention has been drawn to the case of Australia, where a situation not dissimilar to that in the United Kingdom has arisen with high unemployment, a declining manufacturing base and a worsening balance of payments. An austerity programme has been introduced, but the resources allocated to R & D have been increased. In short, there has been a major reordering of priorities. The Australians have recognised that when times are hard, increased R & D is needed for new products, new processes and new tools.

6.11 The Committee consider that there should be a continuing review of priorities in the United Kingdom. They conclude that the health of scientific research and technological development is suffering; that the effect on the industrial and economic performance of the country will be adverse; and that the Government's objectives of improving this performance will be endangered. It is in this spirit that they have formulated, and now commend to the House, the opinions and proposals which follow.

A Policy Objectives

6.12 Once it is accepted that public support for civil science and technology is essential—and the Committee do not believe that this will be contested, for the reasons given in Chapter 2—the difficult decisions about public support begin. Where should money be targeted; how much support should be given; what should be the character of the support? These lie at the heart of the enquiry.

6.13 Except in wartime, the United Kingdom has seldom had a definable policy for the public support of R & D. Decisions tend to be based on an assortment of different policies, not always compatible with each other and often *ad hoc*. It leads to a situation in which the objectives of public support for civil R & D are not clear cut. This makes funding decisions more difficult and discourages the stable conditions which would help science and technology to thrive.

6.14 The Committee believe that a recognised policy for the public support of R & D is required. With that in mind, they set out below some of the objectives which any such policy should meet. The list is inevitably open to argument, especially where priorities are concerned, but they recommend these objectives as the basis for policy formulation.

(i) *The pursuit of excellence*. Excellence in science and technology is vital in itself and because the excellent stimulate and teach others. Sustained mediocrity is a waste of resources. Funding must put the pursuit of excellence before uniformity.

(ii) *A constant flow of skilled manpower*. This is required both to carry out R & D in the United Kingdom and also so that the results of R & D, national and international, will be appreciated and applied. The objective is relevant from primary school upwards.

(iii) *A healthy foundation of basic science*, without which R & D cannot flourish.

(iv) *Assured programmes of strategic research*, to ensure the United Kingdom's long-term economic prospects and its active participation in the next generation of technology.

(v) *Competitive industrial performance* in international markets, with strong support through pump-priming and economic policies to secure (in particular) long-term investment in development ("D") with market potential.

As means to achieve objectives (i) to (v),

(vi) *Stable conditions for funding*, to encourage forward planning and inspire confidence.

(vii) *A positive attitude to participation in European and other international collaborative programmes*.

(viii) *Awareness of the potential impact of other policies on R & D* (for example, tax or public purchasing policies).

6.15 To some extent these goals all depend on subjective judgments. They cannot be assessed in absolute terms. However quantitative tests are being developed to help judgments about such matters as the "health" of basic research.[1] The flow of manpower can be measured; a significant

[1] Evaluation of national performance in basic research; ABRC, Royal Society and ESRC 1986.

brain drain or a fall in the output of suitable graduates are danger signals. Excellence makes itself conspicuous. Industrial performance is judged by results.

6.16 The most useful indicator of all is *international comparison*, even with its admitted imperfections. This is the key. Ultimately the goal is the United Kingdom's survival as a leading industrial nation in world competition. The United Kingdom must therefore spend sufficient to improve (or at least to maintain) its industrial and cultural base relative to those countries which are judged to be its natural competitors, making allowances for differences in size and resources. Neither Government nor industry is spending enough at present levels to restore our industrial position in world markets.

6.17 The point was made to the Committee by the Treasury (p 311) that the national source of science and technology is less important than the ability to assimilate and apply scientific and technological ideas whatever their origin. This proposition is correct but also incomplete. It is based in particular on the experience of Japan in earlier decades, but the international circumstances facing Britain in the eighties are much less benevolent than those which Japan encountered in the fifties and sixties, a point Japan itself has taken as evidenced by its present concern with basic research.

6.18 In addition to higher expenditure, it is of course necessary to target and manage that expenditure effectively. The wide range of public spending on R & D needs to be seen as a whole, as well as the sum of its parts. In two ways therefore past practice ought to be modified. First, Departmental spending on R & D must be looked at horizontally, that is across the whole of Government, in addition to the traditional vertical look by individual Departments. Aided by the Annual Review of Government funded R & D, which makes a horizontal look possible, this process has begun. It is strongly to be encouraged. Departmental sovereignty in R & D planning is a handicap. Both the interactive effects of Departmental programmes and the overall levels of R & D spending should be assessed. The Committee cannot agree with Lord Rothschild (Cmnd 4814 para 58) that "general oversight [of applied R & D] would serve no useful purpose"; they prefer his warning (para 57) that "there is a danger that R & D done by one Department may have an impact on that done elsewhere or by another Department"—a situation which he charged the Chief Scientific Adviser to prevent. Unless the overall level and effect of public spending are assessed, maximum effectiveness in that spending is not likely.

6.19 Secondly, in funding through the Science Budget a balance has to be struck between the rival virtues of academic freedom and selectivity. Both are important. Basic research flourishes when it is unfettered by external targets, because it relies on the imagination and motivation of the scientists in their search for new knowledge. At the same time there is a limit to the amount of money which the country can afford for research which has no conscious expectation of economic benefit. The Committee consider that it is right, in the United Kingdom's present economic circumstances, to devote part of the Science Budget to areas which can be identified as offering some prospect of economic benefit to the country. Recommendations below cover this point, and the Committee support the Government's moves in this direction. But the criterion of economic benefit must not be carried too far, since this would stifle basic research. No one can hope to predict accurately how basic research will contribute to national economic benefit. Therefore the Committee share the view of the Secretary of State for Trade and Industry (Q 1591): "I am concerned with improving the impact of publicly funded R & D on the British economy ... I support the science base very strongly".

B Central Structure

6.20 In *Science and Government*[1] the Committee recommended against a separate executive ministry for science and technology but in favour of designating a specific Cabinet Minister to speak for science and technology in conjunction with his or her other responsibilities. The Committee also recommended a strong central scientific adviser in the Cabinet Office and the establishment of a Council for Science and Technology which would have absorbed ACARD. How do these recommendations and the arguments underpinning them look five years on?

6.21 The evidence which the Committee have taken in 1986 leaves little doubt that the voice of science and technology is more muted in the highest counsels of government than it should be. It is easy to see too why some of those who believe British science to be underfunded argue for a

[1] 1st Report, Session 1981-82, HL 20

separate ministry of science and technology. However, far more is involved here than whether or not the science vote is at an adequate level. It is a matter above all of ensuring that the "science and technology dimension" is fully represented to ministers separately and the Cabinet collectively, and in respect of all relevant policy areas. Where a policy issue is wholly internal to a particular department then the "science and technology dimension" needs to be appropriately articulated at the departmental level itself. This is the strongest reason against the placement in a single department of all responsibility for science and technology. The capacity to give proper weight to the scientific and technological aspects of policy, as to the economic ones, should be regarded as fundamental to all departments in modern government. It follows that in spite of the practice in some other countries, the Committee can see no more call now than they did in 1981 for proposing the creation of a separate and all embracing Science and Technology Ministry.

6.22 The Committee also see little advantage in a less comprehensive ministry, covering only science. This in effect would be a department created mainly out of the science "side" of the Department of Education and Science. Such an arrangement might give science the political weight which many feel it now lacks as a result of its location in a department in which, necessarily, responsibility for education dominates. But it is important to be clear that education issues dominate in the DES not only because of their political importance, but also because science issues are handled by the DES only indirectly, that is through the ABRC, the Research Councils and the UGC. If a new science ministry were to be created this indirect responsibility would still have to be faced. There would also then be an institutional division between education and science and the Committee fear this would damage the position of science and technology in the education system as a whole whereas what is needed is its strengthening. The Committee's view is that it would be better to strengthen the science side of the DES rather than hive this off into a new ministry.

6.23 It is the arrangements for science and technology at Cabinet level which trouble the Committee. There the science and technology dimension ought to be strong. There is some parallel here with the voice which the Treasury provides on the economic and financial implications of policy, though this analogy should not be pressed too far.

6.24 To provide for the science and technology dimension at Cabinet level, the Committee still believe, as they did in 1981, that there is no uniquely suitable arrangement, appropriate for all time and for all those who would have to operate it. Instead, the Committee's preference is to identify a structure with the promise of definite improvement over existing arrangements and which could evolve.

6.25 Given the vital importance of science and technology to Britain's future, the Committee have now come to feel that only the close identification of the Prime Minister with the science and technology dimension will ensure that it receives due weight. In the Committee's opinion there would be both substantive and symbolic significance in such a provision. This is an opportunity to create the new climate of confidence, for which the Committee argue in Chapter 1. At the same time, it is obviously impossible for any Prime Minister to give more than limited attention to the science and technology aspects of policy questions. The proposals which follow are meant to take account of both these considerations.

6.26 Under the Prime Minister the Committee would like to see the designation of a specific minister to be responsible in Cabinet for the science and technology dimension of policy issues. Only if there is a definite individual charged with this duty does it seem possible to be reasonably confident that this dimension will always play its proper part in decisions which are typically the outcome of many conflicting departmental arguments.

6.27 The object in asking that a minister be designated to speak for science and technology in Cabinet is first to ensure that this dimension receives proper weight in all deliberations. But it is also desirable that ministers should be enabled to form a view of the Government's total spending on R & D, the state of the national R & D effort, its congruence in detail with the Government's overall strategy, and any significant gaps in this coverage, especially in regard to newly emerging areas. Such a view would necessarily involve an appraisal across departments, and ideally it would also include an appreciation of what the private sector was doing, or not doing.

6.28 As to which minister might be given the responsibility, the Committee can see several options. A departmental minister is one possibility, and in that event the Secretaries of State for Trade and Industry or Education and Science would have an especially strong claim. On the other hand, there would then tend to be some confusion between these ministers' departmental interests

and their comprehensive appreciation of the science and technology dimension, and for this reason the Committee do not favour this proposal, though they would still prefer it to having no designated minister at all.

6.29 A second possibility would be to associate the science and technology function with a non-departmental minister, such as the Lord President or Lord Privy Seal. This has been tried previously. An alternative provision might be to make the Paymaster General or the Chancellor of the Duchy of Lancaster the responsible minister, bearing in mind the Committee's hope that he would in this capacity be working closely to the Prime Minister (see below).

6.30 A third possibility would be to place the responsibility with a Treasury Minister. This could have an important advantage in its own right, that is, in its impact on the Treasury. Although it may be wrong to place too much emphasis on Treasury evidence about its dependence on other departments for science and technology expertise, it remains disturbing that a department as powerful as the British Treasury has, in effect, and as a consequence of its particular evolution, a definite blind spot in science and technology. Requiring a Treasury Minister to speak to the science and technology brief in Cabinet would eventually upgrade the Treasury's own understanding and appreciation of science and technology, a development which could only be to the general benefit.

6.31 In their report on *Science and Government* the Committee also commended the appointment of a strong scientific adviser in the Cabinet Office. They are therefore glad to note the development of this post. Results here turn ultimately on the relationship between the adviser and the Prime Minister, the Prime Minister needing to have high confidence in the adviser, the adviser ready and independent access to the Prime Minister.

6.32 In addition to a designated senior minister and a strong scientific adviser the Committee see a Council for Science and Technology as a third essential element in the central structure for science and technology. The Committee identified in 1981 what they called a "vacuum at the centre" which they believed could be filled by such a Council, and the evidence they have received in 1986 confirms that this vacuum still exists. Indeed, the Committee now attach more rather than less importance to the role to be performed by this Council. This is the reason for the one significant change the Committee would make to their 1981 recommendations about the body. The Committee now believe that the Council should be formally chaired by the Prime Minister who should preside from time to time. The deputy chairman should be the designated minister for science and technology.

6.33 As the Committee see it, it would be the task of the Council to take a balanced view of the whole of scientific and technological endeavour, international as well as British; to monitor the connection between science and technology and the evolution of government policy; to raise questions of strategic importance; and generally to promote the emergence of the most favourable conditions both for doing R & D and for getting the results usefully applied in Britain. The Council would promote interaction between the work of the Research Councils, universities and polytechnics, Government departments, private research institutions, industry and commerce. It should cover both civil and defence R & D, and seek to maximise the returns from all R & D. It would be concerned equally with publicly funded and private R & D and would stimulate industry to increase its R & D activity. In short, the Committee see the proposed Council as a highly visible sign of the new importance that Britain must attach to science and technology for its industrial regeneration and future economic prosperity.

6.34 Much of the work of the Council would necessarily be confidential. The Committee would want it to enjoy good access to government working papers relevant to its concerns, and to have much of the status and privileges appropriate to a part of the government machine.

6.35 The Council should also produce an annual statement to Parliament, assessing progress and priorities in the field of science and technology. Over time this might become a benchmark by which the nation's science and technology progress could be charted. There is an inspirational quality in science and technology which once infused British attitudes very generally but is now muted, not least by comparison with the more technologically successful countries such as Japan, the United States and West Germany. The Council for Science and Technology would be able to help create a new scientific and technological culture in the United Kingdom—or, more correctly, to revive an older one.

6.36 The Council's composition would need to reflect its remit, with members drawn approximately equally from the industrial, the academic and the governmental spheres. The aim should be

to keep the Council as compact a body as possible. In the Committee's view membership of the Council should be limited to 15-20. Provided that the Council elected to operate through working parties, there would be every opportunity for the involvement in those of the wider academic, industrial and governmental communities.

6.37 ACARD should be absorbed into the CST. ACARD has succeeded in bringing considerable external resources into government, especially from industry and technology, and its reports have illuminated important issues. Its work should continue within the CST. But there is no room for two such bodies, and ACARD has always been hampered by its remit which is focussed upon applied R & D. The cross-fertilisation of basic and applied research has to be encouraged; the opportunity for joint ABRC-ACARD reports, of which there has only been one so far, does not go far enough. ACARD has also lacked the means to convert its advice into action. The Council which the Committee propose might not fare any better, but in asking that it be formally chaired by the Prime Minister, and ordinarily chaired by a senior minister, the Committee expect this arrangement to improve the chances that its advice would be acted upon. Those of the CST's documents which the Council chose to publish—remembering that some and perhaps much of its advice would be private to government—might also receive more public attention than ACARD reports have done.

6.38 The Committee do not believe that anything of ACARD 's important work would be lost if it gave way to a new CST. On the contrary, those studies mainly concerned with applied R & D would be handled through subcommittees of the CST, as they are handled now by subcommittees of ACARD. There is also no reason for there to be a less close relationship between the CST and ABRC than there is now between the ABRC and ACARD, and the CST would also no doubt wish to cement links with other departmental scientific advisory bodies.

6.39 The CST would need a full time, and highly professional, secretariat. It would have oversight of the Annual Review of Government Funded R & D, of the work of the new Science and Technology Assessment Office being established in the Cabinet Office, and of whatever machinery is eventually created to identify and support exploitable areas of science as recommended in the ACARD report of 1986. The Council's staff would be located in the Cabinet Office and, like the existing scientific staff and the personnel of the Science and Technology Assessment Office, would be administratively responsible to the Chief Scientific Adviser.

C A Single Research Council?

6.40 The Committee received evidence both advocating the creation of a single National Research Council and in favour of the existing Research Council system. Of the various arguments in favour of a single organisation, two seem to the Committee to be of particular importance—the more comprehensive perspective and the potentially greater flexibility one would expect a single Council to enjoy. The existing Research Councils reflect the existence of more or less identifiably separate scientific areas as these were recognised at the time of each Council's creation. But science is dynamic and any static structure will inevitably have some difficulties in adjusting to this. Such difficulties are not insuperable—thus a given Research Council can fairly be expected from time to time to reorient its priorities within its own field, and new subjects emerging at the boundaries between Research Councils can be addressed through joint committees. Both these developments in fact regularly, if not quite routinely, occur. On the other hand, there is no reason to suppose that a unitary Council would be less effective in either of these respects, and it could additionally be looked to for a more complete sense of the direction in which science as a whole was evolving—a task now assigned to the ABRC.

6.41 The Committee do not favour a partial reallocation of the responsibilities of the Research Councils, such for instance as would lead to the creation of a Biological Resources Research Council. This would entail considerable disruption, would be somewhat arbitrary, and might even exacerbate uncertainty in the system as a whole. For similar reasons, and because of a reluctance to separate science from engineering, the Committee are also opposed to splitting the Science and Engineering Research Council in two. The Committee's Report on Marine Science and Technology[1] showed that marine science is poorly served by the division of responsibility between SERC and NERC, and said that this problem would be looked at again in the present enquiry. The Committee conclude that the problem will be overcome better by drawing the Councils closer together than by setting up different Councils, and by giving enough authority to the Coordinating Committee for Marine Science and Technology which the Government has announced.

[1] 2nd Report, Session 1985–86, HL 47

6.42 A National Research Council might command greater prestige both within Britain and abroad than is possible for any of the present Councils separately—though the Committee fully recognise the high existing reputations of the Councils. Naturally, a single Council would have to work through subsidiary boards, but here it could be more flexible than the existing structure, for it need not be confined to five boards corresponding to the present Research Councils, or indeed be restricted indefinitely to any given number of subsidiary boards.

6.43 The Committee nevertheless feel that a recommendation for a single Research Council in present circumstances could easily be seen as unhelpful, since its costs would largely be felt before its benefits, and this at a time when morale in the science community is already at an unprecedented low. The Committee are as concerned with the immediate health of Britain's R & D effort as with the long term structures for public funding, and they would not wish the thrust of their report to be misunderstood or its force diminished by prolonged consideration of an issue which, though important, cannot by itself improve the wellbeing of Britain's R & D as rapidly as the evidence shows to be essential. There is also the fact that there are considerable differences between the councils, the MRC and ESRC in particular having distinct areas and approaches.

6.44 The Committee's overall view is therefore that it would be better to encourage evolution in the existing system than to go for any revolutionary departure. In line with this the existing Research Councils, led by the ABRC, should be asked so far as practicable to harmonise their administrative practices, criteria and approaches, and above all to refrain from initiatives which might complicate an eventual process of merger. They would probably also derive advantage from, for example, working more closely together on the process of corporate planning, on the marketing of their commercially valuable results, and on their external relations. Proceeding in this way would bring some immediate benefits—applicants to the Councils, for instance, would welcome greater uniformity, a common attitude to the EEC and representation in Brussels could be worked out, and so on—with few if any significant costs. The logic of joint action along these and other lines might create a momentum in favour of merger and make it more acceptable, but in any case maximising joint action and common arrangements between the Councils is highly desirable in its own right, whether or not the Councils do in the end merge. Increased joint action, or even final merger, should not erode pluralism in funding, since the aim of the Councils is already, when they can, to assign applicants to the appropriate one of their number.

6.45 It is a source of considerable concern to several of the Research Councils that in recent years the ABRC has expanded its role. However, with falling or static expenditure, the need for strong management and clear decisions about priorities between Research Councils has become more apparent. Moreover, the ABRC is uniquely placed to apply common criteria in the allocation of funds and common standards in the evaluation of completed programmes. If, as seems likely, the ABRC continues to expand its executive role, then in time the autonomy of the councils will unavoidably diminish. The Secretary of State for Education and Science in his evidence argued both for an increased role for the ABRC and against the creation of a single Research Council. In the long run a more executive ABRC might tend to evolve into a single Research Council. There need be no false unity in a single Research Council, as the Secretary of State feared, since there is already much diversity within the Councils as well as overlap between them. Other countries do not seem to find a problem in having the equivalent of a single Research Council. At the same time the Committee recognise that administrative reorganisation cannot remove interfaces, only establish the pattern felt to be most appropriate to the problems and opportunities of the time.

6.46 There are always dangers in running advisory and executive functions together, and it will be increasingly necessary to be clear about these dangers if the ABRC continues to expand its present central, and centralising, role. The Committee would therefore welcome a more explicit process, one which would both enable the Research Councils to prepare better for their collective future, and also encourage the ABRC to develop and enhance the managerial capabilities it will henceforth require. The Committee accordingly recommend that the government discuss with the ABRC, the Research Councils, and other interested parties how best to deal with the resulting difficulties. This is a subject which the proposed Council for Science and Technology would also review.

D Methods of Funding Research

6.47 Since the White Paper on a Framework for Government Research and Development in 1972 (Cmnd 5046), public funding for civil research has followed two primary routes. In simple terms, basic research has been funded from the DES Vote, through the Science Budget and the UGC. The allocation of funds within the Science Budget has been the responsibility of the Research Councils. Applied research has been funded by departmental commissions in accordance

with the customer/contractor principle. No explicit mechanism exists to fund strategic research, which has emerged as a concept since 1972 and which has therefore had to rely upon funds either from the Science Budget or from commissions.

6.48 This section of the report looks at two questions: 1) whether the two primary routes are satisfactory for their purposes; and 2) whether these two routes are enough. The Committee's conclusion is to endorse the concepts of the Science Budget and the customer/contractor principle, but to argue that a third funding route is also needed.

Research spectrum

6.49 It is a commonplace that from basic research right through to development, activity is essentially continuous; at the development stage it may be necessary to go back to basic work. However, the purpose to which activity is directed changes significantly as one moves from research through to development. This section is concerned primarily with research. At the basic end the aim is to obtain fundamental scientific knowledge for its own sake, for the better understanding it yields of the natural world. Associated with this is a training process for new research workers, a process in which skills are acquired which can subsequently be used further along the R & D spectrum and not only in the prosecution of other basic research. There is generally a vital link between research and good teaching in higher education. It is also clear that a society which conducts basic research enriches itself in what is effectively a cultural sense; at its most successful this is reflected in the winning of Nobel Prizes or is otherwise marked by the winning of international distinction. It is highly probable that, in an internationally mobile world, a society which fails to provide opportunities for those of its most able people who are attracted to basic research will lose many of them to countries making a more generous provision of resources.

6.50 The level of resources made available to basic research must to some extent reflect the overall economic strength of the country concerned, though this will not be the only influential factor, and it may not even be the main one. It follows that basic research funding will come to seem increasingly squeezed in a country like Britain where GNP per head has fallen behind decisively in comparison with major rivals. The growth over time in the number of available researchers requiring funding, and the sophistication factor in the complexity, and therefore cost, of most scientific equipment then add to the pressure on funds. The result is that morale suffers, there may be a net brain drain, and important areas of research can be lost.

6.51 Applied research results are wanted for specific purposes, usually to improve an existing product or process, possibly to enable the introduction of something entirely new. Improvement or novelty is sought to open up, enhance or maintain a specific market or, in the defence field, to offset technological developments being made by others. At a time of rapid technological change applied research is an integral part of manufacturing success, for without the results of such research, and their application in products and processes, obsolescence is swift. Manufacturing success produces prosperity, whereas obsolescence leads only to poverty.

6.52 There is no lack of enthusiasm among scientists to do basic research and the critical factors here are funds and appropriately qualified research workers. These factors may also limit applied R & D but here there may in addition be a lack of will because the importance of R & D is not fully grasped in relation to more pressing concerns.

6.53 Basic research funds derive almost entirely from public sources and the criteria of allocation have traditionally been grounded in peer review. Applied research and development funds by contrast, would largely be private, except that governments have long offered support here too. Government funding of applied research is then either a consequence of a political decision to support a particular area of technology—for instance, aerospace, nuclear power or information technology—or else a consequence of a particular departmental policy or duty.

6.54 In between basic and applied research there is strategic research. In their report on Science and Government in 1981 the Committee said that, while they understood the underlying rationale, they regretted that the distinction between basic and applied research had become a central tenet of scientific organisation. As must be expected in a continuous spectrum, some research has characteristics of both basic and applied research, to varying degrees. Several terms are used to describe this central ground, which is one of great semantic complexity. "Strategic research" (defined in Chapter 2) is now current. Important also are two terms which fall within strategic research but do not equate with it: "general research" in the sense used by Lord Rothschild (see para 3.31), and the concept of "exploitable areas of science" recently coined by ACARD (see para 6.68).

Science Budget

6.55 This enquiry has not been concerned at any length with the Science Budget, mainly because the House of Commons Education, Science and Arts Committee have reported on that subject so recently. The Science and Technology Committee however have no hesitation in stating their confident belief that the concept of the Science Budget is a good one and that it should be preserved. Funds for the support of basic research should be provided by the taxpayer and administered by the Research Councils, at arms length from Government, under a system of peer review. This arrangement, in conjunction with the funds given through the UGC to higher education to provide well-found laboratories (the dual support system), has produced excellent science, as well as freedom of thought and expression. As explained below the Research Councils have also accepted a responsibility for funding a substantial amount of strategic research. This function has been supported from the Science Budget, and must continue to receive such support.

6.56 The Commons Committee drew attention to the impact on the Science Budget of certain ancillary costs—superannuation, restructuring, and international subscriptions—over which the Research Councils had little or no control. In order to protect the amount of research funded by the Science Budget, they recommended that these should be funded from a different source. The Science and Technology Committee accept the Government's response that the funds will have to come from the Science Budget. But they recommend that the ancillary costs should be separately itemised and if it is apparent that for any year (as in 1986) these costs have risen significantly the Science Budget should be correspondingly increased. As the present Chief Scientific Adviser said "The pure science that we engage in . . . is something on which we need to decide how much we are willing to spend, and then protect it" (Q 1257).

Customer/Contractor principle

6.57 The principle enunciated in Lord Rothschild's 1971 report and subsequently adopted by the Government is that applied R & D should be funded on a customer/contractor basis, the customer indicating his wants, the contractor meeting them if he can, and the customer paying. The accountabilities of the customer as laid down in the report included deciding when an R & D programme was needed, how much should be spent on it and what should be the priorities as between programmes. The departmental customer was seen as being assisted in his decisions by advice both from a Chief Scientist and from a Controller R & D, the latter being chief executive of the R & D function, the contractor providing an R & D service. Lord Rothschild insisted that there should be no line relationship between these two since they were "engaged in quite different activities". He stressed the value of a strong Chief Scientist's team to ensure that the department would be an informed customer, while he identified the responsibilities of the Controller R & D as being to secure an efficient R & D service, with the aid of a 10 per cent general research surcharge which was to be levied on customers (see paragraph 6.61 below).

6.58 Although the customer/contractor principle is the determining criterion for departmentally commissioned research (see para 3.31) it has always been unevenly applied. In the first place, only the Ministry of Defence appears to have maintained the clear division between the Chief Scientist and the Controller R & D. In the second place, the recommendation in respect of a 10 per cent general surcharge has mostly not been implemented. In addition to these failures actually to operate the customer/contractor principle as Lord Rothschild defined it, the Committee have found evidence that, to the extent that the principle has been applied, it has tended both to disadvantage strategic research, and also to increase the degree of specialisation in requirements.

6.59 Nevertheless the customer/contractor principle should remain in force for departmentally commissioned research. In spite of some drawbacks, the Committee remain attracted both to the disciplined cost consciousness which the Rothschild principle implies, and also to its capacity to promote mutual appreciation between customers and contractors, making the former more aware of scientific possibilities and the latter more conscious of the often severe constraints which apply outside the laboratory. The discipline on customers and contractors to formulate needs and targets is useful; it contributes to efficiency and the assessment of priorities. A strong Chief Scientist's team can improve Departmental decision-making, provided that Departments are prepared to give this more attention than most have done so far.

6.60 Although Lord Rothschild, for good reasons, stressed the distinction between the Chief Scientist and Controller R & D in departments, the Committee accept that it is not practicable to separate these functions in the same way in every department. In some, the scale of operations may be too small to warrant separation, though the functions should be clearly identified. But this does

not excuse any Chief Scientist's team which is too small for its job. The scientific element has to be strong enough for an informed dialogue with research contractors to take place. This should help to reduce the time spent by research directors on contract negotiations.

6.61 The significance of the 10 per cent general research surcharge must be emphasised. Failure to implement this has been one of the chief defects in the application of the customer/contractor principle. The surcharge was intended primarily to promote the vigour and efficiency of the research establishments receiving the surcharge. Strong laboratories such as Harwell have been able to insist on the surcharge and this has helped to build up their strength; weak laboratories have been further weakened by lack of it. No laboratory can be expected to flourish without money for underlying research support, the ability to arrange for orderly transfers of staff between projects, and the opportunity to work on projects ahead of commissions to develop expertise and maintain interest. The Committee note how bodies such as British Rail, British Gas and BP fund their research programmes, with business sectors commissioning research in a way analogous to Government Departments and with corporate funds (in excess of 10 per cent of research budgets) providing for general research needs. This approach ought to apply equally in Government Departments. The Committee recommend that a 10 per cent surcharge should be added to all Government contracts for commissioned research. The further operation of the customer/contractor principle will no doubt command the attention of the proposed Council for Science and Technology.

Strategic research

6.62 On the other hand, it must be clearly recognised that the 10 per cent surcharge was not designed, and is not generally suitable, for the funding of strategic research by Government departments. First, it cannot be assumed that strategic research will be needed only in those areas and from those laboratories which are carrying out short-term applied research contracts. Secondly it cannot be assumed that the level of commissions will, even under favourable circumstances, be sufficient to fund strategic research—and anyway the trend in commissions has been downward and shorter-term, so that the void to be filled by the surcharge has grown as the funds theoretically available have declined. Thirdly it cannot be taken for granted that the directors of research establishments are in the best position to identify strategic opportunities; this ignores the element of commercial and economic advantage, which others may be better able to judge.

6.63 Strategic research is a relatively new concept, which was not specifically considered by Lord Rothschild. Even as recently as 1979, when the Government reviewed the customer/contractor principle and made no recommendation to change it,[1] the significance of strategic research was not widely appreciated. In practice the customer/contractor principle has not proved apt for funding a sufficient level of strategic research. For instance Sir Ronald Mason in 1983[2] concluded that strategic research was having to be supported increasingly from the Science Budget, with a consequent reduction in the funds available for basic research. It is easy to see how pressure on departmental budgets and cash limits have squeezed this intermediate and longer-term category of research. Therefore, in the Committee's opinion, a new process for the funding of some (but not all) strategic research is required.

6.64 Accordingly the Committee welcome the ACARD report on *Exploitable Areas of Science*.[3] Funding for exploitable science (see below) can fill much of the strategic research gap giving a new impetus to research in the middle ground between the basic and applied categories when such research has clear potential of commercialisation. If this approach can be developed, the Science Budget (adequately funded) and the customer/contractor principle (correctly applied) can be expected to provide for the rest of the research spectrum.

6.65 As the Committee explain below, strategic research should not be funded from a single source. That would imply that it is clearly distinguishable from basic and applied research. This is not so: the dividing lines are hazy. It would also imply that strategic research is more uniform than it is. Strategic research with commercial objectives is liable to differ markedly from strategic research with scientific, social or environmental objectives. These differences suggest the need for different treatment.

[1] Review of the Framework forGovernment Research and Developmemt (Cmnd 7499)
[2] A Study of Commissioned Research, ABRC 1983
[3] ACARD refers to an exploitable area of science as being "one in which the body of scientific understanding supports a generic (or enabling) area of technological knowledge; a body of knowledge out of which many specific products and processes may emerge in the future". Exploitable Areas of Science, ACARD, 1986, p11

6.66 A new approach is needed to promote that strategic research which is of most significance to the United Kingdom's economic future. This would still leave strategic research of a non-commercial character to be funded. Some would continue to be funded by the Research Councils in furtherance of their responsibilities. Departments in non-commercial fields such as Environment and, to a lesser extent, Transport would retain their duty as proxy customer for research benefitting sections of the public at large. The Committee would be most unhappy supporting a new approach to strategic research if on the one hand this deprived the Research Councils of their present responsibility for some strategic research, or if on the other hand commissioning departments were encouraged in the view that they had no remaining responsibilities beyond the narrow funding of the research which they feel they need for their own purposes.

6.67 Indeed the Committee draw attention to a distortion of the customer/contractor principle which is now developing. Government departments are narrowing their research programmes so that these increasingly support their statutory duties, to the exclusion of research which they should commission as proxy customers for the general public. The role of proxy customer must remain. The responsibility to fund strategic research with social and environmental objectives has to rest somewhere. The Committee see no sensible alternative to Government departments for this purpose. Rather than add unnecessarily to the number of processes, the Committee prefer that the customer/contractor principle should be made to work in this comparatively restricted yet important field. But this will depend on a constructive attitude by both Ministers and Chief Scientists (not excluding the Treasury).

Exploitable areas of science

6.68 ACARD's report on exploitable areas of science draws attention, albeit opaquely, to the fact that the United Kingdom's economic future depends on science-based innovation, and that a new approach is required to ensure that national research is encouraged in areas of commercial potential. Researchers must be actively drawn into these areas, and the motives which inspire basic and applied research must be married. The key to the concept of exploitable areas of science is one of motivation.

6.69 Basic research is funded by a process which identifies proposals of high quality, usually put forward by workers with a successful track record and who can therefore be expected to have a good sense of what is feasible. Peer review may not be a perfect aid to decision in such cases but it is still a sound enough technique for many purposes and, sensibly managed, has usually produced very satisfactory results. With regard to applied research by contrast many decisions turn on commercial advantage (or its equivalent in the defence field), the intent being to arrive at results of more or less immediate usefulness and which are as cost effective as possible. For exploitable science both kinds of consideration apply and the research needs to be not only of high professional quality but also attractive in a commercial sense.

6.70 Exploitable areas of science are administratively difficult to handle and have been neglected in Britain. The research proposals concerned will not emerge only from researchers' perceptions of good science, nor on the other hand will the timescale of commercial returns ordinarily be short. The health of these areas has not been a central responsibility of the Research Councils in the way that basic science has been, though the Committee fully acknowledge the initiative of the Councils in regard to strategic science. On the other hand, departmental R & D does not leave much scope for exploitable science. The exploitable areas of science fall between two stools, with neither the Research Councils nor the departments being structured to identify and support them as their first priority; an idea indeed so much without a champion that until recently it lacked even a name.

6.71 ACARD's intention is that large sums of money should be channelled through a new process.[1] In the Committee's view the Government should support this process enthusiastically. In order to get it started and to test its effectiveness, the Government should first assist in its funding as a process; this is not a major commitment. Then the Government should make pump-priming funds available to it and this must be new money. It is not enough to rob existing research budgets.

[1] ACARD say that the "process" must draw together two perceptions:-
"i) what is possible in scientific and technological terms, and
ii) what is commercially desirable",
the aim being to create "a shared vision of the directions in which to develop this dimension of science policy, visions shared by industry, science, and Government which are based upon continual dialogue and discussion."

6.72 The Government has said in its response (Cmnd 9849) to the Commons Education, Science and Arts Committee that it is "more likely to be persuaded of the value of increasing public investment in science if the scientific community, and the users of its products, can point to increasing economic and social benefits, and in particular to prospects for increased national wealth."[1] This object is precisely what ACARD intends by its exploitable areas of science approach. From the outset, some funds from the Science Budget and commissions from government departments and industry would support work in the exploitable areas of science—as in an undeclared way they already do. If the process proves effective, the proportion of funds from those sources being directed through the process would increase gradually. Ultimately a position should be reached where collaboration between universities and industry would be typical and funding could be shared between the public and private sectors.

6.73 The Committee would welcome any further broad initiative by the Government which involved collaboration between universities and industry on the basis of shared funding. The objective should be to increase industrial R & D expenditure and the economic yield from public expenditure on R & D. As with ACARD's proposal it is however essential that any such initiative should have adequate pump-priming funds, command general confidence, and be compatible with the eventual process selected to deal with the exploitable areas of science.

6.74 The ACARD report represents a big step forward, even though it does not spell out what the process for identifying exploitable areas would actually look like (despite the absolute centrality of this process). The Committee look forward to the advice of the consultants which ACARD has engaged to advise on the method or the body by which the suggested process should be controlled. There will have to be at least four elements in any such process. First, there would necessarily be a substantial input from the Research Councils since they are uniquely placed to assess where excellence is to be found, and there would be no purpose in trying to duplicate their knowledge. Secondly, and in contrast to the existing operations of the Councils, industrial and commercial potential would have to be given a place as influential as the Councils. A third need would be to ensure that any United Kingdom process did not become insular, that it was not cut off from parallel exercises elsewhere. And finally, the Committee see a need for rigorous evaluation of the outcome of decisions, while there is still time to switch priorities. Bringing together these four elements, and there may be others, will not be easy but the rewards could be substantial, establishing a new focus for an increasing proportion of the United Kingdom research effort. The aim must be to generate the soundest possible agreement on forecasts, to turn this into a set of research commitments, and to exploit the results as they emerge both speedily and fully.

6.75 The controlling function for the process will probably not be placed within Government. As stated above the process will need inputs from the Research Councils, industry and the Government. But wherever situated and however composed, it should certainly answer directly to the proposed Council on Science and Technology which would oversee its functioning and the use by it of public funds.

6.76 The Committee see an important connection between the evaluation of past decisions in an exploitable areas of science process, and the functions to be expected of the Science and Technology Assessment Office set up in 1986 in the Cabinet Office. The work of this office might in time become valuable to the wider exploitable areas process, as Ministers recognise (QQ 1599, 1666) The two initiatives are however directed ultimately at somewhat different ends and the Committee recognise that there are significant roles which the Assessment Office can aspire to perform in its own right: "value for money . . . and ensuring benefit to the economy as a whole" (Q 1596).

6.77 The Committee also sound a note of warning. The concept of an exploitable areas of science approach is based on the model Japan has developed. On the other hand the great scientific and technological success of the United States has been built upon other factors, not least on pluralism and the individual initiative which pluralism encourages. A foreseeable danger with an exploitable areas of science process is that it can encourage those consulted in the process to revise their expectations downwards in successive forecasting rounds in response to what they are told

[1] This quotation from the Government's response should not be taken to imply that the Committee see the Universities as mainly responsible for existing deficiencies. In the Committee's opinion industry is at least as much to blame as the universities for the present state of affairs.

about the expectations of others. It will be incumbent upon those who operate any such process in Britain to guard against this.

6.78 It is implicit in what the Committee have said about an exploitable areas process that it must begin modestly, yet with high level government support. It will need commitment and finance from the outset. For unless the existing science establishment can be persuaded that the new process has a role in strengthening both British science and British industry's use of this science, it has little chance of succeeding. Unless it can persuade the best laboratory scientists that it is a serious and worthwhile enterprise which they would benefit by including in their scheme of things, again it is condemned to a dim and probably brief existence. Even if these two groups can be won round, there will still be British industry to be properly integrated with the enterprise, and that will present its own problems.

6.79 The Committee reiterate that these observations, and their general encouragement of the exploitable areas of science concept, are without prejudice either to their conviction that United Kingdom basic science needs to be maintained in a healthy and internationally challenging state, or to their belief that Britain will really begin to reap the full rewards of its R & D effort only when industry generally has geared itself to exploit to the full the results which flow from this effort.

E Industrial R & D

6.80 This report is concerned with public support of R & D and this entails parallel consideration of privately funded R & D because the two complement each other. Public support makes a vital contribution towards the cost of many projects funded by the private sector.

6.81 It is a growing criticism of British industrial performance that the results of research are imperfectly converted into products and processes. Industry may be slow to take up research results; competitors from other countries may step in first, or do so more effectively; the development stage may founder for a variety of reasons. Recent experience suggests that this criticism is well-founded. It also underlines the critical place of development in R & D. Without development, which is by far the most expensive part of the cycle, the fruits of research go to waste or, worse, may be picked up and used by competitors. Unless this stage receives its full measure of attention, the time, money and effort put into (for example) the exploitable areas of science will achieve little for the United Kingdom.

6.82 The main responsibility for funding development rests with industry. That is clear. But overseas governments give support to their industries for development, and this leaves the British Government with no alternative but to do likewise. Otherwise British industry has little hope of competing successfully. Moreover industry needs help, even if it cannot lay a prescriptive claim to it, to surmount a number of hurdles. The first of these is the preoccupation of the City and shareholders with short-term profits, rather than long-term prospects and investment. Secondly, interest rates are higher in the United Kingdom than in competitor countries abroad which makes development appreciably more expensive to service here. Thirdly, low profitability in the United Kingdom manufacturing sector in recent years has produced a spiral of low investment and low returns from which industry finds it hard to escape.

6.83 Public support cannot make good the deficiencies of private spending but, with a judicious choice of targets, it can help the private sector to help itself. Unless it succeeds in this, the omens are bad.

Statistical Information

6.84 The available data on industrial R & D are less complete and up to date than those on public R & D. This is partly because private R & D decisions are made by a multitude of corporate bodies rather than by a few departments and councils. It is also because private bodies do not in general collect and publish information on their R & D efforts to the same extent as public bodies. The statistical information relating to industrial R & D needs to be significantly upgraded. The DTI's full quadriennial survey with partial surveys biennially may be an improvement on its previous triennial survey but it still remains an imperfect base for accurate policy making. By contrast the Annual Review has in recent years greatly improved the statistical information relating to public R & D, and the Committee would like to see the Government promote similar development in regard to private R & D , preferably in cooperation with the CBI and other trade bodies.

Levels of industrial R & D

6.85 Given this deficiency in the information base the next, and central, point the Committee make may seem paradoxical. Even with existing data, there is abundant evidence that, outside the

defence field, the level of R & D being funded and performed within British industry is seriously inadequate. Much of industry is not oriented towards R & D, or mobilised to exploit the opportunities which stream from British university and polytechnic research.

6.86 R & D is commonly the first area to suffer in a recession, on the grounds that it can confer advantage only in the medium and long term whereas the company concerned may be facing a crisis in surviving even the short term. Below some critical size, different in different industries, it may actually be difficult for a firm to maintain a designated R & D capacity at all. But the Committee believe that, as well as these problems, there is a fundamental lack of appreciation of the importance of R & D among many British managers and shareholders. There are, of course, honourable exceptions, and examples of British companies which are well up with the world leaders in their fields. Moreover R & D is only one part in a company's total activity and should not be presented as an end in itself. But many companies are held back in international competition because adequate R & D of high quality has not been a top priority.

6.87 Recognising that here again is an issue with which the proposed Council for Science and Technology would wish to grapple, the Committee have considered at length what beyond mere exhortation they could recommend to improve this situation. First, the links between higher education and industry must be strengthened (see paras. 6.102, 6.103 below). There has already been improvement in these links over recent years, and obviously the higher education institutions share the responsibility here. But it is industry which must be presumed to have the sharper commercial sense and it is therefore vital that companies organise themselves effectively to benefit from research work done in the HEIs. It is regrettable that, while overseas companies take elaborate steps to inform themselves about British university and polytechnic research, British companies do not often do so.

Department of Trade and Industry

6.88 Secondly, the role of the Department of Trade and Industry is most important. Through its earlier Requirements Boards, and now with advice from its single Technology Requirements Board, the DTI has been the channel for most public support for industry. It has had many successes in assisting and stimulating industrial R & D. But the assistance must go further. To begin with, the total amount of DTI support for industrial R & D is simply not enough. The follow-through from the Alvey programme, for instance, if done properly, would absorb most of the current DTI budget for industrial support.

6.89 The direction of DTI support should also be changed. Following a policy decision by the present Government, support is focussed on collaborative ventures and on awareness programmes. Single company project support is now set to fall by 50 per cent in the period 1984-89. Collaboration and awareness initiatives are excellent, but only if coupled with good support for individual projects. As DTI explained in evidence (p65, Q 170), their new emphasis on collaboration and awareness programmes is expected to maximise the gearing of their limited funds. But on their own these programmes are inadequate. In particular they do nothing for the development stage, for which the collaborative approach is hardly suitable, and to which awareness programmes are irrelevant. When DTI funds are also spread thinly between numerous projects they tend to help only projects which would have gone ahead anyway; to act as a real incentive in difficult areas of R & D, support has to be generous. Bearing in mind the expense of the development stage, this suggests that total funds must be increased and that they ought to be targeted more precisely. Although one aim of setting up the new Technology Requirements Board was to shift attention to generic technologies and the collaborative approach, it would still be possible to make a new product and process development scheme work with the advisory committees of the Requirements Board, provided that their advice is generally accepted—as it is. This emphasis on targeted and generous support is likely to be more productive than grants spread widely and thinly, and the Committee recommend that it should be preferred.

Tax Incentives

6.90 In their report on Education and Training for New Technologies[1] the Committee suggested some adjustment to the tax provisions bearing upon private R & D, on the lines of those introduced by the American administration at the beginning of this decade. The Government's response argued that the United Kingdom tax system already provides a number of incentives for United Kingdom businesses and that the American forms of relief from taxation are alien to the United Kingdom tax system and cannot be easily incorporated in its structure. The Government also

[1] 2nd Report, Session 1984-85, HL48

objected on policy grounds that it was generally opposed to the proliferation of special tax reliefs which erode the tax base. Nevertheless the Committee believe that the need to stimulate industrial R & D spending is too pressing to leave matters here. As the Committee said in Chapter 1, a new climate of opinion is urgently needed. Everything possible must be done to persuade industry of the need for, and advantages of, R & D. For an interim period at least, the Government could help create that new climate by incentives to R & D through the tax system, though this should not be regarded as a substitute for selective support. If the American system is unacceptable, the Committee recommend that the Treasury examine constructively the feasibility of other tax measures to stimulate private R & D. Consideration should in particular be given to the new scheme introduced by the Australian Government, which for six years provides a 150 per cent tax incentive for expenditure on R & D carried out in Australia: this scheme is designed to make Australian industry more innovative and competitive and to create stronger links between research institutions and industry.

Disclosure of R & D expenditure in company reports

6.91 The Committee continue to believe that companies should declare their R & D expenditure in their annual reports. This would have at least two advantages. It would bring home to managements their shortcomings in relation to similar firms, but perhaps even more important, it would encourage financial interests to take R & D strength much more into account when weighing a company's future prospects. If, as many have argued, risk capital is available to British firms only on less favourable terms than those open to many of their competitors abroad, then underlining through the annual accounts the importance of R & D strength might be expected gradually to change this shortsighted view. The definition of R & D needs for this purpose to be reasonably strict but this is a technical difficulty and does not detract in any substantial way from the overall advantage. The Committee have already made a recommendation for voluntary disclosure in their Report on Engineering R & D[1]. The Government in response hoped that forward-looking expenditure would be taken into account in the City. However, efforts by DTI over four years to reach agreement on voluntary disclosure have come to nought, the CBI in particular being unwilling to give firm support. In the light of this the Committee now feel obliged to recommend a statutory requirement. They were pleased to note the support of the Secretary of State for Trade and Industry for the disclosure of R & D expenditure in company accounts, and that he did not rule out action to make this a mandatory requirement (Q 1579). This change may lead to only a gradual change in the outlook of shareholders and management; but an appreciation of the value of R & D and a more far-sighted view must somehow be brought about.

Public purchasing

6.92 The Committee have noted the finding of a recent report by the US Office of Technology Assessment, to the effect that federal procurement may have a "far greater and more positive effect" on private R & D expenditures than does federal R & D.[2] The possibility that this may also be true for Britain should lead to a further reassessment of the policy role of public purchasing. The implications of public purchasing have been a concern of British governments for some twenty years, though only, it seems, intermittently. The present Government emphasised their hopes of enlightened public purchasing at the beginning of this decade but from the evidence given to the Committee by the DTI (Q 1619) it seems that this policy since then has had a low profile. The Committee regret this. The objectives of enlightened public purchasing are far reaching and R & D is fundamental to them. By attempting to define its long term needs, by specifying performance rather than detailed design standards, and generally by entering into a symbiotic and continuing relationship with suppliers, the public sector can encourage the private sector both to undertake more R & D and also to become more internationally competitive. The public sector should as well, wherever possible, be in the van in seeking innovative products and processes. The scale of public purchasing makes this an instrument of great potential influence. There are, of course, dangers in too cosy a relationship between suppliers and purchasers, and in particular there should certainly be no question of "buying British regardless". But those British purchasers, both public and private, who have appreciated what can be achieved through an enlightened relationship with suppliers, and who have learned to operate this relationship in a disciplined way, have demonstrated convincingly that such an arrangement can produce, via appropriate R & D, products of a quality and timeliness which ensures for them a place in world markets.

[1] 2nd Report, Session 1982-83, HL 89, para. 15.14

[2] Research Funding as an Investment: Can We Measure the Returns? A Technical Memorandum (Washington, DC: US Congress Office of Technology Assessment, OTA-TM-SET36, April 1986), p24

Role of shareholders and management

6.93 In the end what must be changed is the attitude of shareholders and the management outlook in the average and below average British firm. This may prove a slow process and for many firms the change, if it comes at all, may come too slowly or too late to prevent extinction. The Committee share Sir Robin Nicholson's regret that only a "depressingly small" fraction (Q 39) of the £3 billion relief on national insurance surcharge appears to have gone into company R & D, though like Sir Austin Bide (Q 500), they are not entirely surprised at what has happened. Sir Austin's point (Q 501) about the importance of getting on to boards people who understand R & D and the innovation process is well taken. The business schools must contribute here. The traditional managerial responsibilities for "manpower, material and money" of course remain, but in recent decades they have been joined by a new one, the health of R & D and the innovative process, and business schools should ensure that their curricula take account of this development.

An R & D levy?

6.94 In the belief that British manufacturing industry now needs a decisive stimulus to increase its R & D and technology transfer, the Committee have even considered the possibility of a levy on firms, together perhaps with an appropriately scaled contribution from the Exchequer. Any such scheme would have to be administratively simple, essentially non-discriminatory, and time-limited. It would require careful monitoring. But there would still be criticisms of the compulsory nature of the scheme, the basis of the levy, the new onus which would be placed upon managements, and doubts about the availability, in the short term, of the requisite R & D manpower. Given such drawbacks, the Committee have rejected the scheme. But it cannot be ruled out of future consideration if shock treatment for British manufacturing industry eventually becomes unavoidable.

R & D from overseas

6.95 In this section of their report the Committee are concerned with private industry's ability to benefit from publicly funded R & D. In this context the ability to use R & D results generated in Britain is in fact only part of the problem, for 95 per cent of all R & D results now emerge abroad (Q 39). For those results, in addition to the domestic barriers of inertia and insufficient grasp of the importance of R & D there are as well the international ones imposed by geography, language and access. Any company engaged in international competition has to be acutely aware of R & D results, whatever their origin, which bear upon its activities. Given that the ratio of R & D performed abroad to that done in the United Kingdom is 20:1 this is a matter of simple commonsense. The Committee suspect that, because formerly a much higher percentage of the world total of R & D was done in Britain, the importance of overseas R & D has too often tended to be overlooked. Naturally, access to overseas R & D results will not normally be free but will rather be through fees, licenses and joint development arrangements. Whereas firms in the high technology areas may be able to make international arrangements themselves, this will not be so true of smaller firms in traditional areas, or of new firms generally. The Committee urge the Government to expand its present effort in aiding the inward flow of technology.

Small firms

6.96 The Committee have an especial concern for the circumstances facing small firms in Britain. This concern has several dimensions. Thus the Committee question whether the overall balance of public R & D, and in particular the work of government research establishments, fairly reflects the importance in the economy of the small science and technology based firm. They fear that the proper administrative controls applied to grants and subsidies may discriminate unintentionally against firms too small to be able to devote the necessary manpower to the relevant paper work. They would like to feel that where public support is given it matches the help given by foreign governments to competing firms. And they would like to think that the Government and higher education institutions have a special sensitivity to the needs of small firms for appropriately qualified manpower, the burden of in-house training sometimes being for such firms a disproportionately large one. On all these matters the Committee are uneasy. There is a need for a steady stream of new companies whose activities or products are based upon science and technology. Since the new small firm will always be less articulate than the large old one, it is up to the Government to do what it can to redress this imbalance, and by all available techniques, including advisory services, facilitating international contacts, and enlightened public purchasing as well as through supportive R & D.

F Higher Education Institutions

6.97 Britain's universities do most of the country's basic research and an increasing amount also of its strategic research. The financial arrangements for university research were undergoing a

profound change while the Committee were conducting their enquiry. The Committee have not attempted in this enquiry to focus directly upon the UGC but it is evident that its present difficulties are substantial, and it is to be hoped that the Review Committee on the University Grants Committee (the Croham Committee) will be able to make recommendations on the administrative arrangements which will assist the UGC towards a new equilibrium. The Committee consider that both parts of the dual support system are now inadequately funded and urge the Government to look again at the situation which is emerging. The Committee wish to comment particularly on some of the implications of the changed situation now coming about in university research.

6.98 Whereas formerly selectivity was essentially applied through only one part of the dual support system, UGC selectivity being marginal and unsystematic, since 1986 both parts are engaged in judging research quality, the Research Councils as before on a project by project basis, the UGC for the first time through a broader, department against department, approach. It is also apparent that the measures used by the Research Councils and the UGC are necessarily connected, though only the UGC is concerned with each university taken as a whole. The Committee accept that in its first selectivity exercise in 1986, the UGC made the best assessments it could in the limited time and with the limited information available to it.

6.99 The Committee welcome the willingness of the Secretary of State for Education and Science to take up with the UGC that it repeat its selectivity exercise in two or three rather than four or five years (Q 1691). This is certainly desirable, bearing in mind the complexities of the exercise and the inevitability of some misjudgements having been made. UGC selectivity not only affects the distribution of public funds but will also influence potential benefactors and schools in their advice to intending students. The assessment process should be more open than that in 1986, with clearer identification of the performance indicators used. The Committee share Sir Peter Swinnerton-Dyer's reluctance to establish within the UGC an elaborate assessment bureaucracy, nor would they support a system of appeals, recognising that by its very nature selectivity will never satisfy everyone.

6.100 Repeated selectivity must be expected to lead to a limited number of centres of excellence in any field, together with a larger number of locations in which the research is little more than that necessary to support the teaching function. This trend is reinforced by the fact that the Government has recently made available funds as a contribution to equipping a few selected centres to the highest international standards.

6.101 It may be that concentration of this kind would be desirable even in a system more generously funded than is the present one, but the Committee are nevertheless doubtful that the long term consequences of the policy shift of 1986 have been fully thought through by all those responsible for it, the more so in that the UGC is looking to universities to strengthen only a few of the departments it has judged to be weak.

6.102 Universities faced with cuts in public funds have looked increasingly to collaboration with industry. To a greater or lesser extent all universities have done this in recent years, some with spectacular success. In 1984-85 the research income of all universities from industry was 78 per cent up on 1981-82, at £47 m (Q 1671) and indications are that it is continuing to increase rapidly. Determined efforts should continue to be made, and from each side, to break down whatever barriers have frustrated symbiosis in the past, and the Government should also recognise its responsibility. The internal differences between universities, and to a limited extent the differences in their industrial hinterlands, mean that no simple comparison can be made between universities as regards their involvement with industry, but it is nonetheless right that, carefully handled, this should be a criterion in their evaluation.

6.103 If closer university-industry association assists in overcoming what is commonly agreed to be a long-standing British problem, turning laboratory prototypes into commercially successful products, it is obviously very desirable. If it finds reflection in teaching it could confer a further benefit by helping students to appreciate better the significance of industry and the potential inherent in industrial careers. Since some private funds which universities attract are likely to come from local companies, to be welcomed too is the closer identification which can result between a university and its immediate community. But the universities must guard against the distortions and erosion of scientific capital which can follow from too great a dependence on contract income. Here again the UGC has a key role, in that it alone can take a comprehensive view of each university within the overall system. It is also essential that each university find for itself the approach most suited to its circumstances, recognising that major support from industry will normally have to be built on proven success in more modest involvements.

6.104 The contribution of higher education institutions to civil R & D will be enhanced if they have links with Research Council institutes and Government research establishments (GREs). The Institutes and GREs will benefit likewise. Although relatively little evidence was received directly on GREs, it was apparent that some witnesses entertained doubts about them. There is general agreement that GREs are justified where they provide services directly to government, for example in maintaining and promoting national standards, but there is less conviction about their cost-effectiveness in providing services outside government. However, the issues involved are complex and the Committee hope to return to this subject in a future enquiry. What is certain is that the closest possible links are desirable between GREs and Research Council institutes and adjacent universities and polytechnics. The Committee believe there is scope for considerable improvement in this direction.

6.105 The Committee have noted that in their research contracts with universities government departments and industry are unwilling, and often refuse, to pay overheads as specified in UGC guidelines. The Committee see this as unacceptable, especially at a time when the universities are facing such severe financial stringency. The Committee consider that government departments must adopt the guidelines forthwith, setting an example to industry to do likewise.

6.106 The polytechnics, not having had the benefit of a dual support system, are the more to be commended for their efforts to sustain an R & D capability. With them the emphasis is firmly on applied research and on development and, generally, on the particular needs of companies in their immediate vicinity. The Committee approve the provisions of the Further Education Act 1985 in allowing polytechnics to sell commercially their research and consultancy services, and the Committee also think it right that the NAB has moved to establish a research fund. The Committee hope that in future years a sum nearer the original target of £20 m will be available through this fund rather than the £2.5 m to which financial constraints limited it in 1985/86. The Committee reiterate the importance of offering only selective support, sensitive to the existing and emerging potential of departments.

6.107 The higher education world of the future will, if present policies are continued, have considerably more diversity even than it did in the past. At any given level of public funding the resulting system will be stronger the more each institution plays to its natural advantages. This is not a substitute for more generous funding, only a restatement of the basic principles of survival.

G Education and Training

6.108 The Committee concluded in 1984 in their Report on Education and Training for New Technologies that technological progress in the United Kingdom was being hampered by failure properly to develop the country's human resources. The Committee wish to put the conclusions of that Report in a wider perspective and to draw attention to the urgent need to ensure that science, technology and their industrial implications are fully reflected at the primary and secondary levels of education no less than at the tertiary. A shortage of good science and technology teachers is bound to leave its mark, yet this has for many years been a British problem, and one which it seems demography is currently making worse since teaching is now having to struggle to obtain its share of qualified people. Though commending the efforts being made in this connection by the DES the Committee are seriously concerned about this situation. Provision for science and technology has to be a major objective at all levels in British education. The Committee accept that the reason this is not now the case is only partly the responsibility of the education system, in that society's reward and status systems fail to signal the crucial place of science and technology in Britain's future. Exhortation to young people to study science and technology is not likely to have lasting impact when market signals are pointing in the opposite direction.

6.109 With regard to the production of graduates, two serious problems must be tackled with renewed determination—the small number of women who are attracted into engineering and the excess of science over engineering graduates. In both respects the United Kingdom continues to be out of line with its international competitors and in the Committee's opinion both must be to its disadvantage. In addition, the Committee strongly support curriculum changes designed to make British engineers more flexible. The Committee believe that the proposed Council for Science and Technology would wish to monitor these matters very closely.

H International Collaboration

6.110 By comparison with the disappointments of earlier decades, in recent years scientific and technological collaboration in Europe has made some important and confident strides. Further-

more, this appears to be true not only of programmes within the European Community, in particular ESPRIT, RACE and BRITE,[1] but also of initiatives outside it such as EUREKA,[2] the European Space Agency and the European Science Foundation. The difficulties and disadvantages of collaboration are now better understood than they were, and there has also emerged a sounder sense of realism. At the same time the scientific and technological challenge from Japan and the United States is more clearly appreciated and this has provided a context against which the benefits of collaboration can themselves be more reliably assessed. Another significant shift which has occurred is that instead of the momentum of collaboration deriving only, or mainly, from governments and the Commission, it is companies, universities and laboratories which in the new climate are increasingly making the running. This must be a healthy development for it is these bodies, and not bureaucracies whether national or supranational, which are in close touch with the moving edge of technical change. They can therefore be looked to for a more accurate assessment of what is feasible—and what is truly appropriate—at the international level.

6.111 All this the Committee naturally welcome. At the same time it cannot be assumed that the problems of collaboration will soon disappear, or that its potential in every case will be realised. The Committee are still uncomfortable with the degree of bureaucracy which seems inherent to international programmes and projects, above all in that this may be particularly discouraging to the smaller organisations in Europe which might benefit from collaboration. They also suspect that collaboration would be advantageous in some less technologically glamorous areas than those which tend to receive most international attention. The Committee are aware too that the rewards from successful precompetitive research have to be converted into profits and that this involves a difficult interface. And despite the force of the American and Japanese challenges as motivations, the Committee also think it unrealistic, as well as undesirable, for collaboration always to be conceived in an exclusively European framework. However, despite these reservations, Europe now has a firm foundation in collaboration on which it should steadily build. The historical significance of this should certainly not be underestimated.

6.112 What changes in policy might be called for in Britain to capitalise fully on the new mood in Europe? The Committee accept that overall British organisations have probably enjoyed a more than proportionate access to European collaborative resources. It still does not follow, however, that British interests are all as aware as they should be of what is possible in the European scheme of things. All national bodies in Britain, and not only the Government, have a role here. The things to be aimed at are maximum dissemination of information about current and forthcoming initiatives in Europe, proposals which are sound, relevant and correctly formulated, and the facilitation of European contacts out of which suitable partners may be found. This subject again could be expected to commend itself to the proposed Council for Science and Technology.

6.113 The Committee have no quarrel with two principles insisted upon by the Treasury, that the United Kingdom contribution to R & D expenditure financed through the European Community should be attributed to the departments broadly in accordance with the balance between different types of activity, and that departments should adopt the "same rigorous approach to the scientific and technological quality of Community research proposals and their value for money in meeting policy objectives as they would for other R & D proposals." (P256) The Committee however make three points. First, these principles assume that departments operate the same criteria in R & D evaluation, though there has been no mechanism for ensuring this, and in particular the Treasury has none: the new Science and Technology Assessment Office may in due course be able to help here. Second, "value for money in meeting policy objectives" is inescapably a matter finally for professional judgement and this may be expected to be considerably harder to make when the benefits of proposed R & D are not only uncertain but may also be exploited differentially by the various collaborating partners. Third, the Committee cannot see why, because one research institution has obtained funding from the European Community, that institution or another should in consequence find that its funds from the Government have been reduced. In any event, the evidence shows that there is much confusion about the financial mechanisms. Many witnesses consider that these act as a disincentive to seeking EC funding. If this is correct the system needs changing; if it is not, the position should be clarified.

[1] ESPRIT—European Strategic Programme for Research and Development in Information Technology
RACE—R & D in Advanced Communications - technologies in Europe
BRITE—Basic Research in Industrial Technologies for Europe
[2] EUREKA - European Research C(K)o-ordinating Agency

I The Management of Research

6.114 The Committee believe there is no central organisation which would be proof against managerial weaknesses, and the stresses on management have been exceptionally testing in Britain in recent years. These opinions raise several managerial issues which bear upon the "science system". The first issue is whether the management of science, as part of civil service management in general, is now as professional as was intended when the Civil Service College was set up. The Committee have not taken evidence directly on this since it introduces dimensions wider than their present concerns, but it is not minor in its implications for R & D performance. A closely related matter is whether the career experience of those with executive responsibility is as varied as it needs to be. The Committee suspect that the sharp divisions in Britain between the university, governmental and industrial sectors continue to militate against this. A third question is whether senior managers have the time, or failing this the appropriate staff assistance, to enable them to see beyond their current set of commitments and pressures. A fourth problem centres on the fact that the management of science and the management of engineering (but not engineering research) and technology are different enough from each other to require distinct managerial styles. The Committee's enquiry left them doubtful that this point has been fully taken.

6.115 There is also to be considered the accountability of the system, and this will become especially significant if further centralisation occurs within it. Decision making and implementation processes require to be as transparent as possible and it is not only those who receive public funds who should provide detailed information about their use. It should also be incumbent upon those who dispense these funds to account in detail for their actions. Accountability here is not just a matter of constitutional nicety: rather, it contains within itself the potential to be a powerful managerial technique.

6.116 The Committee have also considered the evaluation of R & D. By this is meant a wide range of approaches ranging from *ex ante* techniques such as peer review, through interim monitoring of various kinds, to *ex post* methods, including those quantitative ones based upon bibliometric analysis. It is clear that the methodology of evaluation is itself less scientific than the science and technology it is designed to assess. Even peer review, the most traditional of all methods, has its problems—it can for instance discriminate against new researchers and be less reliable in fields having few genuine peers. The Committee commend academic efforts to improve this situation and also practical application of the available techniques. The aim should be uniform standards of evaluation across all sectors of public R & D, with evaluations addressing such criteria as economic, social and scientific returns; relevance to explicit policy goals; and straightforward programme and project efficiency. This need not entail any rigidity of method and the Committee concur with the view put to them that it is appropriate for evaluation to attract about 1 per cent of all government R & D expenditure (Q 1164, p434). Evaluation must be approached as a discipline not as a threat and this is an area where the proposed Council for Science and Technology could give valuable guidance.

J The Civil Implications of Defence R & D

Defence/Civil R & D Resources

6.117 At a figure of about £2,300 m in 1985/86 defence R & D accounts for over half of the total Government expenditure on R & D, and the proportion is projected to increase over the next few years.[1] Moreover, with the exception of the USA, British spending on military R & D in 1983 consumed a much larger share of GDP than any of our Allies or main economic competitors,[2] and as all spend broadly similar proportions of their GDP on R & D,[3] it follows that the United Kingdom spends a much larger share of its total R & D expenditure on defence.

6.118 Of equal and, arguably, even greater significance to the national economy is the employment on defence R & D of a large proportion of the nation's qualified scientists and engineers (QSEs). Quoted information on the deployment of manpower in the private sector on defence R & D is scarce, but from a total national pool of some 65,000 QSEs[4] 4,700 are employed on R & D directly by MoD[5] and from this it has been estimated that more than one quarter of the skilled

[1] Annual Review of Government Funded R & D 1986, Tables A.1 and A.3
[2] Kaldor, Sharp and Walker, Industrial Competitiveness and Britain's Defence, Lloyds Bank Review, Oct 1986
[3] Annual Review of Government Funded R & D 1986, Table F.2
[4] British Business, Jan 18 1985
[5] Annual Review of Government Funded R & D 1985, Table 7.1

scientific and technical effort of the country is associated with the procurement of military equipment.[1] Whatever the precise figures, there can be no doubt that a substantial share of the nation's QSE manpower is working at the leading edge of modern science and technology in demanding defence areas such as electronics, in its many forms, and aerospace.

6.119 Against this background, the wisdom of committing such a high proportion of R & D resources, both financial and qualified manpower, exclusively to defence at a time when the resources deployed on civil R & D are under such heavy pressure has become a subject of urgent and growing importance. It is not surprising therefore that, almost without exception, evidence received by the Committee from those not concerned with defence R & D strongly attacked the current priority given to it (Q 153). The broad argument underlying this evidence is that the pursuit of military R & D drains resources that should, in current circumstances, be better employed nationally to greater benefit or, even more critically, that the greatest current threat to national security is a failure to reverse the trend of economic decline and this is not reflected adequately in the Government funding of civil R & D when compared with defence R & D.

6.120 The Committee agree with the Fellowship of Engineering that "if the post war period is viewed as a whole ... defence and defence-related R & D has weakened civil research initiative, especially in industry, and ... this has had a harmful effect on product innovation and industrial competitiveness" (p133). Several factors contributed to this weakening. In the early years defence R & D establishments continued to grow and QSEs were attracted to them by the challenging problems and excellent facilities, also defence work performed by industry was generously funded which reinforced industries' own short-sighted attitude to the private funding of its own R & D. At the same time British Armed Forces were the customer and little attention was paid to overseas military markets in the design of equipment. The demanding specifications of defence equipment led to different design attitudes in the industrial civil and defence R & D teams and even, in some cases, to physical separation within the same company.

6.121 Since then, with growing Ministerial awareness of the dangers of a rapidly increasing ratio of military R & D cost to production cost, steps have been taken within MoD to improve the effectiveness of equipment procurement, reduce R & D costs and increase production possibilities. For example, international collaboration on major projects, although not without its problems, is an essential policy objective and is now pursued vigorously, also the export of defence equipment is a prominent element of our export performance. Marketing initiatives have improved against intense international competition and the overseas market is a more significant factor in procurement decisions. Over the last three years the greater use of competition in the placing of R & D contracts has achieved marked success and steps have been taken to widen the range of potential suppliers. Within the Department the strength of the R & D establishments has been reduced substantially from 34,000 in 1971 to 23,000 in 1985 with further reductions planned. More of their work has moved to industry and their function is now tending towards that of assisting MoD to fulfil its role as an "informed customer of the defence industry".

6.122 The Committee commend the various initiatives taken so far within MoD but are far from satisfied that the wider implications of the substantial national investment in defence R & D have received sufficient examination. Sir Robin Nicholson was of the view (Q 47) that "the amount of money the Secretary of State for defence chooses to spend on R & D out of his £18 billion budget does not directly affect the outcome of the bilateral negotiation between the Secretary of State for Education and the Treasury for his budget". He considered it "rather facile" to believe that the science budget is "too small" because the defence spend is "too large", but accepted the possibility that "in some areas the MoD is so dominant—for example in electronics and in some of the computer areas—that there are not the people to do the research in the civil area or in the scientific area because so many of them have been taken up by the MoD spend".

6.123 The full economic implications of defence R & D are complex and the lack of relevant statistics on certain elements of the subject compound the problem. Several recent studies which were brought to the notice of the Committee have attempted to examine in some depth the origins of the present defence R & D programme, appropriate international comparisons, the resource allocations, the impact of defence R & D on the competitiveness of manufacturing industry and the merits of international collaboration in defence procurement. A critical analysis by the Science Policy Research Unit[2] which draws heavily on international comparisons, (see Chapter 4), deduces

[1] Kaldor, Sharp and Walker, Industrial Competitiveness and Britain's Defence, Lloyds Bank Review, Oct 1986
[2] Kaldor, Sharp and Walker Oct 1986

that the military divisions of industrial companies serving defence markets tend to employ highly qualified manpower more intensively than their civil divisions, with the emphasis on product performance as against process efficiency, and that management's knowledge of and ability to compete in the increasingly competitive market of civilian high technology has been eroded by their defence commitment. It concludes that "on available evidence for the present the defence sector, far from helping promote the competitiveness of British Industry, actually detracts from it" and that "if Britain is to break the vicious circle of decline, an important precondition must be a reduction in the relative size of the defence sector and level of military R & D." Another report[1] found that "our study has not uncovered grave deficiencies in Military R & D in Britain calling for urgent, radical action. But .... present policies and practices should be revised over the next few years ... to ensure a reduction of overall effort and concentration of resources, a closer relation with other sectors of national scientific and technological activity and more public accountability".

6.124 From much of the evidence received the Committee are conscious of the possibility of misunderstanding and misinterpretation of the relatively massive expenditure on defence R & D and feel it necessary to put it into the perspective of their enquiry.

6.125 The defence R & D programme, first and foremost, is formulated to support the procurement responsibility of the department in meeting the weapon and equipment needs of the Armed Forces.[2] The development work (£1,933 m in 1985/86)[3] is directly related, item by item, to the design, development and procurement of specific military equipments such as particular aircraft or radars for which definite operational requirements have been established, and is the essential forerunner of their production. It accounts for 80 per cent of defence R & D expenditure,[4] has little parallel in other Government departments and is spent mostly in British industry. In the later stages of development attention is focussed on prototype manufacture, trials and testing, activities which are not so demanding of highly qualified manpower. About 15 per cent of defence equipment is produced collaboratively, and 5 per cent is produced by direct purchase from abroad (Q 1305). Research work is aimed at producing an underlying base of scientific and technological expertise for application to the selection, development, production and operation of weapon systems or equipments. In 1985/86 it accounted for about £400 m[5] and was thus similar to the sums spent on research by DTI, the Research Councils and the UGC.

6.126 Earlier (para 6.122) the Committee expressed their general support for initiatives taken by MoD to obtain improved efficiency and better value for money from their procurement programme, but they agree with the Council for Science and Society[6] and Sir Robin Nicholson (Q 47) that the scope for significantly reducing defence expenditure on R & D by other than radical means is strictly limited. The Committee accept the broad level of research funding as a not unreasonable sum to support the present development programme, and are of the view that to reduce the development expenditure significantly requires either a major change in defence policy or a change in procurement policy aimed at a sharp reduction in indigenous manufacture of defence equipment. These matters fall far beyond the limits of their enquiry and the Committee do not wish therefore, in this report, to comment further on the overall level of defence R & D expenditure. But neither do they wish to conceal their concern over the substantial proportion of R & D resources committed to the defence equipment programme. The Committee emphasise the need for procurement decisions to pay greater regard to the more effective use of resources of both money and manpower in the broader national interest as well as in the narrower defence interest. The Committee expect a thorough examination of defence R & D expenditure in its many facets to be an early and important task for the proposed Council for Science and Technology using the Science and Technology Assessment Office (Q 1283).

Spin-Off

6.127 Whatever the overall levels and balance between defence and civil R & D expenditure, defence R & D, by its very nature, will always be concerned with the "sharp edge" of advanced science and technology and therefore has an important role to play in the development of high

[1] Council for Science and Society, UK Military R & D, 1986
[2] Annual Review of Government Funded R & D 1986, para 1.11
[3] Annual Review of Government Funded R & D 1986, Table A.1
[4] Annual Review of Government Funded R & D 1986, Table A.1
[5] Statement on the Defence Estimates 1986, Table 3.1
[6] Council for Science and Society, UK Military R & D 1986

technology in the civil sector. In their report *Science and Government* in 1981 the Committee[1] considered the interface betwen defence and civil R & D and made several organisational proposals for more effective communication of defence work to industry and other civil fields. A joint ACARD/ABRC study in 1983[2] stated "there has been, and remains, considerable concern that the very large research effort devoted to defence purposes . . . is not sufficiently exploited for commercial purposes". In *Engineering Research and Development* in 1983[3] the Committee again expressed its concern over the matter and in response the Government[4] endorsed "the need for positive steps to enhance the level of significant civil spin-off" and outlined the steps that were being taken. It was raised yet again in the Committee's enquiry into Marine Science and Technology in 1985.[5]

6.128 There are many examples of military technical innovation which have diffused successfully into civil application (pp 357, 469). Furthermore in the Defence Estimates 1986 it is stated "In the wider field of research and development we are looking at the relative priorities of civil and defence needs for scarce scientific and technical resources. Our aim is to increase the contribution that these resources make to the development of the economy." Nevertheless it is quite clear from the evidence received by the Committee that serious doubts still remain about whether the problem is being tackled sufficiently energetically, (Q 731) or even whether the will really exists to make it happen (Q 154).

6.129 In assessing the evidence the Committee have found it necessary once again to consider defence development separately from defence research. This is not because of the different sums of money involved but because the prospects for civil exploitation are different in the two areas.

6.130 When a project is in development the enabling technologies have largely been established in the earlier research and the project proceeds against a tight specification to high military standards for the manufacture of a particular product or system. Security considerations and the military standards of quality may demand separation of the team from related civil work in the company. In general the supplier, with his subcontractors, will take the lead in commercial exploitation of the product which is most likely to be aimed at other military markets either by a direct supply of the product or through licencing agreements. Any civil version or derivative will generally need extensive modification to meet market pressures. Industrial Property Rights (IPR) will depend upon the funding arrangements for the project, but in a fully funded contract MoD will obtain free use of Industrial Property and the flexibility to offer elsewhere if progress on exploitation is considered to be unsatisfactory.

6.131 In 1983 Sir Ieuan Maddock[6] argued that too little was being done within the major electronic defence contractors to encourage spin-off. The Committee also concluded in their 1983 Engineering R & D report that there was the need to increase the spin-off from MoD contracts by widening the circle of firms which are awarded defence contracts or sub-contracts or which are given access to defence R & D results that show promise for civil fields. Whilst recognising that the possibilities may be limited, for the reasons mentioned above, the Committee again recommend that MoD examine the machinery that is needed to pursue more vigorously the industrial opportunities for gaining more civil benefit from the very large development expenditure.

6.132 Better opportunities for innovation and spin-off arise from the £400 m research budget. £140 m of this is carried out in industry to underpin its technology base in key, high technology areas as a prelude to development activity, £10 m is carried out in HEIs on directly commissioned research to sustain relevant scientific capabilities there and the remaining £250 m is spent on the management, test facilities and intramural programmes of the R & D establishments (Q 1317). The establishments provide the skills and unique test facilities for an additional £40 m of work for the civil sector (p403), largely in aerospace and electronics, which is paid for by civil Ministries (notably DTI), industry and other agencies. Numerous formal arrangements exist for consultations and coordination of these programmes with workers in industry, ministries and other Government Departments and valuable, though unquantifiable, personal links are forged with staff who are concerned with civil as well as military research. The results of the research are disseminated,

[1] 1st Report, Session 1981-82, HL20
[2] Cmnd 8957, para 4.26
[3] 2nd Report, Session 1982-83, HL89
[4] 3rd Report, Session 1983-84, HL218
[5] 2nd Report, Session 1985-86, HL47
[6] Civil Exploitation of Defence Technology, Report to the Electronics EDC, NEDO, 1983

within security constraints, through learned journals, the Defence Research Information Centre, patenting, and through commercial exploitation by the Ministry or the British Technology Group.

6.133 Whilst, it is strongly argued, and not disputed, that spin-off from defence is no substitute for direct funding to the civil field, whether in universities or in industry, much of the evidence acknowledges the past value of defence research. This lies often as much in the positive interaction of specialists on the two sides, and in the exchanges on the enabling technologies and processes, as in the direct product applications. "I cannot think of a major area of military research which has not generated a very great deal of spin-off" (Q 845).[1] "There is no doubt the military research certainly provides a spin-off as shown in the past" (Q 1044)[2] "I think there is a great deal of spin-off" (Q 728).[3]

6.134 But equally the evidence indicates that there is still room for improvement (Q 154, pp 118, 223).[4] It suggests that technology transfer is still constrained by the lack of information to a wider audience about the work in progress and the facilities available in the defence establishments. The comments centre on three widely held views, first that more defence-related research could be done in HEIs where similar civil work is undertaken and, secondly, that access to defence research and the establishment concerned is too tightly confined to groups already known to the establishment teams. Small firms in particular seem poorly informed and think that spin-off would be greatly improved if MoD research was spread more generally to the smaller companies and research organisations where, in contrast to the larger companies, the same staff are employed alternatively on civil and military projects. Thirdly it is felt that compared with other countries, particularly the USA, the security risk is overstated and the work overclassified.

6.135 The Committee are encouraged by the higher priority now attached by MoD to enhancing spin-off and the more positive attention being paid to it. They support the renewed attempt to arrange more staff exchanges with industry and the Research Councils and the discussions with the Research Councils to explore the possibilities of making more effective use of MoD's research facilities. But more significantly, the Committee note the two new initiatives taken towards the end of 1985, the joint MoD/Research Council grant scheme and the formation of Defence Technology Enterprises (see para 3.26).

6.136 The Committee recognise that it is too soon to assess the success of these two initiatives. With regard to the joint grant scheme the Committee do not share the anxiety of some[5] that given the present shortage of Research Council funds the military interest might considerably affect the direction of research since the subjects chosen will be pursued only if already of interest to the academic community. They welcome the assurance given by the SERC (p116), through whom most of the work is likely to be done, that the subjects will be unclassified and that publication in accordance with academic practice will normally be expected. The Committee fully support the objectives of these two schemes and wish to see them pursued energetically.

6.137 Security considerations, it is argued, make it necessary for much defence R & D to be conducted out of sight of the public. But the Committee are disturbed that the criticism of over-classified research should still be made and associate with it the need for a more open attitude towards disclosure. Relevant information can be gleaned from different sources but it is clear from the evidence that the defence R & D scene and associated statistics can be easily misunderstood. Comparison with the United States on this topic raises delicate policy issues, but the qualitative and quantitative documentation on R & D published annually by the Pentagon is revealing. More information is now made available in the Defence Estimates and the Annual Review, but with the subject now so prominent in public debate the Committee recommend publication of a more detailed annual report on defence R & D, including a clear distinction between R and D.

[1] The Plessey Company plc
[2] Association ofIndependent Research and Technology Organisations
[3] GEC plc
[4] Sir John Kingman, Fellowship of Engineering, The Royal Society
[5] PP73, 109

CHAPTER 7 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

7.1. The advance of science and technology, which is essential to the economic recovery of the country, must be a central objective of government policy. A recognised policy for the public support of R & D is required. (paras. 6.1, 12-14).

7.2. A new impetus is needed to raise the morale and focus the effort of the scientific community and industry. This requires action at the highest levels of government. (paras. 1.9, 6.25).

7.3. Both research and development in the United Kingdom are underfunded. Neither government nor industry is spending enough at present levels to restore the United Kingdom's industrial position in world markets. (paras. 6.2, 16).

7.4. Departmental policies and spending on R & D must be looked at horizontally across the whole of government, in addition to the traditional vertical look by individual Departments. (para. 6.18).

Central Structure

7.5. A Minister in the Cabinet should be designated to be responsible, under the Prime Minister, for the science and technology dimension of government policy and the promotion of national effort in R & D. (paras. 6.26-30).

7.6. A Council on Science and Technology should be established, under the chairmanship of the Prime Minister with the designated Minister as deputy. Its secretariat should be located in the Cabinet Office under the Chief Scientific Adviser. It would oversee the *whole* of scientific and technological endeavour, absorb the Advisory Council for Applied Research and Development and submit an annual science and technology statement to Parliament. (paras. 6.32-39).

Research Councils

7.7. The Research Councils should as far as practicable harmonise their administrative procedures, criteria and approaches and work more closely together on corporate planning, marketing of results and external relations. (para. 6.44).

7.8. Strong management and clear decisions about priorities between Research Councils are essential in present circumstances. The Advisory Board for the Research Councils should continue to expand its executive role, and the Government should discuss the implications of this development with the Board, the Research Councils and other interested parties. (paras. 6.45-6).

7.9. The Committee favour evolutionary progress, recognising that this might lead to the eventual unification of the Councils. (paras. 6.40-44).

Methods of Funding Research

7.10. The concept of the Science Budget is a good one and should be preserved. (para. 6.55).

7.11. It is right to devote part of the Science Budget to areas which can be identified as offering some prospect of economic benefit to the country. (para. 6.19).

7.12. The costs of superannuation, restructuring and international subscriptions should be separately itemised in the Science Budget, and if for any year these costs rise significantly the Science Budget should be correspondingly increased. (para. 6.56).

7.13. The customer/contractor principle for R & D funded by government departments is endorsed. Departments should ensure that their scientific strength is adequate to conduct an informed dialogue with research contractors. (paras. 6.59-60).

7.14. A 10 per cent surcharge should be added to all government contracts for commissioned research, as originally recommended in the Rothschild report. (para. 6.61).

7.15. In addition to the dual support system and the customer/contractor principle, a third method of public funding of R & D is required. (para. 6.48).

7.16. To this end a process should be introduced for funding that strategic research which is of most significance to the United Kingdom's economic future. The Research Councils and Government Departments, as proxy customers in non-commercial fields, should retain their responsibility for some strategic research. (paras. 6.66-67).

7.17. The Government should assist in the funding of the process for generating strategic research in the exploitable areas of science, and should make new pump-priming funds available for research generated by the process. (para. 6.71).

7.18. Any other initiative to ensure that the Government's R & D funding makes a greater contribution to the economic well-being of the country is to be welcomed, but it must be adequately funded and its relationship with exploitable areas of science must be clarified. (para. 6.73).

7.19. The Science and Technology Assessment Office is welcomed in its own right and also to help evaluate the operation of the exploitable areas of science process. (paras. 6.74, 6.76).

7.20. Approximately 1 per cent of all government R & D expenditure should be devoted to evaluation. (para. 6.116).

Industrial R & D

7.21. The development phase, the "D" of R & D, must receive substantially more attention, or the United Kingdom's research effort will go to waste. The main responsibility for "D" rests with industry but some public support is essential to allow fair competition in international markets. (paras. 6.81-82).

7.22. All possible steps should be taken to persuade shareholders and managers of the need for, and advantages of, R & D. (paras. 6.85-87, 6.93).

7.23. The total amount of DTI support for industry must be increased. In addition to support for collaborative ventures and awareness programmes, targeted and generous support for a new product and process development scheme is necessary. (paras. 6.88-89).

7.24. Other countries stimulate private R & D through the tax system. The Government should examine further tax incentives in the United Kingdom for this purpose. (para. 6.90).

7.25. Legislation should be introduced to require companies to disclose their R & D expenditure in their Annual Accounts. (para. 6.91).

7.26. Much greater efforts must be made to exploit the potential of public purchasing as an instrument for stimulating R & D in the private sector. (para. 6.92).

7.27. The Government should expand its efforts to assist industries large and small to increase their knowledge and awareness of R & D results from overseas. (para. 6.95).

7.28. The statistical information relating to private R & D is inadequate. The Government, in cooperation with the CBI and other trade bodies, should seek ways of bringing this up to the standard of information on public R & D. (para. 6.84).

7.29. Government should do more to meet the R & D needs of small firms. (para. 6.96).

Higher Education

7.30. Further collaboration between higher education institutions and industry should be actively fostered. (paras. 6.72, 6.102-103).

7.31. The University Grants Committee's selectivity exercise should be repeated in less than five years and the process be more open in future. (para. 6.99).

7.32. Polytechnics have a valuable contribution to make to R & D in selected areas. In future years the research fund established by the National Advisory Body should be increased. (para. 6.106).

7.33. Closer links are desirable between government research establishments and research council institutes and adjacent universities and polytechnics. (para. 104).

7.34. Government departments must adopt forthwith the UGC guidelines on overhead payments in research contracts with universities. (para. 105)

7.35. British output of engineers must be brought more in line with that of its international competitors. (para. 6.109).

International Collaboration

7.36. A positive attitude to international collaboration in R & D is to be encouraged. Treasury rules relating to EEC or international R & D funding should, as necessary, be amended or clarified. (paras. 6.14, 6.113).

Civil Implications of Defence R & D

7.37. Civil and defence R & D budgets should normally be recorded separately. The size of each should be determined by the civil and defence programmes which they support. The Committee draw attention to the consequences of the high proportion (over 50 per cent) of the total R & D budget devoted to defence and recommend that a thorough examination of defence R & D expenditure should be an early task of the Science and Technology Assessment Office and the proposed Council for Science and Technology. (para. 6.6-7, 6.126).

7.38. The Committee welcome recent initiatives to improve the effectiveness of defence procurement, reduce R & D costs, and increase spin-off, and recommend that further efforts be made to pursue the industrial opportunities for obtaining more civil benefit from defence R & D. (paras. 6.122, 134-136).

7.39. The security classification of the results of defence R & D should again be examined with a view to introducing a more liberal policy, and a more detailed annual report on the results of defence R & D should be published. (para. 6.137).

Conclusion

7.40. The Committee's enquiry has revealed the gravity of the United Kingdom's prospects in R & D. To remedy this, the Committee have recommended a high profile for science and technology, dynamic leadership at the centre, and a new approach to funding R & D. These all matter greatly. But what matters most is the determination of both the public and the private sectors to create new confidence and to restore the United Kingdom's prosperity and its international position in science and in industry.

APPENDIX 1

Sub-Committee I (Civil R&D)

The members of the Sub-Committee which conducted the enquiry were:

V. Blakenham
L. Butterworth
E. Cranbrook
L. Flowers
L. Gregson
L. Hunter of Newington
L. Melchett
L. Shackleton
L. Sherfield (Chairman)
B. White

APPENDIX 2

The following gave written evidence, except where otherwise marked.

Witnesses who gave oral and written evidence are marked*

Witnesses who gave oral evidence only are marked**

**Advisory Board for the Research Councils
**Advisory Council for Applied Research and Development
*Agricultural and Food Research Council
R J Allwood, University of Technology, Loughborough
Antec Systems Ltd
Professor E A Ash, Rector, Imperial College of Science and Technology
*Professor J M Ashworth, Vice-Chancellor, University of Salford
Association of British Pharmaceutical Industries
Association of Consulting Engineers
*Association of Independent Research and Technology Organisations
Biochemical Society
Biological Council
Birkbeck College, University of London
Brighton Polytechnic, Mr Geoffrey Hall, Director
British Aerospace
British Association for Cancer Research
British Bryological Society
British Cartographic Society
British Computer Society
British Embassy, Bonn
British Embassy, Paris
British Embassy, Tokyo
British Geriatrics Society (Scientific Committee)
British Lichen Society
British Microcirculation Society
British Mycological Society (President)
British Petroleum Company plc
British Pharmacological Society
British Psychological Society
British Society for Plant Pathology
British Society for Research on Ageing
British Society of Animal Production
British Society of Soil Science
British Telecom
British Veterinary Association
Building and Civil Engineering EDC (Research Strategy Committee)
Bureau of Applied Sciences Limited (Dr B Denness)
Cancer Research Campaign
Professor Elizabeth Canning, President, Society of Protozoologists
Mr A D Caplin, Imperial College
*Confederation of British Industry
Dr R E Challos, University of Keele
Chartered Institution of Building Services Engineers
Chemical Industries Association
Clinical Research Nurses' Association
*Sir John Collyear, Chairman, DTI Technology Requirements Board
Committee of Directors of Polytechnics
Committee of Vice-Chancellors and Principals
Coventry (Lanchester) Polytechnic
Mr F K Cowey
Professor A S G Curtis, Department of Cell Biology, University of Glasgow
Mr Norman S Curtis, Whitbread & Company
Professor J B Dawson, Department of Geology, University of Sheffield
Defence Manufacturers Association
*Department of Education and Science
Department of Energy

*Department of the Environment
Department of Health and Social Security
*Department of Trade and Industry
Department of Transport
**Domnick Hunter Filters Limited (Mr B Thompson)
Professor Peter Dunnill, University College London
*Economic and Social Research Council
Efamol Limited (Dr D Horrobin)
Electronic Components Industry Federation
Engineering Council
Ergonomics Society
**Mr John Fairclough, Chief Scientific Adviser, Cabinet Office
*Fellowship of Engineering
Ferranti plc
Glyn Ford, MEP
*General Electric Company
Professor B S Hartley FRS, Imperial College of Science and Technology
Miss Ros Herman
Houghton Poultry Research Station
Mr R L Hoult
Hydraulics Research Limited
IBM United Kingdom Limited
Imperial Chemical Industries plc (ICI)
International Computers Limited (ICL)
Imperial Cancer Research Fund
Institute of Biology
Institute of Energy
Institute of Horticulture
Institute of Marine Engineers
Institute of Physics
Institution of Chemical Engineers
Institution of Civil Engineers
Institution of Electrical Engineers
Institution of Electronic and Radio Engineers
Institution of Gas Engineers
Institution of Production Engineers
Institution of Professional Civil Servants (British Geological Survey Section)
**Integrated Micro Products Limited (Mr S M I'Anson)
Professor Irvine, University of Manchester
Dr J N R Jeffers, Director, Institute of Terrestrial Ecology
Professor Bryan Jennett, Faculty of Medicine, University of Glasgow
Professor David A Jones, Department of Plant Biology and Genetics, University of Hull
**Joyce-Loebl (Vickers plc) (Mr J N Batie)
**Sir John Kingman
Dr R I Kitney, Imperial College
Kingston Polytechnic
**Lancashire Fittings Ltd (Dr R J Wakelin)
Sir James Lighthill, University College London
Professor D A Linkens, University of Sheffield
Linnean Society of London
Robert MacKay, University of Warwick
Ministry of Agriculture, Fisheries and Food
Professor Peter Maitlis, University of Sheffield
*Mecial Research Council
Mr Peter C Michael, UEI plc
**Microvitec plc (Dr A Martinez, OBE)
*Ministry of Defence
**Multispec Ltd (Mr J Shields)
Napier College
National Advisory Body for Public Sector Higher Education
Nature Conservancy Council
*Natural Environment Research Council

*Sir Robin Nicholson
North East London Polytechnic
Northern Ireland Office
North Staffordshire Polytechnic
Parliamentary Advisory Council for Transport Safety
*Plessey Company plc
Plymouth Polytechnic
Portsmouth Polytechnic
Professor J R Postgate, University of Sussex
Royal Aeronautical Society
Royal Institution of Naval Architects
*Royal Society
Royal Society of Chemistry
Royal Society of Edinburgh
Save British Science
Scottish Office
*Science and Engineering Research Council
**Secretary of State for Education and Science
**Secretary of State for Trade and Industry
Professor R T Severn, University of Bristol
Professor Keith Short, International Association of Plant Tissue Culture
Professor Ralph Slatyer, Australian National University
Mr B W Small
Professor R M S Smellie, Institute of Biochemistry, University of Glasgow
Professor Sir David Smith, FRS, University of Oxford
Society for Applied Bacteriology
Society for Companion Animal Studies
Society for General Microbiology
Society for Low Temperature Biology
Society of British Aerospace Companies
Soil Survey of England and Wales
**Spectros Instruments plc (Dr D C Finbow)
Dr Ian Stewart, University of Warwick
Systems Designers
Teesside Polytechnic
Professor R J Terry, Brunel University
*HM Treasury
Trent Polytechnic
Trades Union Congress
**Ulvertech Ltd (Mr G Colquhoun)
*University Grants Committee
*United Kingdom Atomic Energy Authority
University College of North Wales
University of Birmingham (Departments of Chemistry, Chemical Engineering, Civil Engineering, Genetics and Physics)
University of Cambridge
University of East Anglia
University of Glasgow, Faculty of Medicine
University of Glasgow (Veterinary Faculty)
" " " (Faculty of Science)
" " " (Professor Brooks, Chemistry Department)
University of Lancaster (Board of Studies concerned with Science and Technology)
University of Leeds (Faculty of Engineering)
University of London, The School of Pharmacy
University of Manchester (Department of Science and Technology Policy)
University of Manchester (Programme of Policy Research in Engineering, Science and Technology—PREST)
University of Oxford
University of Sheffield
University of Southampton
University of Surrey (Faculty of Science)
University of Wales College of Medicine
**VSW Scientific Instruments Ltd (Mr D Whitehead)
Water Research Centre

APPENDIX 3

Letter of invitation to witnesses

The following letter was sent to invite evidence from witnesses:

SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY
SUB-COMMITTEE I—CIVIL R&D

The Select Committee on Science and Technology have set up a Sub-Committee under the chairmanship of Lord Sherfield to consider *the policy and practice of public support for civil science and technology in the United Kingdom.*

The Committee intend to concentrate mainly on the funding of civil science and technology but they propose also to consider certain aspects of organisation. They envisage four main areas of enquiry as described below.

(i) *The organisation of civil research and development*

Specific questions on which the Committee seek evidence are:

(a) how far public support for science and technology ought to be an objective of national policy;

(b) whether the present division of responsibility between five Research Councils could be improved; and

(c) what changes, if any, are needed in the organisation of research and development in Research Council institutes, higher education, and Government, industrial and other research establishments, and in the links between them.

(ii) *Sources of funds for basic, strategic and applied R&D*

Under this heading the Committee seek evidence both on existing sources of funds—their extent and effectiveness—and on possible new sources of funds. Two such possibilities may be the European Community and support from industry. The Committee wish to focus especially on strategic and applied research, since the House of Commons Education, Science and Arts Committee has recently reported on the Science Budget and the Committee will take note of the conclusions of that report and the evidence on which it was based.

Witnesses are encouraged to comment on the availability of the human resources to exploit any increased funding of R&D.

(iii) *The working of the customer/contractor principle*

The customer/contractor principle was adopted for Government R&D following the recommendations of the Rothschild report (Cmnd 4814) of 1971. The Committee invite evidence on the strengths and defects of the system. How well does the principle cope with the identification, funding and management of R&D needs and projects? How has it affected the balance between applied and strategic research? How has it affected the organisation of Government Departments and their relations with R&D establishments, and the administrative burden involved?

(iv) *The civil implications of defence research*

The Committee invite evidence on the extent to which defence research contributes to civil research objectives and on the balance between Research and Development in the defence area.

Evidence on the general issues raised by the Sub-Committee's terms of reference but not covered by the questions listed above will also be welcome.

L F Rutterford
Clerk to Sub-Committee I

APPENDIX 4

List of Abbreviations

ABRC	Advisory Board for the Research Councils
ACARD	Advisory Council for Applied Research and Development
AFRC	Agricultural and Food Research Council
AIRTO	Association of Independent Research and Technology Organisations
BP	British Petroleum Company plc
BRITE	Basic Research in Industrial Technologies for Europe
CBI	Confederation of British Industry
CST	Council for Science and Technology
DES	Department of Education and Science
DTE	Defence Technology Enterprises Ltd
DTI	Department of Trade and Industry
EC	European Community
EEC	European Economic Community
ESPRIT	European Strategic Programme for Research and Development in Information Technology
ESRC	Economic and Social Research Council
EUREKA	European Research C(K)o-ordinating Agency
FRG	Federal Republic of Germany
GDP	Gross Domestic Product
GEC	General Electric Company
GRE	Government Research Establishment
ICI	Imperial Chemical Industries
ICL	International Computers Limited
HEIs	Higher Education Institutions
IT	Information Technology
MAFF	Ministry of Agriculture, Fisheries and Food
MOD	Ministry of Defence
MRC	Medical Research Council
NAB	National Advisory Body for Public Sector Higher Education
NERC	Natural Environment Research Council
OECD	Organisation for Economic Cooperation and Development
QSE	Qualified Scientists and Engineers
RACE	R&D in Advanced Communications-technologies in Europe
SERC	Science and Engineering Research Council
TUC	Trades Union Congress
UGC	University Grants Committee

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