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Salt debate spiced up

Following the September launch of a slick "anti-salt" campaign by the government-backed Food Standards Agency (FSA), the long-running debate on what constitutes a "safe" level of dietary salt has reached new levels of intensity.

In May 2003, the Scientific Advisory Committee on Nutrition (SACN) published the *Salt and Health Report*, that concluded the evidence for a direct association between salt intake and high blood pressure had increased since this issue was last considered by the Committee on Medical Aspects of Food and Nutrition Policy (COMA), eight years earlier. High blood pressure is a serious public health problem and raises the risk of developing heart disease and stroke, SACN concluded, and reducing the population average intake of salt would help to reduce high blood pressure and therefore contribute to lowering the burden of cardiovascular disease.

The FSA took these recommendations on board. Two television adverts and a website (www.salt.gov.uk) packed with information and free downloads featuring the salt-hating cartoon character *Sid the Slug* have spearheaded the campaign launched earlier this year at a cost of £4 million.

On average, people consume 9 grams of salt per day. The FSA accepted the SACN recommendation that consumption of salt should be reduced by one third to no more than 6 grams per day for adults, considerably less for children. As 75 per cent of salt intake is from processed foods, the campaign stresses that a reduction of salt levels in processed foods is necessary to make a significant impact on average population intakes.

The Salt Manufacturer's Association rejected the SACN recommendations as "unbalanced, superficial, lacking in evidential support… in no way can it be regarded as a serious scientific review" and have responded strongly to the FSA's campaign. They have filed an official complaint to the Advertising Standards Authority, claiming that the Sid the Slug campaign is based on incorrect evidence of the dangers of salt.

The manufacturers stress that salt supports life and there is "no evidence to show it has ever been responsible for death". Their new website (www.saltsense.co.uk) sets out to "persuade the UK Government that its blanket advice on cutting salt consumption carries with it risks that have not been properly assessed".

By and large the report of the Foundation's April 2001 meeting on salt in the diet (*FST Journal* **17**(5), 14-16; 2002) still reflects the state of knowledge in the field, as does the accompanying chronology of major publications on salt, blood pressure and heart disease. Recent additions to the literature include the SACN report (www.sacn.gov.uk) and a review of data from 11 clinical trials that concluded that without the intensive dietary interventions used in trials, comparable reductions in blood pressure are less likely to be routinely achieved in primary care, particularly in the long term (Hooper, L. *et al.* "Systematic review of long term effects of advice to reduce dietary salt in adults" *British Medical Journal* **325**, 628-636; 2002). ❑

Kyoto: progress of sorts

With the Russian parliament finally ratifying the treaty on Friday 22 October, the chances are that undertakings made under the Kyoto Protocol will become binding during 2005. Russia's move has taken the "signed up" nations above the benchmark of 55 per cent of the world's greenhouse emissions at 1990 levels, the point at which the obligations of the treaty begin to take effect.

Few observers believe that a sudden concern for the environment is behind Russian ratification. A balance of economic and political factors may have tipped the balance. Economically, the decline in heavy industries following the break up of the Russian federation means that its carbon dioxide emissions have fallen and there may be money to be made by selling carbon dioxide quotas to nations that are above their targets. In addition, signing the treaty may have advantages in terms of global trade relations in general.

Most of the industrialised world has signed the Kyoto Protocol, with the exception of the United States, China, India and Australia. ❑

No end in sight in UN cloning debate

The United Nations General Assembly has again revisited the human cloning issue. In 2001 all 191 UN members agreed on a plan to draft an international convention against reproductive cloning. But the drafting work has all but stalled because of the dispute over "therapeutic cloning". The General Assembly voted last December to postpone a decision on human cloning for a year. Following the debate held on 21–22 October this year, the stalemate remains.

A resolution tabled by Costa Rica would outlaw all forms of human cloning as "unethical, morally reproachable and contrary to due respect for the human person". This resolution is backed by the United States and more than 60 other nations, many of them Roman Catholic. A compromise resolution table by Belgium and co-sponsored by Britain and 19 other countries would ban human cloning for reproductive purposes outright and proposes three options for dealing with therapeutic cloning nationally: a total ban, a moratorium, or regulations prevent misuse.

More nations expressed support for medical research during this year's debate than last year, but the fundamental divisions remain and no vote was taken. Belgian diplomats have continued efforts to find a consensus and informal discussions will continue. ❑

Spending framework gets the thumbs up

The UK Government's 2004 Spending Review (discussed on pages 3–8 of this issue) were broadly welcomed in a statement from the Royal Society. Stephen Cox, executive secretary of the Royal Society, said that the extra money will help redress the difference between the United Kingdom and our economic competitors. (The ten-year plan increases the United Kingdom's total spending on R&D from around 1.9 per cent of GDP in 2004 to 2.5 per cent a decade from now.) He welcomed the continued investment in research infrastructure at universities and research council institutes. While the additional £80 million of funding for the full economic costs of projects funded by research councils is welcome, the Royal Society remained concerned about the extra administrative burdens and over-management of university research in the recent proposals for costing research council projects.

Speaking on behalf of Research Councils UK, Professor Ian Diamond was also positive: "the infrastructure has been creaking in terms of long-term support for facilities and for bringing on the next generations of researchers [but] government has listened to the research councils and acted on key messages about the importance of basic research. This reverses previous short-term approaches to funding."

Professor Paul Murdin, of the Royal Astronomical Society, said that the review should potentially mean more young people being trained as scientists and that some of the additional money for research should allow the United Kingdom to take part in the European Space Agency AURORA programme ❐

HM Treasury, the DTI and DfES jointly published, in July, a report setting out a framework for science and innovation policy over the next ten years. Key participants and commentators were invited to speak at a Foundation meeting on 20 July, at the Royal Society. The discussion that followed was summarised by Sir Crispin Tickell

Elements of the framework

John Kingman

John Kingman is director of the Enterprise and Growth Unit at HM Treasury and has led the work on the ten-year framework for investment in science and innovation. He also has overall responsibility in the Treasury for many policy issues that affect business, on public-private partnerships and the remaining state-owned industries. Previous roles in the Treasury have included head of productivity and structural reform and press secretary to the Chancellor.

I am going to take you briefly through the main elements of the ten-year framework. We have avoided referring to it as a plan, because this document does not attempt to map out the science priorities of Britain over the next ten years; rather, it attempts to set out a framework for spending and policy.

I will begin by examining the total expenditure on R&D, both in the public and the private sectors, in Britain since 1985 (Fig.1). A number of things stand out: first, expenditure has been going in the wrong direction for a long time; second, the target that we have set ourselves in the framework, to get to 2½ per cent in the next ten years, is an ambitious but, we believe, achievable goal. Some have criticised us for setting an objective of 2½ per cent when the EU has a notional target of 3 per cent. For the UK, 2½ per cent is a credible ambition and will put us in a very strong position in the international league. However, this ambition has to respect and understand the complexity of the system and that there are a number of things that we have to get right to get that line moving in the right direction.

Funding for the bedrock of the system, funding for the science base through the Office of Science and Technology (OST) and through the Higher Education Funding Council for England (HEFCE), is one of the fundamental things that has to be right. The change in direction in Figure 2 is therefore very marked indeed. Over the three years of the most recent spending review, spending on science will continue on the trajectory not of the final year of the last spending review but of recent spending reviews taken as a group. This does not show the whole of the ten-year framework but it is a significant beginning.

What lies underneath these numbers and patterns? In the framework we have said that the broad shape of our present funding system is going to be left essentially unchanged. For example, we have looked at the case for a change to the dual support system and have concluded that, while you can make a case for it, it is not a worthwhile change. Funding will continue to be allocated according to excellence and that should be the key criterion of both HEFCE and research council funding.

Underlying this is the continued long march to funding the present public science base on a sustainable basis. We have been pursuing this important aspect for the last five years or so. The only responsible policy here is to reach a point where we are funding research at its full economic cost, rather than living off the capital of the past, as has been happening for some time.

The framework is not just about the next three years, it is about the next ten years and the overall objective is about R&D and the economy as a whole. The document also suggests making important commitments about funding for the public science base over the ten-year period.

We have made a clear commitment to develop public-funded science at least in line with the trend growth rate of the economy — that is to say 2¾ per cent in real terms. But we have also said that,

discussion

Implications. The increased expenditure of the ten-year framework was welcomed, but there were detailed comments and questions on the practical implications. There was a need for more transparency in how grants were given. Not only were markets unsettled but shareholders were increasingly assertive and more interested in short-term profit than long term R&D. So far as possible innovation should be market-led rather than directed from the top. A key point for investors in both small and large enterprises was whether the new programme would survive any change of Chancellor of the Exchequer or Government. Stability in the long term prospects for R&D was essential.

It was often hard to know exactly how and where business invested in creative thinking and innovation.

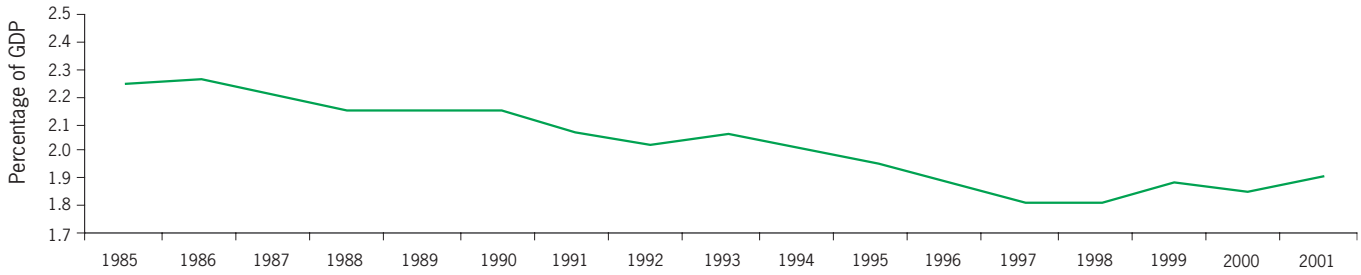

Figure 1. UK gross expenditure on R&D as a percentage of GDP. Source: OECD, main science and technology indicators, May 2003.

to reach the goal of 2½ per cent GDP, research spending will have to grow even faster rate than that — at 5.7 per cent in real terms. We are going to monitor progress annually and to look, in each spending review, at whether we can go higher than the 2¾ per cent real. There is an implicit challenge here to the private sector and that is one of the most important elements of the strategy.

On the public science side, the other important aspect, about which Keith O'Nions will talk in a more detailed way, is a more robust funding allocation process at the heart of OST as well as between the research councils.

Collaboration with charities has been a very important theme of both this and past spending reviews; the Wellcome Trust, in particular, has done a huge amount. Wellcome has made some important commitments over the next five and ten years concerning the extent to which they see the United Kingdom remaining their centre of gravity. They have also announced an important collaboration with us on specifics, including, for example, some work with the Department for International Development (DFID) on drugs for malaria and so on.

We have also created a more structured funding partnership with charities so that the march to full economic cost does not put that partnership in jeopardy.

An important theme of the framework is the way in which the science base engages with the economy. Sir Tom McKillop of AstraZeneca has played a very important role in bringing together leading R&D chief executives to work with us on this. There are a number of ways to continue to encourage and make sure that the funding systems we operate give the right incentives. For example, we are continuing to grow the funding for the Higher Education Innovation Fund and HEFCE is going to ensure that the 2008 Research Assessment Exercise (RAE) does reward excellence in applied and collaborative work in the same way that it rewards excellence in pure research.

There will also be goals and targets for the proportion of the research councils' activity that is collaborative. The DTI has also been given significant funding for the industrial front end, such as knowledge networks and, indeed, funding for some research in industry through the DTI's technology strategy.

Lastly, the Regional Development Agencies have a crucial role at the regional level in funding a certain amount of applied work around the country.

When we started down this road it was made very clear that, if we are to have the objective of taking the United Kingdom to a different place in terms of R&D, we need the people to do it. Sir Gareth Roberts' Review in 2002 of the supply of engineering and science skills highlighted this (see *FST Journal* vol 17(9), 2003), and a good deal has been done. Nevertheless if you look at the number of science and maths pupils in schools and undergraduates in universities, in too many subject areas the numbers are declining. This is a major strategic issue (see also the report on pages 9–12 of this issue).

We therefore worked closely with the Department for Education and Skills (DfES) to create this aspect of the framework and we set out here a serious strategy, including getting enough science teachers into schools, with talent that will attract young people. We are going to monitor this situation annually with DfES and attempt to turn this around.

Medical research is an important theme. The Chancellor made some important announcements in the Budget about funding health research. Again, Wellcome plays an important part here. The Medical Research Council and the Department of Health will be working together so they can drive this ahead in a more collaborative way.

Finally, it was brought home to us very forcefully by the business participants that we have to tackle the issue of animal rights extremists in order for things to move ahead. The Home Office and the police will shortly be publishing documents setting out their approach to this problem.

In conclusion, this is a very ambitious framework but it is achievable. The bedrock for the framework is the growing funding for the public science base; there is a unique opportunity to get a stable period where we know that the funds will not be raided in the short term; there is a continued emphasis on getting the ideas out of the science base. We wish to encourage the excellence of British universities and the strategy on skills in schools and universities. On the medical side there needs to be collaboration with universities and research councils, and with the charities and business. Collaboration is vital for the success of the framework. ❐

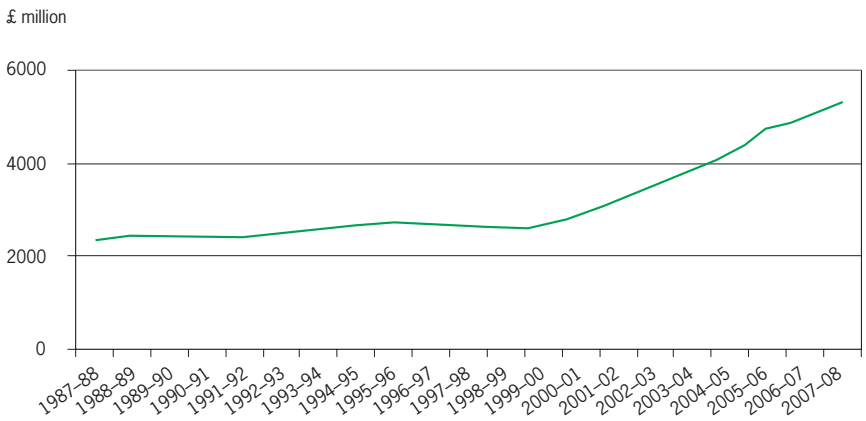

Figure 2. Investment in public science base (OST and HEFCE). Figures are in real terms, based on 2001-02 prices. Source: DTI, 2003 Forward Look.

The document can be found on the HM Treasury web site www.hm-treasury.gov.uk

An OST perspective

Keith O'Nions

Sir Keith O'Nions FRS is director general of the Research Councils, Office of Science and Technology, DTI. He has held academic positions at the universities of Oxford and Cambridge and at Columbia University. He was chief scientific adviser to the Ministry of Defence from January 2000 to July 2004. Sir Keith has been involved in a broad range of academic and technological committees.

I am going to talk about the significance of the 2004 settlement from an OST perspective.

For me, working with the Treasury over the past few months to achieve this framework has been a surprising and pleasant experience.

The starting point for the framework was the announcement by the Chancellor, in March this year, when he established the vision for the Science and Innovation Framework. Two elements of that were to make Britain one of the most competitive locations for science, R&D and innovation and to show the science community that the Government was committed to the future of British science.

This was well received in the community and one would have to be very cynical not to feel some identity and enthusiasm for that vision. The question for many people was whether that vision or rhetoric was going to come through in pound notes. I am going to summarise a few details, without getting into too many numbers, of the outcome of the settlement and what it means for the OST and the science base.

John Kingman has already shown these numbers but I have presented them in a slightly different way (see Fig.1). The solid bars represent actual and agreed spending, while the hatched bars represent how the science budget would evolve if it continued to increase at the same "per annum" rate as the 2004 settlement. For the years 2005–06, 2006–07 and 2007–08, the increases are about 13 per cent, 5 per cent and 7 or 8 per cent, respectively. In cash terms, these increases are quite large and in Treasury-speak "'real", that is inflation-corrected, represent an average increase of 5.66 per cent per annum. Within the overall context of the last settlement, science in cash terms has done well and is benefiting from a longer-term vision of where things might be going.

John Kingman has already alluded to the challenge set by the Government in the ten-year investment framework. For 2004, the science-base budget is 0.35 per cent of GDP; other Government spending on R&D is about 0.31 per cent, a very similar figure. The private sector, as John showed, has been in gradual decline over the decade and is about 1.24 per cent of GDP, making a total of about 1.9 per cent. The aim set by the Government and by the published document for the year 2014 is a total of 2.5 per cent, still significantly less than a number of other countries at present. The challenge is clear: the science base could increase to 0.5 per cent of GDP and to achieve that the Government will have to maintain this level of investment. While other government R&D is maintained at about 0.3 per cent of GDP, the private sector will require close to a 50 per cent increase in R&D investment — up to 1.7 per cent — to achieve that 2.5 per cent.

The EU has attempted to set itself a notional goal of 3 per cent investment. Can the United Kingdom sign up to that? It will be very challenging to get to 2.5 per cent with those sorts of figures. The challenge will be that business responds to this government investment.

Business investment in R&D in the United Kingdom puts us fifth out of the G7 countries. Between 1997 and 2002, we hovered at a little over 1 per cent up to 1.2 per cent of GDP. The target for business R&D in 2014 is 1.7 pre cent; you can see the challenge.

But there is some extremely good news. The annual growth in science spending over the settlement period, the next three years, is 8.1 per cent annual real growth and that includes about 2.5 per cent inflation. The previous spending review three years ago had already provided a £338 million increase for next year; that has been maintained, and, in this settlement, over the next three-year period there is an extra £515 million of new money. Some of that considerable amount of money is targeted at particular initiatives, such as:

- £38m extra for knowledge transfer (Higher Education Innovation Fund)
- £80m extra for sustainability (Full Economic Costs)
- £80m extra for research council institute infrastructure
- £85m extra for research careers
- £35m strategic fund/health of disciplines
- Science Research Investment Fund (SRIF) to continue at £500m pa.

You could view this either as being highly directed or as being sensible minimal investments in the key issues that have been identified over the past five or six years; I believe that it is the latter.

It is good news for the research councils which have lobbied hard for infrastructure in the research council institutes. The £85 million for research careers follows directly from the Roberts Review: it is paying for proposals that

research studentships should be funded for three and a half years instead of three and that the graduate student stipend should be £13,000. The £35 million strategic fund refers to £35 million per year, starting in 2006–07 (£70 million over the period) that the Treasury decided to make available to the director general of the Research Councils to use in a strategic way. I have earmarked it for the strategic health of disciplines, which will help us to respond to challenges of which we have no knowledge at present.

The SRIF is a fund that has been going to the universities; it is a capital expenditure that has been filling in the black hole of under-investment in universities. This will continue at £500 million per annum, the current level of expenditure.

Overall, the new money totals £550m + £338m. If that does not cheer you up, I do not know what would!

The key messages are clear. These are: research excellence; greater responsiveness of the system to maximise knowledge transfer from our universities and from our research institutes through innovation into GDP growth; and sustainable universities and laboratories, moving towards a system where there is enough money being recovered on research projects to maintain a healthy university system. This is a big part of the settlement.

Last, and extremely important, there needs to be an increase in public confidence in science.

With respect to research excellence, in no sense are we moving away from world-class research. This ranges from bio-medical sciences, for example, to the arts and humanities. Although we have been talking about science, innovation and technology, the budget in the OST is for eight research councils, ranging from the Arts and Humanities Research Board, about to become a research council, and the Economic and Social Sciences Research Council, through to Particle Physics. This is good news for the whole research enterprise and, although, of course, a very large amount of project money does go to science, the aim of this expenditure is to be world class across the board.

The framework has an emphasis on infrastructure; without our good infrastructure, the United Kingdom would not be attractive as a location, as a place for well-qualified people to come from, to come to, to work in or for organisations, to invest in and around.

Attention to health of disciplines is, in effect, to respond to areas that we feel, or the research councils and others feel, are important but are not quite on the right trajectory for where we want to be in the future.

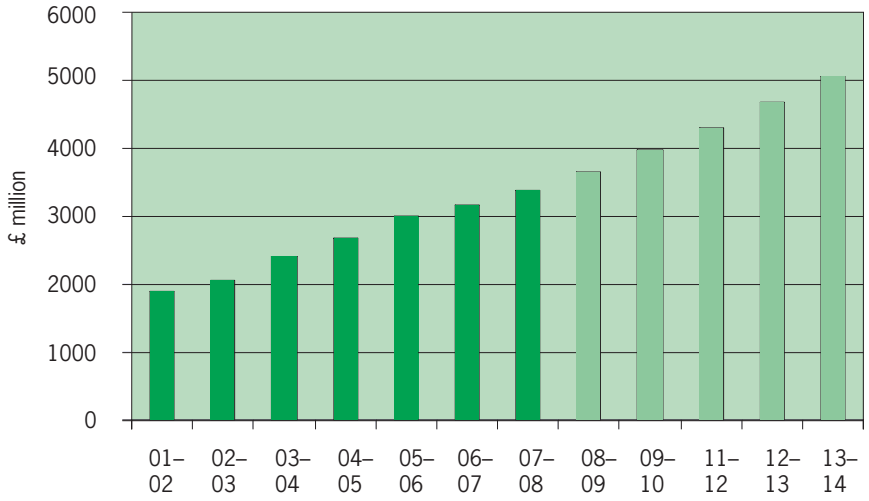

Figure 1. The science budget. The budget for the years 2008-09 onwards assumes the same continued increase as for 2004-05.

Improving knowledge transfer derives from the DTI's innovation strategy; it is at the core of "Lambert" and it is a key challenge in the provision of such rates of increase in budget. This is part of the overall innovation strategy and, in the short term, it requires a degree of "joined-upness" at the Government end that is not always that easy to achieve. In particular, in the near term, the sources of government money that we have earmarked to promote and develop this innovation agenda include the science budget money.

In the DTI innovation group there is an increase in funding that has gone to the Innovation Group and to the Higher Education Innovation Fund. From my point of view this means making sensible plans and programmes with David Hughes in DTI innovation and Howard Newby in HEFCE and I am very optimistic that can be achieved. Other government departments have a big part to play; some of their expectations and aims for defence, health and so on are also expressed in the ten-year framework.

We are trying to support sustainable universities, universities that receive the appropriate amount of money for the research that they perform and to maintain their infrastructure in a way that enables them to move confidently into the future. This is a key policy initiative that goes back to Dearing; it is not a topic to which you can give much spin, gloss or glamour but it is exceedingly important. We have to lay the foundation stones properly to create sustainable universities and sustainable laboratories.

The aim is to move towards the full economic cost of research. On our present trajectory, that would take us to the beginning of the next decade. It may well be that, in the next spending round, if we are confident, we may propose to proceed faster than that. At 100 per cent economic cost, all relevant, direct project costs, including the relevant element of academic salaries identified by those projects, would be recoverable.

I want to point out that the dual support system remains fully intact; indeed, the support for the DfES, the HEFCE money, is increasing by 6 per cent real over the next three years. At the same time, that dual support fund from the quality-related part of HEFCE is also growing in real terms so this is not the shift of money from one part of the dual support system to another, it is both parts growing and that is absolutely critical. If you think that there are "smoke and mirrors", I have not spotted them yet.

With respect to the need for public confidence in science, there will be a new impetus given to public engagement and an increasing role for the research councils. We need this to be "joined up" with the other agencies and groups that are involved in the public understanding of science and public confidence in science, such as the Royal Society, the Royal Institution and so on.

The challenges are there for the Government to take up, an outstanding science and technology base where business will chose to increasingly place R&D and where the public will be with us. To end with statement by the Chancellor, associated with his announcement on the spending review, "the future of the British economy depends upon the future of British science". ❐

R&D and the stock markets

Andrew Barker

Andrew Barker is head of European Equity Strategy and managing director of UBS. He joined SG Warburg after graduating from Oxford University with a degree in Oriental Studies. During this time he researched companies across a spectrum of the industrial sectors and in most markets around the world. Mr Barker has been with UBS and its predecessor firms for the past 16 years.

I am neither a scientist nor an economist, but what I hope to show you is the experience, over the past 16 years, of being at the turbulent end of the stock market. In particular, I want to focus on what Keith O'Nions was drawing attention to: how the private sector might raise its R&D expenditure by 50 per cent over the next ten years. There are three questions that occurred to me when I began to look at this topic more deeply.

Stock market: asset or liability?

It seems that academic research shows that the problem of lack of business R&D expenditure in the United Kingdom is not on the part of small companies but, rather is due to lack of investment by the larger companies. The framework document also raises the question about the capital markets and whether they have some feature that has stopped UK businesses realising their full R&D potential.

When I mentioned to one of my investor clients that I was coming to do this talk, he said "are you going to tell them the truth?", so I asked: "well, what is the truth?" He replied: "We are just obsessed with this year's cash flow. We may put investment in our forecasts but judge in ten years' time whether that has generated any value."

Despite what stock market participants like to say, there is a big pool of liquidity available to UK businesses and the market does not make judgements on this year's cash flow. It is easy to forget how big the UK stock market is relative to others in Europe; it is bigger than the next three stock markets in Europe combined. It is the third largest in the world after the US and Japan. There should be no shortage of funds available.

What is the value of the long term and the open-ended at the minute? There are many intangibles in the equation, including a mixture of the products of R&D, or the expectations for R&D, advertising and promotion, human resources (both the workforce and management) and a company's particular growth opportunities. These all go into a soup that the market implicitly spends most of its time thinking about and which we could call "the potential for innovation", that is, the potential for a company to innovate and create growth in the future. The UK stock-market value is represented to the tune of 62 per cent by this intangible asset. So, it is not true to suggest that the City is short term, that it is just thinking about today's business, it is thinking about the business of the future and R&D is a big underpinning of that.

Perhaps the United Kingdom is less willing to finance that future? When we compare a US company such as Honeywell, that you would expect to have big R&D exposure, with its biggest UK competitor, Smiths Group, we find that the UK market is much more prepared to ascribe value to the open-ended part of Smiths Group than the US market is for Honeywell.

This raises many questions about what Smiths Group does relative to Honeywell that an expert on these companies could answer — for example, how balance sheets are structured — but it illustrates that the UK market is by no means shy of valuing R&D.

It is interesting that, for all Germany's R&D spend, the market does not ascribe much value to the open ended and the long term. I conducted a study on German profitability versus European profitability last week and I found that, for every Euro of capital invested in German quoted companies, it makes 40 per cent less profit than it would if it was invested in UK companies. Intangible assets account for only 19% of the German stock market's value. So the market is simply reflecting an idea that the R&D and innovation that is going on in German companies is not creating as much value as UK companies.

Whatever investors' scepticism and whatever people's obsession with this year's earnings or cash flow, the key to valuing companies is the medium term and the investment that is going into that now. Again, we see the importance of R&D. I have been involved in the privatisation of airlines, the privatisation of Railtrack and the flotation of EuroTunnel, so I have personal experience of persuading people to believe in the medium and very long term. I also have experience of somewhat hostile audiences several years later!

But there are many salutary short-term lessons. Nokia, for example, is increasing its R&D budget and we increased our R&D forecast substantially for the company. However, after Nokia produced its results for the second quarter last week, the net result was that the company lost nearly 16 per cent of its value — 15 billion — in five days.

Why did Nokia's second-quarter results produce such a loss of value? It was simply because the market decided that the intangible asset Nokia has was suddenly

worth less because the company was having to spend more to sustain it and thus the value of that R&D was less. You could also explain it in terms of the risk premium: people decided that Nokia was much more risky if it had to increase its R&D by that much.

So companies have to be very careful about making these announcements and about talking about the medium term to their shareholders. At the moment, companies around the world are being extremely cautious in the way they use their money. We have a corporate surplus; companies are actually paying money back to their banks and shareholders; this is very unusual and represents quite a huge degree of conservatism compared to the last 30 years.

Portugal Telecom is the opposite of the Nokia example. This company has generated 30 billion worth of cash, but it is not investing and its capital expenditure is very low. Portugal Telecom said that, rather than spending on its asset base, it was going to give the shareholders their money back. That was immediately rewarded by an increase in the valuation of its shares. Here and now, in the market generally, investors are not thinking too much about long-term prospects.

In summary, the UK capital market is a big asset to UK businesses; this pool of liquidity is not averse to financing "intangible" investments in the future such as R&D; but investors at the moment are quite risk-averse.

The case for the long view

Investors can be persuaded to back R&D if they can be convinced that it will help the performance of their funds.

I have created an index that tracks the performance of R&D heavy spenders in the US for the last 25 years. From a sample of 2,000 stocks, I have ranked the ones that spent the most on R&D and the least on R&D in any particular month and then created a basket of stocks, going long on high R&D and short on low R&D. From January 1979 to the present, if we put in US $1 into the US large capitalisation stocks and we bought the ones with the highest R&D spend every month, and sold the ones with the lowest, that would have returned us $150 now - a good return compared with the market!

The benefits of R&D investing, if one had followed that strategy, would not have become evident until 1995. We can speculate why that might be: perhaps, in the lower inflation environment post-1995, a higher level of R&D spend is one way to guarantee growth longer term and therefore a higher valuation.

It is also interesting to contrast the success of R&D investing with a strategy based on companies that invest heavily in their physical, rather than intangible assets. There is a very strong differential in favour of R&D in the long term, using the US market as a guide.

However, the market much prefers, at least since 1995, R&D spend in large companies. You might think this is because large companies have a portfolio and are therefore lower risk from the investors' perspective. This is speculation; I have no answers.

There is also a very different result by sector. There are R&D-sensitive sectors, such as IT and healthcare; there are also unexpected ones, such as industrials generally, including industrial services like airlines and materials; and there is a consumer-discretionary sector that would have lost US $150 for every dollar invested.

So it should be relatively straightforward for investors to persuade themselves that favouring companies with strong R&D spend will make their funds perform better in the long run. In today's shareholder-friendly world, if the shareholders start discriminating in that way, then private sector managers should start doing the same.

Is there a latent limit that the United Kingdom can reach, given its industry structure? Although the large UK stock market should be more of an asset than a liability in any aspiration to raise R&D, is the heavy presence of the UK financial services industry — an inevitable consequence of having such a large stock market — an asset or a liability?

Science graduates in banking

The City is a heavy investor in technology. Much of this technology might not be classified as R&D in company accounts; indeed, the definition of R&D in company accounts is not as standard across Europe as it is in the US, which is one reason why we could only carry out a study on investor returns from R&D using US data.

On the other hand, the heavy weighting of the City in the UK jobs market, coupled with relatively high rates of pay, means that the City uses some of the best UK science graduates in the frontline of wholesale banking, rather than in furthering R&D. This may have positive benefits for the UK economy, but it could be one reason why the United Kingdom would find it difficult to reach the kind of R&D as a percentage of GDP of other G8 nations.

To gauge the difference in jobs market significance of the City to the UK economy, relative to other economies, I looked at the global employment patterns of my own employer, UBS Investment Bank. Not only is the UK stock market pre-eminent in scale among its European peers, but London as an investment banking location accounts for 60 per cent of the human capital input for the other European stock markets. Because of this heavy invisible export the significance of the City in the UK jobs market is well out of proportion with what a simple set of UK national economic data might tell you.

The City is more than twice as significant in the UK jobs market than Wall Street is in the US and more than 20 times more significant than the French, German and Italian equivalents. We source our best graduates from all over Europe but the fact that the industry is based in London and that English is the dominant language, means that there will always be a strong local bias to hiring.

On the one hand, we could accept that the presence of the City means that the UK economy can afford to accept a structurally lower level of R&D than its G8 peers. On the other hand, one might argue that a 10-year goal for the Government might be to encourage top UK science graduates out of their successful stockbroking careers and into senior management outside the financial sector. With the equity markets as they are, this might not be as difficult as it would have been in the late 1990s! ❐

discussion

Accountability. How to encourage R&D in small companies was a particular problem. In the past some had been dismayed at visits from analysts trying to identify R&D and to demonstrate linkages in knowledge transfer, and now feared the activities of regulators. But some measure of public accountability was essential. True economic costs were hard to establish. Was inflation properly accounted for? It was of course different in different sectors. In universities more flexibility over salaries to attract and reward was vital. The same was true of engineering.

R&D was often driven by personal enthusiasm and charisma, but financial managers and shareholders still had to be convinced. Somehow the message had to be got across to investors and the public generally.

The Roberts Review emphasised that the pool of skilled scientists must be fed by well-educated pupils from schools. Yet school science teachers often lack tertiary education in science. On 24 May 2004 the Foundation hosted a discussion meeting entitled: Training teachers — have we got it right?

Attracting scientists to teaching

Ralph Tabberer

Ralph Tabberer is chief executive of the Teacher Training Agency (TTA). Starting as a teacher, Mr Tabberer has also worked as a senior official in local government and, between 1994 and 1997, was assistant director of the National Foundation for Educational Research. In 1997, he joined the Standards and Effectiveness Unit in the Department for Education and Employment (DfEE) as senior education adviser, working with Michael Barber.

During the 1990s I was the publisher of the third International Maths and Science Study, a major study on performance of 8 to 13-year-olds in maths and science. The press reported how dreadfully our children were doing compared with children abroad, focusing on the maths results: nobody looked at the science figures. In the third study, as in the second study, science literacy among school children in England was in the top three in the world.

Science literacy in our schools is not in a state of crisis; it is rather good compared with other countries. We have much more of a problem in mathematics. How do we raise our game in a vastly more challenging science world of the future, not beginning from weakness but starting from strength?

I have worked for the Teacher Training Agency (TTA) since 2000. We recruit people to teaching, giving them their initial education and training. We buy training provided by schools, universities, colleges and others around the country: about £250 million worth of training for teachers every year.

During the 1990s our general success in recruiting people into teaching was in decline and worsening year on year, partly reflecting the economic cycle. Teachers are a big part of the economy: 30,000 graduates is roughly 10–15 per cent of the graduate population. It is very competitive: industry seeks more people, especially at times of economic boom and it becomes harder to recruit teachers. Along with that economic cycle and probably with a diminution in the status of teachers, we found it increasingly difficult to recruit people. We have now made steps forward but some massive challenges lie ahead.

During 1999 and 2000 the press was full of stories about schools finding it hard to recruit. Government made education their priority: both spending and aspirations started to rise in schools and they began to look for teachers who would fill vacant posts. However, with the decline in recruitment, head teachers and school governors saw their lists of applicants for posts diminish dramatically. There were many teachers teaching in science, maths, or languages who were not specialists these subjects. Now we are not generating the cohorts of GCSE, A level, undergraduate and postgraduate trainee teachers of the future. During 1999–2000 we estimated that we needed around 40 per cent of the graduate cohort from physics, chemistry and science in general to come into teaching.

Since then we have seen a marked change in teacher recruitment, not just because the economy has turned: we have, for the first time, managed to increase recruitment, against the trends in the economic cycle. We have done that largely by working with government, teacher training institutions and schools in innovative ways using a mix of marketing methods. We have seen increases of about 5 to 8 per cent a year in the number of people coming into conventional teacher training, mostly because of the introduction of a training bursary, removing a financial constraint for postgraduates coming into universities and schools to train. People were, perhaps, worried about doing a postgraduate year, building up more debt, so we provided them with a small bursary and, in some subjects, a "golden hello". This means that people can live through the year and not increase their debt.

A further increase has come through introducing on the job training. We introduced thousands of new places, largely through the Graduate Teacher Programme, which allows people to change career: we have been very successful in bringing in people who are 30 or 40 plus. They needed more help than the training bursaries so we offered them a year's training in schools where they get a salary on the job and train as they go. On the job training is thoroughly modern and in step with lifelong learning aspirations and with what is being done in other recruitment sectors — such as British Telecom or PricewaterhouseCoopers.

The TTA has developed an astonishing marketing and recruitment regime; we adopt every modern recruitment technique. We run customer relationship management programmes. Our websites include tools that pick up people's interests as they consider the possibility of coming into teaching. We recruited over 40,000 people into teaching last year. So far we are about 5 per cent up on

applicants in this year and we hope to hit 40,000 again.

In science the set of data is smaller (between 2,000 and 4,000 rather than the 20,000–40,000 range) but shows a similar pattern. Recruitment was rising slightly in the early 1990s but then began to decline and we have started to push it back. The career changing side is important in science. Without that, recruitment would have been below that of the early 1990s.

We do not, however, attract enough scientists. We are still not able give those who take trainees onto our science courses enough choice about who they take on, while schools do not have enough choice in their shortlists of candidates. There will be more competition ahead. For years the supply chain for science teachers has been broken and, although in recent years we found some interim fixes, they will not be enough for the future. We have worked hard to attract new people into science teaching but we must start doing something new. I need your help and the help of people like Mike Tomlinson, who will be changing the curriculum for 14–19-year-olds. I need the help of the Association for Science Education and people like Derek Bell (see page 11) in giving us a better supply chain for the future.

One solution may, of course, be to do just biology. There are many more prospective biology teachers than physicists and chemists. Many people who were physicists and chemists now do biology. Changing the curriculum of schools to be more focused on biology results in more students of biology at GCSE, A level and undergraduate level: and we could move things that way. That solution would make the whole business much easier.

A second possibility would be to encourage more conversions of people early or mid-career. We could take people with oceanography, nuclear medicine and degrees of that sort and give them enhancement courses so that their subjects are brought up and they could teach physics and chemistry in schools. We have started to do this and it could be built upon.

A third option is to retrain other teachers. They may not have the correct A level or even GCSE, but we could retrain people with some pedagogic skills and move them into science. I was interested in Adrian Smith's report on maths, raising the possibility of having a qualification that allows people to teach maths up to the age of 14 as distinct from the qualification allowing them to teach up to the age of 19.

A fourth idea is that we could re-engineer the workforce. Instead of spending all our time thinking about teachers, we could spend more time training the science laboratory technicians and others, moving away from the model where most of our education is done through teachers and use a far richer mix in schools. We could consider changing the way we train and bring on the whole workforce, using people in new ways, as in medicine where, these days, the mix of doctors, nurses and para-professionals is changing the experience of health sector workers.

My final idea is to do something about the supply chain: give me some means of increasing the number of people coming out of schools with high-level qualifications in science, then we can reduce the need to recruit 40 per cent of each generation, to something like 20 per cent. The only thing I ask is that you do not do nothing. What I want is not just to be in the top three for science in the world: I want us to be the top. ❐

Training and professional development

Mike Tomlinson

Mike Tomlinson CBE is chair of the Learning Trust, the body set up to manage the education services for Hackney's schools. He held various teaching posts in Nottinghamshire and Leicestershire before joining HM Inspectorate of Schools. On the creation of Ofsted in 1992 he became deputy director of Inspection and in 1995 director. In 2000 he became HM chief inspector, retiring in 2002 and in January 2003 became chair of the working group set up by the Government to take forward the 14-19 agenda and has recently published the working group's final report.

The discussion has centred on what is happening in science in our schools, but we have many teachers in further and higher education who have not been included in this debate. The training issue applies across the board. Teachers, along with the teaching assistants who support them, are the most precious resource we have in our education system. Despite their central role in raising the overall levels of achievement, in enthusing young people about the subject they teach and enthusing them to continue to learn, we do not treat them well enough. My emphasis here is on initial teacher training and professional development.

Over 20 years ago George (later Lord) Young, working within the DTI for the Manpower Services Commission, wanted to introduce a systematic approach to the professional development of teachers. He proposed introducing a specific grant, Grant Related In-service Training. This scheme (which I was involved with as HM inspector of initial teacher training and in-service training) provided designated funding for CPD which could not be used for any other purpose. It allowed for the funding of both national and local priorities at the levels of both the local education authority and the individual school and teacher. This had to be covered within an agreed plan for teacher development involving all the schools in its creation. That was in 1982–83: since then we appear to have moved backwards rather than forwards.

What is needed for the future? First, if we have a 14–19 phase, we must train people capable of teaching within and across that phase with no cut-off at 16. That should cover not just the subject itself but also the strategy of encouraging and developing people within the vocational routes, where science is used and applied. If students are to be challenged and stretched there needs to be considerable knowledge updating in science, both for those already in service and also those in vocational areas (such as engineering) that are relevant to science.

We need teachers who can manage students' learning programmes. That requires cross-subject planning, a concept common in special schools and further

education but almost absent from secondary schools. It would include programme management on behalf of the students, personalising their learning and maximising their potential for achievement. We need teachers with more skill and knowledge of assessment, both formative and summative. Assessment gets little attention in teacher training yet is central to good teaching and learning. We should give back to teachers their proper professional role and credibility in making assessments of the performance and attainment of young children.

I welcome the Secondary Heads Association's proposals for the development of accredited examiners and assessors. There is a continuing need for the use of IT for e-assessment and the development of e-portfolios describing and recording students' achievements. There is an unhealthy tension between the increased autonomy of schools and their capacity to make their own decisions (which I strongly defend) and delivering national priorities and needs.

There is no entitlement to CPD for our teachers: undertaking CPD has no explicit bearing on pay or, in many cases, on promotion. We do relatively little to prepare people to progress in their career. We do much more in training head teachers and deputies now than ever before but continued training is needed throughout the profession. There is no effective coherence between initial teacher training, induction and CPD. We have a big problem with retention. For young people considering a career, salary is not at the top of their list; being respected, cared for and helped to develop personally and professionally are factors often strongly overruling considerations of pay. I believe that if we improve professional development then retention will also improve enormously.

In further education there are highly qualified people with first degrees, masters' degrees, even PhDs, but unless they have Qualified Teacher Status (QTS), they cannot be employed on the teachers' salary scale to teach 14 to 18-year-olds in our schools. But the school can send students down the road to the further education college where they are taught by the same person who could not be employed in the school. We cannot afford to have this sort of division amongst our teachers and lecturers.

Reference has been made to the science centres. Through the generosity of the DfES and the Wellcome Trust, £50 million has been put forward to create the national and regional centres. Will science teachers have the funding available to make use of those centres? I want to see, within our CPD policy and teacher development, due emphasis on knowledge as well as on teaching and learning skills.

We should consider what happens after initial teacher training and the QTS statement that a teacher now gets: that states what subject they are qualified to teach; they can have any amount of CPD subsequently but that statement is never amended. Yet in other countries (Canada, for example) if you get a recognised qualification the QTS statement changes immediately; it also carries with it an immediate salary threshold change in recognition of increased skills. I think we should provide this. We must have some trade-off in terms of what we regard as the school working year for the teacher and lecturer and the general conditions of service, because there is reluctance to release teachers to undertake training within teaching time.

In science, the teaching resource is limited and we must find ways of maximising its use. If we began to look at how we could share the science teaching resource across our schools, further and higher education, we would go a long way towards helping to improve that science experience for young people.

The challenge is not just for schools, or for initial teacher training, but for every one of us. Are we up to meeting that challenge? If we are, then for the sake of our children, our future citizens, we must crack this problem. We will never get it absolutely right but we need to be more right than we are now. ❐

The quality of teacher training

Derek Bell

Dr Derek Bell is chief executive of the Association for Science Education. After teaching science, environmental studies and physical education, he became head of biology at the Grange Comprehensive School in Runcorn and moved into science teacher education at what is now Liverpool Hope University College. Before taking up his current post he was vice-principal at Bishop Grosseteste College, Lincoln. He has undertaken research into children's understanding of science, in particular children with learning difficulties and has written a book entitled *Towards effective subject leadership in the primary school.*

To improve the quality of learning of our students, effective teaching is critical. Thus the need for high-quality teacher training is central to the future of science education. In response to the question "Training teachers — have we got it right?" my answer is definitely "No". That does not mean that we do not have good teachers: the 2003 Ofsted report indicates that 60 per cent of science lessons are good or better, compared with 50 per cent in 1996. Nor does it mean that we do not have excellent people involved in teacher training: the quality of the newly qualified teachers entering the profession has never been higher. Other evidence however indicates a less rosy picture, illustrating the complex nature of what constitutes a good teacher and what contributes to the quality of teacher training.

Everyone involved in training teachers over the past ten years has seen dramatic changes. Although some of the reforms introduced by the Teacher Training Agency (TTA) were unpalatable at times, they have brought benefits. The standards achieved by newly qualified teachers have improved in large measure because of the high expectations of those working in initial teacher training and also because of the quality of the training provided. We can take heart in the good teachers we have but must accept that the training available is not right.

There are three phases in training teachers. First, the initial teacher training has three different routes: the BA/BEd route (mainly for primary teachers), degree and the postgraduate certificate of education (PGCE) route (secondary and primary teachers) and the employment-based routes. Second, there is the induction phase, the bridge between pre-service and full service teaching. Finally there is continuing professional development (CPD).

Initial teacher training requirements are set out in a document called *Qualifying to Teach*. In terms of professional values and practice it outlines the attitudes, the commitments and the professionalism a qualified teacher is expected to have. Newly qualified teachers (NQTs) are expected to be confident and authoritative in the subjects that

they teach, understanding how students progress and how they can help students achieve their various targets and standards. Finally, teaching requires skills of planning, monitoring, assessment, pedagogy and classroom management: all the day-to-day basis of lessons.

The demands for secondary science trainees are arguably greater than for many other subjects because in science most, if not all, entrants have to teach a different discipline as well as their major one. Biologists, for example, have to be proficient in physics in order to teach the breadth of science required in school. Science teachers must also understand health and safety requirements and practice in the laboratories. That makes a big demand on science trainee teachers, leading to concern about crowded training programmes and the time spent in teacher education.

Both primary and secondary trainees are pressured with very little time for reflection. The standards identify the complex nature and size of the task that we ask trainee teachers to take on in what is, for a PGCE student, a very short time — about 36 weeks.

The initial training of teachers is like providing them with a toolkit to take into school. There is no point, however, in providing tools without an explanation as to how to use them. There is also no point in providing a toolkit that has only one tool for one job. Teaching brings together complex and subtle instruments and techniques to support students' learning. Knowing which approach to use and when to switch from one to another is an important aspect of effective teaching, especially when trying to meet the needs of individual students. Developing the expertise to handle the situation requires time for reflection, understanding and appreciation of some of the underpinning theoretical perspectives. Too often, trainees (and more experienced teachers as well) do not have the time necessary for that.

Induction is a relatively short period in the life of a teacher, but it is a critical time. Going into your first class on that first morning is a very big responsibility. NQTs prepare with their tutors a career entry profile that lists their strengths and areas for development. This provides an important step between the pre-service training and full-time employment.

NQTs should have a reduced timetable and, throughout their induction year, support for their professional development in meeting the induction standards. However, that experience is variable. Although the present requirements have brought about improvements, there is still much to do to improve the consistency and coherence of their experience in moving from initial teacher training to the early years of their teaching career.

The third phase, CPD, is currently under the spotlight. Much of the training is good quality, but there is a lack of coherence and planning across the whole system, despite having a CPD strategy, issued by the Department for Education and Skills in March 2001. It was designed to increase teachers' opportunities for relevant, focused and effective professional development, placing that development at the heart of school improvement. The big question is "What impact has the strategy had?". Sadly it seems to have been very little.

Other initiatives have been underpinned by professional development. The Key Stage 3 Strategy for science took an approach aimed at developing the teachers, on the basis of school and individual needs. Despite all the activity, CPD for the vast majority of teachers has largely been a hit and miss affair for many years. Many teachers have taken advantage of some of what has been available, both formally and informally, but there are many who have never been fully engaged in CPD.

So what can be done to get the training of teachers right? We will never be able to create a perfect system. There will always be room for improvement and adaptation to meet needs. A start might be to stop referring to the "training" of teachers; with the implication it is something that is done to teachers rather than being a learning process in which they fully participate. Professional development starts from day one of pre-service training.

We must engage individual teachers in their subject and with their pupils. If we can achieve this, there is more likelihood that they will engage in professional development. We must take advantage of the opportunities created by the network of Science Learning Centres, which have been charged with developing new approaches to CPD. They will run courses, but with the expectation that the work undertaken as part of the course will be followed up in school, used to inform practice and lead to more sustained professional development.

Professional development does not happen in a vacuum; it requires guidance and reference points against which to judge teachers' progress while setting aspirations and objectives. The development of a professional framework with a subject focus might be more acceptable, especially if it involves teachers in the development process. Such an approach is currently being explored through the AstraZeneca Science Education Forum. Models have been developed with groups of teachers and they will be disseminated more widely, encouraging further discussion.

We must also raise professional standing, recognising the achievement and commitment of teachers as part of their professional development. The standards set for qualified teacher status (QTS) and induction provide this to some extent at the beginning of a teacher's career but there is no universal professional recognition for the expertise of science teachers. The Association for Science Education is applying for a Royal Charter with powers to award chartered status to science teachers. This will provide recognition of highly accomplished science teachers and their expertise but bring with it a responsibility and a commitment by the individual to maintain their level of expertise through further professional development.

If we are to get the training of teachers "right", we must provide opportunities for teachers in all phases of their careers to reflect on the processes of teaching and learning as well as their subject knowledge. We must improve the access to CPD for all teachers and strengthen the coherence and progression between phases of professional development. Even if we do not owe this to ourselves, we certainly do owe it to our students in order to provide them with teaching of the highest possible quality to support their learning. ❐

discussion

Classroom disruption. One speaker recalled that inability to manage behaviour used to be the worst failing a teacher could have, because it meant 40 years of public humiliation. Now it was a central standard: to become a teacher you had to be able to control children. Nevertheless, new teachers all said they wanted more help with it. Other school staff needed the same skill and discipline problems called for a team response. The skills of managing behaviour could not be taught academically and it was an advantage of school-based initial training that new teachers could be supported by their colleagues. It took time and experience to learn different ways to handle different groups. Head teachers and heads of departments also had a responsibility not to put new teachers knowingly in front of difficult classes.

On 12 May 2004 the Foundation held a discussion meeting at the Royal Society to debate how the developed world can build stronger links to help to improve the science and technological infrastructure in the developing world.

Reducing world poverty

Hilary Benn

The Rt Hon Hilary Benn MP is secretary of state at the Department for International Development and the prime minister's personal representative to Africa. In June 2001 he was appointed as parliamentary under-secretary of state for International Development. Between May 2002 and May 2003, he was parliamentary under-secretary of state for community and custodial provision at the Home Office. He was elected as MP for Leeds Central in June 1999.

There has been a perception in some quarters that the Department for International Development (DFID) is not doing enough on science, but I hope I can show that this perception may not fully reflect the work we are actually doing. I also acknowledge, however, that we have things to learn from you. One thing that is clear is that we need to talk more, so that we understand each other better. I see this evening as the start of a bigger conversation between us.

Let me start by setting out where we in DFID are coming from. DFID has an absolutely clear mission — to help reduce world poverty. What matters to me is outcomes: lives saved, people better off, children living to celebrate their fifth birthdays. I was in Ethiopia recently and visited a clinic where far too many mothers die in childbirth. How can we reduce those deaths?

Scientists have come to us with ideas. For example, evidence from Nepal suggests that, if mothers took vitamin A, as many as 40 per cent of maternal deaths could be prevented. So DFID is spending £5 million on a trial with the Ministry of Health in Ghana, to see if this result can be generalised. The results so far are encouraging. That is what we need: science at the service of the poor.

Take another example. Every day, 16,000 people contract HIV/AIDS and a further 8,000 will die from it. Women are increasingly the most affected and they need a technology that they can control. The UK is a world leader in microbicides that could reduce the chance of HIV/AIDS infection. Imperial College and the Medical Research Council are developing them, in the form of a cream or gel. The DFID is putting £17 million into this cutting-edge scientific research — indeed we were the first government to do so — and large scale effectiveness trials of possible microbicides are now about to start in five African countries. With only moderate uptake, they could prevent 2.5 million deaths every three years.

Science and technology are of fundamental importance in the fight against poverty. There are vital problems for which developing countries need better solutions.

Malaria kills 3,000 people every day, but there has been no new anti-malaria drug for 50 years. There is no vaccine against HIV/AIDS. We do not have adequate high-yielding, drought-resistant crops appropriate for the diverse and rapidly changing ecosystems of Africa. The list is a long one.

There are some areas where we do have answers, but these answers have not yet reached the poor. Two-thirds of deaths are from illnesses that we know how to cure. Most Kenyan farmers still use seed varieties that are 20 years old. We need much better links between researchers and users — not just discoveries, but innovations that are actually used.

DFID has been committing resources to scientific research to tackle these problems. We are in the top three countries for research spend by development agencies. The Central Research Department spent £80 million last year, including £30 million on agriculture, £26 million on health and £10 million on infrastructure. I have announced an extra £30 million over three years to the Consultative Group on International Agricultural Research.

We plan to increase our central research spend substantially in the next few years: from £80 million last year to at least £100 million in 2006-07. Our funding framework[1] emphasises four main areas: agricultural productivity in Africa, killer diseases, the impact of climate change and the problems of states that do not work in the interests of the poor.

It is, of course, crucial that developing countries have the capacity both to utilise science and to put research into practice. In practice, the quality of research capacity varies widely across the developing world. It is strong in China and India, but weak throughout much of Africa.

DFID supports capacity building in four ways. First, strengthening developing country research is built into our DFID research programmes. We expect our major research programmes to include capacity building as one of their outputs. In the past three years, we have let almost half of the contracts for our agriculture research programme to institutes in developing countries.

We can point to considerable successes. Return for a moment to that vitamin A trial in Ghana. It is a very major piece of work, involving over 100,000 women. Over four years, the Kintampo Research Centre carrying out the research has

already acquired invaluable skills and is now a real resource for other clinical trials. Likewise, 15 years of collaboration with the London School of Hygiene and Tropical Medicine has enabled the National Institute of Medical Research in Tanzania to run an HIV/AIDS laboratory to full World Health Organisation (WHO) standards. Laboratories and clinical trials capacity are essential to Africa's ability to fight the diseases that kill so many.

Second, DFID supports links between developing countries and the UK science base. Our aid is untied, which means that, by law, we must not discriminate in favour of UK suppliers. But because the UK science base is world class, I am happy to say that UK researchers very frequently win open competitions for DFID research funds. This means that DFID's research programme has been able to underpin some of the long-term collaboration between UK research institutes and the developing world.

Our DFID Higher Education Links Programme has also been redesigned. The programme enables stronger links to be built between universities in the North and those in the South. In 2003 the current programme funded 430 university links in 48 countries in partnership with 124 UK institutions. The new scheme will have a stronger focus on sub-Saharan Africa, on support for the Millennium Development Goals and on capacity building for science and technology. It will commence in April 2005 and we will invest £3 million a year once the programme is fully operational. I think it is important for us to back the enthusiasm and goodwill of partners both in Britain and in developing countries, to promote a valuable exchange of knowledge and skills.

Third, DFID supports capacity building through the international community. I have already mentioned the Consultative Group on International Agricultural Research: it spends more than 20 per cent of its US $400 million budget on support for national agricultural research systems. We have just funded the International Foundation for Science to provide assistance to African researchers to direct their activities towards meeting the needs of farmers. We support the efforts of several international bodies — including WHO and the Food and Agricultural Organisation — to allow developing-country scientists free access to scientific journals.

In Cambodia and Vietnam DFID research programmes have put into practise new technology for converting local clays to road surfaces that has assisted local communes in remote locations to construct and maintain their own accesses. These techniques are now incorporated into Asian Development Bank loan applications from the Cambodian government. This type of innovation is incorporated in the DFID-funded Transport Knowledge Partnership, facilitating getting sustainable solutions into practice.

Finally, DFID's regional and country programmes fund African science and technology capacity. As an example, we have supported the establishment of the East African Network for the Monitoring of Anti-malarial Treatment. This has built up the skills available to ministries of health to set up high-quality drug efficacy testing and so decide which drugs to buy.

But the biggest contribution of DFID's country programmes to science and technology capacity building lies elsewhere. Where science capacity is weak in the developing world, the main causes are not specific to science. Rather, they affect the whole public sector: unreliable finance, poorly paid and managed staff, weak and unreliable electricity or telecommunications. In too many places, there is also a lack of physical security. Tackling these issues is central to DFID's country programmes.

Return again to that Ethiopian clinic and to the prospects of a vitamin A programme to reduce maternal mortality. You will readily agree that vitamin A alone will not do the trick for those Ethiopian mothers. The clinic needs staff who are regularly paid, trained and supervised. The clinic needs a reliable supply of drugs. It needs a road so that urgent cases can be moved to hospital. And staffing, drug supply and roads all require government systems that work.

The main task of our country offices is to support governments that are prepared to tackle these underlying problems. We are no longer devoted to funding individual projects —— a road here, a training course there. Projects that are not part of a government's own programme generally do not survive. Rather, we are backing broad poverty-reduction strategies: strategies that have put two million children into school in Uganda and restored health systems in Mozambique.

Science holds out the opportunity of major benefits for the poor. And for those opportunities to be seized, the country has to have working systems of government and of commerce.

For all of these reasons, DFID is determined to back both science and systems that together can make a real difference to people's lives. ❐

1. The draft research strategy has now been superseded by the Research Funding Framework 2005–07. The link is http://www.dfid.gov.uk/pubs/files/researchframework/research-framework-2005.pdf

discussion

Successful model. One successful model for North–South collaboration had been developed by the Royal Society with the aim of building links with South Africa following the collapse of apartheid. Five projects in South Africa were funded at relatively modest cost, linked with five project leaders in the United Kingdom. Postgraduate students rather than postdoctoral researchers were supported because the latter were in short supply in South Africa. Activity was galvanised in local laboratories and young scientists had their eyes opened to opportunities. The programme was said not to have led to any brain drain. There could, however, certainly be conflicts of interest. Scientists from developing countries needed to go to established centres to complete their training and there was a market for their services in the host countries, yet the home country needed them to go back and make their contribution. The problem did not just concern research: UK healthcare was heavily dependent on doctors and nurses from abroad.

discussion

Local involvement. One speaker recalled how Professor Abdus Salam, founder of the International Centre for Theoretical Physics, had explained how it was no use going into "us and them" mode and trying to tell people in developing countries how to do science. The key was to boost indigenous science and deal with the local culture. Development meant different things in Rwanda, Argentina and Vietnam. The way to help was to get local people to identify the problems and decide what their development path should be, helping to equip them to become independent scientists who did not just listen but had something to contribute.

Challenges of the South

Silas Lwakabamba

Professor Silas Lwakabamba is rector of the Kigali Institute of Science, Technology and Management in Rwanda. He is also a member of the Executive Board of UNESCO and the African Virtual University (AVU). In February 2003 he was awarded the silver badge of honour for distinguished contributions to engineering education by the UNESCO International Centre for Engineering Education. He has over 30 publications in the areas of combustion, higher education, science and technology, energy and power production.

Rwanda has a history of weak scientific and technological skills base. In particular, engineering education was almost non-existent until after the war and genocide of 1990 and 1994. During the early years post-independence, the country depended almost entirely on imported goods and services. This did not encourage local capacity building and new initiatives. Consequently, the country lacked skilled personnel, resulting in a low level of technical innovation and economic development. It has become imperative to create a national education policy that specifies areas of intervention.

The Rwandan government is committed to developing the role of science and technology to help improve the quality of life. The Rwanda Government Vision 2020 aims to have sufficient scientists and technicians to meet the needs of the national economy. The Ministry of Education, Science, Technology and Scientific Research was formed about three years ago but a key problem is a lack of experienced scientists and technologists.

Universities in developing countries have a special role in building science and technology capacities; they are responsible for orchestrating the brainpower of the faculty and training new generations of talent. The government of Rwanda has established a number of higher learning institutions to assume this role.

The Kigali Institute of Science, Technology and Management (KIST) was the first Rwandan technological institution of higher learning. Established in November 1997, its main objective is to build a technical base that will help rebuild the economy. Through our regular, part-time and outreach programmes, we have been able to respond to the need for high quality and professional manpower and a positive impact is already being felt in many parts of the country.

We place a strong emphasis on a practically orientated curriculum rather than theoretical or academic models. The full-time academic programmes in the Faculty of Technology have been designed to provide needs-based market-sensitive skills at the levels of craft, technician and engineer. The structure of these programmes is demand driven in that different levels of skilled technicians are annually availed to the labour market as a short-term measure, in parallel with the medium- and long-term training of engineers.

We are implementing a continuing education programme covering a variety of practical courses, such as computer applications, masonry, carpentry, electronics and telecommunication, radio and television repair. These are usually short courses of three months to a year. Their objective is to impart and update knowledge and increase the efficiency of the working population from both the private and public sectors.

In collaboration with the Department for International Development (DFID) UK, KIST is running an intensive programme to train information and communication technology (IT) technicians to maintain computing hardware, software and networks. This addresses the shortage of skilled technicians to maintain and repair the growing stock of IT equipment in Rwanda. Entrance to these courses has become highly competitive.

Through our Centre for Innovations and Technology Transfer (CITT) we are involved in developing and implementing appropriate technology in the following areas:

- Water supply for domestic use and for irrigation purposes;
- Agro-processing and food storage;
- Alternative energy supply systems;
- Wastewater and solid wastes management systems;
- Animal traction for transport and cultivation;
- Labour-intensive rural roads and bridges;
- Low-cost housing.

Projects completed successfully by CITT include the development and installation of seesaw and treadle pumps, which cost much less compared to petrol or electric pumps. We have also developed off-the-shelf designs of rainwater harvesting systems that are standardised and suited to household and community water needs as an alternative to piped mains water.

Several households have been fitted with solar electricity lighting systems. A standard solar water-heating system has been developed, while a double-glazed water heater has been installed in one of the provincial hospitals providing hot water up to 80°C. We have constructed several biogas plants and burners and CITT provides a biogas training course to complement this. The housing unit has developed low-cost building techniques and methods that can provide affordable houses to low- and medium-income earners.

As for other innovations, we manufactured and installed higher performance cook stoves and bread ovens. A community-based fuel-efficient bread oven using

Figure 1. A students' community project in Rwanda built a suspension bridge to cross a 40-metre span of river where a bridge had been washed away, giving the community access to markets and a hospital.

just one piece of firewood to bake more than 4,000 scones in two hours won a top international award in London in 2001.

In 2001 three students of the Civil Engineering and Environmental Technology Department pioneered the design and installation of a suspended bridge (spanning 45m) that crosses the Mbirurume river in Kibuye Province, connecting two provinces. Previously, a 5km walk had been required.

Universities in developing countries have a special function in scientific and technological capacity building. There are a number of barriers, however, that hinder contributions from the international scientific community to the promotion of sustainable development, both in Rwanda and in many other developing countries.

One of the major challenges is general infrastructure and training hardware. Most institutions start with very limited teaching space and inadequate teaching facilities, including a lack of up-to-date laboratories and research equipment, current textbooks, reference books and journals. IT is also presently unaffordable.

The shortage of well qualified Rwandans in the field of science and technology has necessitated the recruitment of some expatriate academic staff that are very costly to maintain. We are beginning to realise a big increase in Rwandan nationals, particularly at the level of tutorial assistants, but it may take up to five years before they are ready to replace the expatriate staff.

Good scientists and engineers need practical experience. The costs involved in fully equipping engineering laboratories to fulfil this objective are prohibitive to Rwanda at present. Most developed countries are characterised by too weak an industrial base to facilitate practical training for their engineering students.

Low R&D investment is another significant difficulty facing science and technology in developing countries. African countries (except South Africa) spend about 0.2 per cent of their GNP on R&D, compared to around 3 per cent in developed countries. As a result developed countries carry out 80 per cent of world R&D activities.

African countries have tended to invest their limited resources on an *ad hoc* basis. As a result, no meaningful contributions are made towards sustainable development. It is imperative for African countries to focus their efforts on carefully identified priorities. These countries can then direct their differentiated capabilities to common R&D challenges. A coordination of resources would avoid duplication, allow specialisation and result in networks of centres of excellence.

Another significant barrier to capacity building in developing countries is that of "brain drain". The cream of Africa's R&D personnel have moved outside the continent to more lucrative jobs. Salaries in our institutions are low and, recently, researchers have been taking up political, civil service jobs or moving into business within the continent. Many of Africa's research institutes are mere skeletons of their past and some are now more like consulting outfits.

Developed countries can help us by offering support in the areas of establishment of policy, regulatory and institutional frameworks, capacity building initiatives, physical and/or capital investment projects and studies to prepare new priority projects. In particular, developed countries may consider the following needs:

- To establish a science and technology policy analysis capacity. This requires leadership from institutions whose mandate involves training and research;
- To assist in the study and measure of the effectiveness of past initiatives in science and technology in developing countries. Such a study may determine the way forward;
- To collaborate with various institutions in IT to promote capacity building in this area, increasing accessibility to information in developing countries;
- To support accelerated training of personnel, including in research and consultancy;
- To support strong links between South–South and North–South training and research institutions;
- To offer support in compiling approved developed rural technologies worldwide, disseminating these in developing countries and piloting new technologies that have not been tested in rural areas;
- To provide extensive support in promoting entrepreneurship skills, small business and technological development training programmes in both urban and rural areas;
- To establish national and regional centres of excellence in science and technology.

Stronger science and technology capacity in developing countries is not a luxury but an absolute necessity if they are to participate as full partners in the world's fast forming, knowledge-based economy. However, the current disparity between developed and developing countries is likely to grow as the industrialised countries continue to outspend the developing countries in R&D and capture some of the developing countries' most precious human resources for their own use.

A growing level of investment in R&D is generally correlated with improved GDP. Developing countries need to increase their R&D spend considerably to bridge the development gap. Governments in developing countries should also consider retention schemes for their best talents by providing special working conditions, including income supplements and adequate research supports.

KIST has shown that universities in developing countries can play a very significant role in building science and technology capacities. However, these universities lack the required resources to realise their full potential. There is therefore a need for support from the North. ❐

Building sustainable skills

David King

Sir David King FRS ScD is chief scientific adviser to the Government and head of the Office of Science and Technology at the Department of Trade and Industry. In 1988 he was appointed 1920 Professor of Physical Chemistry at the University of Cambridge, a post he retains and in which he is still active in research supervising PhD students

There are few more important topics than the one we are discussing this evening and I want to emphasise the word "sustainable".

I use Partha Dasgupta's description of sustainable development: 'Each generation should leave at least as large a productive base for its successor as it inherited from its predecessor' (ref.1). The productive base is composed of, in Dasgupta's very quantitative model, first the manufactured capital, second, human capital, third, natural environmental capital and, finally, the institutional and cultural coordinates. I am going to focus on the second of those — the development of human capital in developing countries — because from the development of human capital, other things will flow.

I also want to use sustainability in a very special form here to imply that, if a country in the North is involved in sustainable development in the South, it ought to be of such a form that, if that country stops that activity, there is something left in place that will continue.

Economic strength is linked to indigenous science and technology capabilities, and it is the word "indigenous" that I also want to focus on.

The key problems we are currently engaged in — poverty eradication and engaging fully with Islamic countries to bring them into the modern world — both require the same response: capacity building between North and South in science and technology.

When I say science and technology I am talking very broadly. I am referring to the whole process of education that involves the knowledge base in science, engineering, mathematics, medicine, agriculture, technology, business, social sciences and economics. The suggestion is that, without that base being fully developed, we are not going to see sustainable development in any of these countries.

I have been analysing the strength of science in different nations which goes into detail of the contributions to publications of the top 26 nations in the world[2]. The first important point to make is that those top 26 (of the 190 countries represented at the United Nations) are producing around 97.5 per cent of the world's publications in science and citations in science. That highlights the problem. China comes 18th in my rank order list and India 21st. In overall contributions to world science they are still quite lowly; nevertheless, each of them has developed a significant science base in particular institutions. That science base is essentially responsible for the rapid evolution of their societies which is currently taking place.

If a developing country boasts an increase gross domestic product (GDP) of 7 per cent per annum, but of its birth rate is producing an increase in population of 5 per cent per annum and the rate of inflation is 3 per cent, the country is actually going backwards. This is one of Dasgupta's key points: you cannot simply look at growth in GDP

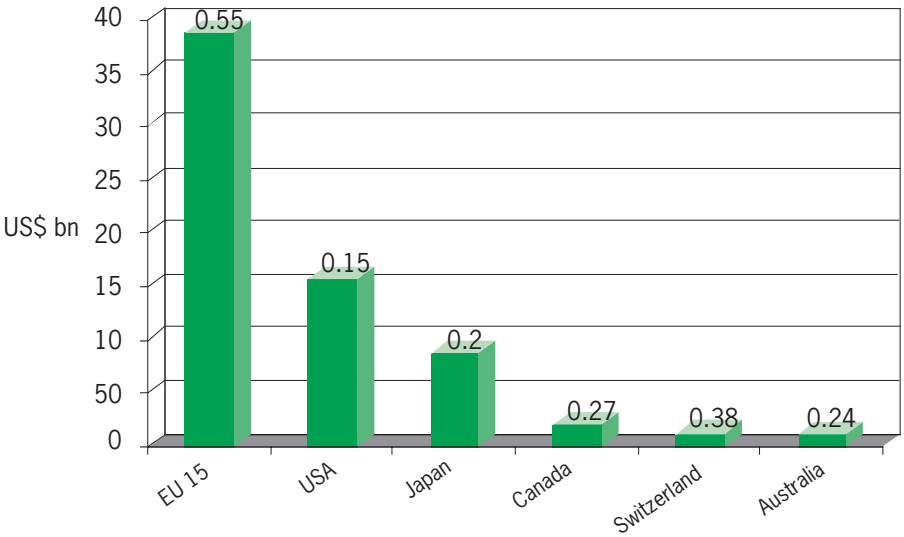

Figure 1. Net official aid as a percentage of the GDP of the donor country to developing countries in 2003. Total aid = US $ 67 billion. Source: OECD.

to see how well a government is doing.

Our world is under enormous pressure at the moment. Global warming is the key issue here. If population continues to grow in this way, and it is very likely to, this is going to put enormous pressures on our ability to deal with many of these global problems.

Now I want to look at examples of best practice and I am going to spend a little time talking about India. The country's first prime minister, Pandit Jawahlal Nehru, was deeply interested in the power of science and technology. When independence came and the great powers asked him what he would like for the country as a gift, Nehru said that he would like each of them to give an Indian institute of technology. I suspect that that was the wisest move made by a leader on achieving independence. Each of the great powers — Germany, Britain, USA and Russia — contributed to the building up of each of the Indian institutes of technology; and each of those institutes today is attracting enormous numbers of applications per place.

Today they are the most attractive higher education institutes in India and their output is of such a high standard that a very large number of their graduates end up doing PhDs and staying for their careers in Northern countries. This is a negative capacity building process but, nevertheless, there are sufficient people returning and there is a sufficiently sound base emerging from that to provide the engineering skills and the science-based skills that the country has required for its economic generation.

One example is Professor Swaminathan, who gained a PhD in genetics at Cambridge in 1952. Swaminathan is widely given credit for the green revolution in India. He founded the M S Swaminathan Research Foundation where the latest biotechnology/plant science is used to promote sustainable development and continues his work to the present day.

Professor Jhunjhunwala trained at the Indian Institute of Technology in Kanpur. He has been offered posts in the USA but has chosen to stay in India. He is currently developing the capacity of villages to communicate with each other and with major cities in a way that they could never do had they simply relied on Western technology. Indian researchers are developing their own appropriate technologies.

The capability of the institutes of technology has contributed to India's ability to transform itself. I do not suggest that Indian institutes of technology were solely responsible for the economic regeneration of India; but they have an enormous capability for good science-based advice in government and the ability to carry through projects, because they have the training and the skilled people to do that.

We should also focus on Africa, where the challenge is enormous. The governments there have set up the New Partnership for Africa's Development, which is a science and technology action plan for Africa. But I believe that what is required in Africa is to build on existing educational capabilities from primary, through secondary into higher education sectors. One part of that cannot be done without the other; an holistic approach to the problem is the only way to deal with it. If we take primary school education by itself, we are going to leave bewildered children who no longer use the capacity they learned in primary schools if there is not secondary school training to follow. Without higher education institutes, we have no targets for the secondary schools and if we do not allow research to be carried in these institutes, we lack the highest standards that prevent the brain drain too.

We have heard about the remarkable work that Silas Lwakabamba has been doing in Kigali. That is the kind of model we need. It is producing fairly modest achievements, but building a suspended bridge for pedestrians, for example, requires significant advances across the whole spectrum of the knowledge base.

The African Institute of Mathematical Sciences is a new highly innovative North/South collaborative project that three South African universities have agreed to set up. The University of Cambridge is to provide teachers, largely from their Department of Applied Mathematics and Theoretical Physics and, in collaboration with local teachers, the course material. The first 35 students have just received the first Masters degree course there and 169 applications for next year's 45 places have already come in. Those initial 35 students came from 15 different African countries and it is important to stress that only 6 of those were from South Africa; it has made an impact throughout Africa.

In this way, we can help the process of setting up institutes of technology in Africa with specialities; we can anticipate that people will travel to those institutes in different parts of Africa and then travel back to their homelands.

I am reminded of the International Centre for Theoretical Physics in Trieste. Many scientists, throughout the world, will have spent time there, exchanging information with top scientists from the North. That was set up by the Nobel Laureate Abdus Salam, a man of enormous personality and, of course, a great scientist.

Let me close with an indication of some of the official aid that is internationally available. The overall global aid budget is around US $67 billion. The EU is by far the biggest contributor — 0.55 per cent of its GDP goes towards the aid budget. The small northern European nations, Norway, Sweden, Denmark, are contributing 0.8 – 0.9 per cent of their GDP and the United Kingdom contributes around 0.35 per cent. Out of that significant budget, a considerably bigger impact could be made in the area that we are discussing. We might anticipate a significant portion of that going into a programme of institute of technology development of the kind that we have heard about today.

I think that we need more recognition of the value of science and technology, not just research but the wealth of activity that can be generated by developing the human capital, the skills base in the country itself, through North/South interaction. ❐

discussion

Priorities. One speaker called for greater priority for the promotion of sexual health in developing countries in view of its influence on population control. Girls who went to school had fewer children, later in life and these children grew up more healthily. The general question was: how could the case for science be made, in the face of pressure to use resources to deal with chronic poverty worldwide? There was competition between the claims of basic education and nutrition on the one hand and higher education and science on the other. One answer given was that the return on science was better than any other investment and even more so in the case of those scientists who applied their minds to the practical problems of developing countries. It was necessary to persuade politicians to focus on the longer term and capture the interest of the public.

1. Dasgupta, P. & Serageldin, I (eds), Social Capital: *A Multifaceted Perspective* World Bank (Washington, DC) 2000.
2. Dickson, D. China, Brazil and India lead Southern science input *Nature* **430,** 311 (2004).

An important strand of last year's GM debate was about farm management methods and the reality that growing crops reduces biodiversity. On 28 April 2004 the Foundation hosted a follow-up discussion meeting at the Royal Society to debate the balance between farming and amenity in our countryside.

Facts provide the key

Alun Michael

The Rt Hon Alun Michael MP is minister of state for rural affairs and environmental quality at the Department for Food and Rural Affairs (Defra). He was deputy home secretary from 1997 to 1998, secretary of state for Wales from 1998 to 1999 and first secretary of the National Assembly for Wales from 1999 to 2000. In 2001 he chaired parliamentary hearings on volunteering in the United Kingdom. Before entering Parliament, Mr Michael was a journalist, a youth and community worker and city councillor in Cardiff (1973-89). He became a JP in 1972.

I believe in an evidence-based approach to public policy and that is the angle I have brought to rural affairs. This is a pivotal moment for the future of the European countryside: later this week the EU will be enlarged by the accession of 10 new member states, radically increasing the diversity of the union.

The implications of the EU enlargement are clear for rural policy: farming and food will continue to play an important part in the rural economy of all EU member states. However, the countryside is now host to many other employment sectors that are more important than farming in economic terms. Our rural policy must, therefore, reflect that diversity in the countryside.

When I was appointed minister for rural affairs in 2001, one of my first priorities was to improve the evidence base available for rural policymaking. We have awarded a three-year contract to a new Rural Evidence Research Centre, headed by Birkbeck College to collate and analyse the available information.

The centre is taking forward work, following its report in January this year, called *Social and Economic Change and Diversity in Rural England*. The analysis will include constructing a new definition of rurality that is currently being validated and on which we would welcome comments. The new definition is intended to provide us with a tool to analyse rural trends in much more detail.

With respect to rural policy, the department is committed to funding high-quality relevant science on which to base and inform its policies on sustainable food and farming. Last year, Defra set up the Sustainable Food and Farming Research Priorities Group, following the publication of its strategy for sustainable farming and food. That group will examine research priorities for 10–15 years' time in farming and food, including issues such as rural land use.

Over the next six months the Research Priorities Group is holding a series of interactive workshops in which representatives from throughout the food chain will be taking part, along with environmental specialists and consumer groups. Science plays a very important part in this. For example, the two consultations that we have undertaken recently on pesticides and chemicals policy are underpinned by clear science, as is our decision-making in general.

These issues bring home just how difficult it is to get intelligent evidence-based discussion on any issue. How is the public to get informed answers about safety? The Food Standards Agency is looking at issues about what the public finds acceptable in terms of pesticide residue, but the real issue is what is safe. If you are not careful, you end up with an incremental policy that says "there must be something worrying about all of this because people are worrying about it".

We need to be absolutely stringent about the standard of the evidence that we use and the way we talk to the pub-

discussion

Economics. It was argued that farming and forestry were the only economic activities that could deliver positive environmental benefits. It was also observed, however, that the nature of the farmed landscape depended on what kind of farming was profitable. Sheep and orchards were to be seen in Herefordshire 20 years ago, but now ploughed fields had taken over because farms were producing strawberries and raspberries in response to the demand for soft fruit all year round. Farming was influenced through commercial incentives.

A lot of farmland was now being bought by non-farmers and high-tech industries were contributing to the rural economy but perhaps not to the landscape. It was agreed that the landscape needed to be managed, but not necessarily as it had in the past. What mattered was to generate economic activity whilst keeping the impact low.

lic. It is clear that people are debating on the basis of prejudice rather than information.

Research and stringent analysis are fairly new in rural issues. What does the research and analysis tell us about the countryside and about our rural areas? First, rural communities in the United Kingdom are dynamic and are changing rapidly in ways that blur traditional urban and rural distinctions.

Second, rural England is no longer driven by agriculture: the percentage of UK gross value added from agriculture in 1973 was 2.9 per cent; by 1993 it was down to 1.6 per cent and it decreased to 0.8 per cent in 2003. The proportion of the national economy arising from farming has halved in the past 10 years. Likewise, there has been substantially reduced employment in farming: 1.8 per cent of the total workforce in employment in 2003, down from 2.4 per cent in 1993. Employees in rural businesses are now more likely to be in manufacturing (25 per cent), tourism (9 per cent), or retailing (7 per cent), than in agriculture (6 per cent).

An increase in rural employment has taken place since 1997 and in many rural areas the local economy is almost identical to neighbouring urban areas, with people employed in very similar sectors.

There are areas of weak economic performance which tend to be in areas that are more peripheral, in social and economic terms. Rural areas like the former mining villages of Nottinghamshire and the clay mining areas of Cornwall are good examples where it is not simply countryside that has informed the creation of a rural area that has economic difficulties but a much more complex past.

As the 10 new countries join the EU, changes in their rural areas along similar or even more drastic lines are likely, posing real challenges to the whole of Europe. In Poland, for example, there are over two million small farmers working under 5 hectares of land each.

Faced with such potential Europe-wide restructuring of the farming and food industries, we have to ask, what is our countryside for? First, food production can continue to play a central role in the countryside. The recently announced reforms in the Common Agricultural Policy (CAP) allow farmers to reconnect to their customers — it is about serving the public. The CAP reforms will:

- facilitate a shift towards a profitable, competitive, adaptable and resilient farming industry, very much the direction in which the strategy for sustainable food and farming points;
- allow farmers and other land managers to have a vital role in protecting and enhancing the countryside;
- herald the move towards more sustainable farming practices for the environment as well as for the farming business, repairing the CAP-subsidised damage that has been done to our rural environment over the past decades.

Already the voluntary use of modulation in the United Kingdom has brought positive and tangible improvements in the environment and economy of the countryside: habitats, landscapes and heritage sites restored, public access and education improved, bringing income to rural communities.

Posing the question of food versus amenity sets up a false dichotomy: the countryside is for both food and amenity and far more besides. Take our national parks, which demonstrate how food production, amenity value and other uses can be brought together in the countryside.

I have promoted a partnership between the national parks and the Regional Development Agencies, so that the RDAs recognise the contribution being made by the national parks, while the national parks understand what they need to do to fit into the regional economic strategies.

The Sustainable Development Fund is in its third year of operation and provides each of the parks in England with £200,000 a year to support community projects that aim to develop or test new ways of achieving more sustainable living in the countryside. This opens the way to collaborative and cross-cutting work.

The national and other parks are also working towards sustainable tourism. Tourism can bring economic, social and environmental benefits. Appropriate tourism can help to secure a future for the local pub, the post office or the bus network; at another level, it can help drive rural regeneration and deeper understanding of our landscape and countryside.

The third element is lean and effective administration. The parks are run by single-purpose local authorities. When these authorities were reviewed in 2002 we had 54 recommendations on how they could further improve their performance. We will be implementing changes to enhance the parks' capacity to work effectively and economically.

The fourth element is promoting recreation. Britain's countryside has long been prized for its rich and diverse landscape and the opportunities that it provides for people to get away from it all.

The fifth element is offering opportunities for health. Each year, two-thirds of the population in England visit the countryside, generating social benefit, particularly in terms of health, a major issue for the Government. Defra is playing an important part in this. Only 32 per cent of Britons take exercise regularly. A 10 per cent increase in adult activity would benefit England by some £500 million a year and save about 6,000 lives.

Our refreshed rural strategy sets out the new evidence available and a clear statement of the Government's policy priorities in rural England. The strategy recognises the great diversity of activity and employment in the countryside. Recognising this diversity will be ever more important if policymakers are to respond, in a relevant way, to the challenges ahead. ❐

discussion

Research. The Government put a great deal of money into advising developing countries on food security and the nutritional value of food, but the advice did not seem to be applied in Britain. In continental Europe, it was suggested that ministers were more concerned about shortages of food than keeping on the right side of the farmers. Applied research was needed in the United Kingdom. Another speaker advocated research into the food chain, to identify waste. Only about a third of the carbon fixed in photosynthesis ended up as food, but later losses were still important and lifecycle analysis could be valuable.

The farm-scale trials of GM maize and oilseed rape represented progress, because they raised questions about the relationship between farming and the wider world. What mattered was not the technology but its impact on the environment. Both the worst and the best crop varieties, from the environmental point of view, were conventional, yet modification of characteristics through traditional breeding was subject to minimal scrutiny.

Biodiversity, which was a major factor in the decisions on GM maize and oilseed rape, called for further debate.

Back to the future

Chris Pollock

Professor Chris Pollock is director of the Institute of Grassland and Environmental Research in Aberystwyth. He joined the institute in 1974, when it was the Welsh Plant Breeding Station and became a member of the senior management team in 1989 as head of the Environmental Biology Department. He is an honorary professor of the University of Wales and of the University of Nottingham. He was a Fulbright fellow at the University of California, Davis, from 1979 to 1980 and a NATO senior visiting research fellow at Purdue University, Indiana, from 1987 to 1992.

In one way, the golden age for the UK countryside lies in the past. The Norman three-field system was extremely sustainable: it was a closed cycle agricultural system, where all waste was returned to the land at the site of production and all consumption was local. Also, I suspect that the absence of chemical fertilisers and chemical prophylatics meant that large numbers of animals, plants and microorganisms were present, many undesirable in the human context but all contributing to biodiversity.

Some would have us move back to this type of scenario. I think the future is different: the future offers an opportunity for science and technology to contribute towards sustainable land use and I will share some thoughts with you on this.

I want to put forward a few examples as to why UK agriculture today is not wholly sustainable and I will give some examples of where science can help.

One of the elements of the debate that has concerned me over the last few years is the idea that there is a single easy thing that we should be doing and that, once we start doing this, everything is going to be all right. There are areas where there are very difficult policy decisions to be made and we have to look at UK agriculture in a global context.

The application of agricultural technology in Europe has been a phenomenally successful enterprise since the Second World War in terms of reducing the real-terms cost of food and in ensuring security of supply. This progress, however, has come at a cost. The Environment Agency's report *Agriculture and Natural Resources: Benefits, costs and potential solutions – May 2002* (1) calculates the net annual environmental cost of UK agriculture as £326 million; £900 million of environmental services are delivered, but £1.2 billion worth of damage is caused. Farming is now the major source of serious pollution incidents in the United Kingdom and in comparison with the manufacturing sector, farming is a dirty industry.

That is unfortunate, because already we have the tools to reduce that impact; we could turn this situation around within five years. However, we must also look to the future, to where the research agenda can be managed to meet these needs. Political decisions, such as the reform of the Common Agricultural Policy (CAP), that create a clearer and more visible opportunity for a range of land management options, have to be examined in terms of providing a research base and outcomes that support sustainable land use.

It is not only about environmental pollution. In Europe, there have been two major declines in biodiversity attributable to agriculture. The first was deforestation during the Iron Age and the second marked the onset of chemical or intensive agriculture (see Fig. 1).

The diversity of our crops and our domestic animals has declined equally

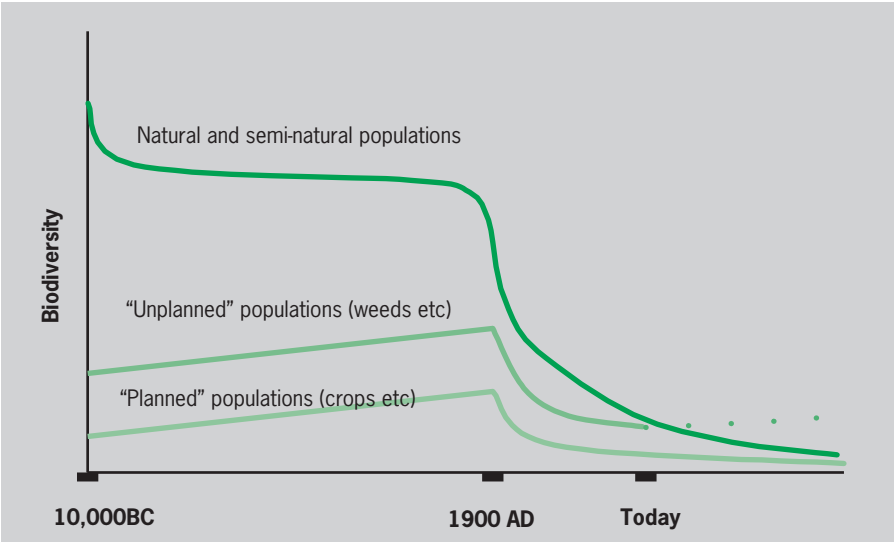

Figure 1. Changes in biodiversity attributable to the development of agriculture. Redrawn from Edwards & Hilbeck, 2001.

sharply since the beginning of chemical agriculture, so we are putting a lot of eggs into one basket, expecting a reliable food supply from a very restricted range of crops and systems. Some 80 per cent of the UK land area is managed, mainly by farmers for whom there has to be economic benefit. We should strive for a sustainable future where economic benefit and diversity of management can contribute to a rich and varied landscape.

I now want to look at two sets of challenges: reducing the impact or footprint of agriculture and the relationship between farming and biodiversity.

It is possible to reduce the impact of agriculture and reduce cost without affecting yield, output or profitability. Take the application of nitrogenous fertiliser. By incorporating animal waste into the overall fertilisation package, so that it becomes part of the production system, nitrate losses can be reduced considerably in both poorly-drained and well-drained soil for both cut and grazed pastures. The reduction in total yield is almost imperceptible at 1 or 2 per cent, creating a win/win environment where both costs and the pollution load are reduced.

Changing some of the fundamental processes of animal production can achieve similar gains. Grass is a low-protein feed from which we gain a high-protein product — milk or meat — yet 70 per cent of the protein comes out of the back end of the animal as dung and urine. The process is highly nitrogen inefficient because the grass feeds microorganisms in the rumen and then these rumen microorganisms feed the cow.

If you introduce extra sugar into this process, you block this conversion of plant protein into peptides and amino acids, stopping the release of ammonia. But the sugar content of grasses is genetically determined, so you can feed high-sugar rye grass to cattle and find that, although this grass has a lower crude protein content and a slightly lower total nitrogen content, the nitrogen output in the milk is significantly greater. The nitrogen efficiency of animal production goes up as a result of using these high-sugar grasses; another win/win situation.

The less good news is that rebalancing may have a considerable cost in production terms. I want to talk about the relationship between farming and biodiversity and expose some of the difficult choices that are going to have to be made. Again, I am going to draw an example from livestock agriculture. Over the last 150 years there has been a combination of habitat degradation and loss that has led to major declines in a large number of iconic species, particularly farmland birds. If farming becomes more efficient, inevitably it is at the expense of the natural food chain that shares the same environment.

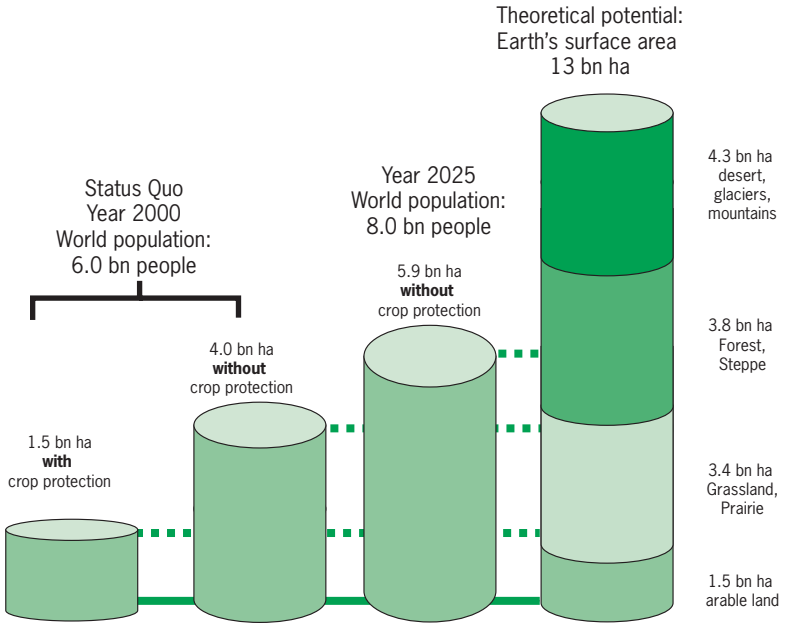

Figure 2. Global land usage today (2000) and in 2025. Source: DT Avery, US-Hudson Institute (FAO). One hectare (ha) = 10,000 m^2.

If you look at the changes in grassland management between 1970 and 1990, a number of things have happened: inorganic nitrogen application has peaked; there are more sheep than there used to be, but the major change is the decline in hay-making and the increase in silage production. In hayfields, the weeds that grow in the field set seed before harvest, but in silage fields they do not because the harvester goes through long before the weeds mature. Silage fields are consequently poor in terms of biodiversity since there are few weeds or weed seeds.

To get more birds we would have to go back to hay instead of silage and that would mean much lower productivity and potential problems with animal nutrition. Policy changes would be required to provide financial support for land managers to farm in a way that would replace silage by hay. So, there are going to be some difficult choices.

It is not all bad news, however. At Bronydd Mawr in Brecon, we put Welsh black cattle out on a site of special scientific interest with very poor quality pasture for three months and compared their production over the annual cycle with others pastured throughout on good grazing. There was only a very small decline in total liveweight gain, but, in return, after three years of grazing, certain flora — orchids for one — began to proliferate.

Next, I would like to put the UK challenges into a global context. Data from the Food and Agriculture Organisation (FAO) indicates that, out of the 13 billion hectares of the Earth's surface, we currently need about 1.5 billion hectares to grow crops. If we were to stop using crop protection and fertilisation, at least double the land area would be needed to produce the same amount of food (see Fig. 2). If we take a conservative estimate of world population 25 years from now, about half the land area of the world would have to be under "sustainable" agricultural systems to feed the population. That is not going to be easy, given the need to sustain natural habitats like tropical forests.

In essence, this debate is about balance. We have to take the global issues into account because global commodity production has kept food prices low and much of that food comes from countries that mine their resources. There is more land and forest being lost in Brazil to beef and soy-bean production now than there is to commercial logging. That vegetation is irreplaceable.

By 2020 another 300 million tons of grain will be needed annually to feed animals for consumption by humans. Northern European agriculture is lucky to have young, resilient soils but it cannot compete in cash terms with production systems that are much less sustainable and much more fragile.

In conclusion, I have three questions. First, how much extra will you pay for sustainably-produced food, because the more you pay, the more benefits can be delivered? Second, are you prepared to pay even more to look at that sustainability globally rather than nationally? And, finally, if you do all that, is there then going to be enough land to feed everybody? ❐

www.environment-agency.gov.uk/commondata/105385/natrespt1_673325.pdf

Farming today

Oliver Walston

Oliver Walston is a farmer at Thriplow Farms near Royston. He was educated at King's College, Cambridge and Princeton University. In 1977 he was awarded a Nuffield Farming Scholarship and in 1984 he founded and organised the "Send a tonne to Africa" appeal which raised £2.2 million. He has also worked as a television presenter and has written three books.

As an arable farmer who, at one time had livestock and used to make hay, I was fascinated by Chris Pollock's descriptions of the environmental consequences of producing hay rather than silage. At my farm in Cambridgeshire haymaking used to be a fraught business, while making silage was relatively easy. I stand before you as a barley baron who is neither a baron nor do I grow barley!

The answer to the question before the house this evening is easy: the countryside is for both amenity value and food production. The countryside has four main functions; it provides:

- the source of this country's temperate food supply;
- the home of this nation's wildlife;
- a recreation area for this nation's human population;
- landscape, what the Americans call "eye candy".

Over the millennia, these four functions have remained fairly static in this league table of importance. However, in the past 50 years wildlife has become an important issue while today, with nearly 60 million relatively rich people, we have a rather different order of priorities. As recently as five years ago, if you had asked a farmer what his job was, his reply would have been short and to the point: "to produce food".

I started farming in the village of Thriplow in South Cambridgeshire in 1972 when the CAP was gathering speed. In those days, my job as a farmer was crystal clear: I had to produce as much as I possibly could. I was happy that, during the 1970s, we were able to achieve something that was fundamentally unique in the history of agriculture. Since the first seed was planted somewhere between the Tigris and the Euphrates, 8,000 odd years ago, agricultural yields, be they milk or wheat, have increased slowly and incrementally. In the 1970s, however, yields almost doubled in 10 years, due to a combination of factors.

We were able to achieve this because scientists and plant breeders came up with new varieties, new fungicides and new techniques. In Brussels they showed us their gratitude by tipping a cornucopia of cash into our bank accounts; it was called the Common Agricultural Policy.

In the 1970s there was no green movement to speak of, almost nobody worried about spray drift, pollution or pesticide residues and no one had heard of genetic modification. When it came to agricultural subsidies, these, like old age pensions and the NHS, were considered well deserved and non-controversial. We were given grants for grubbing up trees and hedges; when I bought a new tractor or lorry or combine, a taxpayer paid 10 per cent of the cost.

Younger farmers began to believe that this new policy was not only the norm, it was also our right. Our fathers, on the other hand, who had grown up in the Depression, shook their heads and said that it would not last and, of course, they were right.

Now, voters and governments are fed up with paying me to produce food that nobody wants and which has to be stored. Not only that, the urban 85 per cent of the population has discovered that it is pleasant to walk, ride or even bicycle through the British countryside. At the same time, the green movement started to grow and then came BSE, foot and mouth, GM press hysteria, Franken foods and so on.

One morning, the farmers of Britain woke up to find that, once national heros, they were now national villains. The politicians in Brussels found themselves in a very different world too. Not only was the EU expanding eastwards, bringing with it millions of subsidy-starved farmers, but the World Trade Organisation pointed out that it was economically stupid and morally unjust for British farmers to grow expensive sugar beet, the surplus of which is exported to the developing world, when sugar could be made far more cheaply from sugar cane grown in the tropics.

Eventually was born the most recent reform of the CAP, today known as the mid-term review. As a result, I will no longer be paid for every acre I have planted but, instead, will be paid a fixed sum on condition that I am environmentally benign or, at least, environmentally responsible. The link between subsidy and output has at last been broken to which I say "Halleluia"! But this raises the fundamental question that, if my role is no longer to produce as much as possible, what should I be doing and what should the landscape be used for?

Nobody can pretend that South Cambridgeshire is among the prettiest parts of England. However, we are within 40 miles of London and so the footpaths across my farm are well used. I erected signs welcoming walkers and riders to the tracks on the farm 27 years ago, but I will come back to those later.

It is not just access that concerns me

in South Cambridgeshire; there is no doubt that the amount of wildlife on my Thriplow farm is less varied than when I was a child. To some extent this is inevitable as our cropping has changed from that of a mixed farm with animals to a purely arable operation. The effect of this has been exacerbated by the fact that, in the old days — the days of lousy pay, lousy jobs, lousy conditions when a farmer's single ambition was to get the "Hell out of it" — most of the crops were planted in the spring, giving animals of all shapes and sizes a period from late August until mid-February to get on with their lives; now, by the middle of October, 90 per cent of the farm is planted and there is not a great deal of scope for wildlife.

Today I have a responsibility to do more than produce the maximum possible amount of wheat and sugar beet and oilseed rape. We have about 60 acres, on a farm of 2,000 acres, that produce absolutely nothing and this completely separate from set aside. I must admit that we are compensated for these 60 acres by government. We are members of the Arable Stewardship Scheme which pays me for leaving:

- 2-metre beetle banks dividing some fields — an area where beetles frolic and gambol;
- 6-metre strips around the other fields which we leave untouched and unsprayed where larger animals can find homes;
- two fields totalling 44 acres which alternately year on year, we leave fallow in an effort, so far not entirely successful, to encourage the re-appearance of the stone curlew, once common on the Cambridgeshire chalks but now very rare.

My green acquaintances tell me that I am only green on the edges of my farm and I am simply tinkering with the problem.

There is no doubt that organic farms have more flora and fauna than intensive, arable farms such as mine. If we were to follow the organic route, the cost of food would rise by at least 40 per cent and we would have to import a substantial quantity of our cereals, oilseed proteins and milk. Farmers would have to employ more men. Quite where they would live is problematic, as in my commuter village of Thriplow the smallest house costs in the region of £300,000. If the day dawns when the Government decides that wildlife is more important than cheap and plentiful food for humans, then no doubt, they will change the laws and I will change my methods.

I see no problem in a countryside whose primary purpose is to produce food but whose secondary purpose is to restore and maintain a rich and relatively varied ecology. I accept that this ecology will probably be less rich and varied on the Cambridgeshire prairie where I farm than it will be on what is left of the Somerset Levels, for example. Also, it will be less rich than in my father's day.

The next generation that farms on my land at Thriplow will have to accept that they are park keepers as well as farmers. I am going to end with the words of the signs that, as I mentioned earlier, have been on my farm for more than a quarter of a century. They sum up my feelings about the real purpose of the countryside: "we welcome walkers and riders to this farm but remind them that this is cultivated land; please keep to the paths; and we hope that you enjoy this countryside". ❐

discussion

Organic farming. One speaker complained that Oliver Walston had been too kind to organic farming, which was less effective than integrated farm management and no-till farming in reconciling production with the environment. The Government ought not to subsidise organic farming. It was suggested that, even for those who did not believe in it, organic farming could have a value as a comparator.

events

Recent lectures and dinner/discussions organised by the Foundation in the past year are listed below.

20 July 2004

Science & innovation investment framework 2004–14

Mr John Kingman, Director, Enterprise and Growth Unit, HM Treasury
Sir Keith O'Nions FRS, Director General Research Councils, Office of Science and Technology, DTI
Mr Andrew Barker, Head of European Equity Strategy & Managing Director, UBS

Research Councils UK

13 July 2004

Partnership in research in Europe

The Lord Sainsbury of Turville (Represented by Jeremy Clayton), Minister for Science and Innovation, DTI
Dr Reinhard Grunwald, Secretary-General, German Research Foundation
Professor Ian Halliday, Chief Executive, PPARC
Professor Julia Higgins DBE FRS FREng, Foreign Secretary, The Royal Society

PPARC

23 June 2004

The future of science publication -— open access or library serials?

Dr Mark Walport FMedSci, Director, The Wellcome Trust
Dr Mark Patterson, Public Library of Science
Sir John Enderby FRS, Vice-President, The Royal Society
Mr Robert Campbell, President, Blackwell Publishing

BT Exact, Institute Physics Publishing and SQW Limited

26 May 2004

How can science support the Home Office in reducing and detecting crime, improving security, controlling immigration and managing the prison service?

Mr John Gieve CB, Permanent Secretary, Home Office
Mr Paul Wiles, Chief Scientific Adviser, Home Office
Mr Peter Neyroud QPM, Chief Constable, Thames Valley Police
Mr Alastair Rose MBE, Crime Detection & Prevention Technologies Programme Manager, EPSRC

EPSRC, MRC, National Grid Transco Foundation and QinetiQ

12 May 2004

North–South Capacity Building — how can the developed nations support the developing world to build science capacity?

The Rt Hon Hilary Benn MP, Secretary of State for International Development, DfID
Professor Silas Lwakabamba, Rector, Kigali Institute of Science, Technlogy and Management, Rwanda
Sir David King KB ScD FRS, Chief Scientific Adviser, Office of Science and Technology, DTI

CABI Bioscience

28 April 2004

What is the countryside for — food production or amenity value?

The Rt Hon Alun Michael MP, Minister of State for Rural Affairs and Local Environmental Quality, Defra
Professor Chris Pollock, Director, Institute of Grassland and Environmental Research
Mr Oliver Walston, Farmer, Thriplow Farms, Royston

BBSRC, Defra and Rural Economy and Land Use Programme

24 March 2004

Training teachers — have we got it right?

Mr Ralph Tabberer, Chief Executive, Teacher Training Agency
Dr Derek Bell, Chief Executive, Association for Science Education

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