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Sponsors - first half 1996

Sponsors for Foundation events held during the first half of 1996 are listed below. We are grateful for their considerable support.

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The Comino Foundation
Esso UK plc
Premmit Associates Limited
RHM Technology Limited
Anonymous

Future visits being planned

Visits being planned for the future are to the new Public Record Office at Kew on 16 April 1997 and to the new Southampton Oceanography Centre on 21 May 1997.

**David Andrews
earns first
medal: page 9**

Foundation makes it a Prize double



▲ ABOVE: *The Lord Butterworth, CBE, DL, Chairman of the Foundation for Science & Technology, presents Dr W. Graham Richards, Technical Director of Oxford Molecular Group plc, with the Lloyd of Kilgerran Prize 1996.*

▼ BELOW: *Professor Sir William Stewart, FRS, FRSE, receives the Lloyd of Kilgerran Prize 1996 from Lord Butterworth.*



The Foundation took the unusual step of awarding two prizes for 1996. One was to Professor Sir William Stewart, FRS, FRSE, as 'father' of the Science White Paper and for introducing the Technology Foresight programme. The prize was presented to him at a Foundation event on the subject *A Forward Look at Science Technology and Engineering* on 26 June 1996, when among the speakers was his successor as Chief Scientific Adviser, Professor Sir Robert May.

The second prize was presented to Dr W. Graham Richards, Technical Director of Oxford Molecular Group plc, as one of the pioneers of computer aided design, now a key technology in the finding and development of targeted drugs. Again, the choice of event for the presentation of the prize was relevant, being *Partnership in Technology: USA-Europe*. Oxford Molecular Group plc proved to be an excellent example of such partnership.

...and hears about some high-flying visits



▲ Mr Gordon Doggett, General Manager, explains the way operators will work. On the right is Derek McLauchlan, Chief Executive, NATS.

Air centre visitors get a bird's-eye view

On 4 July about fifty members of the Foundation visited the new Swanwick Centre for air traffic control of the future. Indeed, on arrival, the guests were welcomed to a futuristic-looking building in pleasant surroundings near Southampton. The building itself had won the Association of Project Managers' *Project of the Year* award for 1996. It was planned to be able to cope with the huge growth in air traffic, which is at present some 1 million air movements a year being managed by far smaller facilities at West Drayton.

Some of those on the visit had attended the visit to West Drayton and Heathrow five years previously and so could well see the astonishing comparison. Derek McLauchlan, the Chief Executive of National Air Traffic Services, came down from London to welcome guests and give the introductory talk with Gordon Doggett, the

General Manager of the Swanwick Centre.

Guests then toured the facility, whose grand scale reminded some of the Glaxo Wellcome Medicine's Research Centre at Stevenage, which was visited in 1995. In the case of Swanwick the massive computer power and the layout of the massive control room impressed all. They were told of the major contribution the service will make to the European ATC Harmonisation and Implementation Programme. Of the Centre itself, they learned that there were two matching systems, so that if any part of the building failed there was always back-up. It is probably the only building in Britain where, if there is a fire, the occupants must remain inside - that is until all the air movements in the sky are under total control. The Southampton Fire Brigade took a good deal of persuading on this issue!



▲ Foundation guests outside the Rutherford Appleton Laboratory in Chilton, Oxfordshire; the flags representing CCLRC's international nature.

Lab flies the flags for science

At Lord Dainton's suggestion, a party of about 50 visited the Rutherford Appleton Laboratory on 14 May 1996. Dr Paul Williams, Chairman of the Council for the Central Laboratory of the Research Councils, and Director of the Laboratory, was host for the afternoon and evening. It started, as most of the Foundation's visits do, with a run-down of the organisation, how it makes its revenue, and principal issues facing it. There were then visits by small parties to various parts of the Laboratory. One was to ISIS, the world's most powerful pulsed spallation source, providing intense beams of neutrons and muons to probe and discover

the make-up, properties and behaviour of materials. The plant was on a truly massive scale, and was being used by many different countries, as the flags at its entrance illustrate (*see photo, left*).

Another party was visiting the Space Science facilities, where they saw some of the instruments being prepared for the European space flight. Some members of staff joined the guests for the dinner discussion. The dedication and enthusiasm of the scientists were clear to the visitors, and all must have felt deeply for them when they heard of the destruction of the Arian spacecraft and the tragic loss of all the instruments and work involved.

A FORWARD LOOK

The Foundation held a lecture and dinner discussion at the Royal Society on 2 June 1996 on the subject 'A Forward Look at Science, Technology and Engineering'. The Lord Butterworth, CBE, DL, was in the Chair and the evening was sponsored by Zeneca Group plc. The speakers were *Professor Sir Robert May, FRS*, Chief Scientific Adviser to the UK Government, and Head of The Office of Science and Technology, DTI; *Professor G.K. Radda CBE, FRS*, Chief Executive (Designate), Medical Research Council; and *Mr John Parry, MBE*, Chairman, Parry People Movers Ltd.

Sir Robert May, FRS*

Introduction

I am very pleased to be able to talk to you this evening. It is an appropriate time in a year that has seen:

- the Office of Science and Technology's (OST's) fourth birthday (it was set up in 1992 by John Major following the General Election);
- the third anniversary of the 1993 White Paper *Realising our Potential*¹ (produced under the expert leadership of my predecessor, Professor Sir William Stewart);
- publication of the third annual Forward Look;² and
- the second anniversary of the launch of the Technology Foresight Programme (in February 1994) and the first anniversary of the publication of the Foresight reports.³

It is timely, therefore, to review what OST has achieved with the White Paper agenda, both generally and specifically in relation to the Forward Look and Foresight, and, looking to the future, where we go from here.

The 1993 White Paper: context and agenda

The White Paper was hugely significant. It was the first major statement of UK science policy for twenty-five years; the product of wide-ranging consultation with the scientific and business communities. *Realising Our Potential* continues to provide the broad policy framework for OST and wider science, engineering and technology (SET) activity within Government.

The 1993 White Paper was significant because:

- it reflected a generally shared determination in the UK to stop hand-wringing about our poor record in exploiting the science base and to do something about it;
- in setting out the goal of using SET more effectively to increase national wealth creation and improve the quality of life, it provided a unifying theme for the UK's annual £6 billion public sector investment in SET as well as giving OST its mission; and
- it demonstrated that the Government was willing - enthusiastic even - to take a strategic view of the deployment of total public investment in SET, against the White Paper's goals.

The White Paper was forward-looking. Other countries have followed in its footsteps. The 'Press Report'⁴ suggested that the US should take an overview over the totality of its activity (although I personally am not convinced that this will happen), and Japan and Australia are thinking along similar lines.

As well as setting out the aims of policy for SET, the White Paper also set out the means and mechanisms through which

Summary: **Professor May reviewed what OST had achieved with the White Paper 'Realising our Potential' and the Forward Look and Foresight programmes, giving relevant statistics and the principles underlying the Foresight programme in relation to R&D investment. Mr Parry discussed the innovation process and the achievement of market opportunities by practical solutions, including the provision of finance. He gave some examples.**

the agenda was to be taken forward. The Technology Foresight Programme and the publication of an annual 'Forward Look' are key mechanisms in this context.

The Forward Look - what does it tell us?

The White Paper stated that the Forward Look would be published each year 'to give the industrial and research communities a clear and up-to-date statement of the Government's strategy'. The Forward Look would set out the planned portfolio of publicly-funded SET best suited to the needs of the UK, the extent to which departments' and Research Councils' programmes were matched to that portfolio, and the measures being taken across Government to achieve the objectives of the White Paper.

In some ways, I think that we are perhaps beginning to take the Forward Look for granted. Before the Forward Look there was no document which drew together the Government's forward plans for SET. The old Annual Review of S&T was predominantly backward-looking. Moreover, the White Paper has given us a clear set of objectives against which the changing overall balance and direction of Government SET, as set out in the Forward Look, can be assessed. It is worth reiterating those here:

- to develop publicly-funded SET to meet the country's future needs, taking account of Technology Foresight, and fostering partnership between the science and engineering base, industry and Government
- to maintain the excellence of UK science, engineering and technology, to advance knowledge, increase understanding and produce highly educated and trained people
- to improve public awareness and understanding of SET
- to maximise the effectiveness of our EU and international collaboration in meeting UK objectives
- to promote collaboration between Government departments and ensure that trans-departmental SET issues are handled effectively, while improving efficiency and value for money

As I have already said, we should not undervalue the window on the Government's SET plans which the Forward Look offers us. You may well not like what you see there, but at least it offers us the basis of informed debate, both inside and outside Government. It often annoys me the extent to which these facts are selectively quoted to support particular points of view; it is worth remembering that science, of all subjects, should be about setting out the facts.

* *Chief Scientific Adviser to the UK Government and Head of The Office of Science and Technology, DTI*

Within Government, the horizontal overview of plans for SET laid out in the Forward Look, and the issues which these highlight, provide the basis for my input as Chief Scientific Adviser to the annual Public Expenditure Survey.

So what does the 1996 Forward Look tell us about the Government's strategy for SET? How does the picture presented stack up against the objectives the Government set itself in the White Paper? Is the White Paper making a difference? Is OST having an impact in its so called 'trans-departmental' role? I shall try to answer these questions, but let me first set out some interesting statistics from the 1996 Forward Look:

- overall Government spending on SET has gone down by 16 per cent (over £1 billion) in real terms over the last 10 years (1986-87 to 1994-95);
- much of that reduction reflects the run-down of defence spending following the end of the Cold War. The Ministry of Defence's spending on research and development, related to its procurement of equipment, has fallen by nearly £1 billion since 1986-87;
- spending by civil departments has also fallen over the last 10 years - by nearly £700 million. Most of that reduction (£650 million or so) reflects the ending of support for the fast breeder reactor programme and DTI's reduced spending on technology development for industry (DTI's figures are also affected by the netting off of receipts against payments for Launch Aid made in the 1980s which are now bearing fruit). Other civil departments have also reduced their spending, in part reflecting their withdrawal from near-market research (for example, MAFF's spending is down by 37 per cent or £80 million in real terms over the last 10 years);
- conversely, Government spending on the science and engineering base has risen by 14 per cent (£280 million) in real terms over the period in question (1986-87 to 1995-96), while the UK's spending on S&T through the European Union has risen by 160 per cent (£230 million) in real terms - (1986-87 to 1994-95);
- industry has also increased its spending on R&D over the last 10 years, with the net effect that the UK's total (public and private) expenditure on R&D has risen in real terms by £2 billion (1994 over 1985) - that is 16 per cent. As a proportion of GDP our total spending on R&D is now (1994) 2.2 per cent, only slightly less than the 2.3 per cent for 1985. (Our 2.2 per cent in 1994 compares with 2.4 per cent for Germany and France, 2.5 per cent for the US and some 2.8 per cent for Japan.)
- in terms of the relative funding of R&D by public and private sectors, the UK non-Government sector now makes a larger contribution (68 per cent) to the UK's total investment in R&D than in any of the other G7 countries, excepting Japan. (The UK non-Government sector is very largely industry, although the private non-profit sector - mainly the charities - makes a significant contribution, particularly in the biomedical area, spending £0.5 billion a year.)

What do these statistics tell us? First, that, as in most other countries, public sector spending on SET is under pressure as governments struggle to contain public spending and taxation. Secondly, that the Government has protected, and indeed been relatively generous to, basic research, at least up to 1995-96. Thirdly that, inevitably, our membership of the EU is changing the balance of what we spend unilaterally at home and what we spend multilaterally with our European partners, particularly in the area of strategic and applied research to support industrial competitiveness and quality of life objectives. And fourthly, that within the UK the balance of our investment in R&D has changed, possibly irreversibly: defence is still very significant

but now makes up just 15 per cent of the UK's total investment in R&D rather than the 23 per cent of seven years ago; spending by the private sector is now nearly 70 per cent of total UK investment in R&D, up from 57 per cent in 1985.

These changes in the pattern of our R&D investment have not just happened: they have reflected conscious policy. Standing where we are now and looking forward, the major strategic issues which OST needs to tackle for the next 10 years include, I suggest:

- defining the boundary between public and private sector responsibility for R&D, particularly in the strategic and applied areas. The boundary has shifted over the last 10 years: looking ahead, we need to consider how much further this shift should go;
- adjusting to the reduction in MOD spending on development which is set to continue. The defence industries are still significant in the UK industrial base, and MOD's support for technology development in the defence sector has had a significant spill-over impact on the civil sector. We need to watch that the peace dividend does not leave a development gap in the UK's industrial and technology base;
- acclimatising ourselves to the reality that increasingly support for R&D will come from Brussels. UK academics are already good at getting money out of Brussels; UK business less so;
- raising the game of UK industry's investment in R&D. While industry's own spending on R&D has risen over the last 10 years, it has risen less than other countries, and, with certain notable exceptions, our companies are not investing enough in R&D to stay competitive. I shall have more to say about this later when I talk about the Foresight Programme;
- last, but certainly not least, we must urgently tackle the question of how we can nurture research excellence within what is now a mass higher education (HE) system. Equally, we need to ensure that we attract young people of the highest calibre into SET and that we have adequate facilities within HE for teaching them. These are two of the major issues facing the Dearing Committee. Funding for the research infrastructure in universities is also an issue to be addressed more immediately in the context of this year's Public Expenditure Survey. My own view is that, by analogy with the situation in the US, where the great majority of research effort is effectively concentrated in only 100 or so of the 2,000 HE institutions, we can only realistically expect to support 20 to 30 research universities of world standing.

As well as highlighting and providing the basis for discussion of these major issues, the Forward Look - and the process which leads to it - is the means by which OST exercises its role of overseeing publicly funded SET. This involves, for example, following up with Departments how far they are responding to the priorities identified in the Foresight reports; how they are increasing their focus on the national wealth creation and quality of life goals which the White Paper set; reviewing the adequacy of Departments' arrangements for co-ordinating their programmes in areas of overlapping interests; and examining with Departments their general progress towards the White Paper objective of increasing the amount of their SET which is subject to competition. The Forward Look presents an account of where Departments are in all of these areas, reflecting a very great deal of OST activity with Departments behind the scenes.

Technology Foresight - what is it about?
Technology Foresight is central to OST's agenda. The Foresight Programme reflects three principles of the 1993 White Paper:

- that we have to make judgements about priorities in allocating finite resources for S&T and that these judgements must take account not only of our scientific strengths, but also of potential to lead in due course to exploitable outcomes. This is not inconsistent with protecting the seed corn of curiosity driven basic research which of its nature cannot be planned or directed. Much research is directed towards more strategic or specific ends, and it is essential that in these areas we do have a clear sense of priorities;
- that the setting of priorities should be not be imposed top down, but should be informed by dialogue between the users of research (in industry, commerce, etc.) and the providers of research; and
- that the key to improving the UK's effective exploitation of its science and engineering excellence is to bring the business and scientific communities into closer contact with each other - in my terms, to increase the cross-talk so as to break down the cultural barriers which still exist.



▲ Professor G.K. Radda, CBE, FRS, Chief Executive (Designate), Medical Research Council (centre), with (left) Dr P.M. Williams, CBE, Executive Chairman, Oxford Instruments plc, and Dr T.D. Inch, Secretary General, Royal Society of Chemistry.

Foresight embodies all of these principles, with its twin objectives of:

- establishing partnerships at all levels between the science base and industry (to increase mutual understanding and cross fertilisation and to effect a culture change); and
- using consensus about market opportunities and key technologies generated by the Foresight 'cross-talk', to inform decisions about prioritisation and resource allocation both within the public sector and in business.

Let me explode some myths. Foresight is not about:

- driving the science base short-term. The 1996 Forward Look shows that 90 per cent of the research funded by the Research Councils is basic and strategic, broadly the same proportion as for many years;
- changing the balance between Research Council responsive and directed mode funding. The Foresight reports themselves have emphasised the importance of maintaining a broad underpinning of undirected basic research, but equally we should not confuse directed research with short-termist, problem-solving science - some of the most fundamental discoveries in science have come from applied research, the second law of thermodynamics was deduced from work on steam engines, for example. Indeed, a major aim of the Foresight process is to encourage academia to appreciate the intellectual challenge of marketplace problems;
- nor is Foresight exclusively about influencing public sector S&T. Absolutely essential to Foresight agenda is that the process should also engage industry, and influence industry's forward investment strategies.

What Foresight has achieved

Firstly we must recognise that just having the programme at all, and keeping it going, represents a major achievement. Sustaining the Foresight exercise across the originally 15, now 16, economic sectors has represented a huge commitment. The

last two years have seen an enormous input of time and effort from Panel Chairmen and members.

Hard work as it has been, the first phase - discussing the issues, producing the reports - was the easy bit! We are now facing the much harder task of spreading the messages and encouraging action in areas which are not easily reached. Each of the different sectors presents its own unique challenges. Many include industries where there is simply no culture of drawing on the science and engineering infrastructure of the UK.

UK business needs Foresight. It needs to be ready to innovate; to be more receptive to new technology; to be readier to invest in the 'D' which is essential to build on the know-how and skills which the science base offers. Pharmaceuticals excepted, UK industry's R&D investment record is relatively poor. Most sectors are investing considerably less in R&D as a percentage of their total sales than their overseas competitors - and the gap is growing.

Tomorrow we shall see the publication of the 1996 R&D Scoreboard,⁵ which lists UK companies' latest reported investment in R&D, both for 1996 and the previous four years. The five-year time series shows that over the period even the top UK R&D investors lagged well behind the average world top thirty companies, with the all UK average R&D intensity frankly dismal.

Foresight has a major challenge to rise to if it is to influence the culture and attitude which underlies UK companies' consistent record of poor investment in R&D. This must be prime goal of the next phase of the Foresight Programme. The science base has responded admirably to the challenge - the task now is to fully engage industry. In some cases this will require no less than a change of culture.

When I took on the job of Chief Scientific Adviser, people asked me why. Some questioned my judgement; others questioned that of the Government! I consider there to be two absolutely vital tasks which I felt I had to take the opportunity to influence:

- preserving the strength of the UK's science and engineering base - we must not lose sight of the fact that we are very good at basic science; and
- trying to do something about our awful record of translating that scientific and technical excellence into economic success in the broadest sense.

These are enormous challenges. I hope you will join with me in rising to them. If we do not, the UK is in danger of becoming little more than a Disneyland theme park.

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INNOVATION AND FORESIGHT - SOME SELF-TAUGHT LESSONS FROM A TRAM BUILDER FROM THE BLACK COUNTRY

Mr John Parry, MBE*

Self-taught lesson number 1:
the market comes first

You may have heard the story of the marketing men from a shoe firm who went to a remote and rarely-visited country and encountered a culture where everyone went about barefoot. The first marketing man reported home by fax: 'Waste of time coming here, the people don't wear shoes!', while the second man reported 'Marvellous market prospects here - no-one has any shoes!'

However, nobody realised that there was a third executive on the plane who had just returned from a secondment to the Technology Foresight programme. He also prepared a report which was different again. 'Unusual situation here! What can we learn from it? Are there opportunities or even threats to consider? Just imagine a widespread conversion away from use of shoes! How would it also affect the sock industry and ancillary supporting supply chain - shoelace makers and shoe-horn suppliers? However, new markets may emerge for foot products; make-up, jewellery, etc? Could employees' toes serve as additional "fingers" available to increase computing speeds? I will investigate ground conditions which makes it possible/desirable to do without shoes. There could also be new construction market opportunities - flooring materials developed which feel good - a pleasure to touch - cool in summer, warm in winter. There could be therapeutic opportunities to improve health and sense of well-being while walking, standing or sitting with feet in contact with the floor surface.'

The way I see Technology Foresight is not just as a brainstorm forum to brief the Science Research Councils on how to direct R&D programmes more closely to market realities. It was/is an exercise for everyone to accept what stares them in the face but to look for lessons which are not so obvious and for trends, driving forces which might actually bring about a change in the culture. Most of the lessons which I have learned about innovation have been self-taught. The first example showed how R&D can be triggered not by what customers say but what they do.

Once the innovation process has been triggered, I firmly believe that you are embarking on a long, hazardous journey with only moderate prospects of success. It makes sense to learn from those who have gone before you and work out how to take sustenance along the way, like a marathon runner snatching drinks. Looking for money to support the R&D task is often as difficult as the task itself. However (and this may raise a few eyebrows), there is such a thing as too much money! If you accept that research scientists are just as human as workers of more humble origins - for example old cowhands from the American West who soon spot the fact that times are a little bit

easy. But you keep busy - don't quite finish mending the fence and a few cows stray out on the range and have to be rounded up. Another day, another dollar! When developing a new machine there is a temptation to develop a new electric motor or new switchgear rather than looking whether somewhere on the shelf there is a component which is already good enough - not the best - but the best can be the enemy of the good. The extra money going into design can delay the prototype process - and until you have the prototype you lack empirical evidence - the all-important trials and testing results without which it is hard to break into a market.

Self-taught lesson number 2:

don't go for the big money at the beginning

It will be wasted. You'll need every penny at the end, for the final stages of refinement to match market prescriptions and for the investment in manufacturing equipment to produce reliability in volume and quality.

Self-taught lesson number 3

This is connected with the previous one. Don't go for high-tech solutions for their own sake. Avoid witchdoctors and black arts. Even though it strains the brain - always understand, always know. The previous employers of Nick Leeson and Mr Hamanaka have learned the lesson of employing spell-binding super-skilled individuals who operated with such flair and speed we mere mortals could not keep up with them.

The right solution is sometimes the least expected. In the late 1960s I was called in to sort out the problem of a small brickworks which was an industrial equivalent of the *Coelacanth* - the prehistoric fish which swims around in the Red Sea even though it was thought to be long extinct. Using wooden moulds, sand and their bare hands, a group of East Midlands workers were producing bricks with techniques which Brindley and Telford would have seen in the last century. The brick market was in a slump but additions and extensions of old college buildings, halls, churches, etc, could only be matched to the architect's satisfaction by genuine hand-thrown bricks. So the old factory was still quite busy while more modern and productive units in the parent group couldn't find enough work to keep going. This story had two endings. Working with the Brick Development Association, my team began to rebuild an enthusiasm for beautiful bricks as fashionable surface material; the top end of the market expanded in spite of the recession. Then various devices were developed which enabled the traditional hand-thrown texture to be reproduced with better efficiency.

But the second and most interesting example of 'don't reject unexpected solutions out of hand' (my **self-taught lesson number 4**) came when in 1985 the Overseas Development Administration asked a colleague, Andrew Gordon, and me to take a look at the problems of and discuss solutions for squatter settlements where most of the people in developing countries

* *Vice Chairman, Technology Foresight Transport Panel*

live. Could there be new approaches to land tenure policies for provision of cheap building materials and development of skills to help upgrade these slums? A few fundamental questions confirmed our suspicions that slum- and shanty-dwellers are where they are because of the proximity to employment opportunities, and when provided with a decent patch of land could soon put up quite a reasonable dwelling. But the only land of reasonable price was in the distant outskirts of the city and the problem of residing there would be how to get to work in an acceptable amount of time or for a cost which did not take too much of the wage packet. A simple example - the return bus fare from the industrial area to the outer suburbs of Nairobi or Dar es Salaam costs between a quarter and a third of the wage of an unskilled worker. So they walk. The principal driving force causing people to squat on marginal land in these cities is the cost of transport.

Treating a clearly perceived problem as one which might have a technical solution and therefore a market opportunity, we began to look at the fundamentals, the factors which cause transport to be expensive. Out of this came the basis for a prescription for a new form of transport to serve the people of these cities:-

- it should be collective rather than personal transport, with each vehicle carrying 50-100 passengers.
- It should have the option to run over off-road alignments so as to avoid hold-ups due to traffic congestion.
- It should also, where necessary, be able to cross or to share ordinary roads and be compatible with ordinary vehicles to avoid costs of bridges and tunnels.
- The propulsion energy used should be minimised and also the cost of wear and tear on the running gear, particularly tyres.
- So as to be able to be powered with cheap, locally derived energy in place of imported fuel, the vehicles should use electricity.

When this prescription was examined by my Board it pointed clearly to a tracked system, steel wheel on steel rail. A colleague, Dr T.F. Wright, who is an economic historian (now retired) remarked that we were about to invent the vehicle known in Britain as the tram! And this was not so surprising, as one of the most significant contributions of such a vehicle, described as 'History's Orphan' by Mr Winstan Bond, was the provision of penny working men's tram fares at the turn of the century. A means to travel to work cheaply made it possible to develop the land on the edge of cities in Europe and America for decent housing, and to clear the slums.

For the orphan to repeat its historic task it was not just a case of implementing known technology. Engineering had moved on, trams have become 'LRT' - Light Rapid Transit - far too big, complex, sophisticated and costly for cities of the tropical world, and for most places in Britain, if the truth were known. Our concept returned to the bus-sized vehicles of the earlier era. The biggest technical problem was how to get the electricity to the tram. Forests of poles and miles of overhead wire were clearly expensive and impracticable. Assessment of battery technology, then as now, showed up the flaws of insufficient useful range and high replacement cost.

Just as the realisation that we were contemplating a resurrection and redesign of the traditional tram, the rediscovery of the flywheel as an energy storage device was equally unexpected. Amongst ways of taking in and then releasing energy, spinning a heavy flywheel is surely the simplest, but earlier attempts by British and Swiss engineers had failed to come up with an easily operated means of converting that energy into the variety of speeds at which a vehicle in normal service needs to operate. Over the last few years we have developed a new type of tram

- powered by electricity which it draws only at passenger stops and which can accelerate, coast, slow down and stop, alternatively taking energy out of and putting it back into a large, flat, spinning flywheel housed invisibly under the floor.

A world-beating technology you might think, but that is far from the end of the story.

Just as prehistoric man used to wading across rivers with a bundle on his head probably looked with suspicion at the early attempts to use pieces of floating logs as boats, a flywheel tram builder from the Black Country would be wrong to expect his unusual ideas to be taken up readily, especially in these nervous times!

Self-taught lesson number 5

There is a whole orchestra pit full of musicians who can each mess up the music if they don't know the tune, don't come in at the right time or want to play a different tune.

To introduce a new tracked transport technology you have to take along with you the local authorities, the property owners,

When this prescription was examined by my Board, it pointed clearly to a tracked system, steel wheel on steel rail. A colleague . . . remarked that we were about to invent the vehicle known in Britain as the tram

the health and safety authorities, the police and the transport regulators. And that just deals with the people who can stop you - you also have to find the money to buy the vehicle and pay for the track. More innovation was needed here - this time financial.

Self-taught lesson number 6:

treat your finance providers not as 'predators' but as potential friends and supporters

Another of my Board colleagues, on realising that my enthusiasm for bringing about a new technology of transport knew no bounds, endorsed the fact that we should go ahead, but the exercise would need 'new money'.

This meant embarking on capital-raising. At first we went the conventional route of stockbrokers and venture capital funds and learned the difference between 'venture' and 'adventure'. By 'venture' financial people mean 'sure thing'. Anything which is in any way adventurous involves 'risk', a word which is very low in the popularity stakes. We then discovered that there was a type of small investor who could be individually contacted who is keener for his or her money to be put to use on worthwhile activities than for it to bring in the highest return. These investors are also aware that innovation would not be innovative if that awful word 'risk' were not involved.

Many of these already knew us, or knew people who knew us, and were keen to give strength to our arm to bring the new type of tram into being.

Parry People Movers has nearly 100 such shareholders spread out over the length and breadth of Britain. These shareholders not only made funds available to the enterprise but also act as eyes, ears, ambassadors and supporters in the field. We know them all, many have visited our factory and we keep all up to date with regular newsletters and copies of letters and press cuttings relating to their local area. In return, where they are able, they provide us with local news which we may have

missed, and have responded to a rights issue when the company needed interim finance.

To complete the relationship the company has taken steps to make a market in its shares through one of the new off-exchange trading facilities. This provides the opportunity for shareholders to withdraw if they need to recover their investment for any reason. Even before the product itself successfully penetrated the market the price of the shares had risen to five times the original issued price. We take this to indicate that while the existing investors have been inclined to stick with the company, there have been more people prepared to buy shares, even at a premium.

I believe this beginning has established a reasonably firm platform from which to fund the necessary growth as the company begins to realise its potential.

Self-taught lesson number 7:

don't sell trombones, sell the band

To deliver the dream of an affordable rapid transit system to the tropical world it seems necessary to gain experience closer to home by finding applications in Britain where the technology could bed down. However, that is easier said than done. Whilst Britain is a marvellous place to undertake technical innovation - knowledge, skill, materials, components, facilities, all close to hand - it is a very tough place to get new ideas taken up. I think it is something to do with morale.

However, conditions turn out to be ripe for trams to return to the streets of Britain. Yes, I know about Sheffield and Manchester, I mean small bus-sized trams more similar to the vehicles of yesteryear than the train-sized supertrams which only suit routes in big cities where several thousand passengers can be expected to ride each hour. But how to get the message across?

In the old Hollywood film, *The Music Man*, the salesman representing the musical instrument manufacturer came across a town with severe social problems, untidy streets, young people hanging around jukeboxes and no feeling of civic pride. Realising the uphill task of selling trumpets and trombones in such circumstances, he came up with the idea of the town having its own band. The vision of parades led by 76 trombones eventually caught on and presumably the salesman walked away with

a pocketful of commission.

However, the irony in the film was that the strategy worked both ways; the townsfolk were not resentful of the salesman's success - morale *was* restored as a result of the focus created by a smartly-turned-out band which was an object of pride for both young and old. The salesman may have sold a few trombones but he also brought about a change in the culture.

In Britain in 1996 the centres of many towns and cities are no longer the preferred place to be to enjoy the combined pastimes of leisure and shopping. The effects of traffic - fumes, noise, difficulty crossing roads and the clutter of parked vehicles - are turning people away. Edge-of-town and out-of-town shopping centres are gaining popularity and creating more traffic and doing harm to the environment.

The vision to change this, which has been taken up by Technology Foresight (with enthusiastic endorsement from the tram builders of the Black Country) is that town centres should be cleared of ordinary traffic. But instead of becoming completely pedestrianised, access into and mobility within the area should be made possible by the use of nil-emission vehicles including public transport, some of which should run on tracks. In this country putting a vehicle on tracks has two effects - for those inside, the ride is smoother and steadier; for those outside the vehicle's direction is entirely predictable, and so it is less intimidating than a vehicle which is being manually steered.

Of course, the 'Clear Zones' vision of the Technology Foresight Transport Panel involves a lot more than vehicles. There will be access control technologies, new handling and tracking systems to get subdivided consignments from the edge of town where they are unloaded from the articulated lorry or train to the shops within the Zone, and there will be the very best in passenger information and service organisation to make travelling by public transport a convenience and a pleasure.

My hope is that like the salesman with his trombones, the changes which need to come about in towns and cities in Britain and elsewhere will not only improve the quality of life, one of the principal goals of Technology Foresight, but create business opportunities to keep our factories and service industries busy into the next century. In my case for 'trombones' read 'trams'. ■

MORE NEWS *in pictures*



David Andrews earns first Foundation's Medal

◀ *The Lord Butterworth, CBE, DL, Chairman, Foundation for Science and Technology, presenting Mr David Andrews, CBE, with the first Foundation's Medal at the Annual General Meeting on May 16. Mr Andrews retired as Honorary Treasurer at the meeting. He had held the position with distinction for seven years.*

SCIENTISTS AND PUBLIC OPINION

This contribution to the lecture and dinner discussion held on 13 December 1995 was held over from the Summer issue of the Journal.

Professor Robert M. Worcester*

Introduction

Socrates: *Think you then, said I, that opinion is more obscure than knowledge, but clearer than ignorance?*

'Far, said he.

Does it lie then between them both?

'Yes.

Opinion then is between the two?

'Entirely so.'

(Plato 1900, 165-66, quoted in Noelle-Neumann 1984, 60)

Harwood Childs (1960, 14-26) undertook the task of collecting definitions of 'public opinion' and was able to assemble around 50 from the literature. WAPOR's Dinerman Award winner W. Phillips Davison, professor emeritus of journalism at Columbia University, began his article 'Public Opinion', written for the 1968 edition of the *International Encyclopaedia of the Social Sciences*, with the sentence: "There is no generally accepted definition of "public opinion". Nevertheless, the term has been employed with increasing frequency . . . Efforts to define the term have led to such expressions of frustration as "public opinion is not the name of something, but a classification of a number of somethings" (Davison, 1968, esp. 188).

Montaigne, Machiavelli and Shakespeare
Michel de Montaigne, in the 1588 edition of his essays, twice used the collective singular *l'opinion publique*, explaining why he quoted so often from writers of antiquity that 'It is really for the sake of public opinion that I appear with this borrowed finery' (Montaigne 1962: 1033). And the second time was in addressing how custom and moral notions can be changed (Noelle-Neumann: 66).

The English translations of Machiavelli use the term 'public opinion' as the synonym for the Italian phrases *opinion universale* (I: 58), *commune opinione* (II: 10) or *pubblica voce* (III: 34). Machiavelli would likely have employed pollsters to determine the public will for his prince and must be the patron saint of today's spin doctors, for he warns the prince he is trying to instruct that, in order to rule, he must know the nature of his subjects thoroughly (Machiavelli 1971: 257). Machiavelli's 1514 *The Prince* says there are never more than a few who 'feel' a government, but everyone *sees* it, and everything depends on its seeming, in the eyes of the viewers, to be powerful and virtuous.

Shakespeare, political scientist that he was, has King Henry IV reprimanding his son, the future King Henry V, for being seen too often in bad company. He should have more regard for opinion. Opinion is of the greatest importance; the king says: 'Opinion that did help me to the crown' (*Henry IV*, Part I, Act 3).

Locke, Hume and Rousseau

John Locke, David Hume and Jean-Jacques Rousseau read Montaigne, and no doubt Shakespeare and Machiavelli, and all

contributed to their thinking about public opinion and public policy. The first of these (modern) thinkers to write at length on the topic of what we now call public opinion was Locke, in his *Essay Concerning Human Understanding* (1671), in which he distinguishes between three kinds of laws: divine law (morality, sin); civil law (legal, criminal); and opinion and reputation (virtue, vice).

Hume, in his *Treatise of Human Nature* (1739-1740), joins Lockean theory of the power of opinion/reputation (fashion) to political science as did Shakespeare before him: 'It is . . . on opinion only that government is founded' (Hume, 1963: 29). ' . . . we shall find, that . . . the governors have nothing to support them but opinion. It is, therefore, on opinion only that government is founded; and this maxim extends to the most despotic and most military governments, as well as to the most free and most popular' (ibid.).

At the same time, in France Jean-Jacques Rousseau was writing of *public opinion*: Rousseau's writings are permeated with concerns and comments about the strength of public opinion. Rousseau is torn, according to Noelle-Neumann, by ambivalent evaluations. Seen in terms of society, public opinion seems to be a blessing: it fosters social cohesiveness; insofar as it makes individuals adjust to morals and traditions, it is a conservative force; and it protects morals from decay. Its value lies in moral rather than intellectual functions. (1984: 81)

Rousseau accepts three laws upon which the state is built: public law, criminal law and civil law. But he goes on: 'In addition to these three types of law there is a fourth, the most important of all, which is graven not in marble or bronze, but in the hearts of the citizens; which forms the real constitution of the state; which day by day acquires new strength; which revives or replaces the other laws when they grow old or are extinguished, which preserves the people in the spirit of its original institutions, and imperceptibly substitutes the force of habit for that of authority. I am speaking of manners, morals, customs and above all, of public opinion, a factor unknown to our political theorists, but on which the success of all the rest depends' (Rousseau 1953: 58).

'We have seen that the legislative belongs, and can only belong, to the people (60). The initiative for issuing laws, however, comes from the prince. To discharge this office he needs a good vantage point from which to survey the climate of opinion, a matter with which the great legislator is secretly concerned (58). In this observational task he is helped by the activities of the censor. The prince must decide which convictions of the people are active enough to support legislation, law may be based only on prior agreement, on the sense of community which constitutes the actual foundation of the state. "Just as an architect, before erecting a great edifice, observes and sounds out the ground to see if it can support the weight, the wise legislator does not begin by drawing up laws by which are good in themselves, but first investigates whether the people for whom they are intended is capable of bearing them"' (46).

Hume's basic principles became the doctrine of the founding fathers of the United States of America, and were incorporated

* *Chairman, MORI*

both in the Declaration of Independence of 1776 that set the American colonies past the point of no return against the English Parliament under Lord North and the King, George III, and in the draft Constitution of the United States signed in 1787 and adopted in 1789. In the period of adoption of the Constitution, Hamilton, Jay and especially Madison developed their political philosophy in a series of polemic papers under the general title *The Federalist*.

In number 10 of *The Federalist Papers* Madison avowed 'all governments rest on public opinion' and speaks of collective will.

'If it be true that all government rest on public opinion, it is no less true that the strength of opinion in each individual, and its practical influence on his conduct, depend much on the number which he supposes to have entertained the same opinion. The reason of man, like man himself, is timid and cautious, when left alone, and acquires firmness and confidence, in proportion to the number with which it is associated' (Madison, 1961: 340).

English statesman Edmund Burke gave careful consideration to the views of his electors, while his best known statement pertaining to the public will, often quoted by today's politicians in support of their independence of view, is in his declaration on his election for Bristol in 1774:

'... his unbiased opinion, his mature judgement, his enlightened conscience, he ought not to sacrifice to you, to any man, or to any set to men living. These he does not derive from your pleasure - no, not from the law and the Constitution. They are a trust from providence, for the abuse of which he is deeply answerable. Your representative owes you, not his industry only, but his judgement, and he betrays, instead of serving you, if he sacrifices it to your opinion.'

Four years later, he confirms this in his letter of 23 April 1778 to one of his most prominent constituents and supporters, Samuel Span, of the Society of Merchant Adventurers:

'... a Member speaks the language of truth and sincerity, and that he is not ready to take up or lay down a great political system for the convenience of the hour, that he is in parliament to support his opinion of the public good, and does not form his opinion for your sake, that I wish to preserve this character' (O'Brien: 1992).

Less well known is that at the next general election, two years later, his beloved electors of Bristol threw him out of office, following which he seemed to have second thoughts, saying 'No man carries further than I do the policy of making government pleasing to the people. I would not only consult the interest of the people, but I would cheerfully gratify their humours'.

No doubt Lady Thatcher blames her Cabinet, her staff in Number 10, her advisers at Conservative Central Office, her backbenchers, the media and uncle Tom Cobleigh and all, but in truth, in the quiet moments she must blame public opinion, and herself for getting too far out of touch with it

The reflection of Burke I find most appealing, and one that I would have today's politicians heed is 'You ask, Sir, whether I lead or follow public opinion? The truth is I meet it on the way.'

Lady Thatcher would have done well to have paid more attention to Burke's advice, and, for that matter, that of Machiavelli, when attempting to force the poll tax down the throats of her countrymen. For her downfall in the end was the fear on the part of her own backbenchers that she could no longer guarantee them a victory at the following election, unpopular as she was by then, once again, as she had been in 1981 before the Falklands War, the 'least popular Prime Minister in British polling history'.

No doubt Lady Thatcher blames her Cabinet, her staff in Number 10, her advisers at Conservative Central Office, her backbenchers, the media and uncle Tom Cobleigh and all, but in truth, in the quiet moments she must blame public opinion, and herself, for getting too far out of touch with it.

De Tocqueville

The French writers of the eighteenth and nineteenth centuries, Rousseau and de Tocqueville, were discerning observers of the impact of *l'opinion publique*. Alexis de Tocqueville's *Democracy in America* (1835-1840) is required reading for American political science students, and rightly so. Noelle-Neumann considers that de Tocqueville's approach to public opinion most closely approximates what can be seen today with our empirical methods of observation (ibid: 88). His book is full of accounts, assessments, explanations and analyses of the consequences of American public opinion. He saw the universal characteristics of public opinion, but believed the American culture, spirit and governing systems - based as they were on a backlash against English systems and structures - to be the furthest advanced in incorporating public opinion as the base on which American political systems stand, with their separation of powers, fixed terms of office for both the executive and legislative branches of government, two-year terms for Congressmen and, eventually and especially in the more independently-minded Western states, state constitutional provisions for referendum, recall and petition.

Interestingly, de Tocqueville introduced his interpretation of public opinion as the opinion of the numerical majority. He also observed that the more equality, the more pressure can be expected from public opinion.

Shortly thereafter, again in the United States of the nineteenth century, Henry David Thoreau in his journal of 1840, when he was 23, observed: 'It is always easy to break the law, but even the Bedouins in the desert find it impossible to resist public opinion.' (Walden).

Lippmann

The first book entitled *Public Opinion* was not published until 1922 and was written by the philosopher-journalist Walter Lippmann. He observes, as have others, the perplexing fact, true today as seventy years ago, that since Public Opinion is supposed to be the prime mover in democracies, one might reasonably expect to find a vast literature, yet one does not find it. The existence of a force called Public Opinion is in the main taken for granted (161). His plea is that it should not. That there is an alternative to government by 'patronage and pork' amalgamating and stabilising thousands of special opinions, local discontents, and private ambitions; as well as government by terror and obedience. And that is government based on such a highly developed system of information, analysis and self-consciousness that 'the knowledge of national circumstances and reasons of state' is evident to all men (184)

Lippmann concludes with this:

'There is no prospect, in any time which we can conceive, that

the whole invisible environment will be so clear to all men that they will spontaneously arrive at sound public opinions of the whole business of government. And even if there were a prospect, it is extremely doubtful whether many of us would wish to be bothered, or would take the time to form an opinion on 'any and every form of social action' which affects us. The only prospect which is not visionary is that each of us in his own sphere will act more and more on a realistic picture of the invisible world, and that we shall develop more and more men who are expert in keeping these pictures realistic. Outside the rather narrow range of our own possible attention, social control depends upon devising standards of living and methods of audit by which the acts of public officials and industrial directors are measured. We cannot ourselves inspire or guide all these acts, as the mystical democrat has always imagined. But we can steadily increase our real control over these acts by insisting that all of them shall be plainly recorded, and their results objectively measured. I should say, perhaps, that we can progressively hope to insist. *For the working out of such standards and of such audits has only begun* (197) (my emphasis).

Why then in 1922, if public opinion polling as we know it today was still some fifteen years from invention, did Lippmann see that the auditing procedure that it represented is still so far from being accepted by the policy makers and industrial leaders seventy years on? Lippmann, wise man that he was, had even then the answer, or at least partly so. 'Bureaus of government research, industrial audits, budgeting and the like are the ugly ducklings of reform. They reverse the process by which interesting public opinions are built up. Instead of presenting a casual fact, a large screen of stereotypes, and a dramatic identification, they break down the drama, break through the stereotypes, and offer men a picture of facts, which is unfamiliar and to them impersonal. When this is not painful, it is dull, and those to whom it is painful, the trading politician and the partisan who has much to conceal, often exploit the dullness that the public feels, in order to remove the pain that they feel' (233). The statesman, the corporate executive, the party leader, the head of a voluntary association, found that he needed assistance and so called in the expert, the scientist, the chemist, physicist, geologist. Although they called in experts, he observes, they were 'slow to call in the social scientist'.

He goes on at length both to demonstrate the need for outside, independent, well-funded, expert social science, and suggest ways in which it might come about, saying:

'If the analysis of public opinion and of the democratic theories in relation to the modern environment is sound in principle, then I do not see how one can escape the conclusion that such intelligence work is the clue to betterment . . . The number of social phenomena which are now recorded is small, the instruments of analysis are very crude, the concepts often vague and uncriticized. But enough has been done to demonstrate, I think that unseen environments can be reported effectively, that they can be reported to divergent groups of people in a way which is neutral to their prejudice, and capable of overcoming their subjectivism (248)'.

But seventy years on we still see the hesitance of politicians and senior civil servants to fund, to encourage, utilise, to employ objective, systematic, interpreted, independent research tools that in the intervening years have become almost instantaneous, statistically sound, and free of bias.

What is it about policy makers that engenders the fear of the findings of survey research? Some pick at it as a bird picks at crumbs on a table, seeking the bit that supports their own prejudice, so they can hold it up to the assembly, quote it to the media, building it into their speeches to proclaim 'My idea is

Too many politicians, and for that matter, managers, drift too far away from those they lead, either through ignorance, hubris, or indifference

sound, and has the support of public opinion on its side'.

If it inconveniently does not support the politician's case some will invent a surrogate, as did Tony Benn in his argument in the House of Commons against Britain's participation in the Falklands War. Brandishing a handful of letters that supported him (and those who did so would of course be those who wrote - a self-selecting sample), he avowed 'Public opinion is swinging massively against the War!'

Others will dismiss it as mercurial, or irrelevant, or both. Three years ago the then British Foreign Secretary, Douglas Hurd, wrote to me to say in reference to my plea (on behalf of the British public) for a referendum on Maastricht:

'I believe that if we had followed the polls, we would have been in and out of the Community several times in the last twenty years. On matters of principle, like the Monarchy and membership of the European Community, the job of the politician is to persuade, not automatically to follow. If he fails to persuade, he will lose his objective and fail in his profession' (Hurd, letter to author, 18 January 1993).

I am firmly on record in agreement with the principle enunciated in Douglas Hurd's letter, and endorse the idea that the job of the politician is to lead, not follow, public opinion as it is the job of managers to manage, not necessarily to endorse the results of either customer or staff attitude surveys. I am also personally opposed to referendums on any matter other than ones of constitutionality. Having said that, I feel that too many politicians, and for that matter managers, drift too far away from those they lead, either through ignorance (difficult in this day of instant poll, but Mrs Thatcher managed it), hubris (Sir Bernard Ingham once told me that 'the boss' had dismissed one of my poll's results out of hand, saying I'd only asked a thousand people, and she had 13 million behind her!), or indifference.

My own definition:

Public opinion is the collective view of a representative sample of a defined population.

Thus workers in a factory, of interest to the factory manager, trade union or civic leaders in the plant community; residents of a local community, of interest to civic leaders again, politicians, the local media, pressure groups, industrialists thinking of siting a plant there; students at LSE when they conducted an opinion poll in advance of the mock American presidential election, and had more taking part in the poll than took part in the mock election! (which, ask I, was the more representative?); 'certain to' voters, of greater interest to me at the last British general election in determining who I thought was going to win, and of greater interest to my client, *The Times*, and therefore of greater interest to the broadcast media who diffused my findings, and therefore to the political actors whose hold on office or prospect thereof was promised or threatened, and therefore to the public: full circle. Or young people, perhaps studying science at university, or the elderly, or women, or Captains of Industry, or institutional investors, or editors, or parliamentarians, or any slice of society that can be defined with precision and replicability.

I would argue that *public opinion*, like the weather, exists whether you measure it or not. Polling is a simple business really: all that needs be done is to ask the right questions, of the right sample, and add up the figures correctly. With the tools of

my trade there are five things that I can measure: behaviour (what we do), knowledge (what we know) and opinions, attitudes and values.

I have defined these terms, rather too poetically, I fear, for scholarly adoption, as '*opinions*: the ripples on the surface of the public's consciousness, shallow, and easily changed; *attitudes*: the currents below the surface, deeper and stronger; and *values*: the deep tides of public mood, slow to change, but powerful'. Do government's and industry's scientists and engineers listen to public opinion? The indications are they do not. Should they? is perhaps the more interesting question. This summer, when we asked the public in this country if they trusted what government scientists have to say about the environment, only 38% said they do; and when asked if they trust what industry's scientists have to say about the environment, only 48% said they do, but when we asked if they trusted what environmental groups' scientists have to say about the environment, 82% said they do. When I quoted these figures in September at the Prince of Wales's Business and the Environment Forum at Cambridge, a government scientist came up to me afterwards and said: 'But we don't lie to people', to which I replied: 'But you don't talk to people!' When Energy Minister Tim Eggar says on the box: 'Our scientists tell us . . .', and Shell's chairman says: 'Our scientists tell us . . .', and then Greenpeace's spokesman says: 'Our scientists tell us . . .', then which do you think the public believes?

Recently I was at a reverse Ditchley conference in Canada on Business, Government and the Environment, and a German civil servant said heatedly that Greenpeace International was out of control and 'a threat to the values of the German people'. My response was to point out that on the issue that he was speaking of, the French decision to test nuclear weapons at Mururoa Atoll, 3% of the German people I polled were in favour of the French programme and 85% were opposed; who, I asked, was threatening the values of the German people?

We found in a survey in 1985 for the Technical Change Centre that by 84% to 7% people believed that 'New technology is essential to Britain's prosperity', and by 76% to 9% that 'Government should do more to encourage the introduction of new technology'. But by 75% to 12%, people believed that 'to direct scientific and technological research in the right way, it would be better to take more account of what people like you and me think', and the jury, then, was out on the threat: when asked to agree or disagree that 'Technological development poses a considerable threat to mankind', 39% thought that it did, 40% that it did not.

On balance, most people *support* further development of medical transplants (79% to 5%), new medicines (75% to 3%), alternative sources of energy (73% to 2%), alternative medicines (63% to 7%), advanced methods of transport (59% to 10%), nuclear power for peaceful purposes (52% to 18%) and 'test tube' babies for otherwise infertile couples (51% to 25%), but *oppose* use of human embryos for medical research (58% oppose, 17% favour), nuclear weapons (61% to 13%), central databanks (62% to 12%), synthetic foods (63% to 9%) and cross-breeding (68% to 7%). In the same poll, when asked whom they trust to tell the truth about the effect scientific and technological developments will have on our lives, 67% say they trust doctors (10% do not), 57% clergymen (15% do not), but only 45% university science professors, 37% presenters of scientific programmes on television, 20% scientists working for major companies, and not statistically significant, tied for bottom of the poll, senior civil servants (12%), government ministers (11%) and newspaper journalists (10%). Yet Gallup has found that more people, 45%, say that newspapers and TV have most influence in shaping their opinions, for better or worse, about science and technology. Perhaps this explains why when asked in 1979 'which two or three of the groups of people on this list do you yourself have most respect

for', 24% said 'scientists', but in 1986 this had fallen to 17% and by 1989 to 11%. That's the bad news; the good is that in 1995, we found a recovery to 18%.

Part of the 1985 study was updated in 1994, and it was interesting to see that the sharpest changes came in public awareness of the impact new technology has had on their jobs, with 'having to learn new skills' up 18 points, from 35% in 1985 to 53% in 1994, and 'increased the amount of pressure at work' up 10 from 25% to 35%.

Does all of this matter? I would argue that it does. On Friday evening, on the chattering classes' favourite radio programme (save the *Today* programme), *Any Questions?*, the panel were united during the discussion on BSE and British beef that the credibility of government scientists has declined over the past few decades. Nuclear testing in the atmosphere, egg and beef scares, cigarettes and cancer, diet and heart disease were all mentioned as examples where science has either been indeterminate or misleading. And whose fault is that? The cause is likely to be laid at the door of ministers, but now with a code of practice for civil servants published it may be easier for government scientists to resist manipulation; with 'whistleblower's charters' becoming the norm in industry, perhaps we will see more courageous actions on the part of industry's scientists when pushed too far by the marketing people. We'll see.

Technology

In 1994, MORI undertook a massive study of the values of the British people, under its *Socioconsult* programme. A number of value-based statements were included in the battery of scales that has enriched and informed our clients and ourselves in more deeply understanding the psyche of the British, following up on the Agorometrie work I published in my book, *We British* (apologies).

In this work we found that a quarter (24%) of the British believe that 'Modern science does more harm than good', and those agreeing tend to be more women than men, more young and old than middle-aged, three times more in working-class occupations than middle-class, and nearly half (48%) of our so-called 'Victorian Romantics' who represent 8% of the electorate. Perhaps more worrying is that four in ten believe that 'Technology is only an excuse to make people buy more', and 46% say they agree with the idea that they 'are concerned that technology will take over humanity someday', and, once again, it is women, older people and working-class people who are most concerned about this, although that it is agreed with by a third of ABs, managerial and professional-class people must cause concern (72% of our Victorian Romantics agree). Yet 82% believe that 'New technologies, if correctly used, are bound to benefit mankind'.

It is well known that some people have psychological barriers to the adoption of new ideas and new methods of working, and yet others seek out the newest technologies and systems to help them in their work, and sometimes 'just for fun'. Research methodologists have for decades used attitudinal scaling and computer multivariate techniques to segment populations into psychographic classifications to augment the more traditional demographic ways of classifying and studying populations. These techniques generally, and MORI's *Socioconsult* model specifically, can inform scientists and engineers and others interested in science on the types of people who welcome, and fear, the application of new technologies as an interface between them and the things they have to deal with in modern society.

A sizeable proportion of the population is concerned about what perils technology brings to the world. When asked to agree or disagree that: *I am concerned that technology will take over humanity one day*, 46% agree, and 10% agree strongly. Who are these technophobes? In demographic terms they are more likely to be women, older people and the working class. But

more interesting, when we look at the sociocultural 'map', there are four clusters which stand out: two strongly in sympathy with this and other statements of concern about technology, two much less so; and each of these clusters are very different types of people psychologically.

The technophobes

The two clusters that are most concerned about technology taking over humanity are those with **modern** values, including those who particularly value *authenticity* in their relationships,

Among the educated, forward-looking parts of the population there is a cautious optimism, rather than pessimism, about the impact of new technologies

the *searchers for meaning in life*, and the *intuitives*, and, secondly, the rather more **traditional** groups who *value individual experiences* and *personal liberty*, and tend to react against all forms of institutional control of their lives.

A second, less threatening, statement, *I'm a bit suspicious about all these technological innovations that come on the market*, is agreed with by 34%, and 7% agree strongly - still a substantial minority. Their psychological profile is very similar to the 'taking over humanity' technophobes, with the two distinct value clusters driving their attitudes.

A third statement, *New technologies, if correctly used, are bound to benefit mankind*, was agreed with by 86%, 22% strongly. The 22% agreeing strongly are tightly clustered in the upper left quartile of the socio-cultural map, their values being distinctly modern and social in orientation. Several of these values were also associated with concern about technology taking over; it seems that the key phrase in understanding these people is 'if correctly used' - among the educated, forward-looking parts of the population there is a cautious optimism, rather than pessimism, about the impact of new technologies.

A fourth statement was: *New technologies will have to imitate nature, not confront it*: 78% agree, 18% strongly. This statement represents a balanced view of technology; neither is associated with most of the same values as the 'if correctly used' people. But, as we would expect, the *imitate nature* people are strongly motivated by concern for the environment: a value that is not strongly correlated with the **modern/social** value cluster, much more central on the British socio-cultural map.

The pattern that emerges among the 'technophobes' is one of concern tempered by some cautious optimism about new technologies; both of these attitudes being associated with the same underlying values that lead to a commitment to heritage and culture. There are, however, others in the population who are much less concerned about the impact of technology, and these groups also have distinctive socio-cultural characteristics.

The technophiles

As with the technophobes, there are two distinct value clusters associated with more favourable attitudes to technology - attitudes which are shared by between half and two-thirds of the population.

The two clusters that are relatively unconcerned that technology might 'take over humanity' are the most traditional clusters. The first consists of the very young and the alienated *under-wolves*, both of which groups are not only **traditional** in their values but also **individualistic** rather than **social** in their

orientation. Their motivations may be very different: the very young have grown up with new technologies and typically enjoy the leisure applications; the *under-wolves* may look to technology to help solve their problems. The second technophile cluster consists of the more socially integrated groups, whose values are focused on their relationships with other people. Older and more stable, they are relatively confident that technology will be manageable.

Acceptance of technological innovations is a feature of the traditional, socially integrated value cluster, but the very young and the under-wolves are neutral in this respect. There is one group of people outside these clusters, whom we have identified as *adaptive navigators*, who are willing to cope with change by adjusting their personal goals and strategies, adapting to new circumstances rather than asserting themselves. This group is among the least doubtful about technological innovations, and they are relatively uninterested in heritage. The technology-culture divide is evident here also.

Similar patterns emerge when we look at the other statements about technology: the technophiles are **traditional** rather than **modern**, and form two distinct clusters on the individual/social dimension.

The role of polls

What are polls for? As in the case of the media, to inform, to entertain, to educate. The role of the modern newspaper, radio and television is to let the reader, the listener and the viewer know what is happening in the world in which they live. Further, to do so in an entertaining way and, as a result, improve their understanding of the circumstances surrounding the events being reported.

That is their public mission. As a by-product mainly, but occasionally specifically, it is the role of the media to communicate a better understanding to the elite, the opinion-former, the politician, the pundit and the commentator of what is happening, so that they will be better informed and thereby be in a better position to play their own role in the process of diffusion of information to the public and to each other. They are often the carriers of information to the opinion-former.

Opinion-formers are widely read, widely informed, or at least they should be. Those in that position know that they must follow the detail of the news, read the leader pages and editorial comment in the heavyweight newspapers as well as the news stories, watch other opinion-formers debate and discuss current affairs in order that when their turn comes, they will appear informed themselves and thereby enhance their own status as informed, educated and influential.

Information diffusion is a complex process in the electronic age. And because of their intensity, modern election campaigns are among the most complex of all. For instance, it is almost impossible to separate the effect of political advertising in a political campaign in the classic way of using advertising research to isolate the effect of advertising in the private sector via pre-post, exposed-controlled tracking studies. This is because of the enormous focus of attention on the election itself. Elections are the one recurring event that capture the focus of the nation in such a sustained way during a finite period of time. When every news bulletin, every newspaper front page, every current affairs programme, many pub conversations and much dinner table talk is about one event, the election, it becomes difficult to separate out the effect of one or another part of the information process going on. Opinion poll results are, or should be, a help to the public's understanding of this process, offering, as they do, one of the few systematic and objective parts of the information flow.

Opinion polls have no axe to grind, no incentive to manipulate or guide the decision-making process of the voter. They are there not to persuade a person to act in one way or another, to

think or vote in a certain way. They are there to provide information about what others think. Politicians and some newspaper proprietors and editors are guided by their own desire to see a certain election outcome. Opinion polls are not, and there is no incentive for them to be.

Opinion polling is widely misunderstood. It can provide understanding, analysis and tracking of the behaviour, knowledge, opinions, attitudes and values of the public. By measuring this, within the limits of the science of sampling and the art of asking questions, surveys can determine what people do and what they think. Via the media, polls can then be used to inform others of this information, for their own use in whatever way those who receive this information may wish to use it.

Those who report poll results have a responsibility to their readers and viewers and to their own profession of journalism as well as to the pollsters who carried out the survey. This includes accuracy in reporting the findings, completeness in ensuring that the information reported is not so divorced from other information that it is misleading, that the basic information of the precise question wording, sample size, fieldwork dates, etc., are reported to give the reader confidence that the poll was carried out according to proper procedures, and, to the journalists' ability, relating the poll results to other known information about the subject of the survey's findings.

Pollsters have a great responsibility in carrying out their work. They must do so to the limits of the science of sampling and the art of asking questions. It may indeed be a simple business, but they must design their samples so as to ensure a representative sample is questioned. They must ask relevant, unbiased and comprehensible questions. They must analyse the results in such a way as to obtain the best understanding possible of the results. And they must do their best to ensure that their results are presented in a fair, complete and unbiased way. This is their

responsibility to the public, to the profession and, above all, to themselves.

Concluding comments

We don't know enough about a number of things. Thanks to the good work of the Committee on the Public Understanding of Science and to the annual Gallup survey on attitudes to science, we have been informed of some of the things people think, know and, indeed, are confused about science. We know too little about risks - and the current debate on BSE is the most recent witness to that. We know too little about values and how deeply-held views about the relationship between science and humanity are held by the citizen. We know too little about what leads to change in behaviour for things such as the environment and we know too little about the basic motivations that encourage young people to take up careers in science, engineering and technology and what are the barriers of entry into these vocations.

In this overview I have tried to summarise the thoughts of those who have considered the relationship between public opinion and public policy and not just to answer the question posed by the Foundation for tonight's debate. Many have attempted to shed light on what I have described as the quicksilver of *public opinion* and I have tried to examine their writings and summarise them in this paper. I believe that the relationship between public opinion and other social sciences is one of independent and dependent variables, and that the principles of the impact of public opinion on matters of concern will pertain whether studying *Public Opinion and Public Policy* at the London School of Economics and Political Science, *Public Opinion and the Media* in the Department of Journalism at City University, *Public Opinion and Business* at the London Business School, or *Public Opinion and Science* at Imperial. ■

A full bibliography is available.

LETTER to the Editor

We must train teachers to deliver technology education

Professor Keith Foster writes:

Having attended the Foundation's evening dinner and discussion on the subject of education of technicians, I thought that I should write to you.

There is much discussion on the subject internationally. At an international conference in Jerusalem on technology education last January, 87 countries were represented by almost 1000 delegates. To many of them, technology was a relatively new subject in the curriculum of schools and colleges, and all were debating how best to deliver the subject. It is worth reflecting on why there should be such an interest in a subject that has not previously been in a central role in the school curriculum. During the last two recessions, manufacturing industry has shed many jobs, but, because of production gains, we are producing enough manufactured products for our needs. There are now not only fewer training places available, but there are many fewer role models for young people to emulate.

At the same time, technology is essen-

tial to the way we live, and so it is as important that society understands the role and the impact of technology just as much as it understands the role and impact of science and of agriculture and of medicine, and so on. If this understanding is not being delivered in the traditional ways, the onus falls back on the educational system to fill this need. In this country we could indeed be optimistic, because technology has been in the national curriculum for some six years and during that time has evolved to begin to meet current needs. Thus, although we may complain about the current shortage of people wishing to become technicians, the output may well improve over the next few years.

The Engineering Council runs a Technology Enhancement Programme (TEP) to help develop material to support the national curriculum and also to support General National Vocational Qualifications and the equivalent in Scotland. In particular, the programme has been influential in encouraging pupils to carry out design and make

activity projects to a certain quality, and in particular to build the projects around the modern technology of electronic controls and new materials. We shall only successfully compete with the emerging nations such as those in the Pacific Rim if our young people have confidence in their own ability to work in these newer areas.

The experience of the TEP programme is that in order to disseminate these ideas at a reasonable rate, it is of the utmost importance that adequate training is given to teachers to deliver the subject. Many are enthusiastic and put a great deal of personal effort into the subject, but more often than not they lack the strong base of experience in either technology or engineering. Effort in this direction would never be wasted, and although there would clearly be a considerable expense to do the job properly, the investment would have a strong leverage.

Professor Keith Foster

Development Director

Engineering Occupations Standards Group

A-LEVELS AND QUALIFICATIONS

On 13 May 1996 the Foundation held a lecture and dinner discussion at the Royal Society on the subject: 'A-Levels and the Qualifications Framework'. The Lord Butterworth, CBE, DL, was in the chair and the sponsors for the evening were the Department for Education and Employment, the Department of Trade and Industry, Esso UK plc, Software Production Enterprises and contributors to the Foundation's Shared Sponsorship Scheme, including the Comino Foundation, Esso UK plc and RHM Technology plc. The speakers were *Sir Ron Dearing CB, Hon FEng*, Chairman, School Curriculum and Assessment Authority; *Professor Alan Smithers*, Director of Policy Research, Brunel University; and *Dr Michael Young*, Director, Post-16 Education Centre, Institute of Education.

Sir Ron Dearing, CB, Hon FEng*

Introduction

I introduced my report on the National Curriculum and the tests with a quotation from Disraeli. He said 'Upon the education of the people of this country, this country's future depends.' I thought that was good, but in the course of doing the 16-19 Qualifications Review, I came to the conclusion that we must go further than that.

In the Far East, the commitment to education is daunting. The only strategy for nations which want to enjoy an increasing standard of living in the future is to move upmarket. The only way to do this is to have a well-educated and well-trained workforce, and therefore the most successful nations will be those which are most effective in their development of their education and training systems. It is no surprise, and indeed quite right, that all three of the main political parties have now put education at the top of their policy priorities.

In my review of 16-19 qualifications, I was concerned to address the needs and opportunities of students of every level of ability. Those of the lowest attainment are at immense peril: we must do all that we can to lift their achievement, to stimulate them into seeing that there is something good for them and relevant to them in being involved in further education and training after the age of 16. So perhaps significant in my report are the proposals I make for Youth Training and Modern Apprenticeships, on which we currently spend some £700,000,000, with nearly 300,000 young people involved. But there are many indications that we are not getting value for money in this area, nor are all of those who should be taking part in fact doing so. I hope that my report has pointed the way on how we can make Youth Training more effective as an entry to the vocational and applied routes to achievement.

Balance between breadth and depth

However, the main focus of interest tonight is on A-levels. The longest section in the report covers A-level and, in the limited time that we have tonight, I therefore propose to comment on two of the main aspects. The first is the continuing concern about the balance between breadth and depth. As we know, the practice in England and Wales is in contra-distinction to that in the rest of Europe and the Western world generally. Second, I should like to talk about the issue of rigour, which is important, of course, in all qualifications but has become an issue and was part of my Terms of Reference with particular reference to A-levels.

On the first issue, the balance between breadth and depth,

Summary: **Sir Ron Dearing concentrated on two aspects of A-level. The first was the continuing concern about the balance between breadth and depth and his introduction of the Advanced Subsidiary. The second was the question whether or not A-level was still the most appropriate way of selection, or the basis for further study. Professor Smithers, examining the future of A-levels concluded that A-levels and the new ASs, academic and applied, provided opportunities for the high-level study of fundamental ways of making sense of the world as well as opportunities in vocational education.**

the debate has been both lively and long-standing. The Crowther Report back in 1953 was perhaps the first official document which questioned whether we have got it right to have a narrow focus for A-levels. Attempts to develop a broader option have, however, come to nothing. The Higginson Report failed to get off the blocks. Nonetheless the Government has recognised that there is an issue here. A White Paper published in 1991 said that the specialised study of two or three subjects, which are often closely related to each other, is too narrow a preparation for many students given that their next steps into further study or work are likely to take them into a broader arena. All attempts to respond to that, the Advanced Supplementary course, has again failed to take off in any large-scale way. There is only one AS being taken for every 15 full A-levels.

The market has clearly given its view on this particular product, and it must be time to consider how and in what way one can change the product to satisfy what is a clear demand. The AS is difficult to timetable alongside the full A-level programme and many schools commented that without sufficient resources, and without flexibility in the timetable, the AS is a non-starter for them. The AS itself has a number of structural problems. Because it includes most of the A-level core, it contains perhaps the most difficult elements of the A-level course. Some teachers would argue that it therefore represents more than half an A-level in terms of the weight of demand and the challenge to students. Furthermore, it does not fit some subjects that are skills-based.

All of these considerations led me to offer an alternative to the existing AS. This alternative, which I have termed the Advanced Subsidiary, is a way of introducing breadth into post-16 studies. It will in effect be a horizontal slice of the A-level, aimed to be at the standard and covering the content that would be expected of a first year of A-level study. It should allow students to continue with subjects that they might otherwise have dropped and give an opportunity to those who may not make it to the full A-level to leave a course with some recognition for a full year of study. I am pleased to say that schools, colleges and universities have welcomed this as a proposal, and we

* *Chairman, School Curriculum and Assessment Authority*

are now working out with the examining boards ways of implementing it. That is one strand of the proposals by which I would hope to respond to those who argue for broadening of post-16 study.

The second approach is to offer an option which incorporates study in depth with complementary studies in breadth. This proposal could apply to all three pathways - A-levels, GNVQs and NVQs - but would concentrate on the A-level pathway. The essence of the proposal is that a student would need to cover four major domains of knowledge. The first domain would be mathematics, the sciences and technology. The second would be the arts and humanities. The third would be modern foreign languages and the fourth would be the way society works, including such subjects as economics, business studies, sociology, law, government and politics.

The requirement would be that all four domains would have to be covered to at least the standard of the new horizontal AS. The student would have to complete two full A-levels in one or two of the domains. In addition, all students, and especially those on this pathway, would take an AS in the three key skills of communication, number and the use of information technology. This would be an extremely demanding challenge and would combine study in breadth with study in depth with achievement in the key skills which universities and employers continually emphasise as most necessary.

This, of course, is only an option for the brightest and most motivated students. I do not accept the arguments that it should be mandatory for all. In all areas, my belief is that we should have choice, which would enable young people to follow their interests, enthusiasms and aptitudes. These are so diverse that it is unlikely that any one formula or system could contain all the options required to fit individuals' wishes.

Problems with A-level

To move on to the other issue on A-level, that of rigour.

The A-level has now had over forty years to establish itself in public regard as the gold standard by which other qualifications are measured. However, it has changed significantly over that time, not least because the numbers taking A-level have risen from a few thousand to over three-quarters of a million. When A-levels were introduced only about five percent of 18-year-olds went on to university, and the A-level was designed as the key selection mechanism. Now over 30% of young people go on to university and there is some doubt as to whether A-level is still the most appropriate way of selecting, or of basing further study upon.

There are also problems within A-level. While the newer market system in which the competing A-level awarding bodies operate is one way of maintaining vitality in the system, there is a danger of proliferation of small-entry options. In mathematics, for instance, we have nearly 100 syllabuses. In history, I understand that the syllabuses and options within them run into the hundreds. This diversity and complexity make it difficult to maintain comparability between courses, and to ensure that standards are maintained. Schools allege that others are shopping around and moving around from one examination board to another so that their candidates achieve better grades. This anecdotal evidence

is difficult to substantiate but too frequent to be ignored. My report points to problems with maintaining common standards, and suggests that we should reduce the number of options in A-level courses to enable us to ensure standards and regulate effectively.

Universities also have a view on this. They would like a larger common core of material which all students should have studied, and fewer options so that admissions tutors have a better sense of what candidates would have covered. The plethora of options causes them difficulties in working out the common factors between the syllabi that students have studied and in establishing a baseline from which university courses can take off. If different candidates enter universities having covered different sets of material, university tutors argue that they need to spend time bringing all candidates up to a common start point. This is of course not an effective use of the first term or two at university.

In addition to the other proposals that I have made about A-levels, I recommended that there should be a rolling review of all A-level subjects over a period of five years, aiming to cover all subjects in that time. At the moment, subjects are reviewed about once every ten years, which in my view is not good enough.

There is also an issue over the relative demand between subjects. We commissioned research by the A-level Information Service, based at the University of Newcastle upon Tyne. They concluded that, for some A-levels, the demand in terms of the gap between the GCSE and A-level standard is greater than for others. Subjects where the gap between GCSE and A-level is widest include mathematics, modern foreign languages and history. Some other subjects are well below average: they include English, business studies, home economics, and drama and theatre studies. We have done a check on the methodology and data which the University of Newcastle used and have come to broadly the same conclusions.

In my report, I suggested that we put these conclusions, and the way in which they were arrived at, out for public debate. If they are substantiated, then there ought in equity to be action to ensure that A-levels in general are closer to an average level of demand. I am not suggesting that we should level down the demand of those which are now rated as the most difficult;



▲ Sir Ron Dearing, CB, Hon FEng, Chairman, School Curriculum and Assessment Authority (right), who spoke at the meeting, with Professor M.J.H. Sterling, FEng, Vice-Chancellor and Principal, Brunel University.

there are already enough comments that our attainment in subjects like mathematics and modern foreign languages are not as high as they should be. What we should do, obviously, is to level up the least demanding subjects towards the average. This would give us parity across the system, so that a candidate putting the same amount of effort into a course in English, for instance, would gain the same grade in those A-levels given a comparable performance in the examination.

There is also an issue as to whether we should try to be more specific about the outcomes expected from A-level study and to make those explicit in the requirements which we publish for the guidance of the examination boards. We are also examining the question of whether standards have changed through time, and a study of that has been launched in collaboration between SCAA and OFSTED. There is a problem with this study in that the archives of examination papers, mark schemes and scripts retained by the awarding bodies are not as full and extensive as we would have hoped.

However, there is evidence from many representations to me, not least from the mathematics and engineering communities, that the content of the A-level mathematics syllabus has certainly changed over time. There seems to have been a reduction in algebra, in the requirement for formal proofs and in the ability to tackle multi-stage problems. There may be room for debate as to whether all students for all university courses which require a mathematics element should have done the same topics. It is of course possible to argue that the need for statistics for those who are doing an economics or business type of course is far greater than for those who are doing chemistry or physics, for instance. We should perhaps be considering alternatives which are more tailor-made for the particular needs of specific university courses and recognise the different mathematical skills needed by engineers, or by economists, or by accountants.

There is a further issue to do with A-levels: the introduction

of modular syllabuses. Modularity has of course been introduced throughout much of the university sector. To some extent, practice at A-level has reflected this. However, it raises again a number of questions over whether standards are being maintained, and specifically whether the standards on a modular syllabus are the same as those on a traditional linear A-level with the one final examination. Again, I make proposals in my report to cover this point. I believe the jury is still out on the question of modularity, but I think it prudent to take action to ensure that standards are indeed being maintained, and the demands of the two types of A-level are compatible. So, for instance, I recommend that in the modular syllabus the final examination, which counts for not less than 30% of the total marks, should have a number of questions which assess knowledge of the whole syllabus and of the interrelationships between the knowledge.

This so-called synoptic assessment should count for not less than 15% of the total marks for the course, in other words at least half of the marks within the final examination. Critics of modularity also argue that the unlimited, at least theoretically unlimited, number of resits that students are able to take, allows them to ratchet up their grades and get a higher overall grade from the modular course. I suggest that we should limit the opportunity to resit modules, and there are of course a number of ways of doing this. The intention should be to make the opportunity to resit in the modular syllabus no more advantageous than the opportunity to resit the terminal examination in the linear syllabus.

My intention here is not to throw into question the whole trend towards modularity. It is the case, however, that there are sometimes enthusiasms which seem good at the time, but less good in retrospect. Given that A-levels are well established and have built up a considerable reputation over time, not just in England, it may be best to approach the trend to modularity



▲ Pictured at the meeting were The Lord Butterworth, CBE, DL, with (left) the Rt Hon Baroness Blatch, CBE, Minister of State, Home Office; and (centre) Ms Jane Wheatley, Chair, Association for Science Education.

with some caution. As a very tentative suggestion in my report, I put forward the idea that there may be a way of getting the best out of both systems, for many of the proponents of modularity argue strongly that it motivates students to do their best throughout the two years of the A-level course. It might be possible to have a first year of an A-level course which is modular, and which fits with the horizontal AS, but then in the last year to have a lot more depending on the final examination. This would be a way of combining both the motivation of modular examinations with the well-recognised demand to test a wide range of knowledge in a challenging final examination.

The issue of key skills

Finally, I should like to return to the issue of key skills. In the consultation which I carried out during the Review of 16-19 Qualifications, a point that came across most strongly was a sense of dissatisfaction with standards in literacy, communication skills and basic numeracy. This dissatisfaction was expressed both by universities in terms of student entrants to university courses and by employers who were recruiting school-leavers at 16 or at 18, or indeed recruiting university graduates at the age of 21 or 22. That is why my report pays considerable attention to the ways of lifting achievement in key skills and tries to ensure that, at every stage of their education, students have the opportunity to build up achievement in these areas and gain some certification which will show that they have reached a standard which is acceptable for employment and further study. Of course, more must be done in statutory schooling to lift standards in these basics.

My review of the National Curriculum aimed to emphasise the early learning of literacy and numeracy in that first vital two or three years of compulsory education. But we need to do more than this. So, for instance, I have suggested that there should be more emphasis on arithmetic in the GCSE, with a separate grading on the GCSE certificate for arithmetic. Frankly, that basic ability to count and estimate is what most employers are interested in. They want to know whether the stock-room assistant can get the stock figures right. Beyond this, I suggest that those who are going to specialise in mathematics and the sciences should take a further GCSE in mathematics which

might address the more specialised topics in mathematics that they are likely to need for their further studies. This should have a greater emphasis on algebra, for instance. At age 17 or 18, as I have mentioned, I would also propose that students should take the new horizontal Advanced Subsidiary Examination in the three key skills of communication, number and use of information technology. This must recognise a threshold level of achievement in all three key skills. It is no good for a student to have outstanding performance in two of them; this will not compensate for negligible competence in the third. This is my way of responding to the strong complaints from higher education and employers that they cannot take it on trust that school-leavers with GCSEs and A-levels really have mastered these basic skills. Of course, in the GNVQ pathway, the key skills are part of the course.

I have in this speech covered mainly the needs of high achievers in the A-level pathway. My report actually spends more time on ways of motivating and recognising the achievements of those who are lower on the achievement ladder.

International comparisons

Many international studies have shown that we in Britain have a long tale of under-achievers: some estimates put it as high as 40%. That is the critical way in which our educational achievement differs from that of Germany, Japan and the Scandinavian countries. It is increasingly differing from the educational achievement in the fast-rising Far Eastern nations such as Taiwan, Malaysia and Singapore. If we are to prosper as a nation, in a global economy which will depend far more on educational achievement and brain skills, then we simply cannot afford to have nearly half our population under-performing. Indeed, if we are to serve all our young people well and provide for all our futures, then we must be concerned about the educational achievement of them all.

We need a system of courses and qualifications for 16- to 19-year-olds that will recognise every level of ability and will promote and secure a higher level of achievement. That is my justification for the length of my report, the vast number of recommendations that I make, and the whole review. It is too important an enterprise not to succeed.

THE FUTURE OF A-LEVELS

Professor Alan Smithers*

Introduction

A-levels tend to get a bad press. In part, this is because two of their functions tend to become confused. On the one hand, they are a rationing device for prized university places. On the other, they are an opportunity to study in depth academic subjects, the fundamental ways of making sense of the world.

Selection by A-levels

As a rationing device, they do not do badly. They enable people to be identified who can be educated to a high standard in a short time with few dropouts. Despite mistaken claims to the contrary, they are a good predictor of degree success. As the higher education system has expanded, so they have adapted. Even with 30 per cent of school-leavers, and as many later in life, going on to university, three-quarters of all admissions are by A-level.

But there is a downside. They are exclusive. They do emphasize

depth rather than breadth. The prestige attached to 'the academic' leaves 'the vocational' as second best. Too few choose the sciences. And A-levels do pick out many fewer people than they reject, leaving a majority predisposed to dislike them.

A grouped award

An alternative widely canvassed is for a grouped award based on the accumulation of academic and vocational modules. This embodies the view that breadth is so important that it must be prescribed. Breadth to some means combining the arts and sciences, but others would include vocational studies as well.

I can see the argument for a grouped award at age 11 to indicate readiness for secondary education. There is also a strong case for one at age 16, at the end of compulsory schooling, to emphasize the importance of core subjects such as English, maths and science. But, at age 18, when young people of different talents and interests are wanting to go in different directions, it becomes difficult to know what to specify.

National advanced diploma

Sir Ron Dearing, in his review of qualifications for 16- to 19-year-olds, responded to the support for a grouped award by

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recommending that a National Advanced Diploma should be on the menu. This would be obtained by achieving two full A-levels and three half-A-levels (ASs) across the five areas:

- science, technology, engineering and mathematics;
- modern languages;
- the arts and humanities;
- the way the community works;
- key skills.

The proposed diploma appears to meet the concerns about breadth, but if we look at what might emerge in practice, we can see that the combinations can be quite arbitrary. A-levels in biology and sociology, plus ASs in history, English and key skills, for example, would fit the bill. This is more a patchwork than coherent breadth. Furthermore, it is difficult to see how general national vocational qualifications could be brought in to bridge the academic/vocational divide.

Opportunities for breadth

Much better, in my view, than seeking to impose breadth would be to facilitate it. The problem with A-levels is that a norm of just three subjects restricts breadth. If we moved to the expectation that students would normally take five subjects, we would cause all students to think seriously about breadth, but still cater for those who wished to specialise. Five subjects would enable students to keep more options open for longer, and allow higher education and employers to ask for a broader range of requirements. We would also pave the way for combinations of academic and vocational learning. But we would not be forcing the issue.

A norm of five subjects might mean some slimming down of

In reforming A-levels we must recognise that any successor expected to act as a selection device would be likely to attract the same opprobrium as A-levels because it too would be weeding out

existing A-levels. International studies, however, show that our sixth-form students are timetabled for only about three-fifths of the time of their continental counterparts, so there is room for some increase. The proposed new half-A-level would be a useful stepping stone and students embarking on five ASs might well wish to continue for a second year to obtain full A-levels.

Conclusion

In reforming A-levels we must recognise that any successor expected to act as a selection device would be likely to attract the same opprobrium as A-levels because it too would be weeding out. We must also ensure that opportunities continue to exist for the high-level study of the fundamental ways of making sense of the world. We should also improve opportunities in vocational education.

A-levels and the new ASs, academic and applied, provide those opportunities, and enable combinations to be tailored to particular needs. The successor to A-levels could perhaps most appropriately be A-levels themselves, but with a norm of five subjects rather than three. ■

LETTER to the Editor

Action for Engineers: polish up those links

Dr Brian Kington writes
Bernard Dyer's letter in *Technology, Innovation and Society* (Spring 1996) draws timely attention to the importance of education-industry link organisations in attracting more young people into science and technology and to the need to work through existing organisations, rather than create new ones.

Much attention has been focused on the need to rationalise and co-ordinate such bodies and little on how to ensure their continuity and growth. Many of these initiatives resulted from individual enthusiasm and enterprise, akin to small businesses with a niche market, and are not amenable to co-ordination by an outside body. Indeed, past attempts to achieve this have not been successful. What is

required is greater collaboration and communication between the link organisations and, as Bernard Dyer points out, the mechanisms already exist.

One example is the collaboration between the Standing Conference on Schools' Science and Technology and the Engineering Council. This is bringing together Young Engineers for Britain, Young Engineers clubs, Neighbourhood Engineers and CREST (a joint initiative of SCSST and the British Association for the Advancement of Science).

Thus several, previously separate, activities providing resources, activities, recognition and accreditation, which were previously separate, are now working closely together and complementing each other. Most importantly, local delivery

of the programmes can be co-ordinated through the Science and Technology Regional Organisations (SATROs).

Already, other partnerships have been forged (the BAAS/SCSST management of CREST is but one example), based on mutual interest and benefit. Developing the existing collaboration between SCSST and the Engineering Council, with the possible involvement of any other major players, will do much to clarify the 'alphabet soup', provide an effective and efficient support for schools' science and technology and ensure a more complete and reliable service.

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Professor Keith Foster writes on teachers and technology: see page 15

THE PLACE OF PRESSURE GROUPS

On 23 January 1996, the Foundation held a lecture and dinner discussion at the Royal Society on the subject 'Science, Industry and Government – the Place of Pressure Groups'. The Lord Butterworth, CBE, DL, was in the chair and the speakers were *Mr Jonathan Porritt*, author, broadcaster and environmental campaigner; *Mr J.G. Speirs*, Managing Director, Norsk Hydro (UK) Ltd; and *Sir Crispin Tickell*, GGMG, KCVO, Warden, Green College.

Mr John Spiers*

Introduction

Although I am speaking in a personal capacity today, it may be helpful if I comment briefly on my background. My company, Norsk Hydro, operates in a number of sensitive business areas which have been targeted by pressure groups. It operates in the chlorine industry producing PVC, which some would wish to have closed down; it is in the oil and gas business and will eventually face the problem of disposal of redundant platforms; it is in the salmon-farming business, which has incurred the opposition of pressure groups in Scotland for allegedly polluting lochs; it is in the aluminium business, which in the UK has had to cope with an alleged link between aluminium and Alzheimer's disease and also with the understandable, though irrational, opposition to the addition of aluminium sulphate to water since the Camelford incident in Devon.

As chairman of the public affairs committee of the Chemical Industries Association I am reminded each year that the only good news in the annual MORI survey is that the general public still remains more favourably disposed towards our industry than to the nuclear industry. And, finally, to show that I am completely unbiased on the topic under discussion, I can also declare that I am also chairman of a pressure group - it is my local residents' association in Wimbledon, which in true NIMBY style fights any unacceptable local development.

Although there are a great variety of pressure groups, which for example could readily be defined as including trade associations and trade unions, I think it would be more useful if I mainly concentrate on those pressure groups associated with the environment, health, amenity and animals. They are the ones which have the greatest impact on industry and which are frequently in the news. I plan to discuss them in terms of three issues - promoting change; accountability; and scientific values.

Promoting change

My first issue, then, is promoting change. Pressure groups, particularly the campaigning ones, are usually in business to promote change. They are generally led by people committed to a cause and they attract members who feel strongly enough about the cause to pay the membership fee. Unfortunately the behaviour of some of these groups can often make it difficult or impossible for industry to work with them, even when sympathetic to their main objectives. I would list four main difficulties:-

Firstly, on the basis that the end justifies the means, they may engage in illegal or criminal acts. While industry remained indifferent to environmental issues, one can understand why pressure groups sometimes resorted to illegal acts when frustrated in achieving their objectives through legal means. For example, a new pressure group called Bellona broke into Norsk Hydro's largest site in Norway in 1988, took soil samples and

Summary: **Mr Speirs discussed the influences of pressure groups in relation to industrial activities. Giving examples, he said the behaviour of such groups in attempting to seek changes often made it difficult or impossible for industry to work with them. Moreover, there were problems about their accountability and the adverse effects they could have on the credibility of the chemical industry.**

then accused the company of polluting the soil and water with mercury. The shock transformed Hydro's approach to environmental issues.

On the other hand, two years ago Greenpeace broke into our PVC site at Newton Aycliffe, took water samples and accused the company of emitting pollutants for which it did not have a licence. In fact, the drain which they sampled served the local housing estate, not the factory. Furthermore, Greenpeace knew that they would be received through the front gate if they were concerned about our emissions.

Given the more general willingness of industry now to consult and to improve its performance, it is unacceptable that a very few pressure groups are still prepared to engage in behaviour which they would not condone in companies which they are opposing.

The second difficulty is that some groups are in business solely to oppose. They are unable to say 'well done' and give praise when a company remedies a problem. It is always carp, carp, carp. It is depressing that they have no intention of working constructively with industry, and it is discouraging for the large number in industry who are committed to continuous improvement. Furthermore, such groups tend to undermine the credibility of those pressure groups which are keen to work with companies. It reminds me of the bad old days, when I started my industrial career, when any shop steward who started to work constructively with the management was rejected as a tool of management by the workforce.

A third difficulty is that a few pressure groups are following an alien agenda. Their idea of change is anathema to industry. Their criticism of companies has little to do with their performance and everything to do with undermining the free enterprise capitalist system. In addition there are the few who are prepared to take human life for their cause.

The fourth difficulty is an interesting one. There is a tendency for pressure groups to want revolutionary rather than evolutionary change and improvement. If in their view something is wrong, they want it put right immediately, regardless of cost. Cost-benefit analysis and prioritizing amongst a number of options are seen as delaying tactics. The evidence of research is that except in cases of crisis it is usually better for companies to introduce change steadily and continuously. In the case of small and medium-sized companies, survival is often the highest priority, and I have had to remind some friends that a bankrupt company is usually incompatible with sustainable development.

Having discussed these four difficulties, I turn to the question

* *Managing Director, Norsk Hydro (UK) Ltd*

which has been put to us - are pressure groups an important part of promoting efficient and sustainable change or are they a disruptive force? I would answer that in the 80s and early 90s they were an important force in developing a new agenda and in persuading companies to recognise and adapt to this radically different agenda. We owe them a debt of gratitude. And as I explain later, I believe that they can continue to be useful in promoting efficient and sustainable change, provided they adapt themselves.

Accountability

I now turn to my second issue, which concerns accountability. It is frequently pointed out that many pressure groups have more members than the political parties. This reminds us, of course, that the British public is more concerned with birds and other animals than with politics and politicians, or even with children. But the assumption that as a result pressure groups should be treated as an equally important part of the democratic process seems to me absurd. Political parties generally encompass a variety of opinions; they have to have a view on a multiplicity of issues, which invariably entails compromise; they are forced to set priorities; and they are accountable continuously in Parliament and in the media and periodically at elections. Pressure groups, on the other hand, are usually dealing with a few issues, and they attract members with strong and similar views, and there is usually no need to prioritize and no need to compromise. Most fundamentally of all, political parties must deliver and are held accountable for their performance; pressure groups can blame others if they fail to achieve their goals.

The issue of accountability is also important in the relationship between industry and pressure groups. That relationship may be direct, as a pressure group tries to persuade a company to change its behaviour, or it may be indirect as it tries to persuade the public to stop buying the company's product, or the government to change the law and thus affect the company's behaviour. I would like to discuss three aspects of this relationship.

The first aspect concerns to whom they are accountable. I am not sure to whom pressure groups are accountable other than to their employees and their members, at least to some extent. But the legal position is much clearer for companies, which are accountable to their shareholders. In recent years it has been asserted that companies are more widely accountable to their stakeholders, i.e. employees, customers, suppliers, the local community and to the general public. I have found the distinction between accountability to shareholders and accountability to stakeholders of minor value, other than in strict legal terms, since any company which makes a mess of its relationship with a stakeholder is likely to damage the interests of its shareholders.

This difference in accountability can be crucial when major incidents occur. Let me give an example. Although I don't believe that Greenpeace encouraged or condoned the fire-bombing of Shell's petrol stations in Germany, I am sure that it did not feel responsible or accountable in any way. Shell on the other hand, leaving aside the damage to its profits and reputation, certainly felt that it was responsible for and accountable for the safety of its employees and customers.

There is one further point concerning this aspect of accountability. Sometimes pressure groups claim that they are a stakeholder for companies since they represent so many members and that therefore companies are accountable to them. I certainly accept that given the power of many pressure groups, it would be foolish for a company to ignore them. However, the lack of accountability of pressure groups in my view undermines this claim. I don't have an answer and I hope this issue will be addressed later by some of the eminent people in the audience.

My second aspect in the relationship between industry and pressure groups deals with the question of what are companies

and pressure groups accountable for. Companies are certainly accountable for their actions and their statements. For publicly-quoted companies the rules regarding public statements are quite strict. But all companies will be concerned as to how what they say and do affect their sales, their profits and their stakeholders. For pressure groups the situation is quite different. They will primarily be concerned about their reputation and image, and, particularly for the campaigning groups, about how events will affect membership. This difference in accountability can be profound.

Let me give an example from the aluminium industry. I referred earlier to the serious incident at Camelford. Because aluminium sulphate was publicly branded as a pollutant by pressure groups and on the media, the water companies felt compelled to withdraw it from use and replace it with less effective iron sulphate. The result was that the relevant aluminium subsidiaries lost 15% of their business and had to make 10% of their workforce redundant. I believe also that the increase in problems from cryptosporidium has stemmed from the change. The response to the incident had implications for employment and health, but I doubt if the pressure groups would consider that they were at least partly accountable. I accept that companies may react too slowly or inappropriately to problems, but they do have employees and customers to care about.

In the example I have just given, I also accept that pressure groups may genuinely have felt that they were acting in the public interest and that what they were saying was true. But what of cases where the public statements prove to be so manifestly wrong that they appear only to be justifiable on the basis that the end justifies the means? When Bellona correctly accused Norsk Hydro in 1988 of leaking mercury into the soil and water, it also accused it incorrectly of numerous other faults. By the time Hydro had investigated and rebutted the relevant statements, the public was no longer interested as events had moved on.

I believe the same is true of the Brent Spar saga. It was an odd mistake that Greenpeace at one point accused Shell of leaving toxic waste in the buoy equivalent to its total weight. I found that more members of the public were aware of the accusation than the retraction, at least until DNV reported. If it is right that companies should be accountable for taking great care over the facts and avoiding any suggestion of using the Big Lie technique, then I think that it is reasonable to expect pressure groups to take equal care.

In concluding this section on accountability I would add that I believe that most pressure groups do act responsibly. However, a minority act as if they were accountable to no one, and it is their irresponsibility which gives a bad name more broadly to pressure groups, at least in the eyes of industry.

Scientific values

My third and final issue is scientific values. I recently spoke at a conference of university chemistry teachers to try and convince them that the poor reputation of the chemical industry was as much their problem as it was ours. I suggested that they needed to take time out in their senior common room to educate their arts colleagues about the unscientific nonsense regularly appearing in the media, such as 'Trees will be sprayed this week due to an infestation of gypsy moths and aphids. The material to be applied is environmentally safe since it is an organic compound, not a chemical.' It is lamentable that such a statement could be produced. It is even worse that most of the population would not even realize that it was absurd. Because we have failed so abysmally for a long time in education, we have a populace which is often irrational about risk, doesn't appreciate scientific values, doesn't understand how science and technology have transformed their lives, and is a prey to anyone peddling the latest snake oil or scare story. Do you recall the scare about

a natural toxin found in apple juice? One of my wife's fellow English teachers was distraught at the news because one of her children would drink little else. She didn't comprehend, and the media didn't explain, that one would have to be drinking unbelievable quantities to be at any risk.

I am afraid that we in the chemical industry are not seen as credible and therefore we have an uphill task in spreading scientific values. Scientists are much more credible, I am glad to say. But COPUS - the Committee on the Public Understanding of Science - seems to me to have made little mark so far. None

of the other members of an ACBE working group on Managing Environmental Issues, of which I am a member, whether businessmen or civil servants, had ever heard of it and, as far as I am aware, it did not contribute in any public way to the debate on Brent Spar.

I am sorry that I keep returning to Brent Spar, but it was such a public event and it encapsulated many of the themes on which I have touched. It may also prove the scientific values, so that decisions can be taken reflecting good science as well as legitimate emotions. ■

PROFILE OF COUNCIL MEMBER

Dr Peter Williams, CBE

Dr Peter Williams, CBE, member of the Foundation's Council, is Executive Chairman of Oxford Instruments plc and also Chairman of the Particle Physics and Astronomy Research Council. A Fellow of St John's College, Oxford, Dr Williams was made a CBE in the New Year Honours in 1992, and in 1995 became the first British speaker to give the President of the Board of Trade's prestigious annual Innovation Lecture. He was recently elected to a Fellowship of the Royal Academy of Engineering.

After an MA in natural sciences from Trinity College, Cambridge, and a PhD in solid state physics from the Cavendish Laboratory, Peter Williams initially pursued an academic career. A research fellowship at Selwyn College, Cambridge, was followed by an appointment as University Lecturer at Imperial College, London, in the Department of Chemical Engineering and Chemical Technology.

In 1975, however, he joined VG Instruments, a high-technology manufacturer of scientific instruments, later becoming Deputy Group Managing Director. Since 1982 he has been with Oxford Instruments plc. Through his work with Oxford Instruments, Dr Williams has built up close associations with many countries, especially Japan, with which he has created extremely successful collaboration. Oxford's wholly-owned subsidiary company there, OIKK, now accounts for 20% of the group's worldwide business. Dr Williams admits that a 'limited working knowledge of the Japanese language' has helped business there.

In 1986, Dr Williams was named *Guardian Young Businessman of the Year*, and in an article which appeared in *Management Today* the following year, he was interviewed for a profile of the company, Oxford Instruments:

Sticking close to the leading edge of technology, including work being carried on in universities, 'the research-orientated jobbing shop' of the 1960s emerged in the 1980s as one of Britain's few genuine high-technology stars: fast-growing, impressively profitable, the undisputed market and technological leader in its most important business sector.

Oxford's progress during the 1980s was overwhelmingly due to its biggest business, and to a single product type. For many

years, superconducting magnets found their principal outlet in chemical research - in nuclear magnetic resonance (NMR) spectrometers used for analysing matter. However, in the 1970s, it became clear that the NMR system had an important place in medicine. Linked to a computer, MRI, as it became known, could generate pictures of the human body in very much the same way as an X-ray computed tomography (CT) scanner. Oxford began developing magnets for whole-body scanning in association with two British universities in 1978 and not long after, in the words of Dr Peter Williams: 'MRI just took off.'

'Oxford spotted it just before the big medical companies, and backed it by instinct,' says Williams. 'When demand for scanners exploded in the early 1980s, we were almost the only game in town. The group doubled in size as a result of MRI.'

Today, the MRI business is a joint venture with Siemens, negotiated by Peter Williams and colleagues in 1989. It is still a vital part of the company's activities, but is now only part of a multi-disciplinary diversified group. The joint venture with Siemens in 1989 was rapidly followed by the acquisition of the Link Scientific Group. This brought both X-ray microanalysis and nuclear measurement into Oxford's portfolio.

The original core businesses have also expanded considerably in the 1990s. Dr Williams initiated the development of the 'Helios' compact superconducting synchrotron, the prototype of which is installed at an IBM facility in the USA. A second unit is due for completion this year, the target being the world's semiconductor industry. Helios was developed jointly with the then SERC's Daresbury Laboratory.

Dr Williams is a member of the Council for Science and Technology, which advises the President of the Board of Trade on national policies for science engineering and technology. The theme of science base-industry co-operation has, of course, become central to policy since the White Paper of 1993. Communication of such goals to the wider public is also of vital importance, according to Peter Williams. He became Chairman of Trustees of the National Museum of Science and Industry in January of this year, a role in which he sees the promotion of the public awareness of science, engineering and technology as central, especially to the young of all ages.

Dr Williams admits to a little 'bad golf' and a great love of mountains as a backdrop for family holidays when business commitments permit - skiing in winter and hiking in summer. ■



Dr Peter Williams, CBE

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