fst journal

The Journal of the Foundation for Science and Technology
(formerly Technology Innovation and Society)

Volume 18, Number 1, October 2003

THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

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 ISSN 1475-1704

fst journal

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Nuclear waste developments

The new Committee on Radioactive Waste Management (CoRWM) now has a chair, Katharine Bryan. Secretary of State for the environment, Margaret Beckett, announced the appointment in a written parliamentary answer in July. Katharine Bryan was previously chair of the Joint Nature Conservation Committee, the Government's wildlife advisory body, and chief executive of the North of Scotland Water Authority.

The CoRWM's task is to review the options for safely managing the 20,000 tonnes of solid, long-lived radioactive waste in storage around the United Kingdom. This will rise to half a million tonnes over the next century as nuclear reactors and other facilities come to the end of their lives.

The CoRWM was created following the controversial decision to disband the previous independent watchdog, the Radioactive Waste Management Advisory Committee, earlier this year (FST Journal Vol. 17 (9), p. 2). The new committee's terms of reference require it to make its recommendations — to the UK Government and the devolved administrations for Scotland, Wales and Northern Ireland — no later than the end of 2005. Margaret Beckett also announced a change in the status of Nirex (the Nuclear Industry Radioactive Waste Management Executive). The executive is now independent of the nuclear industry and under greater government control, "up to the point where future policy is decided".

Nirex has long campaigned for separation from the waste producers and managing director Chris Murray said the decision increases transparency and accountability and is a "significant and positive step forward" in the United Kingdom's efforts to tackle its nuclear legacy. This arrangement, says Murray, "moves us more into line with nations such as Finland and Sweden who have made real, tangible progress towards finding a solution".

In May 2001 Finland became the first country to annouce plans for burying nuclear waste in a permanent underground site. The Finnish waste-disposal company Posiva is expected to begin researching possible sites in western Finland. Although the location of the site is not yet determined, Finland plans to start building the deep waste dump in the year 2010.

In Sweden, where research into deep geologic disposal has been under way since the late 1970s, the plan is for spent nuclear fuel, in oxygen-free copper waste canisters, to be stored in a deep repository in granite bedrock. The Swedish site should be operation by the year 2015. ❐

UK Stem Cell Bank

Following on from the select committee on stem cell research report (*FST Journal* Vol. 17 (4) p.2 March 2002), the UK Stem Cell Bank has been established at the National Institute for Biological Standards and Control (NIBSC) in Hertfordshire. The bank, funded by the Medical Research Council (75 per cent) and the Biotechnology and Biological Sciences Research Council (25 per cent), is due to open shortly. It's remit is to curate ethically sourced, quality controlled adult, fetal and embryonic stem cell lines and it will be open to academics and industrialists from the United Kingdom and overseas.

The facilities for research-grade stem cells at the UK's stem cell bank are ready for use, and applications to deposit and access the research-grade stem cell lines are being processed. However, facilities for clinical-grade stem cell lines, which will conform to EU pharmaceutical standards, are not due to become operational until early next year.

There will be no restrictions as to which countries can use the bank, although they will be expected to abide by the bank's code of practice. Regardless of their own country's regulations, researchers will be expected to demonstrate that they have acquired appropriate ethical consent for any donated cell lines and that their research project has been ethically agreed before they access cell lines. Director of the bank, Glyn Stacey said: "We have to be careful with countries like the US. If we supplied an embryonic stem cell line to a US group who were receiving government funding, we would be acting illegally. But we could supply whatever we like to commercial companies in the US." ❐

Higher profile role for CST

Plans to beef-up the role of government advisory body the Council on Science and Technology (CST) have received a warm welcome. The advisory body is to be given a higher profile in helping make the country a world leader in what Lord Sainsbury, minister for science and innovation, calls "the knowledge-based economy". Following a quinquennial review, the terms of reference for the CST have changed to make clearer the "broad, cross-cutting nature of its work". From now on, it will advise the prime minister on ways to bolster science, engineering and technology in the United Kingdom, as well as promote international cooperation. ❐

Global warming agreement gets cold shoulder

The International Conference on Climate Change wrapped up in Moscow earlier this month with rising concern that the agreement may collapse after senior Russian officials questioned the science behind the agreement.

Although 113 countries have signed the Kyoto Protocol, the pact to combat global warming can only be brought into force by Russian ratification, since the United States pulled out. But the agreement has yet to be put before the country's parliament for a ratification vote.

Yuri Israel, a top Russian scientist who is also the vice-chairman of the Intergovernmental Panel on Climate Change, the international body that oversees the Kyoto agreement, said that Russia "should not be in a hurry" to ratify the pact, as it could do unknown damage to the country's economy. He also challenged the base assumption behind the agreement, saying "nobody knows for certain whether this [global warming] is caused by human activity or by natural factors".

President Vladimir Putin surprised many in his opening speech at the conference to joke that global warming "might even be a good thing — we would spend less money on fur coats and other warm items."

Many observers had been expecting Putin to announce that Russia would soon ratify Kyoto. Instead, he wished participants good luck as they studied the problem of climate change and said his cabinet had not yet made a decision about ratifying.

The emissions-reduction targets contained in the Kyoto Protocol are pegged to 1990. As Russia's emissions have fallen 32 per cent since then, the country won't have to do anything to meet its reduction targets, but would benefit from selling its credits — the unused portion of its emissions cap — to countries that exceeded their targets. ❐

Dear Sir…

FST Journal invites correspondence from readers for possible inclusion in the journal. Preference will be given to matters arising from the Foundation's lectures and discussions. Address material for consideration to:

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On 16 July 2003, FST hosted a meeting at the Royal Society on the proposed reform of the Research Assessment Exercise (RAE) and of plans to identify the full economic costs of academic research in the United Kingdom. The discussion that followed was summarised by Sir Geoffrey Chipperfield.

Research assessment made more friendly

Gareth Roberts

Sir Gareth Roberts FRS, president of Wolfson College, Oxford, is chairman of the inquiry into future arrangements for research assessment. A physicist by training, he has been senior research scientist with Xerox Corporation and director of research at Thorn EMI. He is a former vice chancellor of the University of Sheffield and a member of the Higher Education Funding Council for England. He is president of the Science Council.

About half of my recommendations are designed to meet deficiencies in the present RAE and will, I suspect, receive the blessing of the community. The other half express my belief that it is time to move away from a one-size-fits-all assessment to a more discipline-specific approach and one that concentrates effort where the stakes are highest. Although the recommendations constitute a radical overhaul of the RAE, they are not a wholesale rejection of RAE 2001; indeed, I propose retaining many of the key features of that process.

At the outset, some of us believed it might be possible to dispense with a complex and labour-intensive assessment process, perhaps by using self-assessment or a purely metrical approach as happens in Australia. But I am now convinced that a system that enjoys the confidence of the academic community must be based on expert peer review. Any assessment ultimately deciding the annual distribution of £1.18 billion that is not so based would, in my view, lack credibility and legitimacy. This, my first recommendation, underpins the whole review.

Academics appreciate that any system providing the necessary fairness will be time- and labour-intensive. Therefore, I have focused on discriminating between the very good research and the very best. The burden of assessment is then linked to the quantity of the funds for which an institution is competing. I appreciate that I have proposed a system that at first sight looks more complex than the present. To some extent I have sacrificed simplicity for efficiency and fairness.

I will focus on only 3 of my 14 recommendations. My selection is guided by the questions I have most frequently been asked by stakeholders.

The first is the hierarchical panel structure I have proposed (in recommendation 6) based on 20-25 units of assessment (subject categories) together with 60-70 subpanels. Virtually everyone has approved of the reduction in the number of units of assessment and the prominence given to interdisciplinary and multidisciplinary research. There is also support for the use of international experts with experience of UK research as panel members.

The formal introduction of moderators (recommendation 6(b)) is more often questioned. Here is the rationale. It is difficult to guarantee that a given grade in one subject is equivalent to the same grade in another, especially where there is little overlap between subjects. RAE 2001 left the impression that some panels were more generous than others and that panels in adjacent subjects had failed to interpret the criteria consistently. To be sure, umbrella panels were used, but they covered too large an area, met too infrequently and were peripheral to the process.

In the panel structure I propose, the subpanels will be equivalent to the existing RAE panels and will judge the quality of submissions. The higher order panels, comprising panel chairs and moderators, will ensure consistency of practice.

The differing needs of different disciplines are dealt with in recommendation 7. Working with the research community, we shall develop over the next couple of years discipline-specific performance indicators to guide both institutions and panel members. The weight placed on these indicators as well as their nature may vary between units of assessment.

In disciplines such as engineering, clinical medicine, social work and many others, publications in learned journals can be less relevant than the impact of research on professional practice. Panels should therefore ensure that practice-based and applicable research is properly assessed (recommendation 7(b)). After all, outputs other than academic publications were accepted in RAE 2001 — in the creative arts, for example. Why should not a researcher or a group describe their research and the impact it has had, adding testimonials from research partners who have benefited? That would compare with how the

Background
RAE present and future

John Maddox

The “dual-support system”, repeatedly referred to during the accompanying debate, is an almost uniquely British institution for the support of academic research. The idea is that the costs of specific research projects are funded from two independent sources.

Between 1945 and 1960, the University Grants Committee (UGC) had a duty to equip universities so that their staff could carry out research, while a single public grant-making agency (the Department of Scientific and Industrial Research, or DSIR) made grants from public funds to support the extra costs of peer-reviewed projects. Several charities, most of them small, did the same. The two research councils established at the time (in medicine and agriculture) spent most of their budgets on in-house research.

The virtues of dual support in these circumstances were evident. Good research departments or even groups could be productive on the basis of internal funds, but they were also favourably placed to compete for external support. In principle, no university was denied the chance to earn a reputation in research. The drawbacks were also plain: the UGC made “visitations” only every five years, its distribution of funds was coloured by the general standing of individual universities (and even the charms of their vice chancellors) while the eventual recipients of its funds were partly influenced by university politics.

Nevertheless, by 1960 the doctrine of the “well-founded” laboratory had taken root: grant-making agencies would allow their judgements of applications to be coloured by the adequacy of UGC support for the putative recipients. Ill-founded laboratories presumably drew the short straws.

The passage of decades has brought complexity. The UGC has been replaced by four “funding councils” (for England, Northern Ireland, Scotland and Wales). And there are now seven research councils dealing with particle physics and astronomy, engineering and science, economic and social research, medicine biotechnology, biosciences, the natural environment and central facilities, which deal on an equal footing with all the universities in the United Kingdom. With time, the Medical and Natural Environment Research Councils have chosen to spend increasing proportions of their funds on research in universities. For completeness, the Arts and Humanities Research Board is likely soon to become a research council, while Lord Puttnam’s National Endowment for Science, Technology and the Arts (financed by the National Lottery) is potentially another source of research funds.

The dual-support system survives in the new regime. The research councils continue to make project or programme grants as before, while the funding councils have collectively taken over the functions of the defunct UGC. Their function is to make annual allocation of funds to their roster of universities, taking account of student numbers, maintenance needs and the like. They have also inherited the provision of “well-found” laboratories. The last of these functions has prompted the periodic research assessment exercises (RAEs), the first of which was in 1986 (before the election of the present government).

> …smart British academics are quickly learning how the ground rules can best serve their needs…

The objective is to apply uniform yardsticks to the grading of all university departments (or their equivalents) that believe they have a claim on public research funds. Originally, there were five grades, labelled 1 (at the bottom) to 5 (the top). Now there are seven (with 4-star and 5-star added). The grading is carried out by panels of appropriate academics, which interview appropriate people and consider documentary evidence (including reprints of published papers up to a maximum of four per person).

The ground rules have always been complicated. The funds eventually awarded are known as QR (for quality-related) and are awarded to universities on behalf of all departments included in the competition and in the light of the grade awarded to that department. A further refinement of the rules allows departments to exclude from their submissions the research records of individual faculty members. Excluding members whose research interests have lapsed, or whose chief interest is in teaching students, is an obvious means of enhancing a department’s grade; the downside is that the QR awarded is *pro rata* with the numbers submitted to competition.

Any national system for assessing the quality of academic research is bound to be contentious, especially when the funds at stake amount to more than £1.25 billion (the figure for the current year). The RAE process has thus provoked questions about the comparability of grades awarded in different disciplines and the neglect of researchers’ work on government committees, as reviewers for journals, industrial collaboration and even as assessors on RAE panels.

The most recent RAE, completed in 2001, sharpened other problems evident at an earlier stage. While fewer departments and academics were submitted to the competition than in the previous exercise, the numbers of departments graded 4 and 5 increased. Part of the explanation is that there has been a general improvement in the quality of British academic research. Another is that smart British academics are quickly learning how the ground rules can best serve their needs. Either way, the point has now been reached at which departments graded 4, supposed to represent research of national interest with some international pretensions, may not be allocated QR.

Many of the reforms proposed by the Roberts Review will be improvements. The restructuring of the assessment panels and the recruitment of overseas scientists as panel members should strengthen the process. The longer interval proposed until the next exercise will be generally welcome.

But the real difficulties centre about the question of where the threshold for attracting QR will settle. The outcome of the 2001 exercise suggests that many highly-regarded research programmes would fall over the edge. In the long run, the outcome will hang on whether the Government is prepared to project forwards its generous treatment of academic research in last year’s budget increases. Whatever happens, the dual-support system will have survived. ❐

quality of scholarly books is judged by what acceptable reviewers say.

The third recommendation (number 5) on which I wish to comment has to do with the grading system. Suspicions have been voiced that the financial consequences of gaining or losing a grade are so great that institutions have felt obliged to play games with staff to ensure that they fall the right side of a grade boundary.

It is also unfair that a five-star quality researcher should be branded with the lower grade of his/her department. Moreover, a label of 4B attached to a unit says little about the volume of high-quality research it may encompass. Indeed, grades that express in a single measure the strength of research across a unit, force attention to be paid to mediocre as well as good research. Surely, the task of assessment should be to identify the strongest research wherever it is found in a department or faculty.

The alternative system we have proposed solves these problems. For each submission, the panel would decide how much work could be defined as meriting one, two or three stars, or none. In other words, the focus would be to discriminate between the very good research and the very best. This would also provide a continuous grading system, thus avoiding the problems created by grade boundaries.

What I have described so far will be viewed by the majority of academics as a significant improvement, so I turn to the more controversial parts of this recommendation.

The first relates to the proportion of one-, two- and three-star ratings. We are proposing a normative approach in which panels will be given guidelines on the distribution of star ratings they might expect to award. This, I emphasise, does not amount to imposing a distribution; the moderation process will establish whether a panel is justified in departing from its guidelines.

The advantages of this arrangement would be several. It will prevent grade inflation and help guarantee the integrity of the ratings. Departures from the guidelines would be justified when there was evidence that a subject outperformed or underperformed other subjects when measured against international benchmarks. Perhaps citation indices might, in some subjects, be a suitable proxy for their strength. Of course, this approach would not be used in small subjects or those where there is little tradition of research such as sports science. Institutions would then need to recognise that they are being funded on the basis of their relative rather than their absolute performance.

There are many aspects of my review I have not had time to reflect on: the six-year cycle, the institutional-level assessment of research competence, the multitrack assessment scheme, the 80 per cent submission rule, group submission, the census date for submissions and the rules of engagement, for example.

I conclude by trying to put my report in the context of the other consultation papers and the white paper on higher education.

First, I am not recommending that any institution should cease to be funded for research. Nor does my review support the further concentration of research funding. Moreover, I have spoken consistently against raiding the grade 4 funding pot to introduce a six-star rating. It is such a pity that this transfer of less than 2 per cent of the annual QR distribution has distorted discussions around tonight's debate. Indeed, many of the negative attitudes in academia at present simply reflect the funding problems generated by the post RAE-2001 settlement. Given the amount of disquiet, a visitor to this country would need real convincing that there had been a 30 per cent real terms increase in research funding between 2002/3 and 2005/6 and that research spending will have doubled over a seven-year period.

At the outset, I was advised by all concerned to assume that the Dual Support System would continue, and that third stream activities and partnerships of excellence should be separate from the main research assessment exercise. Strong cooperation between the funding councils and the Office of Science and Technology/DTI are thus essential in allocating funds to the different streams. In this context, I do have some concern that the two sides of the Dual Support System are functioning less cooperatively than they might be. I look forward to Chris Henshall's presentation and hope that he will suggest some possible modifications to the preferred route for the research-council funding of universities.

I will refrain at this stage from commenting on the OST Review but will make a plea that the eventual outcome will ensure that vice-chancellors have sufficient funds and flexibility to invest in the areas they believe will prosper and provide the best return on public investment. Many ventures at the University of Sheffield, such as the Humanities Research Institute, the Health Services Research school and the Boeing Research Centre, would not have prospered as they have without the essential pump-priming funds from the Block Grant that my colleagues and I invested several years ago.

There are several areas where I have suggested stronger cooperation between the two arms of the Dual Support System. Two that come to mind are: first, the International Assessment of Research where, for example, a few academics from abroad who have participated in research-council reviews would sit as full members of the assessment panels; and, second, the definition of units of assessment and the formulation of discipline-specific performance indicators, where research-council knowledge would be invaluable.

Finally, I reiterate that this document is a consultation paper, not a finished blueprint. Decisions will be reached by the funding councils later this year, whereupon there will be about 18 months of intense activity: in consultation with the academic community, panels will be assembled, units of assessment agreed, and panel criteria and working methods published at least two years before the next submission date.

I am acutely aware that evaluation mechanisms distort the processes they purport to evaluate. Hopefully, my recommendations will encourage enlightened behaviour. It is obvious to us all that, without a flourishing university research base, this country will fail to fulfil its potential. I also hope that the proposed arrangements are flexible enough to survive the many more white papers that will be issued over the next 12 or 15 years. ❐

discussion

Whole system approach. It is teaching, not research, which is the fundamental mission of higher education and the proposals do not link research to teaching. There is need for a whole system approach.

A central concern of the OST proposals is to ensure that QR funding, to avoid "overtrading", properly backs project funding. But this could mean cutting back on projects; do we really want this? Where would the project funding go?

Towards full cost recovery

Chris Henshall

Dr Chris Henshall has been a group director at the Office of Science and Technology since May 2001. He is responsible for the management of the UK science budget of around £2 billion a year. Dr Henshall has chaired the cross-departmental committee responsible for the proposals on sustainability.

It is apt that the discussion of proposals for the reform of the Research Assessment Exercise (RAE) should be followed by a discussion of other reforms of the Dual-support system. Sir Gareth Roberts and I have worked closely together in the development of these policies, which are closely linked. The report from my group, *The sustainability of university research*[1], is also a consultation paper with a deadline at the end of September.

I begin with the problems that need fixing. Over the past few decades, there has been greatly increased pressure on all university staff to conduct and publish research. The last RAE showed that, with increasing numbers entering research, the proportion of research-active staff declared in the top-rated departments also increased. The crucial conclusion is that the system is supply-led, not demand-led. So the funds available for supporting research through the RAE (called "QR") have had to be spread more thinly.

That has been going on for a long time. Between 1988/89 and 1999/00, the income received by universities from all project funders rose about threefold, while the QR funding increased hardly at all.

At the same time, the universities and funders have had a poor understanding of the cost base. That has allowed us all, funders included, to neglect the longer term costs and has led to the low-price culture.

Where has that taken us? To a situation we have known for some years. In 1997, the Dearing Report concluded that the volume of research in higher education had increased without a corresponding increase in the funding of infrastructure, with the consequences of: "longer working hours for academic staff, more time devoted to research at the expense of teaching, underinvestment in new and replacement equipment and [in] improved operational and financial management of research".

In 2002, the Government published *Investing in innovation*[2] that confirmed the consistent failure to invest in the research infrastructure. So the problem identified by Dearing and many before him has finally been accepted as real.

What has the Government done? The comprehensive spending review in 1998 provided significant extra funds for science, but with conditions for the future.

So the transparency review of university finances was launched. Universities embraced the review with enthusiasm. In 1999/2000, eight universities piloted the Transparent Approach to Costing (TRAC) system, which was then rolled out across the sector; in 2001, we had the first reports of what things were costing and where money was going. That had a major role in ensuring that the spending review in 2002 gave science funding 10 per cent a year real-terms growth over the next three years.

But the Treasury now needs to be reassured that the system can be refined to the point where sponsors pay what research costs, so that we do not end up with another funding gap. Hence the dual-support reform work we have launched. The TRAC methodology so far works at the level of the university or department. Work is now in hand to extend it to the project level. We now have to get this right and Spending Review 2004 is fast approaching.

Investing in innovation made it clear that research in universities must be sustainable if we want to build a secure, knowledge-based economy. This means that universities must understand and, overall, be able to recover the full economic costs of research. The spending review published at the same time showed that the Government was putting its money where its mouth was: half of the 2002 settlement for science is for sustainability. For example, research infrastructure funding was increased to £500 million a year and was made permanent. QR is to increase by £244 million by 2005/6, while the research councils will get an extra £120 million for the same volume of project funding.

But there has to be better cost recovery across the whole system; government departments have been told that they will have to pay more for commissioned research, for example. All of us are going to have to work out how we can move ourselves onto a platform of sustainability.

There is one aspect of the recent white paper on higher education that has been less popular than others: the declaration that government intends to focus resources "more effectively on the best research performers". There is a message here for the institutions that now attract lots of unmatched project funding. Either they will continue to overspend or they will have to say, "No!"

to some project funding. The truth is that we cannot afford all the excellent research that the system would like to perform.

It is nothing new that choices have to be made. The allocation of QR on the basis of the RAE is a selective process, while the research councils are already vigorously selective. They respond to excellence wherever it is, but they do not have a policy of being selective around institutions. In our system nearly 70 per cent of the funding the councils provide goes to a group of ten universities. That leaves the question of excellent teams who find themselves in a department or institution that is not uniformly excellent, and who may therefore not continue to enjoy the infrastructure support they may have had in the past.

The proposals from the Group 1 that I chaired are set out in our consultation book[1]. I will draw attention to a few points. First, I emphasise that the principles of the dual-support system are retained, which reflects the overwhelming message that the dual-support system is still the best way of funding research.

In our many discussions, we rapidly came to the conclusion that we are talking not just about accounting or bureaucratic changes, but a culture change. Our proposals are meant to support both good accounting practices and that culture change.

My group has been working on five themes, the first of which is how to estimate full economic cost at the project level. We have a group investigating whether the TRAC system can be used at the project level.

Our second line of enquiry asks how, when the full economic costs of research projects are known, should the university and the research council systems interact? One answer would be to increase the overhead rate the research councils now pay on the current selected set of cost indicators. But, if we can develop a system that tells us the full economic cost of projects, why fall back on a procedure that is a less valid indicator of the real costs of research and which would perpetuate existing perverse incentives (for example, to hire staff rather than buy equipment)?

We believe that the way to change behaviour is to base the terms of trade between universities and the research councils on full economic cost, with the research councils paying some percentage of the full costs of projects and the remainder to be recovered from other sources, including QR.

We have also been doing some whole-system modelling. The initial results suggest that there is enough money in the system now, but much will depend on how much we concentrate and on how various players behave in the future. The funders' forum we are forming will play a key part in monitoring and steering these matters.

There remain some key issues. How, for example, do we handle principal investigators' salaries? This is a complicated question, with ample scope for substantial perverse incentives, perhaps affecting how whole subject areas behave. And how to manage the transition to the new system? Can we do it in 18 months? Or is it so complicated that we need 24 or even 30 months? A major issue is that of how we can monitor the new regime and adjust it so that the opportunities for gaming that ingenious academics will inevitably devise are kept within bounds. And finally, what about world-class researchers in departments with little or no QR?

In conclusion, I would like to say this: the status quo is not an option; it is the problem, to which the Government has committed major resources. But public resources alone will not be sufficient to ensure sustainability across the system. Success will depend on changing the culture. Our goal, remember, is sustainability. ❐

1. *The Sustainability of University Research: A consultation on reforming parts of the Dual-support system* (May 2003). www.ost.gov.uk/policy/invest-innov.htm
2. *Investing in Innovation: a strategy for science, engineering and technology* (July 2002). www.ost.gov.uk/policy/invest-innov.htm

Towards teaching-only institutions?

David Watson

Sir David Watson has been vice chancellor of Brighton University since 1990. An historian by training, his interests are in the history of ideas and higher education policy. He was a member of the Dearing Committee of Inquiry into Higher Education. He currently chairs the Steering Committee for the ESRC's research programme into teaching and learning as well Universities UK's Longer Term Strategy Group.

I begin with a reminder of recommendation 34 of the Dearing Report (1997). That proposed amending the RAE to encourage some institutions to decide not to enter, either in whole or in part. The proposed aspirational floor for taking part was at that stage put at grade 3A. The proposal was howled down by the sector and therefore ignored by the funding councils.

What the figures show is that between 1996 and 2001 there was a reduction in both staff and submissions returned, and in effect, the 3A floor was achieved. Of course there was no compensatory payment for this achievement. Incidentally, the Dearing Committee at that time also reflected, "on the near universal rejection of the idea that some institutions of higher education should be teaching only".

So let us now fast forward to 2003, to the white paper on higher education in England and its aftermath. The relationship between research and teaching is now declared to be indirect; research-degree awarding powers are no longer considered necessary for a university to have that title; and somewhere within RAE grade 4 is a plimsoll line below which researchers are no longer considered worthy of public investment.

Remember how grade 4 is defined. It denotes quality equivalent to national excellence in virtually all of the research activities submitted, with some showing evidence of international excellence. Anne Corbett and Maurice Kogan, in The Guardian of 6 May, wrote that this level, level 4, is the platform upon which our international competitiveness is built.

On the international citation indices about which the Government waxes

discussion

Inconsistencies. It was considered that there was insufficient linkage, indeed an actual inconsistency, between policies as outlined in these two papers and the white paper on higher education. How, for example, did the RAE proposals tie in with the research concentration proposals in the white paper?

What was the justification for dual funding, and why do we have RAEs at all? Does the system really work to add value to the wider economy, rather than just satisfy academic interests?

lyrical in the first chapter of the white paper, research by Jonathan Adams and his collaborators shows that our grade 4s alone perform 25 per cent above the world ratings. So cutting off support below a thus-far metaphysically defined level would be to declare half of our work of attested national excellence to be unsupportable by public funds.

Moreover, that would take place against a background of structural underfunding compared with our international competitors. Such underfunding usually provokes arguments about the necessity of concentration, but why should it? An equally valid claim could be made on behalf of "value for money", which would not necessarily lead to concentration.

When I spoke to the Foundation in 1997 about the Dearing Report and the research base, I pointed to five challenges for research funding in a diverse system. (By that term I did not mean a two-tier system in which some do it and others do not, but one that supports research in a diversity of settings.) Research funding, I argued six years ago, would need to be spread to support new entrants, to develop capacity, to ensure industrial and commercial support and to motivate collaboration. Finally, I argued that spreading research funding reasonably widely would confirm the distinctiveness of higher education.

All of these points are still relevant, but I will concentrate on one of them. Universities UK, through its Longer-term Strategy Group, has been arguing for some time that the concentration of research funding has itself become formally dysfunctional. After a certain point, the capacity of an institution to use QR to gear other research funding — from industry, research councils and other sources — goes into reverse. In other words, the more QR you have, the more dependent on it you are. For example, one of the units in my university achieved a grade-4 rating in the RAE. In that unit, the ratio of QR to external research support is 1:4; and we need the "one" to achieve the "four." Withholding that element of QR would therefore do five times as much damage as the money saved.

These gearing ratios are interesting. Using data from 2000-01, it seems that nationally every £1 of QR attracts approximately £2 of other research funding. There is no sign of the Russell group or of the golden triangle in the universities with the ten highest ratios. But that result may have arisen because the numbers are only small. So let us inject a "significance test", considering only those universities where the QR exceeds £3 million. Then Glasgow, Imperial College and so on appear among the top ten.

Closer inspection of these figures also shows, for example, that subject mix can be important. Thus LSE has a ratio of only 1.15. The Arts and Humanities Research Board (AHRB) has cogently been making the case that QR has special significance for its work. It has now been conceded that the "big science" model will not suit many areas of social science and the humanities.

Despite the uncertainties, it is clear that value for money is not a consideration in the current allocation of QR. These data also call into question the current fashion for stereotyping universities into separate groups.

Another set of sharp differences is between the regions of the United Kingdom. Scotland, for example, has no interest in 6 stars and Wales is still providing QR for grade-3 departments. Wales as a whole has 5.4 per cent of FTEs (full-time teaching equivalents) in the system, but only 4.7 per cent of the total income of the university system and only 3.8 per cent of its research income. Scotland, with 9.7 per cent of FTEs, attracts 11.3 per cent of total income and 12.7 per cent if research spending. Northern Ireland's "gearing" ratio is 1.49. And so on.

So how do we put this all together? It's interesting to reflect on how the Government is slowing down the frenetic pace of development announced in the white paper and the latest DfES "letter of direction." We also need to reflect on the implications of not only the Roberts Review but also the OST review of dual support (which implies that new money will be directed to paying a greater proportion of fixed costs) and the HEFCE consultation on standards in research degree programmes (which explicitly repudiates the myth that high standards correlate with RAE scores).

In these circumstances a significant virtue of the principles set out in the Roberts Review is that they provide a powerful impetus for the Government to think again. Roberts acknowledges that all HEIs do research (albeit at different levels), intends applied research/knowledge transfer to be considered alongside basic/fundamental research in each institutional setting, doesn't type-cast or limit institutional strategies and explicitly tests institutional capabilities.

The main problem is that we have two debates going on simultaneously. There is a debate about research intensity and a debate about institutional diversity. We don't seem able to have a debate about diversity that is properly respectful of the part played by research. ❐

further issues

Other issues that were not raised but which need debate include:

- Is the relationship of project to public funding a relevant consideration? The effect of research concentration and RAEs is to reduce it.
- Is the Roberts' proposal of the three-star system to reward individual excellence rather than averages workable? What will the effect be on teamwork in laboratories and elsewhere?
- The OST is keen on full cost recovery and has promoted the TRAC system. But is it workable, and what does it mean for the total volume of research and the willingness of business to use university research. Have Lambert's emerging conclusions been taken into account?

Are the strategies of the several players in British biomedical research efficiently articulated? Or would there be benefit in stronger links between the funding agencies, health service trusts and universities? These and related questions were the topics of an FST discussion meeting at the Royal Society on 30 April 2003.

Research support from the top

John Pattison

Professor Sir John Pattison is director of Research Analysis and Information, Department of Health. He was previously head of Biomedicine and Professor of Medical Microbiology at University College London. He chaired the Spongiform Encephalopathy Advisory Committee (SEAC) between 1995 and 1999. From 1992 to 1995 he was chairman of the Physiological Medicine and Infection Board and a member of the Medical Research Council.

I always believed that the Department of Health (DoH) would cover the applied end of the research spectrum and that bodies such as the Medical Research Council (MRC) and other research councils would cover the basic science end. When the data from the National Cancer Research Institute on the portfolios of the various funders of cancer research in this country was published, most MRC funding went into biology and aetiology and the DoH's contribution to funding covered a different area, but the two together come close to covering the spectrum. It was also notable that the MRC made a significant contribution to treatment in which it has a strong tradition. (Incidentally there are some areas where no-one, including the other funders, currently puts much research money. Notable shortfalls are in prevention and in palliative care. We are seeking to address those shortfalls).

Our concordat with the MRC is to develop appropriate research strategies together, to make sure that there are no surprises in the sense of one partner developing policies with unintended consequences for the other, to explore joint ventures, to fill gaps and so on. We have similar concordats with all the other research councils.

At our recent concordat meeting with the Engineering and Physical Sciences Research Council (EPSRC) it became clear that we need to explore why the research they fund as part of their considerable health programme stops with the publication of the peer-reviewed paper and is not taken further towards application. Clearly there is a gap that we need to address if we are to benefit from the basic research funded by EPSRC.

We have, jointly in all instances with the MRC, the Wellcome Trust and the appropriate specialist research charities, set up funders' forums; they work variably well, but they are all as yet young. The one that has worked particularly well is the Cancer Research Funders Forum, now the National Cancer Research Institute. We integrate with the MRC in a number of other ways. We try to influence each other's overall strategies. We often use the expertise available at and through the MRC to give us expert reviews on subjects. A recent example is chronic fatigue syndrome, where we need appropriate research to provide evidence on how we should be managing that condition. We also integrate with the MRC in commissioning specific research projects and programmes and also in our personal award schemes that are part of our capacity building programme.

How are we contributing to the applied end of the spectrum? In supporting clinical research, we are providing the major hospitals in which clinical research will take place with approximately £400 million a year, which meets the NHS costs of clinical research under the quality control and strategic development of research councils and major charities. This is our Support for Science funding stream, accounting for about £300 million of the £400 million. The remaining £100 million is part of our Priorities & Needs R&D funding. In addition there is £100 million per annum funding our national programmes and the research in these programmes is commissioned largely in the university sector.

What are these national programmes? The first, the Health Technology Assessment (HTA), has an international reputation. Health technology includes any intervention used in screening, diagnosis,

discussion

Partnership and competition. In discussion it was agreed that partnership facilitated a pooling of resources. Universities were weak in infrastructure; they also suffered from a constant turnover of personnel. The NHS was also weak in infrastructure. Competition provided a valuable spur to research but it was not always compatible with full partnership collaboration. The ideal appeared to be for competition to show the way forward and then for partnership to step in to foster development.

treatment and rehabilitation; its aim is to produce evidence for the effectiveness, cost-effectiveness and impact of health technologies. The programme is based on randomised controlled trials that generally involve multidisciplinary teams. Numbers in the trials are on a substantial scale. For example, we have just finished a comparison of hysterectomy procedures and this single trial involved more patients than all other trials in this area put together.

The Service Delivery and Organisation Programme is more recent but we need more evidence on which to base the organisation and delivery of services. Recent commissions have been concerned with the continuity of care, the requirements of carers and organisational factors related to waiting times.

Another of our programmes has the general title of innovation. This includes the New and Emerging Applications of Technology Programme. In this programme we have had success recently with the development of a vascular graft, helping it through the awkward period when the basic research has been done but there is not yet a clear commercial interest. The programme also now includes a major commitment to genetics, our contribution to which is twofold: first to contribute to Biobank; second to set up five genetics-knowledge parks, which are designed to be collaborative ventures between research funders, universities, the NHS and industry. They will evaluate developments in genetics and tell us how they might impact on the NHS and our health.

We also make personal awards, either researcher development awards or career scientist awards. The latter include clinician scientists, a serious shortage of which was flagged in the Saville report of the Academy of Medical Scientists. In the past our personal awards have often targeted particular specialities (public health, primary care, nursing) but we are moving towards a generic scheme to support high quality applicants irrespective of personal background or discipline.

Finally, the Policy Research Programme (PRP) is designed to produce evidence on which to base policy and provide the capability of evaluating policy. An example is related to the policy of increasing the eating of fruit and vegetables. The PRP commissioned behavioural studies on promoting this policy and they showed that, with counselling and, especially with the young, an individuals' intake of fruit and vegetables can be increased, including among people from disadvantaged backgrounds. The PRP is also notable in being the largest funder of research into social care in Britain.

We also have portfolios that draw together research in a particular area from all our programmes. One such is our cancer portfolio and our contribution to establishing and maintaining the National Cancer Research Institute is an outcome of that, together with the creation of the National Cancer Research Network (NCRN) and the National Translational Cancer Research Network (NTRAC). We now have a National Institute of Mental Health to establish networks for the relatively small number of high-quality staff working in mental-health research and we have been able to fund, with others, some significant projects and trials in that area.

Finally, I must refer to diabetes. The Government is committed to having a policy on diabetes screening in place by 2005, some essential research is underway funded by ourselves and others to accumulate the evidence necessary to formulate a sound evidence-based policy. That would be a good example of "needs pull" that drives a partnership of funders. ❒

discussion

Intellectual property. Conflicting views had been expressed about the value of asserting rights of intellectual property as regards the results of research. In some instances recognition of intellectual property rights had had great value. There had, however, been instances where the benefits had accrued to everyone except the original researchers. It was important to protect the freedom of knowledge transfer. The sharing of knowledge gave opportunities for working in partnership. This was not, however, a matter over which the Government had any control.

Charity research collaborations

Leslie Turnberg

The Lord Turnberg is scientific adviser to the Association of Medical Research Charities and vice-president of the Academy of Medical Sciences. From 1997 to 2002 he was chairman of the Board of Public Health Laboratory Service. He practised as a physician at Hope Hospital, Salford. He has been president of the Royal College of Physicians and chaired the panel that reviewed the health services in London in 1997.

My position as scientific adviser to the Association of Medical Research Charities (AMRC) allows me to focus on some of the problems facing them and to suggest some ways of enhancing their effectiveness.

The AMRC has about 110 members, which in 2001/02 spent almost £600 million on research. That is more than the MRC's contribution and more than the NHS's R&D programme spends, making AMRC a major contributor.

Our funding consists largely of that of a few large charities, with the Wellcome Trust at the top; they spent £273 million in 2001/02 on research in Britain alone. (It spends more than that in total, including on research abroad and on non-research activities.) Then come Cancer Research UK, the British Heart Foundation and the Arthritis and Rheumatism Research Campaign, which spends about £21 million a year. These four charities spend about 84 per cent of the total, leaving about £100 million by the others, with some spending between £1 million and £5 million a year, but many spending less than £1 million.

The charities are diverse in structure. There is an important distinction between those, such as the Wellcome Trust, that are endowed and live off their incomes and the others that rely largely on continuing public support. The policies and strategies of the latter are to some degree in public hands.

This is not the end to the diversity of medical charities. Some are profession-led, as when they are set up by the medical or scientific community and others patient- or carer-led. Some are philanthropic or grant-making, others institutional, such as the Tommy's Campaign. Some are scientist- or department-led, others corporate. How these charities function and what their strategies are differ significantly.

Thus charities exemplify democracy in action. The public supports things it believes are important; cancer, heart disease and arthritis are the big winners. We should not be too complacent, however, because more is spent on the Donkeys' Retreat and on the Battersea Dogs' Home than on all the research into children's diseases or aging.

Where does the money go? The biggest chunk, 45 per cent, goes to general medical research that applies to all disease categories — immunology, molecular biology and so on. About 30 per cent goes to research on cancer and leukaemia; 12 per cent to heart, lung and stroke; arthritis gets 4 or 5 per cent; neurology and mental illness, 2.25 per cent; and sight and hearing, 0.63 per cent. There are many categories of disease in which the research charities are the sole or the major supporters of research, Parkinson's disease and children's diseases, for example.

Charities also provide a diversity of types of research grants. Most grants are project grants: 28 per cent. Some 10 per cent goes into programmes and 16 per cent into personal support — fellowships and so on. It is commonly suggested that the charities do not support infrastructure, but the institutions that receive support of that kind from charities are mostly higher education institutions: very little goes directly to the NHS, although most charitably supported research is conducted in medical schools associated with teaching hospitals.

By law, charity research cannot yield commercial or personal benefit. The range of stakeholders is enormous and they cannot be judged as one. Most charities' research funds are spent in facilities external to the charities themselves, but that is not the case in cancer, for example. Here, funding is predominantly responsive and partnerships (with universities or hospital trusts) are essential. These funds are additional to and not an alternative to government funding and need continuing public support.

Medical science needs help from the AMRC and others to influence public views about medical research. It needs a research community with facilities and it needs patients to be treated safely and ethically. (We value the research governance framework being developed by the DoH.) We have to pay regard to the scientific advice of our referees and we depend crucially on the applications that come to us.

One thing is clear: charities have to work closely with others to achieve their objectives.

There are many excellent examples of close working relationships between the charities, the NHS and the universities: Biobank is one. The Wellcome Trust's Joint Infrastructure Fund has put clinical research programmes into many medical schools; the British Heart Foundation has put chairs into universities. The Cystic Fibrosis Trust has done a very interesting job in stimulating collaboration between the universities of Newcastle, Edinburgh and Oxford.

But there needs to be more discussion between research charities, other funders and users of the money in developing joint interests. There are opportunities for us all, but where are the forums for that to occur? We need a research strategy forum that meets at regular intervals with the funders (the charities, the MRC, NHS R&D) and the users (the NHS and universities). Its goal should be to bring about a better coordination of research strategies. ❐

Building a clinical research platform

John Bell

Professor John Bell is Regius professor of Medicine at the University of Oxford, where he was previously Nuffield Professor of Clinical Medicine. He has held a clinical fellowship at Stanford University, California and was a co-founder of the Wellcome Trust Centre for human genetics in Oxford. Professor Bell is a member of council at the Medical Research Council, a main board member of Roche AG and a trustee of the Rhodes Trust.

I chair a working party for the Academy of Medical Sciences to identify current impediments to biomedical research in Britain. We have agreed that one of our headline issues will be the problems of undertaking clinical and translational research in Britain. We believe this is a fundamental impediment to progress in the whole field.

The issue is important because clinical research is a fundamental platform for translating the basic academic research at universities and research institutes into a clinical setting, yielding innovations that can be applied to the human population. Without a platform, none of that will happen.

John Pattison has described the need for the NHS to have an intelligent service capacity, but for that it needs to do research, for which reason it needs a vibrant and active clinical research community. A third equally important issue is the development of the biomedical industry. Biotechnology and the medical device industry have been fundamental to economic growth in this country, and much of that has stemmed from the ability to do good clinical research. At present, there is disillusion about our ability effectively to deliver what must be a fantastic resource for the development of new therapies.

What is the explanation? I think there is a fundamental misunderstanding about what could be achieved in the clinical arena. Yet from 1975 to now there has been a decline of activity in clinical research in this country; it is now quite serious.

What exactly is clinical research? It includes experimental medicine, involving phases 1 and 2 of clinical trials; the introduction of novel therapeutics in patient populations to prove their efficacy at an early stage; the establishment of disease networks — clinical networks of people with an interest in a particular disease, which can advance new therapies and evaluate them in phases 3 and 4 of clinical trials; and prospective studies on drug and disease monitoring, including projects such as Biobank.

We also have new tools to deploy. Imaging has important clinical research implications. The application of a variety of new tools for epidemiology is vital and the translation of a variety of these new technologies, emerging out of basic science, including genetics, into a clinical framework must be included in the list. To none of these fields is there a commitment, financial or otherwise, that will allow us to be truly competitive internationally.

Experimental medicine is one of the most exciting arenas in medicine, yet it does not have a good uptake among youngsters. It includes what we used to call clinical physiology, clinical pharmacology, the idea of proof of concept by introducing therapeutic interventions to see whether they work — essentially bedside investigation with individual patients.

Now, we have a host of new approaches to this kind of experimental medicine. Here is an example. There was a letter last year in *The Lancet* by Mark Feldman and Tiny Maini that has completely redefined inflammatory disease from a therapeutic perspective, by the use of antibodies against Tumour Necrosis Factor (TNF). In my view, this is a major advance. When you administer the antibody to patients, previously swollen joints in rheumatoid patients return towards normal and the surrogate markers of inflammation are no longer evident. You do not have to do statistics on this kind of data as you move into the clinic. The procedure is already immensely therapeutic.

Much the same has happened with vaccines. There is now a set of techniques to tell whether the response to antigen stimulation is adequate quite early, and without moving into a large-scale trial. A technique developed by our group in Oxford and Mark Davis at Stanford tells us, by means of surrogate markers, the number of T cells in peripheral blood that have been activated by a particular immunological stimulus. Again, single-subject experimental medicine is seen as central to progress.

What does experimental medicine need? Clinical research facilities, running costs, a career structure, a reward structure and research grants are fundamental. So far in Britain, we have only the first item on this list. Five years ago we did not even have that, but then a number of institutions, notably the Wellcome Trust, funded several high-class facilities. But these are expensive to run and there is a serious issue of paying overhead costs. There is also the problem of a career structure for clinical scientists, although some of that is starting to develop; there is a further problem of a reward structure for researchers and a question of whether we really have adequate research support for these people.

discussion

University funding. There had been a shift in the balance between teaching and research. It was in any event arguable that funding related to grading was damaging. The training of a researcher required at least 14 years. A more secure and substantial source of funding for training and research itself was needed. There appeared to be confusion as to which department in government should assume responsibility for medical research. It was doubtful whether adequate funding could be found for research in 28 separate schools of medicine. The resolution of this issue was of the highest importance.

We have made a start on some of these questions, notably within the NHS R&D programme, but development so far is nowhere near as broad as is required.

There is also a translational component. Cytogenetics is expensive; the NHS probably employs a thousand cytogeneticists to look for chromosomal abnormalities in a variety of conditions. It is now possible to do that more accurately using micro-array technology; a group at Oxford is trying to estimate its effectiveness, particularly in cancer, and whether it can be more widely applied to mental health and other arenas.

Large prospective studies are also important. The NHS is not being used fully to generate information about the best application of healthcare. Biobank is a potentially fantastic use of an NHS resource; it has the potential to become a landmark study and could establish Britain as the world centre in genetics and genomic epidemiology.

Britain has a good record in big prospective cohort studies. Our capacity to do the same with genetics will be immensely important, as will large-scale proteomics, affinity proteomics and mass spectrometry. Within five years, it may well be possible to analyse all the proteins simultaneously; that will provide fingerprints for individuals diagnostic of the likelihood of their developing the common diseases. Further ahead is the possibility of using RNA-transcript profiling for the same and other purposes. This is the future of clinical research and there is no better place to do it than within the NHS.

discussion

Gaps and duplication. Although the NHS provided the best vehicle for research it was inadequately funded for this purpose. A serious gap existed which it was important to fill and partnership arrangements might provide the way forward. Weaknesses in the existing arrangements were to be found in the lack of adequate research training and of research methodologies. Some researchers had little awareness of work already carried out.

Beyond getting the infrastructure right and the research programmes right is the challenge of recruiting individuals who can support them. There needs to be a career structure that takes you right through from the bottom to clinical professors. Who funds the person who stands at the bedside doing single-patient studies, writing protocols that will never be published in *Nature*? The present reward system is biased towards the guy who is going to publish in *Nature*, not the poor guy at the bedside. This is a very important issue. There also has to be research support that is not commercial — independent support through the NHS.

This research base will be essential for an effective biopharmaceutical industry and also for biomedical engineering, an internationally competitive industry. If companies do not like what we offer, they will go elsewhere; many are already doing so. That has serious implications for the way that we will develop economically in the future.

Do we need a real NHS R&D budget? We are grateful for the money that is being eked out of the DoH for NHS R&D, but intelligent delivery of healthcare needs much more. This is a crucial partnership in which NHS R&D must be squarely in the middle. But we also need new methods for applying the money effectively and we need to make sure that the engine driving clinical research is properly connected to the AMRC charities, to the NHS trusts and other divisions of the DoH, to the basic science base in universities and also, importantly, to industry. ❐

Current interest in the Arctic is heightened by the region's role in climate change and its potential as a source of hydrocarbon fuels. On 25 February 2003, the FST held a dinner discussion on how UK interests there should be managed. The discussion is summarised by Jeff Gill.

Diplomacy in the "High North"

Graham Fry

Graham Fry is director-general of public services at the Foreign and Commonwealth Office (FCO), where he has been since 1972. He has held diplomatic posts in Japan, France and Malaysia (as High Commissioner). At short notice he substituted for Baroness Amos at the FST debate.

The Arctic has long gripped the British imagination. Over centuries, the British have played a major part in the exploration of the "High North". But the UK's strong links with the Arctic continue today and I want to explore the reasons why I believe the Arctic is deserving of far greater and better coordinated UK attention.

The Arctic and the Antarctic make up around 20 per cent of the world's surface area. They therefore have major roles in driving global atmospheric and oceanic circulation systems and so, importantly, influence the Earth's climate.

Both polar regions also attract political attention. Present international cooperation in the regions is a measure of the political will to maintain peace and stability there. In Antarctica, for example, national territorial claims (including the UK's claim to British Antarctic Territory) are held in abeyance under the 1959 Antarctic Treaty. All activities there are regulated through a form of international governance, provided by a suite of treaties.

In the Arctic, political cooperation between states is more recent. During the Cold War the Arctic was split into two opposing camps. The Soviet Union, controlling nearly half the region's land area and coastal waters, regarded the Arctic as a bastion from which to project naval power into the North Atlantic. In the other camp were the remaining Arctic states — Canada, Denmark (on behalf of Greenland), Iceland, Norway and the United States — all closely allied in NATO and interested in the Arctic primarily to deter or combat Soviet aggression towards Europe. (Finland and Sweden were non-aligned states in the East-West confrontation and seldom thought of themselves as Arctic players throughout this period.)

The political scene has altered dramatically. Today the Arctic has a distinctive political identity. Confrontation has become cooperation. The turning point came in 1987, when Mikhail Gorbachev signalled a sharp distinction between military and non-military issues in the High North. He highlighted several areas for international cooperation, including the development of a pan-Arctic environmental plan and the creation of an international forum for scientific cooperation.

The eight Arctic Rim countries seized on these proposals. In 1990 they formed the International Arctic Science Committee to coordinate and promote research among national science establishments including some in other countries, such as the UK, with a long-term interest in Arctic research. The following year, Gorbachev's environmental plan emerged as the Arctic Environmental Protection Strategy, directed particularly at fragile Arctic ecosystems. Cooperation on science and environmental issues led naturally to a common interest in socio-economic questions and ultimately to the formation of the Arctic Council in 1996.

The Council, the only pan-Arctic body involving all Arctic Rim countries, subsumes earlier mechanisms of cooperation and has extended its remit to the sustainable development of the region. Its work programme is ambitious, growing and significant, ranging from the fate and effects of pollutants and the protection of the region's distinctive ecosystems to the improvement of its indigenous communities.

The Council contributes to regional stability by being a mechanism for cooperation at the political level. It has been particularly successful in promoting dialogue between governments and indigenous peoples (who sit on the Council by right).

Where does the UK fit in? With the emergence of these cooperative arrangements at the end of the Cold War, Britain faced being squeezed out or, at best, having its influence reduced. Having played a major part in the strategic security of the region, it took steps to get involved. At the outset, the Natural Environment Research Council (NERC) joined the International Arctic Science Committee. Later, the government gained observer status at the forerunner bodies to the Arctic Council, at which we enjoy the same privilege.

But why do we concern ourselves with Arctic affairs? Because we are inextricably linked with them. The Arctic is a relatively secure source of raw materials; Europe will rely increasingly on the hydrocarbon resources of the High North, particularly from Russia. The Arctic has also emerged as a leading producer of non-fuel minerals, including copper, lead, zinc, nickel and even diamonds.

But the clinching argument for paying

more attention to the Arctic is the prospect of climate change, expected to be rapid in the polar regions. Understanding the processes in the Arctic will deepen our understanding of what is happening at the UK's lower latitudes.

Climate change is also at the top of the Arctic Council's agenda. An assessment of Arctic climate change and its implications will be presented to the World Conference on Climate Change in Russia later this year. This will contribute significantly to the fourth global assessment by the Intergovernmental Panel on Climate Change (IPCC), due in 2004.

Another immediate concern is the nuclear legacy of the former Soviet Union. Britain will contribute up to $750 million over 10 years to an international clean-up effort. Project work is about to begin and will include defuelling, the safe storage of spent nuclear fuel and the dismantling of older submarines.

British science and technology will also help to strengthen participation in Arctic affairs. Science diplomacy is now a reality. There are many circumstances in which developing international relations begins with cooperation on science and environmental issues. The emergence of the Arctic Council itself illustrates that point.

discussion

Promoting links. The Government was urged to make a bigger direct contribution to the work of non-governmental organisations pursuing development projects in the Arctic, particularly in Russia. Such projects could have the important incidental benefit of promoting links between UK and Russian scientific organisations. Many Russian scientists were sceptical about the need to take action to control climate change, or gave it low priority in the face of other pressures.

In 1997 the FCO established its own Environmental Policy Department and, more recently, a science and technology unit. There are now also networks of environment and science and technology attachés in overseas missions who report on scientific and environmental developments, forge links with local experts, lobby on key issues of UK concern and identify projects to support with our Global Opportunities Fund.

As one of the world's leading countries in polar scientific research through Antarctica, we have much to offer the Arctic. Moreover, the Arctic countries are actively seeking to involve non-Arctic participants, including the UK.

Finally, there is a need for government to pay closer attention to Arctic affairs. While the FCO has a strong interest in developing cooperation between the UK and the Arctic process, we can do so only in concert with others. We need also to engage with the wider agenda of Arctic cooperation and we must ensure that government departments which, up to now, may be unfamiliar with Arctic issues, know of the new opportunities.

2007 is being promoted as the next International Polar Year, to mark the 50th anniversary of the significant polar component to the International Geophysical Year of 1957/8. Then, it was the Antarctic that featured heavily. The chances now are that the Arctic will dominate. We need to make a telling contribution. ❐

Opportunities for prudent operators

Dougal Goodman

Dr Dougal Goodman is director of the Foundation for Science and Technology. He began his career researching the mechanical properties of ice at the Cavendish Laboratory and has led expeditions to Greenland, Alaska, Canada, Svalbard and Antarctica to study ice in nature. For 15 years he worked for BP in Alaska, Canada, North Sea operations and strategy before becoming deputy director of the British Antarctic Survey in 1995. He was awarded a Polar Medal in 1998.

Today I am speaking in a personal capacity — the Foundation for Science and Technology maintains a neutral position on all the topics we debate and therefore does not have a view on the Arctic. For much of my career I have been interested in the polar regions and could not miss the opportunity to speak on this issue today.

The region surrounding the North Pole, characterised by harsh climate, sensitive ecosystems, ice and snow and very sparse human habitation, often by native peoples, was termed the "circumpolar north" by Terence Armstrong in 1978 (ref. 1). This area covers 8 per cent of the Earth's surface, 15 per cent of the land area and 5 per cent of the oceans. When I use the term 'the Arctic' I am referring to the circumpolar north.

I have three simple messages to deliver. First, many British companies — many more than you might imagine — are already doing business in the Arctic. Second, there are significant new opportunities in the Arctic, particularly as Russia seeks partners for future investment. Third, companies must work hard to obtain and maintain a licence to operate in the region.

In February the Government published a white paper on energy and targets for carbon dioxide reduction[2]. Much of what I have to say today relates to our options for future energy supply from the Arctic. UK progress in CO_2 reduction has been largely the fruit of the switch from coal to increased gas-fired and nuclear power generation. Since 1980 UK gas consumption has more than doubled from 4.7 billion cubic feet per day to 9.2 billion cubic feet per day in 2001. Britain will be a net importer of gas by 2006 and of oil by around 2010. We face some tough choices. Where should Britain look for future gas and oil supplies? How diversified should these supplies be? What role if any should the Arctic play in supplying global energy needs?

Most oil reserves are in the Middle East (65.3 per cent of proved reserves or 686 thousand million barrels) but the republics of the former Soviet Union have around 36 per cent of proved gas reserves (1,983 trillion cubic feet)[3]. A sizeable fraction of that gas is in Russia. A significant proportion of our supply of oil depends on the transport of oil, usually by tanker, from the Middle East to Europe. Gas, because it is more difficult to transport, is delivered by pipeline or Liquefied Natural Gas (LNG) vessels. Gas will come to the UK by pipeline from Russia (including the Arctic region), Algeria, the Netherlands and Norwegian Sector of the North Sea.

In the United States, gas could be exported from Alaska directly to Canada and the lower 48 states by pipeline. Experience shows the technical difficulties of pipeline construction over this distance and terrain could be overcome but the economics do not currently support a pipeline and much work remains to win the consent of those who would be affected by the pipeline.

Working in the Arctic is a challenge. The Alaskan oil fields are economic only because economies of scale offset the higher operational costs. There are also logistical difficulties: limited or non-existent infrastructure, extreme weather and the need to export products great distances by pipeline or ship. There is also strong resistance to further development in the Arctic because of fears about the impact on the environment and the native peoples (discussed in the articles that follow by John Lawton and Michael Meacher). But, some native groups are actively seeking development to improve their economic position. Winning and maintaining a licence to operate will require developers to demonstrate that the environment can be protected (technical innovation is important) and by building trust with the communities in whose region they wish to develop.

The opportunities in the Arctic for UK companies are immense. The oil fields developed by BP on the North Slope of Alaska show that in the harshest of conditions development can be profitable. On 11 February 2003 BP announced a $6.7 billion deal to form a new partnership with a Russian oil company, TNK. The partnership will open up many new opportunities in the Russian Arctic for BP. Shell, the Anglo/Dutch company, is operator of an $8 billion scheme offshore Sakhalin to develop the oil and gas resources under the ice-infested waters off the east coast of Russia. This is the first Russian offshore project and the first with a production sharing agreement, allowing foreign investment to develop the field. Its market will be Asia and the Pacific Rim.

There are also new oil and gas exploration opportunities in Russia, particularly in the Barents Sea. None of this is child's play. Surprisingly, the most difficult aspect of onshore operations in this area is not the cold winter but the wet boggy land that emerges during the summer. New technology will be needed to solve the development challenges.

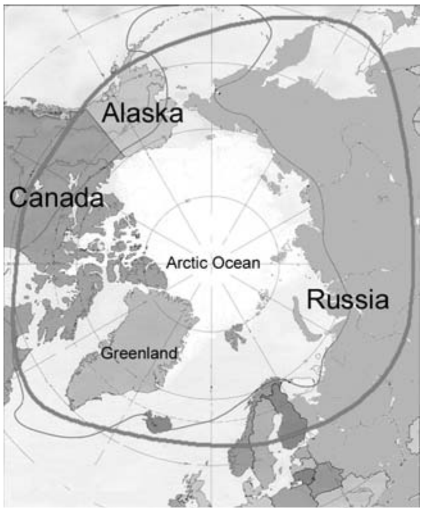
Engineering consultants are needed, as are environmental consultants. Yukos, a Russian oil company, has bought the UK's John Brown Hydrocarbons which is expert in designing production facilities. Also there are new opportunities for service support companies to the oil and gas industries. Many British based companies are involved in these schemes — AMEC, for example, is designing structures for ice-infested waters and ALSTOM Power has supplied gas compressor sets for Russian pipelines. Fugro Geos is providing geophysical surveys in the Barents Sea.

There is a significant amount of undeveloped oil and gas acreage in the northern part of Canada, in the Beaufort Sea. Both BP and Shell hold very substantial acreage in that area, which may become economically viable if a pipeline is built to connect to the rest of the Canadian pipeline network. There are also opportunities for further mineral and precious metal exploration and production.

Development cannot take place without finance and insurance. Financial institutions in London are active in advising companies investing in Russia — the BP/TNK transaction was supported by a group of largely London-based companies. NM Rothschild has over many years provided non-recourse financing for projects in Russia.

On the Northern Sea Route, the shipping route along the north coast of Russia, a Protection and Indemnity Club with its offices in London is insuring one of the largest shipping companies in Russia, the Murmansk Shipping Company that operates ships along the route.

Finally, in this catalogue of opportunities, are fishing and tourism. British fishermen are still fishing in Arctic waters. But what matters is the quantity of fish imported: a large part of the £400 million worth of fish products imported in 2001 came from the Arctic — the seas around northern Norway, Iceland, the Faeroes, Canada and Russia. We shall see increasing quantities coming from Russia. Tourists can now buy a ticket to the North Pole on the Russian icebreaker, the *Yamal*, from a UK-based tour operator.



The Circumpolar North

The key question for companies wishing to invest in the Arctic remains that of obtaining and keeping a licence to operate. Opportunities for British companies abound, but they have to satisfy local, regional, governmental and global groups before they can launch an Arctic project. Doing so requires a partnership between science and industry, not an adversarial relationship. Graham Fry has already argued for more cooperation between scientists, but I believe there could be more science-led cooperation in industry.

In summary, to do business companies need to create trust with local people, the regions, governments and international groups. The developments in prospect are challenging and are economic but must respect the environment.

I have two questions for the discussion. Can government, industry and the research councils work more effectively to coordinate their interests in the circumpolar north? How should companies build trust to keep a licence to operate? ❐

1. Armstrong, T.E., Rogers, G. & Rowley, G. *The Circumpolar North: a political and economic geography of the Arctic and Sub-Arctic* Methuen & Co., London (1978).
2. White paper *Our energy future — creating a low carbon economy* (February 2003).
3. *Statistical Review* BP (2002).

discussion

Technology application. It was argued that doing nothing about climate change was not an option and cynicism was dangerous. Existing technology was not being applied to the extent that it should, because it was not conventionally regarded as economic to do so. That assessment depended on a discount rate which assumed perfect substitutability into the future — an unrealistic approach, given that people only had one planet. The economic system treated capital as income, to an extent that made the accounting practices in recent corporate scandals look virtuous.

The Arctic as a crucible of change

John Lawton

Professor John Lawton CBE, FRS is chief executive of the Natural Environment Research Council. He trained as a zoologist, worked at the universities of Durham, Oxford and York (where he holds a personal chair) before founding the NERC Centre for population biology at Imperial College, London

The surface of the Earth is a complex system of interacting parts — the atmosphere, the oceans, polar ice and the bio-sphere, to name a few. The polar regions are important in the global system because they are covered by ice, which is funny stuff.

First, ice is less dense than water so that it floats; if ice did not float on water, the Earth would not work even remotely as it does. Second, snow and ice have a high albedo: they reflect back to space much of the solar radiation reaching them. Third, when salt water freezes, it ejects salt. The dynamics of the global system are crucially determined by these properties.

Here is an illustration. Both poles are covered by ice sheets that reflect much of the solar radiation reaching them back into the atmosphere. So there is a net energy deficit at the two poles. But that cannot persist; the deficit is made good by massive transports of heat from the Equator to the poles, both by atmospheric circulation and by the oceans.

The Gulf Stream is a part of this oceanic transport system, called the thermohaline circulation. It carries heat from the Equator to the Arctic. When it reaches the Arctic, the water takes a header down into the deep ocean and moves back towards the Equator. The full circulation circumnavigates the globe, returning to its starting point after about two thousand years. If ice did not have the characteristics I have described, the thermohaline circulation that couples the polar regions to the rest of the planet would not exist.

What does this tell us about the science we need to address? Almost all environmental scientists are at present concerned with three issues: global climate change, pollution and sustainable development. All three questions are clamant in the Arctic.

First, climate change. There are three patches on the surface of the Earth where the average temperature has increased by more than 1.5°C in the past 50 years. One of the patches is the Arctic. Yet, despite the overall warming trend, parts of the surface have actually cooled — eastern Canada and Greenland, for example. This behaviour is poorly understood and we need to know whether it is part of the normal variation in the Earth system or is anthropogenic.

Certainly the increasingly sophisticated climate models predict increasing warming in the Arctic as a result of continuing greenhouse-gas emissions. Not many people doubt that the changes are anthropogenic, but we need to understand the processes better. One expected consequence in the Arctic is the melting of sea ice, meaning that less radiation is reflected back into space. But the fresh water from melting ice in the polar regions could potentially turn off the critical thermohaline circulation. Monitoring sea ice using passive microwave data from satellites reveals large regional, seasonal and interannual variability in ice cover, but the average net loss of ice in the Arctic is about 2 per cent a decade. Six of the ten years of minimum Arctic ice since records began have occurred since 1990.

The water from melted ice flows into the oceans, affecting not only the thermohaline circulation, but also global sea level. Although the chief contribution to sea-level rise is thermal expansion of the oceans, the best present estimate is that melting ice accounts for about 1.4 millimetres of sea-level rise a decade, roughly half the contribution of melting Alaskan glaciers.

We know that the oceans are getting fresher, another indicator of melting ice. There is other evidence of what is happening as the Arctic regions warm. Over many years, boreholes have been drilled throughout the region defined earlier by Goodman, where the land is mostly permafrost; many of the boreholes are monitored. The data show that the permafrost over this region is melting, although the rate varies from place to place. Melting permafrost will not affect the Earth's

discussion

Oil transport. The transport of oil from the Arctic presented another hazard. Currently two huge tankers were stuck in ice in the Baltic, and they were single-hulled. Lessons should be learned from the tanker disasters of recent years, and the EU should promote a ban on single-hulled tankers in the Baltic. Against this it was argued that double-hulled tankers could cause worse disasters, because it was more difficult for surveyors to spot leaks. If oil got between the two hulls a spark could cause an explosion.

albedo as does melting sea-ice, but permafrost locks up a great deal of methane in an immobile form and, as the permafrost melts, that methane is released in huge quantities. Methane is a very potent greenhouse gas.

On the key issue of pollution, radioactive fallout, acid rain, increasing numbers of heavy metals and various organic chemicals from industrialised latitudes are being deposited in the Arctic. They threaten the indigenous people and organisms, which are also suffering from habitat loss as the permafrost and the ice sheets shrink.

Britain has strengths in a range of science disciplines to address these issues. The NERC community is already working closely with organisations such as the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), the JNCC and the Hadley Centre to make a significant contribution to Arctic studies.

In some respects, we are world leaders. For example, a new NERC-funded satellite called *Cryosat* will play a leading part in deepening understanding of what is happening to Arctic ice. *Cryosat* uses a new radar altimeter to work out sea-ice movement and the elevation of ice sheets, so that we can nail down the rate at which Arctic ice is melting.

NERC is also about to embark on a major programme called RAPID, costing about £20 million over six years to evaluate the risk of the rapid climate change that might be caused if the thermohaline circulation were to be attenuated. In the RAPID programme, we shall mount a higher-latitude ocean study of the Arctic and sub-Arctic ocean fluxes and shall address the issues of melt-water and salinity change. This programme is a partnership with the US National Science Foundation.

We shall also throw technology at the problem. We are about to send NERC's autonomous submersible vehicle, *Autosub* (designed in partnership with the Southampton Oceanographic Centre), to where we would not dare send people — under the ice sheets in Greenland to learn more of what is happening underneath the ice sheet.

There are surprising twists in these stories. We have all been told that it is a good idea to plant trees and to conserve forests so as to lock up CO_2 in biomass. That is usually true, but not in the Arctic. The NERC Centre for Ecology and Hydrology has shown that snow-covered trees absorb more solar radiation than snow-covered ground. The models then show that carbon accounting alone gives a false impression of the potential for northern forests to mitigate climate warming; they have virtually no effect.

Against this background of major environmental issues in the Arctic, British scientists have participated in the Arctic Climate Impact Assessment and the Arctic Monitoring and Assessment Programme, to name but two of the Arctic Council's working groups. I am certain that we shall continue to contribute to these international assessments, transferring scientific knowledge into policy and decisions about the management of this crucial area.

We also hope to continue to add value to the UK research effort by international cooperation. The NERC Arctic station in the international science village at Ny Aleseund in Svalbard is a good example of what can be achieved by combining modest resources with suitable infrastructure.

I end with two challenges. NERC has a finite budget with which to satisfy many competing demands. How do we respond to new challenges? There is a lot of Arctic science being funded by the EU, the United Kingdom, NERC and the other research councils, but should we invest more in coordination to get a bigger bang for our buck?

Second, we have to make sure that our scientists connect strongly with our end users, the people who want to exploit and develop the Arctic. Take Dougal Goodman's earlier article. There are not enough fish in the sea; arguably, none of the fisheries Goodman talked about is sustainable. Nor can we afford to burn all that oil and gas without seriously affecting the Earth's climate. We have to de-carbonise, before or after we use these resources. These are bigger challenges that extend well beyond Arctic science.

Those are the kinds of questions and issues on which we need to work together with industry and colleagues if we are to have a sustainable future. For what the Arctic is saying is that we are not using this planet sustainably: we ignore what the Arctic is telling us at our peril. ❐

Can the Arctic be conserved?

Michael Meacher

The Rt Hon. Michael Meacher MP was educated at Oxford and lectured in social administration. He was elected to the House of Commons in 1970 and became Minister for the Environment in 1997. He delivered this talk as Minister for Environment and Agri-environment in the Department for Environment, Food and Rural Affairs, but left the Government last June.

The Arctic has one of the most extreme environments on the planet, but the pace of change there is accelerating because of diverse factors — some internal, others global in scope. My visit there last year brought home how this apparently remote and fragile environment is affected by our everyday activities here in Britain and other industrialised countries.Last year the United Nations Environment Programme (UNEP) issued a strong warning in its third Global Environmental Outlook (GEO). Humanity is polluting and using up vital renewable resources — fresh water, urban air, forests and soils — faster than they can regenerate themselves. The polar regions are not exempt from these disturbing trends. Because the region acts as the globe's "canary in the mine", it is clear that now is the time for action.

I shall focus on three of the most pressing environmental issues facing the Arctic: climate change, biodiversity and chemicals.

Climate change

Scientists tell us that the Arctic will be one of the places on Earth most rapidly and dramatically affected by climate change. Over the past century, average temperatures in the Arctic rose by 1°C — more than twice the global average — while Arctic sea-ice has markedly decreased. IPCC's third (2001) assessment of climate change projected that, if concentrations of greenhouse gases carry on rising, winter warming of the Arctic

Ocean will be as much as 16°C in 2080.

We can only begin to predict the impacts of such rapid climate change. The Hadley Centre in Britain has projected that, in a high-emissions scenario, the Arctic sea-ice could completely disappear during September in the 2080s. Melting glaciers will cause sea levels to rise for many centuries to come. New sea routes could open up through the Arctic giving rise to major strategic and trading challenges. The region's distinctive biodiversity and way of life could also be seriously harmed.

So how can we address this challenge? The United Kingdom must promote global action to stabilise greenhouse gas concentrations in the atmosphere at a safe level. We are committed to the Kyoto Protocol and have put in place an ambitious programme of domestic action to cut greenhouse gas emissions. But deeper cuts will be needed. A report from Imperial College has shown that significant cuts in emissions would be feasible over the next 50 years. But that will not happen without a step-change in science and technology and a fundamental redirection of economies towards increased energy efficiency and low carbon technologies.

We also need to focus our attention specifically on the threats posed to the Arctic region. An opportunity will come at the ministerial conference arranged by the Norwegian government later this year. That meeting will include a presentation of the Arctic Climate Impact Assessment (see page 14).

discussion

Energy sources. There was scepticism over the feasibility of closing the gap between energy demand, particularly in the developing countries, and the potential power supply from sustainable sources. Wind turbines would only work when the wind blew, and in the UK it was intermittent. There was plenty of wind in the Arctic, but the turbines might freeze up. Wind power could be supplemented by solar power, but that too was intermittent in middle latitudes. One speaker called for an engineering solution, using large, low-speed turbines in the estuaries of major rivers to produce the large quantities of power consumed by big cities.

Finland considered that, in order to meet its environmental targets, it had to build new nuclear power capacity, although it wished to cooperate with other countries over nuclear power.

Attention was drawn to an apparent contradiction, in that one speaker talked about conserving the Arctic while another advocated plundering it. In defence it was said that the Arctic had to be put into the international context. The fabric of society ran on energy and oil had to be replaced somehow.

Biodiversity

Climate change will have far-reaching consequences for Arctic flora and fauna. Despite the fashionable (but proper) interest in biodiversity hotspots such as Madagascar, in my view it is as important to recognise ecosystems such as those in the Arctic where hundreds of endemic species survive in the most extreme conditions the Earth has to offer.

Much of this biodiversity is genetically distinctive and many species — polar bears and ice seals for example — serve as key indicators of the wider global environmental change. The word "Arctic" comes from the ancient Greek *Arktikos*, or "country of the great bear", yet polar bear populations, along with many other mammal, bird and fish species, are facing unprecedented threats.

Forests too are under threat. Some say that the Arctic's boreal forests are significantly less rich in biodiversity than tropical forests, and infer that the case for their sustainable management is not as strong. I disagree. The biodiversity of boreal forests is unique and requires as much protection and sustainable use as any other ecosystem. These forests provide the same variety of invaluable services to humans and the ecosystem – such as soil stabilisation, fodder and forage, medicinal plants and as a pollutant filter – as their tropical counterparts. They also take much longer to mature and longer to recover if they are fragmented or destroyed.

I am pleased that Britain has been strengthening its links to the Conservation of Arctic Flora & Fauna (CAFF), a working group of the Arctic Council. Only last month, JNCC organised a workshop in Edinburgh bringing together representatives of CAFF with those of the UK Government and its nature conservation agencies. The aim was to explore cooperation on issues of mutual concern (such as migratory species) and identify priorities for further collaboration.

Chemicals

A number of chemicals, such as persistent organic pollutants (POPs) and some heavy metals, are transported to the Arctic and can accumulate in food webs, creating real and potential risks to consumers, both human and wildlife. Some effects (apparently related to PCBs) are showing up in polar bears and seals, while some of the foods of the indigenous people are contaminated with mercury and PCBs to levels that would not be acceptable here.

Efforts are being made globally to reduce the release and even use of these chemicals, with encouraging results. For example, the widespread controls on lead have resulted in declining levels of exposure in the Arctic. We expect that the recently agreed UNEP programme on mercury will have a similar effect.

Implementation of the Stockholm Convention on POPs, expected to enter into force next year, should also reduce future exposures. This convention bans or restricts the use of ten manufactured POPs and requires action to reduce or eliminate the release of unintentionally produced POPs such as dioxins. Although the convention currently lists only what might be called the "old" POPS, it does include a procedure for adding further substances. Some of the chemicals reported to be increasing in the Arctic will be candidates for inclusion.

Conclusion

The Arctic is not an enclave. Many of the problems facing the region do not originate there and cannot be solved in the Arctic alone. Solutions have to come from cooperative action throughout the international community.

Last year's World Summit on Sustainable Development and this month's UNEP ministerial meeting drew attention to Arctic concerns and agreed support for initiatives such as those of the Arctic Council. We need further to develop cooperation between Britain and the Arctic process, particularly the Arctic Councils sustainable development programme. ❒

A UK success story — technology transfer from Formula One and motor rally to commercial car production. The discussion meeting held by FST on 3 December 2002 celebrated an industry in which British companies have excelled.

The British motor-sport formula

Richard Parry-Jones

Richard Parry-Jones is group vice-president, Global Product Development, Ford Motor Co. He was *Autocar* magazine's "Man of the Year" in 1994 for helping to "change the culture of one of the world's biggest corporations" and leading the Mondeo development to "unmatched refinement and dynamics". Ford Motor Co. includes the Aston Martin, Jaguar, Land Rover, Lincoln, Mazda and Volvo brands.

Technology transfer is not the main benefit that Ford Motor Co. gains from motor sport. We do not invest in motor sport to get technology: it would be a very expensive way of doing that. No, we race to publicise and showcase our technological prowess, our professionalism, our passion, our commitment and our enthusiasm for motor vehicles.

The halo effect of successful participation in motor sport is tremendous. The impact on prospective buyers' attitudes towards our brand-mark with our World Rally Championship programme is very significant. Ford starts from a baseline of high product-awareness — over 90 per cent in the European region. But awareness is not enough; potential buyers need to admire the company and aspire to become customers. Rallying showcases our products in an environment where people can identify with an exciting, colourful, high-speed, responsive company that understands and is passionate about the technology involved in building and designing automobiles.

Rallying, in particular, has a direct effect on a brand. Our rally car is recognisably a Ford Focus, not too dissimilar to the one that can be bought at the local dealer's. Having the world's best drivers choose to drive and to be successful in a product that closely resembles the car that you and I can buy as a road car reinforces the driving quality aspects of the brand. The Focus RS does more than its fair share of capturing front covers and free coverage on television and in magazines. The Focus WRC has won many events, including the gruelling Safari Rally.

Ford Focus RS participation in the World Rally Championship is has been pivotal in changing outdated perceptions of the blue oval brand-mark. There is a parallel in (Ford-owned) Jaguar's investment in Formula One. Jaguar is famous for its five Le Mans victories in the 1950s and the Jaguar legend was maintained by victories in 1988 and 1990. But these victories at Le Mans are more relevant to our older customer base. Jaguar is targeting the younger customer with its X Type range and what better sport to prove the modernity of Jaguar than the world's most technologically challenging formula for motor sport. That is Formula One.

Technology transfer may not be why we go racing or rallying, but it is a valuable spin-off and it contributes to the engineering of our road cars. The old saying, "racing improves the breed", is best exemplified by the disc brake. Jaguar was the first to race with disc brakes on the C Type at Le Mans in 1952 and 1953; disc brakes are now standard on most production cars. Today the interaction between motor sport and road cars is more complex. It is no longer simply one-way traffic from motor sport to the road; it is very much a two-way traffic now. Each is learning from the other.

The United Kingdom is the heart of the world's motor-sport industry. There are over 3,000 companies operating in the British motor-sport industry. Their combined annual turnover is more than £5 billion. The industry employs more than 40,000 people directly and, of course, more indirectly. About 50 per cent of the sales I have just quoted are for export and 20 per cent of the revenue is ploughed back into the sector for research and development.

discussion

Stimulating youngsters. It followed from the drama and excitement that motor sport could have a significant impact on encouraging young people to take up engineering skills; it gives engineering street cred. Schemes whereby students or schoolchildren were taken into motor-sport factories were commended, but it was pointed out that it could be just as valuable to bring the industry into universities by establishing closer contact with researchers and getting students to understand that excellence in performance was not just the exercise of skills by individuals, but the result of a seamless teamwork involving many different skills and specialities.

This is a very important underpinning of a competitive economy in a world that is increasingly dependent on technological excellence to add value to consumer goods and services. Ford's investment in Cosworth engines, in Pi Technologies, in Jaguar Formula One Constructors and in the World Rally Championship is a significant portion of the total.

The World Rally Championship is the premier global motor-sport activity and thus is Ford's main focus in motor sport. The team is based in Cumbria, where the facilities rival many of the formula-one teams. We have many partnerships with important rally-team suppliers. The road-going Focus RS features a host of components from companies such as Brembo (brakes), Garrett Air Research (turbochargers), OZ Racing (wheels) and Sparco (seats): all these components are branded on the Focus RS to increase the connection in the customer's mind between the motor-sport version and the version which we offer for sale. We actively promote these links to reinforce the sporting credentials of our road cars. Even the styling cues on the Focus RS are lifted directly from the rally car.

We also use rallying for career development, by nurturing specialist engineers and their management skills and encouraging the mindset of top-level motor sport.

Features that appeared on our competition cars before our road cars include multi-valve engines, anti-lock brakes, many weight-saving components made of magnesium, of aluminium and of carbon fibre and even, believe it or not, heated windshields.

Formula One is a different sport altogether. It is technology's cutting edge; a glamorous, high octane, exciting sport that attracts the powerful, the rich and the famous. It is a wonderful place to do business and, as Jaguar, we are able to attract many corporate sponsors. The cars do not much resemble road cars but there is significant technology transfer on components. Engine management systems, for example, interchange fairly freely between road cars and formula-one cars; many of our early efforts to control engine and transmission technologies were pioneered in our formula-one applications. Paddle shift — semi-automatic gear change — now seen on the Aston Martin Vanquish, began its life in Formula One. Next generation anti-lock brakes and traction control systems were developed in Formula One.

Jaguar Racing is also working on cutting-edge data-logging technology. The front of an Aston Martin Vanquish is made of carbon fibre, manufactured just like a formula-one car. You can have a 50 m.p.h. crash in a Vanquish and all you will need to do is to remove the front bumper and bolt on a replacement. That is one of the advantages of carbon fibre.

Information technology is one of the newer elements of exchange between road and race cars; there is extensive use of computer modelling and simulation technologies for both species. We have six Cray supercomputers interchangeably used for our road and race-car development programmes; this set-up includes a virtual wind tunnel for whole cars and engineering flow analysis. We have a division called the Premier Performance Division that marries our Jaguar Racing, Cosworth Racing and Pi Technology companies. That is a good example of the rapid technological sophistication and complexity happening in Formula One.

WRC and Formula One are just two of many areas of motor sport in which Ford competes worldwide, based on our UK operations. Volvo touring cars, in the past, have led to high performance derivatives for the road, such as the R series 300 b.h.p. vehicles with 4-wheel drive and adaptive suspension and drive trains. That would not have happened if Volvo had not changed its image through the British Touring Car Championship and, later, the European Touring Car Championship. In the 2003 season, every single car that competes in the US Champ Car series will be powered by a Cosworth engine, built and designed in Northampton — a remarkable testament to the outreach of Cosworth.

Although technology transfer is not our prime motivation for being in motor sport, it remains a valuable benefit and the cross-fertilisation is no longer confined to components, materials or hardware, but is more about processes, systems, software and people. That is a significant development that will serve us well in the future. The technological resources of Ford worldwide help to guide our motor-sport programmes but our experience in motor sport is constantly fed back to aid mainstream product development. ❐

An insider's view of the motor-sport industry

David Richards

David Richards, chairman of Prodrive, was co-driver to the legendary Finnish rally driver Ari Vatanen when they won the 1981 World Rally Championship in a Ford Escort RS. He went on to establish Prodrive which, with Subaru, has won three manufacturers' and two drivers' world titles.

At Prodrive we see things from the viewpoint of the participating teams. We are facilitators who sit there between the car manufacturer and the public; we have had experience both of participating in the sport and of using technology and also of building up the technology business alongside our racing and rallying activities.

First, I underline the importance of motor sport to this country's economy. Motor sport valley — centred on the Birmingham to London M40 route — is home to seven formula-one teams, four world-rally teams, and a whole mass of international racing teams involved with sports cars, touring cars racing and the many single-seater formulae that have evolved all over the world. Around these teams and manufacturers is a supporting industrial infrastructure.

At Prodrive, we believe that we play our part in this. Our background – five World Rally Championship titles with Subaru, a string of touring car championships with Ford and other manufacturers, and sports-car racing, where we currently run a Ferrari programme at Le Mans and round the world, chiefly in the USA. In October 2001 we took over the management of the British American Racing (BAR) formula-one team.

Motor racing is a fairly volatile business. If you rely totally on the sponsor's income for a racing programme, or are reliant on a car manufacturer who may change strategy from year to year, you can be left in a very difficult position. So, a few years ago, we took a conscious decision to branch out into automotive technology. We employ 1,500 people and cannot rely on the fickle nature of motor racing.

Our automotive technology division exists to transfer those technologies and those skills into mainstream engineering and the automotive industry. The Subaru Impreza that we run in the World Rally Championship uses a conventional gearbox and yet is fully automatic, operated from the gear lever next to the steering wheel or a paddle shift. Now the Aston Martin road car uses a system derived from this technology. We can change gear within 40 milliseconds while the driver concentrates purely on driving. We have managed to move the technology across to a whole raft of areas with major benefits, and it is not just in the road-car applications. We have also applied it to large trucks and earth-moving equipment, JCB equipment, where the driver needs to focus on the task in hand.

We have also been working on active torque dynamics. In road cars, if you have an emergency and the car starts oversteering or under-steering, it requires fairly expert handling to prevent an accident. Many road cars are now fitted with systems that stabilise the car using the brakes. They are pretty effective at low speed but less good at higher speeds. Rally cars, driven on the limit all the time, will under-steer one minute and over-steer the next and yet they seem to manage the process very well. Of course the top rally drivers are highly skilled and experienced, but they are helped by the cars themselves that use very complex differentials and electronics to control the torque and the dynamics of the car.

With such a system fitted to a normal road car like a Ford Mondeo, any driver can have precise control of the car with a competence that would otherwise only come with years of experience in high-speed rallying.

In the World Rally Championship we are also using Global Positioning System technology to track and monitor the cars — it is easy to see how important it is to know exactly where you are when hurtling through the Rift Valley on the Safari Rally or in the wastelands of Sweden. The system provides detailed information on how each car is progressing along the route, important for safety issues, for managing the event and also giving the public access to the latest results and stage times via the internet. Transferring this type of technology to road cars is an ongoing development: and "e-safety" and "e-traffic" systems are the next big development for road cars.

Aerodynamics has for many years been an important factor in motor racing. We use wind tunnels to hone the aerodynamics, but they are expensive to operate and it takes a long time to change elements in the wind tunnel if you want to simulate different facets of a racing car. So we are now starting to use very powerful computers now to do exactly that — this is called computational fluid dynamics. We can simulate so many things very quickly, linking up high-speed computers to do what would take much longer in a wind tunnel. The refinements of these processes now are becoming so good that you can save enormous amounts of time and development costs in reaching solutions.

We are developing this technology for other applications and now have a team of people selling it in industries beyond the automotive industry. For example, we have developed a mask for painters working in the paint industry, based on efficient channelling of inhaled and exhaled gases. We work with the pharmaceutical industry on clinical inhalers.

For me, the really interesting aspect of motor sport is that it is a real bridge for technology, a high-profile platform for new technologies. Manufacturers are loath to add anything to a car is going to be an expensive addition to their costs and yet, if the public demands it, the public supposedly sees the benefits. Motor sport can provide that opportunity for the public — and for those involved in the automotive industry as a whole — to see what is possible.

In Britain, we are at the leading edge of this high-profile enterprise. We are a success story, although few people realise how big our industry is on the world scale. Companies like ours are beginning link the technology developed on the track to industry. There is so much more that can be done and motor sport offers an extraordinary platform for many ideas for the future. ❐

Motor sport's broader contribution

Stuart Smith

Stuart Smith is technology vice-president, Fuels and Lubricants, BP. After graduating in chemical engineering he joined ICI Specialty Chemicals. His final role with ICI was as planning director, Industrial Specialties, before he joined Castrol in 1998 as consumer technology director.

What, if anything, can motor sport contribute to society in terms of transport development, sustainable development and technological advance? I say "if anything", because there are many people who believe that the contribution is zero. But from the perspective of the fuel and lubricant sponsor and developer, I would say the contrary is true. This is particularly the case for some of the most pressing problems that society now faces — in greenhouse gas emissions, particulate fallout, environmental change. At BP we believe that the big oil companies and motor manufacturers can work together to do something about these important issues.

Castrol's position at the leading edge of technology has been built up partly through its history in motor sport. Castrol's sponsorship and sports involvement dates back to Britain's first air show at Doncaster in 1909, when Leon Delagrange lapped a one-and-a-half mile circuit at 50 miles per hour using a newly developed lubricant called Castrol R. Alcock and Brown were powered by two Rolls Royce engines lubricated with 50 gallons of Castrol R when they crossed the Atlantic in 1919 for the first time. Some of those involved in motor sport and motorcycling will remember the smell of burnt Castrol R, but it actually started life in the air.

Henry Seagrave and Sir Malcolm Campbell broke world land and air speed records using Castrol and, more recently, when Noble and Thrust again broke the world land speed record for the 39th time since Castrol's first involvement in 1914, it was the 21st in which Castrol lubricants had been used. Today BP and Castrol remain involved in motor sport both on land and sea, where we continue to learn from our experiences and add value to the technology pool.

For us, a formula-one engine is a laboratory for learning about both fuels and lubricants. The designer of a production-car engine, however, looks to the lubricant designer to deliver a different range of performance attributes from the racer or record breaker. The key difference between the two is the need to find a lowest cost compromise from a wide slate of engineering needs for the production car compared to the very focused attention to power and reliability for motor sport.

In the production car, fuel economy is a top priority. This attribute is close in implementation and formulation to the motor-sport engine designer's need for the delivery of more power from the imposed engine size. We are already experimenting in motor sport with novel chemical entities that improve friction, viscosity modification, dispersion control and all the things that are important to keep your car on the road. Engine cleanliness and efficiency is essential for the maintenance of good fuel economy and long engine life and, in a race, for the maintenance of power.

discussion

Sustainability. The thrust of the speakers' talks was based on the assumption that the more vehicles sold, the better. But was this a desirable or sustainable end? Car ownership was increasing dramatically as people needed cars to live their geographically dispersed lifestyles; and such lifestyle flourished as car ownership increased. But this could not go on, at least in Europe. The environmental damage was becoming increasingly intolerable. Creditable improvements were being made in vehicle emission reduction and noise, but every technical fix undermined demand restraint. Who was addressing the social consequences of vehicle use? Were existing trends sustainable? Responses suggested that lifestyle is what it is, and it was for industry to find means of supporting it and ameliorating its drawbacks, rather than to concern itself with social engineering.

Long life

Production-car engines are now designed for a life of at least 100,000 miles. This long life is designed into the physics and chemistry of the lubricants — the first task is to use the lubricant to keep surfaces apart, that's the physics. When that fails and the surfaces touch, we are left with the chemistry of surfaces.

The cost of motoring has also improved with the lengthening of service intervals. For some German products, this is heading to well above 30,000 km, but extending crankcase oil life over that distance compromises fuel economy and power.

Another important compromise with production-car lubricants is the protection of catalysts. Many of the things we put into the lubricant to achieve economy, long engine life and extended service intervals don't help very much for the last, so the formulation has to take this into consideration. An even wider compromise is that many motor oils must be in the service of a wide range of engines. Different engine types, automotive competition and emerging technology will continue to ensure these divergent needs and more compromise.

Lubrication requirements for the formula-one engine are in dramatic opposition to the needs of a production car and yet, it is this focus that allows participation in the sport to add to technology knowledge. First, the race is very short, about 90 minutes. Second, the conditions are extreme — the formula-one engine runs at about 19,000 revs and delivers something like 900 b.h.p. from its compact 3-litre engine — and there are high lubricant stresses, high local temperatures and many dynamic changes in that engine throughout its life. Third, and significantly, the development is very specific, for one engine only with its unique appetite for and response to lubricant formulation changes. More specifically, the engine is continuously developed during the season, so the lubricants are continuously optimised to maximise power. In the most advanced cases, changes to engine design can be made to accommodate the further contributions that lubricants can make to power output; we call this co-engineering.

Co-engineering is transferable to the road. It is an expensive process but its value to the world of mobility is immense. The same is also true, but to a different extent, for fuels. In Formula One, a fuel is specifically formulated for one engine's appetite to maximise and maintain power. The rules for fuels are stiffer; there is less freedom for the fuel formulator than for the lubricant formulator.

There is a subsidiary question at the heart of technology management that every research director must make, and that is "on what should I spend the firm's technology investment?" Note that technology is an investment, not a cost.

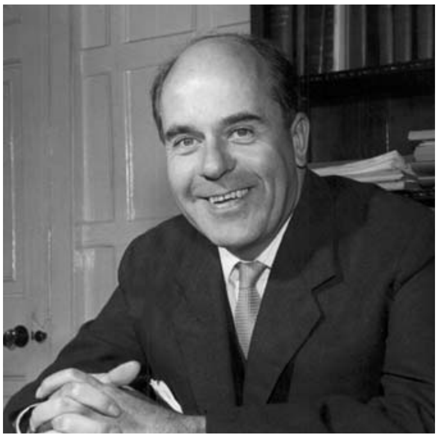
Let me use one example, from the lubricant business, in particular the oil in the crankcase. When I came into the oil business a few years ago, I assumed that the internal combustion engine that has been with us for well over a hundred years must be at the end of its development. But the data show the opposite. A plot of a composite unit measuring the performance of crankcase oil against time, as marked by successive new introductions of improved car engines, illustrates the progression that the design of the internal combustion engine has exerted on the oil in the crankcase, the sump oil. The curve obtained is an "S curve" typical of a technology nowhere near the end of its lifecycle. This tells me that it is still worth investing in this technology and that the lubricant performance is not going to be a limitation to, say, extended maintenance intervals or more energy-intense engines.

If motor sport is a good laboratory and the technology has a long way to go, where is the evidence that the sport is helping to get innovative products onto the market? One example is the new Castrol Elixion 0W-30, a "zero W viscosity" lubricant that has proven its worth in the unlikely arena of truck racing with the giant MAN trucks of Castrol Team Atkins. The low viscosity is designed to improve fuel economy. In some trials we achieved a 7 per cent improvement in fuel consumption by using Elixion 0W-30, and since the fuel bill for some fleet operators can be up to 60 per cent of total costs, this is a significant contribution. In addition, improved economy means reduced CO_2 emissions.

The lubricant requirements of passenger cars, commercial vehicles and motorcycles are complex, extending from wear protection and long life to cleanliness and fuel economy. Motor sport, where engine power and hence efficiency is paramount, has a direct input in terms of fuel economy and benefits to the environment. ❐

Lord Butterworth CBE DL was chairman of the Foundation for Science and Technology between 1985 and 1998. He then became president of the Foundation until he died in June this year. John Maddox reflects on a lifetime of achievements.

The Lord Butterworth



John Blackstocke Butterworth, enobled as Baron Butterworth of Warwick in 1985, was the chairman of the Foundation for Science and Technology during its formative period between that date and his succession by Lord Jenkin in 1998. He was a robust chairman well able to keep the Foundation discussions on track. He continued after his retirement as chairman to be president of the Foundation and made a great effort, despite failing health, to attend all the evening meetings and host a table at dinner. He also took a keen interest in the governance of the Foundation, attending council meetings when he could.

He died on 19 June 2003. At the foundation's meeting on 19 July (also recorded in this issue), the audience stood for about a minute in respect and reverie.

Jack, as Butterworth liked to be known, was a lawyer by training, graduating in jurisprudence from Oxford on the eve of the Second World War. He promptly enlisted in the Royal Artillery and spent much of the war in Scotland, protecting strategic targets from air attack. He took his "bar exams" as soon as was possible, thereby qualifying in 1946 as a barrister at Lincoln's Inn, and then promptly opted for academic life, first as a law tutor at New College, Oxford.

He quickly won a reputation as an outstanding teacher, based on the clarity of his exposition and the iconoclasm he kept throughout his life. (In post-war "socialist" Britain, there were many icons for right-wing Jack to challenge.) In recognition of his teaching, he was made an honorary Bencher of Lincoln's Inn in 1953. He was also gregarious (proud of giving the best parties), quick-witted and shrewd. The last quality accounts for his appointment as bursar of New College for the last seven years of his time at Oxford.

Butterworth's outstanding achievement derives from his appointment as the first vice chancellor of the University of Warwick in 1963. Warwick was one of the handful of new universities created in the wake of the Robbins report (1962) which called for a substantial increase of university places in Britain.

At that point, the sobriquet Jack had been augmented to "Jolly Jack", in recognition of his stentorian laugh, used not merely to signal that he was amused but also his pleasure at the discomfiture of opponents defeated in arguments (of which there were many). One of his colleagues at the time described him as "a noisy" vice chancellor.

It is widely appreciated that Butterworth was inspired in his choice of the senior members of his new university. Warwick was able to hit the ground running in the late 1960s. That initial momentum enabled the university to shoulder its way into the first rank of British universities in the 1970s.

A large part of Warwick's success stems from Butterworth's assiduous cultivation of links with the rich industrial enterprise of the East Midlands. One of his first creations was an industrial centre, intended as a stimulus of advanced engineering in the region. Similarly, he cultivated (and earned) municipal goodwill, giving the city of Coventry in particular the sense that it had a university to call its own.

Butterworth was a determined lobbyist in the cause of his university, trading on the sympathies of his friends on grant-making committees for consideration of Warwick and holding forth to ministers he happened to bump into in corridors (as he did on one occasion when Sir Keith Joseph was in charge of education in Margaret Thatcher's government).

If Warwick was Jack's outstanding achievement, the university's Arts Centre was its jewel. It is a complex of theatre, dance studio and library that functions still as an integral part of the university while serving as a part of the institution's claim on local affection.

It was bad luck for all concerned that Warwick's first decade included the student protests beginning in the late 1960s. One indignity was that the vice chancellor's office was occupied and files rummaged through. Another was that the protests were supported by the social historian, the late Professor Edward Thompson, one of Butterworth's own appointments. Butterworth's combativeness may have delayed the eventual compromise, but secured a better outcome.

I knew Jack best during my five years as director of the Nuffield Foundation, between 1975 and 1980. He had been appointed a trustee in 1964 on the recommendation of the late Dame Janet Vaughan, then Mistress of Somerville College, Oxford, who believed the trustees were in want of an injection of realism. Butterworth provided that in plenty, together with a rigorous appraisal of most applicants' budgets that must have saved the foundation quite a bit of money over the 21 years he served as a trustee.

His other passion was the Association of Commonwealth Universities, a post-imperial organisation devoted to providing assistance to anglophone universities in developing countries. In 1978, when the University of Malta was threatened with the loss of its medical school by an intemperate prime minister, he urged that the Nuffield Foundation should plan avoiding action. The two of us went there for a few days and found that, short of buying votes at the next election, there was nothing to be done.

Jack's appointment to the House of Lords on his retirement in 1985 was a lifeline for one with such a surplus of energy. Breaking with the tradition that vice chancellors made Lords pretend to be above party politics, he chose to be labelled a Conservative. His interest in science and technology stemmed from his experience at Warwick (where his stars were scientists) and from its industrial hinterland.

Butterworth is survived by his wife Doris (whom he married in 1948) and by one son and two daughters. ❐

Recent lectures and dinner/discussions organised by the Foundation are listed below. Sponsors, to whom we are very grateful for their support, are shown in italics below each event. Summaries of these and other events are available on the web at www.foundation.org.uk

2003 Events

16 July 2003
The Research Assessment Exercise Review and Dual Funding Reform
Sir Gareth Roberts FRS, Chairman, RAE Review
Sir David Watson, Vice-Chancellor, Brighton University
Dr Chris Henshall, OST, DTI
OST and HEFCE

18 June 2003
Congestion Management in London: Traffic and Roadworks
Mr Malcolm Murray-Clark, Director, Congestion Charging, Transport for London
Mr Mike Talbot, Head Traffic Management Division, Department for Transport
Mr Jeremy England, Director, Water Operations, Thames Water
Department for Transport

10 June 2003
Adding Value to Research & Development
Professor Gordon Edge CBE, Chairman, Generics Group
Sir Peter Williams CBE FRS FREng, Chairman, ETB
Professor John O'Reilly, Chief Executive, EPSRC
Calderwood Han Ltd, Engineering and Physical Sciences Research Council and QinetiQ

3 June 2003
Horizon Scanning
Professor Sir David King KB ScD FRS, Chief Scientific Adviser to the UK Government and Head, Office of Science and Technology
Geof Mulgan, Director, The Strategy Unit, Cabinet Office
Dr Bill Harris, Chief Executive, Science Foundation Ireland
QinetiQ and the Institution of Electrical Engineers

20 May 2003
Redesigning the Science Curriculum; what does society want?
Dr Ken Boston, Chief Executive, Qualifications and Curriculum Authority
Professor John Holman, University of York
Ms Sue Flanagan, Deputy Headteacher, Forest Gate Community School, Newham and Chair, ASE
Pfizer and SEMTA

14 May 2003
Creativity, Science, Engineering and Technology
The Lord Puttnam of Queensgate, House of Lords
Dr Robert Hawley CBE DSc FRSE FREng, Deputy Chairman, The Foundation for Science and Technology
Mr David Hughes FREng, Director-General, Innovation, DTI
Mr Julian Anderson, Composer
City & Guilds, CCLRC and NESTA

30 April 2003
Building stronger Partnerships in Medical Science Research in the UK
Professor John Bell FMedSci, Regius Chair of Medicine, University of Oxford
Sir John Pattison FMedSci, Director of Research Analysis and Information, Department of Health
The Lord Turnberg FMedSci, Scientific Adviser, Association of Medical Research Charities
GSK and The Wellcome Trust

We are most grateful to The Wellcome Trust for support for publication of the journal.

8 April 2003
The threat to the UK from biological and chemical terrorism: what can be done and what is the risk?
Sir William Stewart FRS FRSE, Chairman, Health Protection Agency
Dr Pat Troop, Deputy Chief Medical Officer, Department of Health
Mr David Veness QPM CBE, Assistant Commissioner, Specialist Operations, The Metropolitan Police
Centre for Applied Microbiology & Research and CodaSciSys

25 February 2003
UK in the Arctic
Mr Graham Fry, Director-General, Public Services, FCO
Dr Dougal Goodman, Director, The Foundation for Science and Technology
Professor John Lawton, CBE FRS, Chief Executive, NERC
The Rt Hon Michael Meacher MP, Minister of State, DEFRA
Alstom Power, FCO and Fugro GEOS

4 February 2003
The Funding of UK Universities - Increased Fees or Grant-In-Aid?
Mr Nick Sanders, Director, Higher Education Group, DfES
Sir Richard Sykes DSC FRS FMedSci, Rector, Imperial College
The Lord Oxburgh KBE, FRS, Chairman, House of Lords Select Committee on Science and Technology
Mr Peter Johnson, Chief Executive, George Wimpey and member, CIHE Council
Pfizer, The Royal Commission for the Exhibition of 1851 and The Michael John Trust

29 January 2003
Women in Science Technology and Engineering
The Rt Hon Patricia Hewitt MP, Secretary of State for Trade and Industry and Minister for Women
Pfizer

2002 Events

10 December 2002
Christmas Reception
The Baroness Wilcox, The House of Lords Select Committee on Science and Technology
Lloyd's Register

3 December 2002
A UK Success Story - Science and Technology in support of Formula 1 and Motor Rally
Mr Richard Parry-Jones, Group Vice President Product Development, Ford
Mr David Richards, Chairman, Prodrive
Mr Stuart Smith, Technology Vice President, Fuels & Lubricants, Castrol
IVECO, The Kohn Foundation and the Michael John Trust

27 November 2002
How is the Internet Changing Business and Government?
Ms Frances Cairncross, Chairman, ESRC and The Economist
Mr Andrew Pinder, e-Envoy to the Government, Department of Trade and Industry
Mr John Leggate, Group Vice President Digital Business, BP
Autonomy, BRIT, Microsoft Research and BTExact Technologies

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