date: 15th April 2008
embargo: 30th April 2008

TUC

Hybrid Cars and Shooting Stars

A trade union agenda for greater participation and understanding of science

TUC Economic and Social Affairs Department

Contents

5 **Introduction**

7 **The Policy and Funding Context for UK science**

Performance

Vision

What is science for? A trade union perspective

Science in the context of Government priorities

Progress on the Science and Innovation Investment Framework

Science Funding

Science and Technology Facilities Council

Laboratories that have been lost

Research Laboratories and Universities

Summary

19 **Science and Education**

Engaging Schoolchildren

PISA

Numbers of Students in Science

Recruiting more science teachers

Factors to encourage the study of science

14-19 Diplomas

Apprenticeships and workforce development

Summary

29 **Science and Society**

A New Science and Society Strategy

Democracy in Science

Science Summits

A High Level Political Debate on Science

'Them and Us'

Science Cities

Women in science

Women and Work Sector Pathways Initiative

Science Clubs for Girls

Doctor Who?

Summary

38 Conclusions

Section one

Introduction

1.1 Pythagorus. Ptolemy. Copernicus. Galileo. Sir Isaac Newton. Albert Einstein. From practical advances in metallurgy, agriculture, transportation and navigation by the early civilisations of the Tigris-Euphrates valley and the Nile valley, to John F Kennedy's historic mission to send a man to the moon, scientific endeavour has walked hand in hand with the development of civilisation.

1.2 It could be argued that the voyages of Marco Polo and Christopher Columbus were driven by the same desire to 'see what's out there' that has excited physicists, astronomers and oceanographers. Physicists, chemists and biologists have also sought to see what we are made of, driven by a similar urge to learn and discover.

1.3 This paper will set out a trade union agenda for science. It will assume that scientists do what they do as part of a quest for discovery. That is important, because political and economic realities mean we must discuss budgets and funding. Such funding will inevitably be driven by the wants and needs of society. The need for higher productivity and competitiveness in our economy. The desire to cure illnesses such as cancer, Parkinson's, Alzheimer's and HIV/AIDS. The need to respond to global warming by developing low carbon vehicles, green industry and renewable energy, such as tidal power. Politicians and the taxpaying public will show more enthusiasm for the funding of such projects than for scientific quests that they do not understand.

1.4 The trouble is, many scientific discoveries that can be of huge benefit to wider society are made almost accidentally, as part of other projects. Kennedy knew this well. His lunar project required him to ask Congress for massive funds. Yet Kennedy knew that, in spite of the costs, the economic spin offs would be so great, the project could justifiably be supported. But that logic is not always so clear.

1.5 This means that science budgeting requires money to be spent on long-term projects whose outcomes are simply impossible to envision. That same money could be spent on basic, immediate demands, like more hospital beds or schoolbooks, or on tax cuts. Yet we know that, if our competitors spend money on science and we do not, our economy and society will lose out. But we won't know the extent of the loss until it is too late.

1.6 Furthermore, some argue that funding fundamental science, i.e. 'science for science's sake', is rather like funding the arts. As a social priority, it is difficult to compare it with health and education, yet if we do not fund it, we become a less civilised society as a result.

1.7 If we are to protect our science base, we must encourage teachers to teach science subjects and students to study them. No student ever chose a career in science to improve Britain's productivity – even if that is the end result. The Teacher Training Agency knows this well. Its innovative advertising campaign, which featured a child in a laboratory, complete with a fascinated look on his face, accompanied by the slogan "That's gravity making his jaw drop!" recognised that it is the desire to understand how plants, animals, people, the earth and the solar system work that brings people into science.

1.8 This paper will be organised in the following way. It will begin by describing the policy context for science in the UK. It will call on 'Innovation Nation', the science and innovation strategy document published with Budget 08 by the Department for Innovation, Universities and Skills (DIUS), as well as the recently published "blue sky" review of the Government's science and innovation policies, 'The Race to the Top', prepared by the former Science Minister, Lord Sainsbury. It will link this to political vision, looking at some of the major challenges being faced by politicians, to which science might provide some answers.

1.9 The paper will then discuss the problems faced by science. Some of these relate to funding, but they also include the challenge of attracting young people into science and the particular problems faced by women in science. If these problems are to be solved, the Government, employers and trade unions all have a part to play.

1.10 The paper will end with an appeal for a public campaign to promote the value of science, aimed at all sections of society, including those who may not have thought much about science at all.

Section two

The Policy and Funding Context for UK science

Performance

2.1 The United Kingdom has been a scientific success story, in the past and the present. As the cradle of the industrial revolution, that comes as no surprise. James Watt and George Stevenson, who fashioned the steam engine and built the first railway, are credited with major inventions that helped drive that industrial revolution and build the UK's prosperity. Our scientific endeavour has been a major factor in UK economic success ever since.

2.2 In a speech to a conference in February 2005, the then Chancellor of the Exchequer, Gordon Brown, reminded his audience that Britain has more Nobel Prize winners in science than any country except America. With one per cent of the world's population, we have over 11 per cent of the world's most cited scientific papers. Furthermore, a higher percentage of our growth is delivered by science-based innovations than in any other industrial nation, including the United States of America.

2.3 Science matters to trade unions. Thousands of trade unionists work on science projects in research laboratories, universities, government departments and in industry. Thousands more work as teachers and lecturers of science, engineering and mathematics in our schools, colleges and universities. Trade union members:

- Undertake research work in key areas such as DNA viruses, links between diet and cancer prevention, and genetic engineering to produce medicinal products;
- Contribute to sustainable food and farming;
- Carry out basic and strategic research aimed at understanding environmental processes, such as global warming, that underpin policy decisions and require action. It was a member of the Prospect union who discovered the hole in the ozone layer;
- Undertake surveillance and research into TB, BSE, avian flu and a range of new and emergent diseases;
- Have invented a range of technologies that have enjoyed successful commercial and medical application, including carbon fibre, liquid

crystal display, uncooled infrared thermal imaging technology and magnetic resonance imaging.

2.4 In 2005, over 85 per cent of people said they think science makes a good contribution to society, up five per cent on five years before. Over 80 per cent believed science will make our lives easier, up ten per cent.[1] The growing public awareness of the environmental threat may explain this increase.

Vision

2.5 The Government's public vision for science is impressive. In its science and innovation investment framework 2004-2014, it said that, by the end of that timescale, the following should have been achieved:

- Building on current strengths in research and exploiting the dominance of the English language in all international scientific communications, the UK should have the state-of-the-art facilities and laboratories, and the skilled workforce, necessary to make the UK the best location globally for research, development and innovation;
- The strengths will be recognised by the economic contribution of a growing high technology manufacturing sector and the influence of R&D on the UK's services industry. Improvements in healthcare, in security and the sustainability of the environment, and an increase in the number and diversity of young people seeking careers in science, engineering, medicine and technology will also be seen;
- Through engagement, openness and dialogue, substantial and sustained progress will have been made towards building a society that is confident about the governance, regulation and use of science and technology;
- The development of the UK's knowledge base through research and scholarship will have made a strong impact on the way UK society is viewed around the world, extending influence in Europe and the rest of the world;
- Through knowledge transfer and capacity-building activities the UK will be making significant contributions to the sustainable development and stabilisation of a world in which issues of poverty, education, water provision, population growth and global warming are tackled; and

[1] Science in society: findings from qualitative and quantitative research conducted by MORI Social Research Institute for the Office of Science and Technology, DTI, March 2005; Science and the public: a review of science communication and public attitudes to science in Britain, a joint report by the Office of Science and Technology and the Wellcome Trust, October 2000.

- The ability to mine effectively into recently developed knowledge from the research base so as to analyse for opportunities and for risk avoidance will be fully developed so as to enable the UK Government to make informed policy decisions on the basis of the best available evidence, and to deliver on these decisions.[2]

2.6 'Innovation Nation' argues that science and technology are a vital source of innovation:

> "The insights generated by fundamental scientific research are important in long-term innovation performance. They produce generic technologies that create new industries, from the physics behind the computer chip to genetic treatments for disease. Many of the UK's most successful businesses build directly on scientific discovery.
>
> However, the path from the laboratory to the marketplace is long, complex and uncertain. Innovations take time to diffuse through the economy and society to create value. For instance, there was an almost 150 year lag between Kelvin's discovery of anisotropic magnetoresistance in 1857, the discovery of giant magneto-resistance in 1988 (for which Albert Fert and Peter Gruenberg were awarded the 2007 Nobel Prize in physics) and their commercial use in miniaturised hard disks for computers and music players like the iPod.
>
> "That is why it is so important to continue to invest in science and accelerate the flow of research into society and to challenge scientists to work more creatively and entrepreneurially with one another and with business."[3]

2.7 In its Comprehensive Spending Review 2007 (CSR 07), the Government also set out a Public Service Agreement (PSA) priority outcome relating to science and innovation, along with a small basket of outcome-focused performance indicators that will be used to measure progress towards achieving it. The PSA and performance indicators are:

PSA 4: Promote world-class science and innovation in the UK

- UK percentage share of citations in the leading scientific journals
- Income generated by UK Higher Education Institutions and Public Sector Research Establishments through research consultancy and licensing of Intellectual Property
- Percentage of UK business with 10 or more employees "innovation active"

[2] Science and Innovation Framework 2004-2014, HM Treasury, DTI and DFES, July 2004.
[3] 'Innovation Nation', Cm 7345, DIUS, March 2008, p. l4.

- Number of UK PhD completers in STEM subjects at UK Higher Education Institutions
- Number of young people taking A levels in Mathematics, Physics, Chemistry and Biological sciences
- UK R&D intensity in the six most R&D intensive industries relative to other G7 economies.

What is science for? A trade union perspective

2.8 The TUC can support much of the Government's vision for science. Making the UK the best location for research and innovation, improving healthcare, protecting the environment, and promoting sustainable development and stabilisation across the world, are objectives of the highest order.

2.9 But the trade union movement seeks to go further. We wish to further the goal of a society that is modern, equal and democratic. A life where society promotes excellent health, first class education, high quality work and dignity in retirement. A better balance between work and leisure. A world where all children – black and white, male and female, from poorer or wealthier backgrounds – can look forward to these rights and privileges and can therefore claim a greater stake in society.

2.10 It is not possible to ascertain the true value of research by simply measuring its economic impact, in much the same way as it isn't possible to understand the importance of education to a child by examining how much money that child makes as an adult. The interrelationship between science and society, just like that between education and society, does not work in that way.

2.11 Trade unions take a particular interest in the world of work: better transport solutions; higher levels of health and safety; excellent skills; the development of the talents of all workers, irrespective of age, gender, race or disability; greener work; technology that genuinely enables workers, rather than ultimately leading to higher work pressure, are the goals that we seek.

2.12 Science is gloriously creative and frustratingly unpredictable. Its limits are set only by our imaginations. Scientific projects usually result in benefits that could not possibly have been foreseen. They can take us along a road that we did not set out to travel, only to find that that journey was more worthwhile than the one we originally intended to make.

2.13 We cannot all be scientists, but for those that can, it is vital that their talents are nurtured and supported as they make quests for discovery, on behalf of all of us. It is almost impossible to answer the question 'What is science for?' The best that we can do is to develop a vision of the world we wish to live in and the life chances that we wish that world to offer to our people. That vision, and only that vision, should set the limits of the science that we support.

Science in the context of Government priorities

2.14 Spending reviews have taken place biennially under Labour, but CSR 07 was the first comprehensive spending review for a decade. CSR 07 was, therefore, designed to address the long-term challenges and opportunities facing the United Kingdom. According to 'Meeting the aspirations of the British people', the 2007 Pre Budget Report and Comprehensive Spending Review, those long-term challenges and opportunities are:

- Demographic and socio-economic change, with rapid increases in the old age dependency ratio and rising consumer expectations of public services;
- Increasing pressure on natural resources and the global climate, requiring action by governments, businesses and individuals to maintain prosperity and improve environmental care;
- The intensification of cross-border economic competition, with new opportunities for growth, as the balance of international economic activity shifts emerging markets such as China and India;
- The rapid pace of innovation and technological diffusion, which will continue to transform the way people live and open up new ways of delivering public services; and
- Continuing global uncertainty with ongoing threats from international terrorism and conflict and the continued imperative to tackle global poverty.[4]

2.15 In its submission to CSR 07, the TUC highlighted globalisation and climate change as two of the major long-term challenges facing the UK. A third challenge that we identified was social justice. In all of these areas, science has a role to play. Science is important for social justice in the light of differences in life expectancy between the better off and the poor and the role that illness prevention can play in reducing that gap.

2.16 'Innovation Nation' reports that the science budget is supporting a number of ambitious cross-research council programmes, which are being co-ordinated by Research Councils UK, the umbrella body for all the UK research councils. These programmes will involve new ways of multi-disciplinary working to address the challenges of energy, living with environmental change, global threats to security, and ageing.

---

[4] 'Meeting the aspirations of the British people', 2007 Pre Budget Report and Comprehensive Spending Review, Cm 7227, HM Treasury, p.2

Progress on the Science and Innovation Investment Framework

2.17 Each year, a progress report on the implementation of the Science and Innovation Investment Framework is published. According to the 2007 progress report, good progress is being made:

> "From an already strong position, the UK research base continues to improve, helped by rising public investment. Knowledge transfer activity from the research base continues to increase, and there are also encouraging signs that attainment and take up for STEM skills are beginning to improve. However, while business investment in R&D is growing in real terms, making more rapid progress in raising levels of business innovation across all sectors and accelerating the translation of excellent research into new goods and services remains a key challenge."[5]

2.18 'Innovation Nation' argues that investment in the research base should drive innovation in the following ways:

- "Qualified people – highly skilled people trained within the research environment are in high demand in businesses across every sector from pharmaceuticals to finance;
- Improved products and processes – research outcomes help businesses and public services create new and better products and more effective and efficient processes;
- Attracting investment – major businesses from around the globe making R&D investments in the UK to gain access to our research base and its extraordinarily talented people;
- New businesses – ideas sparked from research leading to new, exciting commercial opportunities that sustain our knowledge economy, such as through spin out companies;
- Improved public policy – research adding to the evidence base and bringing about more effective policy making – from health care to flood defences, transport to food safety."[6]

2.19 'Innovation Nation' also describes the emerging commercial competition in the race for ideas. China claims to have already pushed the UK into third place in terms of the numbers of scientific papers produced, and it is not just China and India that are in the ascendancy – countries in the Middle East are increasingly investing in research.

2.20 The TUC has some concerns about both public investment in the UK research base and the take up for STEM skills, both highlighted in the 2007 progress report on the science and innovation investment framework. We will

[5] 'Science and Innovation Investment Framework 2004-2014: Annual Report 2007.
[6] 'Innovation Nation', Cm 7345, DIUS, March 2008, p. 43.

discuss these concerns further below. The TUC will also monitor closely the levels of investment specifically going into meeting the environmental threat. Sir Nicholas Stern reported that we need to spend 1% of GDP to prevent future climate change, or a much larger proportion to deal with the consequences if we don't.

Science Funding

2.21 CSR 07 confirmed that total public investment in the science base will rise from £5.4bn in 2007-8 to reach £6.3bn by 2010-11, meeting the Government's commitment to increase investment in the public science base in line with the trend rate of growth in the economy.

2.22 The term "total public investment" is all-inclusive. Giving evidence to the House of Commons Science and Technology Committee on 23rd October 2007, the Science Minister, Ian Pearson, said that the ring-fenced science budget has been doubled over the past 10 years and will have tripled by the end of this Spending Review period. The figures, according to Dr Pearson, were: £1.3bn a year in 1997; £3.4bn a year in the current financial year; and "Just a shade under £4bn" by 2010.

2.23 Put in the context of economic growth, however, the funding increase is less impressive. Since 1997, the actual increase in science budget spending is 0.01 of one per cent of GDP. Furthermore, when compared with the increases in spending of our competitors, the Chair of the Select Committee, Phil Willis, argued that the UK is not keeping pace.

2.24 Whilst the overall ring-fenced science budget has been increasing, some government departments have seen a gradual decline in their science spending. It is difficult to track overall science spending, not least because such spending has not been collated centrally since 2005 and also because there are different funding streams. In 'The Race to the Top', Lord Sainsbury highlights figures based on departmental accounts which show that, as a percentage of GDP, while the science base (Research Councils and HE research expenditure) has increased significantly in the past ten years, civil government spending fell in the last years for which there are figures, and is now lower than at the start of the decade. Defence R&D spending, as a percentage of GDP, has declined almost continuously.[7]

2.25 Sometimes, the effect of a cut in central funding is that scientists are driven to spend more time bidding for competitive funding. This is not only wasteful in terms of a resource, but it can affect the nature of the science being undertaken, as competitive streams often cover relatively short timescales.

---

[7] 'The Race to the Top: A Review of Government's Science and Innovation Policies', Lord Sainsbury of Turville, October 2007, paragraph 2.39.

2.26 Sudden cuts in departmental funding to research institutes can be devastating. For example, the Chief Executive of the Biotechnology and Biological Sciences Research Council told Prospect's Science, Engineering and Technology Conference last year that, in real terms at 2005-06 prices, Ministry of Agriculture, Fisheries and Food (MAFF)/Defra funding to BBSRC-sponsored activities had been cut by more than three quarters over 20 years.

2.27 From a TUC perspective, we warmly welcome the increased funding for the science budget since 1997. At a time when budgets are tight, a commitment to a ten-year science and investment framework is no small promise. Yet this commitment has been made while, at the same time, world-class scientific facilities have been axed. Furthermore, as the Government has come under short term funding pressures – of the kind that all governments face from time to time – it has taken money from science spending to help plug gaps. The TUC recognises the political expediency of this: when a crisis happens, such as the floods in the summer of 2007 or the Northern Rock episode, money is needed quickly and a long-term science budget is relatively easy to trim. Yet such activity undermines science. Scientific expertise cannot simply be turned on and off at will. Furthermore, chopping and changing research priorities according to the fashion of the moment places the UK at real risk of being unable to respond effectively when the next crisis occurs.

2.28 Following the CSR07 allocations, there are winners and losers among the science community. For example, the Medical Research Council is set to experience a 10.8 per cent real terms increase in its Departmental Expenditure Limit. By contrast, the Engineering and Physical Sciences Research Council will effectively have its real terms budget frozen and the Science and Technology Facilities Council (STFC) will have its real terms budget cut by 1.5 per cent.[8]

Science and Technology Facilities Council

2.29 Late 2007 saw, as if from nowhere, a funding shortfall in the STFC, to the tune of £80 million. Claim and counter-claim has gone back and forth, meaning that in early 2008, it is still unclear exactly how this happened. Furthermore, there is a great deal of complexity surrounding the funding of such councils, which means that the Science Minister, Ian Pearson, can quite correctly state that the STFC's budget will rise by 13.6 per cent over the CSR 07 period, while it is also true that an £80 million shortfall exists. Nevertheless, this shortfall was unexpected and has caused huge concern in the science community.

2.30 At the time of the science budget allocations, the Government announced a fundamental review of the strength and role of UK physics. This review, chaired by Professor Bill Wakeham of Southampton University, was

[8] This assumes at 2% increase in CPI inflation, as set out in government targets. In fact, RPI inflation is set to be above 3% for much of 2008, making the effects of this real terms cut worse.

launched in January 2008. Among its terms of reference are to consider the priorities for investment across physics as a whole, taking account of the need both to maintain the health of the discipline, and to strengthen its wider, including economic, impact in the future. Wakeham will report in autumn 2008.

2.31 The TUC is deeply concerned about an £80m funding shortfall to the STFC. We often find ourselves in the position of comparing a situation in the UK with a better record in other industrial countries. For example, we have highlighted the production of wave and tidal energy in Germany and Denmark, using technology that was first developed in the UK. However, regarding UK science, we are in the opposite position: the UK has historically punched above its weight in science, retaining and even attracting scientists to work in our economy as a result of the opportunities on offer. Unless the £80m shortfall is redressed, and we address the issue of insufficient input through our education system (which is discussed further below), we are in danger of losing this hugely important advantage.

2.32 Furthermore, as the trade union centre that represents those employed in research councils, our first priority is to protect those trade union members whose jobs are under threat. Again, numbers are disputed, yet in an adjournment debate in the House of Commons, Ed Vaizey MP, whose constituency covers both the Diamond synchrotron and the Rutherford Appleton ISIS station and laboratory, said that between 300 and 600 scientists could be made redundant at Rutherford alone.

2.33 On 7th February 2008, the STFC appeared to have halted plans to restructure its research facilities until the Wakeham Review had reported. This news was welcomed by the trade union movement. However, in March it was announced that physicists and astronomers had just three weeks to make the case for a number of high-profile projects at risk of being cut. Projects under threat include an upgrade to the Merlin radio telescope array (e-Merlin) at Jodrell Bank and the UK infra-red telescope – the world's largest telescope dedicated to infra-red astronomy, based in Hawaii. Decisions on cuts would be made in April 2008.

2.34 Sir Peter Knight, head of the panel which compiled the lists for the STFC, told BBC News: "Every single programme we looked at was worthwhile. There was not a dud amongst them." Sir Peter added: "There are imaginative people who have put their careers on the line for these projects and they are good projects."

2.35 **The TUC has consistently argued that funding must be found to plug the £80m gap in the STFC's budget. This was a central argument of our submission to the Treasury in advance of the Budget in March and we were disappointed that no action was taken. £80m is not a large amount of money in terms of overall government spending and we believe there are three central arguments for this money being found:**

- **To protect high value science projects;**
- **To ensure that hundreds of highly valued scientists remain in the science community, putting their skills and expertise to good use for the long term strength of the British economy;**
- **To avoid sending the most negative message possible to future physicists, about the value placed on physics by the British Government.**

2.36 In the immediate term, it is essential that no cuts take place until after the Wakeham Review has reported. If Wakeham has been asked to consider the priorities for investment across physics as a whole, taking account of the need to maintain the health of the discipline, it clearly makes no sense to make major cuts until those priorities are identified.

2.37 The TUC recognises the importance of the CSR settlement process and does not call lightly for additional money to be found, after a settlement has been agreed. We also believe that mistakes have been made in the handling of the STFC budget this time and that lessons must be learned, in order to avoid a similar situation in the future. However, to rush through cuts before Wakeham has reported would only compound an already difficult situation.

2.38 Returning to the vision set out in the science and innovation investment framework, it is important to define what is meant by the statement that "the UK should have the state-of-the-art facilities and laboratories, and the skilled workforce, necessary to make the UK the best location globally for research, development and innovation". It is certainly difficult to square that statement with the closures of facilities and funding shortfalls witnessed in recent years.

Laboratories that have been lost

2.39 Quite apart from the STFC issue, a number of highly valued laboratories have closed in recent years.

2.40 Silsoe Research Institute had an international reputation for its research in agricultural, food processing and environmental engineering. From the beginning to the end of the food chain, Silsoe scientists and engineers had a unique body of knowledge. Among its inventions and systems, Silsoe scientists invented the world's first fully automated nutrition control systems for poultry and pigs, an oval saw to remove spinal cord which reduces the risk of spreading risk material into the food chain, and systems for decontaminating food packaging, reducing the transfer of micro-organisms into high-care areas. However, in 2004, Silsoe's main sponsoring body, the BBSRC, decided to end its support due to changes in its own research priorities. Silsoe closed in March 2006 after 80 years of operation.

2.41 The Centre of Ecology and Hydrology is an independent research organisation funded partly through its parent by body, the Natural

Environment Research Council, and partly through commissioned research, much of the latter for government departments and agencies. NERC decided in March 2006 to close four CEH sites, despite widespread condemnation from across the scientific community. Among other initiatives, the eminent naturalist Sir David Attenborough described the closure plans as 'scientifically flawed' in a letter to 'The Times', co-signed by the heads of 15 conservation bodies, including the RSPB, Friends of the Earth and Butterfly Conservation.

2.42 The Hannah Research Institute underpins the dairy industry in the South West of Scotland. The Institute was a world centre for generating new knowledge on the biology of lactation and the interrelationships between mother and offspring and the physical and biological properties of milk and dairy-based products that are related to food quality and safety. The research was strategically related to: dairying (milk is the most important single contributor to the agricultural economy); human lactation (vitally important for health and welfare in neonatal and later life); breast cancer (negative links between the normal function of lactation and breast cancer are of growing importance); and human diseases on which the study of lactation throws light (e.g. diabetes). In 2003, Hannah was rated as delivering science of international quality. Despite this endorsement, the Scottish Executive Department of Environmental and Rural Affairs ceased to fund HRI from April 2006.

Research Laboratories and Universities

2.43 It has been suggested, not least by Lord Sainsbury in his days as Science Minister, that expertise lost through cuts in government research will transfer to the university sector. There are a number of problems with this argument.

2.44 First, whilst it is right to encourage multi-disciplinary research – as also advocated by Lord Sainsbury – there is more interdisciplinary research taking place in research council institutes than there is in individual universities or between them. A good example of such an initiative is research on prevention (rather than treatment) of cancer, which accounts for only two per cent of cancer research funding. Institutes are particularly useful for such work, because of their access to a wide range of skills, including microbiology, biochemistry, cell biology, animal and human studies, epidemiology, statistics and post-genomic technologies.

2.45 Second, R&D on environmental and sustainable farming, one of government's priorities, needs large-scale facilities in various parts of the country in order to test different soil types and meteorological conditions. Universities have generally sold off their land and farms and much of the research cannot be done on commercial farms as it needs controlled conditions and would impact on farmers' profitability.

2.46 Third, teaching is, of course, the life-blood of universities, but it has a negative impact on research targets. Research institutes, by contrast, do not have this distraction.

2.47 Having said this, it is important to be clear that the TUC does not wish to promote a competition between research laboratories and universities with regard to science. Laboratories and universities tend to undertake different types of research, but both are necessary, so we need to retain the capabilities of both. Our point is simply that transferring research laboratories into universities will not achieve this.

Summary

2.48 The United Kingdom has every reason to be proud of its scientific legacy. As the cradle of the industrial revolution, science has walked hand in hand with our economic and social development for 200 years. The British public, quite rightly, value the role of British science.

2.49 The Government has an impressive public vision for science. Its science and innovation investment framework is accompanied by an increase in the total public investment in the science base in line with the trend rate of growth in the economy. The ring fenced science budget has doubled in the past ten years.

2.50 Yet the TUC believes that the Government's vision, built around the important concepts of improving economic performance, better health and meeting the environmental threat, could be even wider. In our view, science should promote the objective of a society that is modern, equal and democratic. There should be no false limits put on the scope of science, so long as it promotes the kind of society that we wish to develop in the UK. Science policy should, in particular, foster a narrowing of the gap between the haves and the have-nots in our society.

2.51 Furthermore, in spite of impressive levels of funding in recent years, some government departments have seen a gradual decline in their science spending. The Government has also taken money from science spending to help plug short-term gaps. A £80m shortfall in the budget of the Science and Technology Facilities Council is a massive own goal that will threaten highly valued science projects, put scientists jobs at risk and dissuade future physicists from studying science. If the Government cannot find the money to address that shortfall immediately, it must at the very least take action to ensure that no cuts are made until after the Wakeham Review has reported.

Section three

Science and Education

Engaging Schoolchildren

3.1 Most people's first conscious engagement with science takes place at school. If we wish to encourage the take up of science careers, it is important to engage school children. Furthermore, the younger they are when we capture their attention, the better.

PISA

3.2 A good place to begin our assessment of the challenge of engaging children is to ask children themselves about their attitudes to science. The Programme for International Student Assessment (PISA) is a triennial survey of the knowledge and skills of 15 year-olds. It is produced by participating countries, through the Organisation for Economic Co-operation and Development (OECD). PISA 2006 focused specifically on science. More than 400,000 students from 57 countries, making up close to ninety per cent of the world economy, took part in PISA 2006.

3.3 The good news is that PISA 2006 found strong support among students for scientific inquiry. On average, across OECD countries, 93 per cent said that science was important for understanding the natural world, 92 per cent said that advances in science and technology usually improved people's living conditions, and 75 per cent said that science helped them to understand things around them. Less encouragingly, only 57 per cent said that science was very relevant to them personally.

3.4 Further good news is to be found in the findings which show that most students have confidence in being able to do scientific tasks. On average, across OECD countries, 76 per cent said they could explain why earthquakes occurred more frequently in some areas than in others, 64 per cent said they could predict how changes to an environment would affect the survival of certain species, and 51 per cent said they could discuss how new evidence could lead to a change in understanding about the possibility of life on Mars.

3.5 PISA also found that attitudes towards the importance of science were higher than personal, future engagement with science. 72 per cent of students said it was important for them to do well in science, 67 per cent said that science was useful to them, but this figure fell to 37 per cent who said they would like to work in a career involving science and 21 per cent who said they would like to spend their life doing advanced science.

3.6 On actual performance, the UK scored well. Proficiency in science is broken down into six levels:

- Level 6: students can consistently identify, explain and apply scientific knowledge about science in a variety of complex life situations;
- Level 5: students can identify the scientific components of many complex life situations;
- Level 4: students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology;
- Level 3: students can identify clearly described scientific issues in a range of contexts;
- Level 2: students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations;
- Level 1: students have such a limited scientific knowledge that it can only be applied in a few, familiar situations.

3.7 Table one shows UK performance in science proficiency at these levels, compared with the performance of Finland, Germany, France and the United States.

Table One: Percentage of students at each proficiency level on the science scale

	Below Level 1	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Finland	0.5	3.6	13.6	29.1	32.2	17.0	3.9
Germany	4.1	11.3	21.4	27.9	23.6	10.0	1.8
UK	4.8	11.9	21.8	25.9	21.8	10.9	2.9
France	6.6	14.5	22.8	27.2	20.9	7.2	0.8
USA	7.6	16.8	24.2	24.0	18.3	7.5	1.5

Source: PISA 2006: Science Competencies for Tomorrow's World, OECD 2007

3.8 As Table One shows, Finland scores much more highly than any other country in the table (Finland actually scores higher than any other OECD country). However, the UK scores more highly than Germany, France or the USA, countries whose productivity we have historically lagged behind.

3.9 Furthermore, the Government, quite rightly, is not being complacent about this position. In a speech to the Manchester STEM science conference in January, Jim Knight MP, the Minister of State for Schools and Learners, said that whilst UK performance was above average, we live in a world where above average isn't good enough.

3.10 There is no great surprise in the finding that interest in science appears to be influenced by student background. Students from families with a more advanced socio-economic background were more likely to show a general interest in science, and this relationship was strongest in Ireland, France, Belgium and Switzerland. Those with a more advanced socio-economic background were also more likely to identify how science may be useful to them in the future.

3.11 While overall gender differences in science performance were small, differing attitudes to science among males and females can potentially affect whether students go on to further studies in science and whether they choose a career in science. PISA 2006 showed that, in some countries, males and females were similar not only in science performance, but also in attitudes.

3.12 Gender differences in attitudes were most prominent in Germany, Iceland, Japan, Korea, the Netherlands and the United Kingdom, where males reported more positive characteristics on at least five aspects of attitude. Of the attitudes, the largest gender difference was observed in students' self-concept regarding science. In 22 of the 30 OECD countries in the survey, males thought significantly more highly of their own science abilities than did females.

Numbers of Students in Science

3.13 So does the UK's above average performance in scientific understanding at age 15 affect the numbers of young people studying science at A level, degree and beyond? Lord Sainsbury provides us with the following valuable information:

> "Compared to other OECD nations, the UK has a reasonable stock of STEM graduates. However, a closer look at the situation reveals some potential problems ahead.
>
> "If we break down the headline figures of graduates, a mixed picture emerges, with a worrying decline in certain key subjects, including chemistry, engineering and technology. At the same time, the numbers of graduates in forensic science, psychology and sports science have increased very rapidly in recent years.
>
> "Looking to the future, the pipeline of STEM students is a concern. In the past three years there has been a recovery in the number of students taking A-level biology and chemistry. As a result the 10-year picture shows only a modest decline. In the case of A-level physics we are looking, however, at a 20-year decline. The number of students taking A-level mathematics fell in 2001-02 and is now recovering."[9]

3.14 These less encouraging figures are affected, in turn, by a shortage of qualified science teachers. Lord Sainsbury quotes Smithers and Robinson

[9] 'The Race to the Top: A review of Government's Science and Innovation Policies', Lord Sainsbury of Turville, October 2007, p. 95.

(2005), who have demonstrated that the qualification of physics teachers was the second most powerful predictor of pupil achievement in GCSE and A-level physics after pupil ability (measured by prior attainment).

Recruiting more science teachers

3.15 There is a serious recruitment problem regarding science teachers. Speaking in a House of Commons adjournment debate, Jim Knight told MPs that "There is not an overall crisis in terms of the future numbers of science teachers, because the numbers entering training has risen by almost a third in seven years…"[10]

3.16 In fact, it is difficult to ascertain the true number of science and maths teachers in the UK. According to 'The UK's science and mathematics teaching workforce: A "state of the nation" report, 2007', produced by the Royal Society: "Governmental statistics do not capture fully the acute problems faced by schools and colleges in maintaining a strong science and mathematics teaching workforce. The quality of the data available is patchy and it is very difficult to establish a complete and clear picture of the situation in any of the four nations that comprise the UK, let alone make meaningful comparisons across these nations."

3.17 As the Royal Society report makes clear, this situation must be addressed if accurate workforce planning is to take place.

3.18 The Royal Society makes two further conclusions that are a cause for concern. The first is that counts of published advertisements and additional considerations show that schools face a much tougher challenge in recruiting appropriate science and mathematics teachers than is reflected in the official counts of vacancies. As the Royal Society says: "This is particularly concerning given the Government's commitment to provide for all 14 year olds in England who perform well in their Key Stage 3 tests a new entitlement to study separate GCSE courses in biology, chemistry and physics, and its desire to see greater numbers of students progress to post-16 studies in science and mathematics."

3.19 The second conclusion is that the Government has consistently missed its targets for recruitment into initial teacher training courses in science and mathematics. Lack of information prevents us from knowing how many science and mathematics teachers are actually needed, but the evidence that is available suggests that there is a serious shortage of such teachers, particularly in England.

3.20 Among its overarching recommendations, the Royal Society begins by calling for a better understanding of what is meant by the term 'specialist' science and mathematics teacher, as well as a better assessment of the supply of, and demand for, science and maths teachers.

---

[10] Hansard, 15th January 2008.

3.21 The next step is, of course, to increase the supply. Three important recommendations are suggested by the Royal Society:

- Higher education institutions that offer secondary PGCE courses and which have strong reputations in science should be encouraged to offer PGCE courses in the separate sciences or in other ways support the training and development of teachers in these subjects.
- Creative strategies aimed at retaining science and mathematics teachers, and at supporting their return to the profession, need to be devised alongside a greater understanding of the reasons why teachers leave the profession.
- The Department for Children, Schools and Families (DCSF) should redouble its efforts to increase progression in science beyond GCSE and, in particular, uptake of the physical sciences and mathematics at university in order to help ensure that there are adequate numbers of teachers available to provide specialist teaching in these subjects in all schools.

3.22 The latter point is a classic 'chicken and egg' scenario. A shortage of science graduates leads to a shortage of teachers and this shortage of teachers leads to less people being inspired to go on to study science subjects at university.

3.23 In fact, a similar point can be made to attracting women into science. Gender issues will be discussed further below, but a lack of female scientist role models leads to fewer female scientists, which means even less role models, and so the process goes on.

3.24 Pay for science teachers is obviously a problem. Numerate graduates who understand science and are well trained in its methods are attractive not only to industry and teaching, but also the City of London, where very high salaries are on offer.

3.25 This paper rejects the notion that people study science subjects simply because they know they can attract high salaries in the financial services sector. In our experience, scientists are motivated by the quest for discovery and science teachers are driven by a public service ethos. It is to the great benefit of society that they are. Nevertheless, the huge debts with which many students leave university, together with the difficulty faced by many public sector workers in affording their own home, will inevitably have an impact.

3.26 Recruitment and retention of specialist teachers, especially those of physics and chemistry, are essential if separate science subjects are to be offered at GCSE. To this end, the TUC welcomes the announcement in the Budget, that the Government will invest £10 million over five years to Project Enthuse, which will provide a comprehensive funding and support package to enable all secondary schools to develop the skills of their science teachers at the National Science Learning Centre.

3.27 The TUC also welcomes moves in The Children's Plan (DCSF, 2007) to establish a Transition to Teaching programme to attract more people with science, technology and engineering backgrounds into teaching.

3.28 In essence, the ways to attract people into science teaching do not differ substantially from the ways to attract teachers in other subjects. By definition, teachers tend to be people with a sense of vocation. Like all workers, they wish to be properly rewarded and respected. Whilst recognising that teaching is a high-pressure job, they do not wish to be ground down by long hours and overwhelming stress. They wish to have space to be creative. They wish to go home at the end of a day with a sense of achievement and, when given the tools to do the job properly, it is difficult to imagine a more rewarding achievement than teaching a child, helping that child to become the best that they can be.

3.29 Science education must, therefore, be structured in such a way that the pressure to achieve the highest grades possible, and for the school to achieve the highest place in a league table that is possible, does not undermine efforts to make science creative, fascinating and fun.

3.30 A separate, but related, point is that sciences have the image of being 'difficult' subjects. Whilst some might see that as a challenge, others might find it intimidating and it could influence their choice to study an 'easier' subject instead. A part of the role of a science teacher is to show that the study of science is achievable to a wider range of pupils and a creative, exploratory approach is more likely to make that happen.

Factors to encourage the study of science

3.31 As noted above, the study of science should be stimulating and fun. The fact that much science is practical by nature gives it an advantage over other subjects. This is the image that the Teacher Training Agency is seeking to capture in the advertisement described at the beginning of this document.

3.32 Science is about exploration and discovery, and the way it is taught should reflect that fact. There is a danger that such an approach could be undermined by high stakes testing and by the search for the "right answer". Many experiments could have many right answers and science education must value the search as much as the result. High stakes testing can inevitably lead to teachers pressurised to "teach to the test", rather than to the abilities and potential of the children in the class.

3.33 There must be room to discuss related, vital issues, most obviously ethics, and its relationship with science. There must also be time for visits and the welcoming of outreach workers, such as outside speakers, visitors, theatre groups etc. In an overcrowded and highly pressurised curriculum, instead of being seen as important opportunities, visits from outreach workers are often seen as intrusions, especially in secondary schools, or are only welcomed after Key Stage 2 SATS in May of Year Six.

3.34 In 'The Race to the Top', Lord Sainsbury advocates a science and engineering club in every secondary school within the next five years. This paper doubts that anyone will object to the principle of this, but the capacity to deliver it is another matter. With plans for five hours of sport and five hours of culture per week, plus two hours of homework per night, the school day is becoming crowded out. We must avoid the danger of overloading both teachers and pupils.

3.35 **DCFS should meet with DIUS and teachers unions to take a look at the school day and the school week from first principles, discussing with professionals how best to structure school work in order to deliver maximum value for pupils in a way that also stimulates and rewards teachers.** In practice, the two go together, as a burnt out teacher cannot teach at his or her best, with the result that the pupils ultimately suffer.

3.36 More will be said about the image of science in the next section, but the stereotype of scientists as 'geeky' and as being predominantly made up of men in white coats is clearly unhelpful.

3.37 High quality careers advice is vital, to encourage children to consider careers in fundamental or applied science, or in science teaching. Careers advisers with sufficient knowledge of science are required. Careers advisers are often generalists, so they can sometimes point children in the direction of the more, rather than the less, obvious. This means that proper training of careers advisers, in the range of options available to children and young people, is important.

3.38 Careers advisers must also avoid the trap of gender stereotyping. By imagining that boys will be more interested in science and girls in softer skilled subjects, they may simply reinforce existing patterns.

3.39 'Innovation Nation' argues that DIUS is playing a key role in supporting STEM subjects, including additional commitments by the Higher Education Funding Council for England of £160m over five years, to increase the demand for and supply of students studying strategically important STEM subjects. Activities include the science and engineering ambassadors scheme. According to the report, there are now more than 18,000 ambassadors who have a significant impact in influencing young people to look at STEM careers in a positive light.

3.40 Regarding future work, 'Innovation Nation' reports that DIUS intends to develop a better understanding of the demand for STEM skills (including an in-depth understanding of the need for different STEM specialisms and the level of skills needed) from different sectors of the economy and to understand how the labour market affects supply through its impact on choices made at all stages of education and employment.

3.41 DIUS will be leading a programme of analysis to develop a view on the UK's future needs for STEM skills, working with DCFS, BERR and the Prime Minister's Strategy Unit and drawing on expert input provided by the Research Councils and business, and will develop new policies as needed to ensure the supply of STEM skills.

3.42 **We call on the DIUS to work with the TUC and relevant unions, as well as business, as it pursues this vital project.**

14-19 Diplomas

3.43 In October 2007, the Government decided to extend 14-19 Diplomas to cover three academic subjects – science, humanities and languages – in addition to the 14 vocational pathways that had already been agreed. In effect, this has extended the reach of Diplomas across the curriculum and this is welcome, as there remain concerns that these new qualifications will be seen as second-best to 'A' levels. It is also welcome that science was chosen as one of the three additional diplomas.

3.44 The TUC believes that ultimately the Government should develop the diplomas along the lines originally recommended by the 2004 Tomlinson Report, integrating all academic and vocational studies in secondary schools into a unified framework of diplomas in order to achieve parity of esteem between academic and vocational routes. There is an opportunity for the Government to do this in 2013, when a major review of A levels will take place. Integrating academic and vocational qualifications would also help to deepen and widen science teaching across the curriculum, for example, by enabling pupils engaged in vocational routes such as engineering to acquire science qualifications at academic standards.

Apprenticeships and workforce development

3.45 Science blends both academic and practical elements, and as such may lend itself well to the notion of Apprenticeship. There are a number of potential pathways that might be beneficial to explore in this regard. For example, an Apprenticeships model could be a mechanism for graduates to gain practical workplace experience. Science Apprenticeships could also be an important pathway for people to gain entry into science by embarking on, for example, level 3 Apprenticeships in science with the possibly of progressing to level 4 and beyond, including pathways to university. A similar approach could be considered as with engineering, where there are comparatively good progression pathways from Apprenticeships to university.

3.46 Adult Apprenticeships in science may be a way to address some of the gender divide in science, as research evidence from the Equal Opportunities

Commission demonstrated that older women are more likely to embark on 'non-traditional' career paths.

3.47 The TUC therefore recommends that Government should also explore the potential for Apprenticeships in science to be developed.

3.48 The ongoing professional development needs of workers in science also need to be properly taken into account. The very nature of science means that it is continually evolving and the skills needs of workers in the sector must therefore also continually evolve to progress. The Government has established Sector Skills Councils as a key vehicle for addressing the ongoing skills needs of different industry sectors.

3.49 In practice, science cuts across the work of many different Sector Skills Councils. However the specialised nature of science means that often, the skills needs of workers in science are not properly represented by the current configuration of Sector Skills Councils. The TUC believes that there would be a benefit in having a more coordinated approach to the cross-cutting issues of science. The newly established Commission for Employment and Skills will be undertaking a process of re-licencing Sector Skills Councils. The TUC believes that through this process, the CES should carefully consider how the needs of science are best taken into account.

Summary

3.50 The UK's proficiency in science at aged 15 is not just higher than average, it outscores that in Germany, France and the United States, countries whose productivity levels the UK has historically lagged behind. However, we cannot be complacent about this. Increasing scientific opportunities among children from poorer backgrounds is important. So is improving the self-perception of girls, regarding their scientific ability.

3.51 The UK faces problems regarding its number of STEM graduates and in A level physics, in particular, we face a 20-year decline. The single most important input to change this would be to increase the number of physics teachers. Teachers pay is a factor here, as education competes with higher paying private sector occupations, for the skills of science graduates saddled with student debt and an inability to get onto the housing ladder.

3.52 Project Enthuse and the Transition to Teaching programme contained in The Children's Plan are two important initiatives that the TUC is happy to support. Science teaching must be creative, stimulating and fun. Whilst a focus on high standards is obviously important, "teaching to the test" can impede creativity and put students off science subjects.

3.53 High quality careers advice is important, to encourage children to consider careers in science and in science teaching. Careers advisers must have sufficient knowledge of scientific disciplines and must avoid the trap of gender stereotyping.

3.54 14-19 Diplomas in science are a very important development that the TUC supports. Ultimately, a unified framework of diplomas, integrating all academic and vocational studies, is necessary in order to achieve parity of esteem between academic and vocational routes.

3.55 The TUC believes that the potential role of Apprenticeships in science should be fully explored. Further, to ensure the skill needs of the science sector are properly address, the Commission for Employment and Skills needs to consider how the cross-cutting nature of science is properly reflected in the re-licensing of Sector Skills Councils.

Section four

Science and Society

4.1 The relationship between science and society seems to work on many levels. We know that people are inclined to trust science. We quote figures above, which show that an overwhelming majority of the population believe science to be a good thing. But, of course, science is bound up with questions of ethics. For example, the potential use of science to screen human embryos for health defects, or for gender choice, causes concern.

4.2 People also see limits to science. If we feel ill, we talk to a doctor, but we are sceptical of doctors who simply wish to give us a tablet and send us away. We seek something more holistic. Furthermore, there are purists who take the view that if it cannot be shown to be true in a laboratory, they will not believe it, yet the continued strength of religion and belief in God, including among many scientists, suggests that many of us like our science to be accompanied by questions of faith, and doubt.

4.3 Of course, to equate science with certainty is to misunderstand it. Science is based on the process of hypothesis, experimentation, results and conclusions, but sciences do not claim concrete knowledge and the roles of doubt and interpretation are important for science.

4.4 Today's citizens are better informed than any before. The Internet gives us immediate access to a huge range of information. This has led to a so-called 'death of deference'. Today's scientists are respected, but we are less likely to accept their word at face value. Instead, we seek a greater dialogue. This provides a huge opportunity for science. If we truly wish to appreciate the value of science, we must develop a greater understanding of its role – and its limits – in our society.

4.5 The TUC understands that, earlier in this document, we called for large amounts of taxpayers' money to be spent on scientific projects. It is quite right for the taxpayer to demand that this spending is justified. A better understanding will hold scientists, who ask for this money, and politicians, who either give it or don't, to greater account.

A New Science and Society Strategy

4.6 In 'Innovation Nation', DIUS reports that the Government is reviewing its vision and strategy for science and society. The aim is to achieve "a society that is excited about science, values its importance to our economic and social well-being, feels confident in its use, and supports a representative, well-qualified scientific workforce."[11]

4.7 This work will result in a strategy that will be published in the autumn. The strategy will seek to develop stronger relationships between science, policy-makers and wider society, challenging them to align policies and work together on a shared agenda.

4.8 **The TUC welcomes this initiative and, as a major stakeholder representing many thousands of research scientists and science teachers and lecturers, seeks close involvement in the development of the strategy through the course of 2008.**

4.9 However, we would go further. We believe that a democratic deficit currently exists with regard to science policy. In our view, the way to achieve a society that excited, confident about, and values the importance of science is to engage with the population to a degree that is currently not envisaged.

Democracy in Science

4.10 This paper has described the Government's scientific priorities. These include: stimulating research, development and innovation; seeking improvements in healthcare, security and environmental protection; and extending the UK's influence throughout the world, addressing issues such as poverty, education, water provision and population growth.

4.11 The democratic questions to ask are: Are these the correct priorities? Does the Government have the balance right? What other issues might be included?

4.12 Trade unions are a vital part of the democratic process. By representing people in work, and raising the issues that are of importance to workers in our dealings with government and other stakeholders, we seek to raise the level and quality of debate.

4.13 In this respect, two motions that were passed at the TUC's 2007 Congress are worth noting. The first, moved by the Society of Radiographers, addressed the issue of genetic testing. It made the point that, without realistic and enforceable control of genetic testing, employers and insurance companies will rely on self-regulation, which has the potential for misuse and discrimination in the workplace and in the wider community. There has been little, if any, debate with unions on the use of genetic testing in employment or in health care.

4.14 The second motion, moved by the National Association of Schoolmasters/Union of Women Teachers, covered the issue of the abuse of technology. This noted that, whilst developments in technology have improved

[11] 'Innovation Nation', Cm 7345, DIUS, March 2008, p. 31.

working practices, technologies such as mobile phones, e-mails and internet sites can be used to bully and harass workers, undermining their health, wellbeing, confidence, self-esteem and, in some cases, their career progression.

4.15 Science has great benefits, but not all science is of equal benefit and some sciences, rather than others, might be preferred by voters – and taxpayers. Furthermore, whether the development of a particular scientific project has popular support may depend, in part, on how it is used. It is not enough to assume that, where people are fearful of the use of science, this fear is simply unfounded and the only remedy necessary is for it to be managed better through improved communications. People need a stronger democratic say over science policy and they need to be listened to.

Science Summits

4.16 This paper proposes a number of science summits, to take place around Britain, to debate some of these big questions. By holding them in different parts of the UK, they would reach out beyond the Oxford-Cambridge-London elite that tends to dominate the governance of science. Balance would be given to rural concerns (such as transport, agriculture, food production) and those of urban areas. On-line participation might be included, so long as those without access to computers are not denied a voice. A specific role for schools, both at primary and secondary level, could be included, so that children who may not yet be old enough to vote could nevertheless have their voices heard among those of adults.

4.17 The summits should include politicians, at government or constituency level, who would describe political priorities and issues of resources, but whilst their contribution would frame the debate, it would not dominate it. Scientists must also be encouraged to take part and asked to grapple with the real problems of conflicting priorities with which politicians are faced. The public would be able to hear both sides of that debate and then contribute about the issues that are of concern to them.

A High Level Political Debate on Science

4.18 At the time of the Democratic and Republican Primaries in the United States, a call developed for a Presidential Debate on US science and technology policy. This idea was described by Lawrence Krauss in 'New Scientist' magazine.[12] According to Krauss, more than 13,000 people have already signed up at www.sciencedebate2008.com and institutions like the National Academy of Sciences are openly endorsing this call. Accordingly, Hillary Clinton, Mike Huckabee, John McCain and Barack Obama were formally invited to take part in such a debate.

[12] 'Ideas that will govern America', World Lines, Lawrence Krauss, 'New Scientist' 16th February 2008.

4.19 This is an idea that should be considered in the UK. There is no similar political tradition of leadership debates in the UK, although they have happened, notably between the Chancellor, Norman Lamont, his Labour Shadow, John Smith and the Liberal Democrat Treasury Spokesman, Malcolm Bruce, during the 1992 General Election campaign. Furthermore, it is not suggested that such a debate is held during the heat of a General Election campaign, but that it is held mid-term, at a time when ideas can be discussed more reflectively. This debate could involve a panel of eminent scientists, as well as members of the public, questioning the science spokesmen and women of the major political parties, on issues such as climate change, medical research, the role of science in industry and the economy, along with the issue of fundamental science as a good in itself.

4.20 We also call on the Prime Minister and the leaders of the other main political parties to make set-piece speeches on science policy, to outline their visions.

'Them and Us'

4.21 It is important to break down the divide between scientists, whom fiction writers tend to portray as time travellers, 'boffins' (like Brains from 'Thunderbirds'), and nutty professors (or worse, such as Baron Frankenstein) on the one hand, and the rest of us on the other. Needless to say, the best way to foster better understanding is for us to talk to each other.

4.22 A wide variety of social institutions have a role to play here. The media, most obviously, has an important responsibility. Public service broadcasting has brought us 'Tomorrow's World' and 'Horizon'. High profile scientists such as Sir David Attenborough and Robert Winston have played a valuable role in making science accessible, as have children's TV programmes like 'The Really Wild Show'. The TUC would urge public services broadcasters to continue to show science programmes at prime time on prime channels, rather than relegate them to BBC 3, BBC 4 or even BBC 2. A year ago, the BBC's astronomy programme, 'The Sky at Night' entered its 50th year. The scheduling of its 650th broadcast, at 1.55am, was unfortunate.

4.23 Scientists must spend more time talking to people, in schools, colleges and workplaces. If society is to spend large amounts of money funding science projects, an investment supported by the TUC, scientists must give back to society by engaging with the ignorant and, especially, the curious about the work that they do.

4.24 Trade unions have an important role to play here. In particular, union learning representatives can help to facilitate short courses in workplaces for workers whose jobs may be on the fringes of science and whose contribution to their company – not to mention their future career prospects – would benefit from additional learning in a science related discipline.

4.25 Eminent scientists in non-scientific roles could also help. For example, members of the Houses of Lords and Commons from scientific backgrounds, of all parties, might do more to use their profiles to promote science.

4.26 The modern tendency to pigeon-hole each other and ourselves is not helpful. We see ourselves as academic or practical/sporty. People make a decision to study the sciences or the arts and, having made that choice, they often feel that their voice in their non-chosen field will not be taken seriously. Our predecessors had no such problem, of course. For example, Wikipedia describes Leonardo da Vinci as a "Tuscan polymath: scientist, mathematician, engineer, inventor, anatomist, painter, sculptor, architect, botanist, musician and writer." A more rounded view of ourselves, in the style of "renaissance man" might be beneficial.

Science Cities

4.27 The TUC supports the Science City Programme, which brings together science and innovation partnerships across institutions. Six English cities – Manchester, Newcastle, York, Birmingham, Bristol and Nottingham – have been designated as Science Cities. They have each established consortia involving RDAs, local authorities, universities and business to translate this designation into practical outcomes bringing together public and private investment in a range of policy areas including science, innovation, urban regeneration, education and business support.

4.28 Beyond the Science Cities, RDAs are leading partnerships in regions to identify and catalyse activity to address innovation. Increasingly regional strategies are focusing on regeneration and economic growth driven by science and innovation, e.g. Diamonds for Investment and Growth in the South East and Innovation Connectors in the North East.

4.29 Trade unionists on RDAs have been involved in the development of the Science Cities initiative. Once again, communication with the wider community on the contribution of science in this context, could help to make science more accessible.

Women in science

4.30 The media portrayal of science and scientists can often present a very narrow (and male) representation of what a career in Science, Engineering and Technology (SET) involves. Classic stereotypes of science depict it as requiring 'masculine' attributes, leading to women working in the field sometimes being portrayed as extraordinary or exceptional.[13] A recent research report by

---

[13] p.6 'Role Models in the Media: an exploration of the views and experiences of women in Science, Engineering and Technology', Jenny Kitzinger, Joan Haran, Mwenya Chimba and Tammy Boyce, Cardiff School of Journalism, Media and Cultural Studies (2008)

Cardiff University for UK Research Councils draws from the views and experiences of women working in SET. One woman commented that:

> "I think it started at school since doing three A-Level sciences…..I always felt myself as sort of a 'not normal' female."[14]

4.31 When women scientists were profiled within media news reporting or stories, it was found that journalists were more likely to comment on appearance when writing about women, mentioning their clothing, physiques and hair styles, while the same was only true of a fifth of the profiles of male scientists. Furthermore, male scientists were more likely to be profiled and also more often likely to be cited as expert witnesses. Five male scientists were profiled in the press for every one female scientist and five men were quoted by journalists for every one woman[15]. The research by Cardiff University concluded that descriptions of men working in SET 'seem to confirm their status as bona fide scientists, computer whiz-kids or technological innovators'.[16]

4.32 The impact of these kinds of stereotypes have an important role to play in the under-representation of women working in SET: only 14% of science and technology professionals are women[17]. At undergraduate and postgraduate level, only 14 per cent of engineering and technology students, 24 per cent of computer science students and 22 per cent of physicists are women.[18] After graduation, these women graduates are also less likely to pursue a career in SET[19].

4.33 However, stereotypes are not the sole problem confronting women interested in pursuing careers in SET. Retention and progression continue to be serious problems, with women less likely than men to be promoted to senior positions. Women comprise less than 6% of the most senior grade staff in SET in institutions of higher education across Europe.[20] In fact, one woman scientist even felt that the lack of positive representation and role models presented a 'realistic' picture of the struggles she would eventually face, saying:

> "Eventually I just figured if I wanted it [a career in SET], and I did, it would be very tough. But fair dues, that is the reality of society – so if anything it helped set my expectations accurately on just how tough it would be"[21]

---

[14] P.9, Kitzinger et al
[15] p. iii 'Gender, Stereotypes and Expertise in the Press: How newspapers represent female and male scientists' Jenny Kitzinger, Joan Haran, Mwenya Chimba and Tammy Boyce, Cardiff School of Journalism, Media and Cultural Studies (2008)
[16] p.iii, ibid
[17] p. 11, 'Shaping a Fairer Future' Women and Work Commission (2006)
[18] p.12, Women and Work Commission report (2006)
[19] p7. 'Tackling stereotypes: Maximising the potential of women in SET' WiTEC UK (2005)
[20] p. 1 'Role Models in the Media' Kitzinger et al (2008)
[21] p10, ibid.

4.34 The Cardiff university research concluded that the normalisation of women working in SET, along with more diverse representations of women scientists, working in diverse areas and from diverse backgrounds, could all helpfully contribute to greater numbers of women working in SET. It is critical that issues of discrimination, isolation, harassment and lack of progression confronting women working in SET are also addressed. UK Research Councils has identified retention as a major issue. Research into the experiences of women working in engineering has found that many women who complete engineering degrees do not go on to jobs in engineering or leave after a few years. The research identifies how subtle aspects of workplace culture, including conversation, humour and social activities combine to exclude and marginalise women.[22]

Women and Work Sector Pathways Initiative

4.35 Following the report 'Shaping a Fairer Future', presented to the Government in 2006, £10 million was allocated to the Sector Skills Councils to work with employers and trade unions to raise opportunities for women. One trade union, Prospect, worked on a twelve-month project with the Sector Skills Councils for Science, Engineering and Manufacturing Technology (SEMTA).

4.36 Prospect worked with 50 women and six institutions in England to promote opportunities and to inspire participation in career development. It also helped to identify barriers and find solutions to those barriers.

4.37 Barriers identified included:

- Translating already-existing HR equality and diversity policies into practical realities in the workplace;
- Problems of academic culture, e.g. "men select from men in academia";
- Academia and research often encouraging and rewarding individual effort, which can result in leaders taking the reward and not encouraging their team members to progress;
- Training and conferences at bad times for female carers, especially for women at senior levels, e.g. weekend conferences for presentation of papers;
- A lack of confidence;
- Feelings of isolation;
- A lack of functioning mentoring schemes;
- A lack of functioning networking schemes;

[22] 'Gadget Girls and Boys with their toys: How to attract and keep more women in engineering, Faulkner, W (2006) ESRC/UKRC, 1-4

- The need to involve and educate men and women on prejudice even within Equality and Diversity-friendly organisations.

4.38 Various initiatives are now under way to follow up these initiatives and to seek ways to overcome the barriers highlighted. There is certainly potential to continue this work. Some of the barriers identified are common to many other sectors where women find it hard to progress, while a few are specific to academia. However, it is important that all workplaces involved in scientific development address the issues outlined above if progress is to be made. It is important to remember that there is no one solution, and that measures need to range from non-stereotypical careers advice and confidence building, to ensuring that the organisation of work supports women accessing and sustaining employment in the sector. Trade unions will continue to play a full part in helping to bring change about.

4.39 **The TUC aims to work more closely with organisations such as the UK Resource Centre for Women in Science, Engineering and Technology and Women into Science and Engineering (WISE) in supporting their initiatives to increase the participation and position of women in SET. The TUC also works closely with trade unions representing women working in SET to tackle issues of discrimination and inequality confronting women within these professions.**

Science Clubs for Girls

4.40 The TUC proposes the setting up of a Science Clubs for Girls (SC4G) scheme, modelled on the successful Computer Clubs for Girls (CC4G) initiative that is run by e-skills UK, the Sector Skills Council for IT and Telecoms.

4.41 Notwithstanding the caveat of capacity that was mentioned more generally in relation to science clubs earlier, the TUC would support science clubs targeted at 10 to 14 year old girls and run voluntarily by schools as an out of hours activity. CC4G, launched in England in June 2005 (and in Scotland in March 2006), is already benefiting more than 120,000 girls in over 3,450 schools. The clubs capture girls' imaginations at an age when they typically become disinterested in IT. The clubs are now involved in over 58 per cent of state funded secondary schools and 17 per cent of all state funded primary schools.

4.42 The introduction of such science clubs should take place in dialogue with teaching unions, so that capacity issues can be addressed. So long as this is done, we see no reason that an initiative such as SC4G could not be successful.

Doctor Who?

4.43 Finally, it would be helpful if the media, including the BBC, could play a more imaginative role. The casting of women in non-stereotypical roles in dramas and soap operas could be an interesting first step. For example, ten actors have officially played Dr Who on television. All have been men and most have had female assistants.[23] What about the next Doctor Who being a woman with a male assistant?

Summary

4.44 As a general principle, people trust scientists. Science is, however, bound up with questions of ethics. It does not exist in a moral vacuum. Neither should science be confused with certainty.

4.45 If we wish the public, through their taxes, to fund science, a greater understanding between scientific work and its application in wider society is necessary. The TUC supports the proposed science and society strategy that is being developed by DIUS and seeks close involvement in this initiative. However, a greater democratic voice on the direction and future of science is important. Science summits, around the UK, would be an important initiative designed to promote such a voice.

4.46 Public service broadcasting must bring science programmes into the nations living rooms at prime times on prime TV channels. More outreach work by scientists is important. A greater role for union learning representatives, promoting science courses, could be enormously helpful. High level political interaction on science matters would also be beneficial.

4.47 If we are to encourage a greater take up of science across the nation, the specific problem of gender stereotyping must be tackled. Some problems encountered by women seeking to work in science are similar to those faced by women in other professions, while others are specific to science and academia. Science clubs for girls, modelled on the successful Computer Clubs for Girls initiative, are one idea that should be promoted. Another is the casting of women in non-stereotypical scientific roles in television dramas.

[23] Although anoraks, who should know better, will know that Joanna Lumley once played Dr Who in a spoof, entitled 'Dr Who and the Curse of Fatal Death' in 1999!

Section five

Conclusions

5.1 It is clear that science and discovery are as old as civilisation itself. Furthermore, the marshalling of science for the good of human kind, what we actually do with it in practice, has always walked side by side with scientific discovery. Sometimes we have got that wrong. The building of the atomic bomb is one example. The arms race that followed is another.

5.2 Since the industrial revolution, science has been tied up with wealth creation, yet in today's world, the greatest scientific challenges are probably in other areas. Speaking to WWF in November 2007, Gordon Brown compared the challenge of creating a low carbon economy, with all its scientific implications, with that of rebuilding Europe after the Second World War.[24]

5.3 Thousands of trade unionists work in science. Thousands more teach it, trying to inspire children to understand it and, perhaps, seek a career within it. A trade union voice on the future of science is one that must be heard.

5.4 This paper has tried to make the link between science, democracy and wider society. It is important to ask about the problems that we wish to solve. But it is also important to ask about the kind of world that we wish to live in. Many of us see individual issues and questions, but don't so often take a step back and look at the bigger picture.

5.5 In our view, political leaders should take more time to set out the kind of society they wish to build. The TUC's vision of our society is tolerant, modern, open and democratic. It is concerned about the cult of wealth and celebrity, at its worst in the 'loadsamoney' days of the 1980s, but still too prevalent in UK society today. It looks to Scandinavian examples where a large gap between rich and poor is considered to be undesirable. It seeks a greater stake in our society for the less well off, with better health, educational and overall life chances. It rails against the injustice of women or black workers earning less, often significantly less, than their white, male counterparts. But this is not just an issue of money. Poorer people should have more opportunity to enjoy the fruits of science, culture and the arts. The PISA study, quoted above, found that students from more advanced socio-economic backgrounds had a better understanding of the use of science to them, not just in the UK, but across the OECD. This is simply not good enough.

5.6 For the TUC, these are the main challenges facing our society. In our view, society's main challenges should be science's main challenges. Communities

---

[24] Gordon Brown, speech to WWF, 19th November 2007.

must feel that science and its application is not the preserve of an academic elite, but is practical and relevant to people like them. Along with critical issues of climate change and globalisation, creating greater equality and fairness in a troubled world is a challenge for science. Most obviously, medical research could play a big part in helping to reduce life chances between rich and poor. Making healthy food more readily available to poorer communities is another challenge for science. Making poorer communities safer is a third challenge, whether that means safety to walk the streets or to travel on public transport after dark.

5.7 And what of those working in science? The TUC proudly defends the ethos of public service. We rejoice in the decisions of doctors and nurses to heal the sick, and teachers to develop the hearts, minds and souls of our children, not because those professions offer large financial rewards, as they certainly do not, but because their social contribution cannot be valued highly enough.

5.8 So it is with many scientists. It is true that scientists can often earn large salaries in the City of London, but the trade union members that we speak to are motivated by their fascination for scientific discovery and their desire to make the world a better place.

5.9 The way to keep them in science is for them to be properly paid. Interviewed in 'New Scientist' magazine on 5th March 2008, the Secretary of State for Innovation, Universities and Skills, John Denham, said:

> "It is true that only one in four engineers that graduate work as engineers. There are two ways of looking at that. One is that engineers are really good people to employ because they have a scientific background, they're problem solvers, they're well organised. The other view is that perhaps if you want more engineers working as engineers, the labour market needs to offer pay and conditions to attract people. I think you've opened up an important debate and it's one that I'd like to continue."[25]

5.10 The UK has built a reputation for itself as a centre of scientific excellence. This is an exceptional achievement, but it is in danger of being lost to closing laboratories and funding cuts. Apart from reputational damage that is bound to ensue, once scientists are lost to UK science, they are likely to be lost for good. We cannot allow that to happen.

5.11 Science education must be structured in a way that it nurtures the joy, excitement and fascination of the discipline, among girls as well as boys. A culture must be developed whereby science is not a discipline to be afraid of or intimidated by, but should provide an outlet for the immense creativity of children and young people.

---

[25] 'Whose hands on the levers of power?' New Scientist, 5th April 2008.

Conclusions

5.12 This paper has only touched the surface of the issues and concerns that surround the future of science. We look forward to taking part in this vitally important debate in the months and years ahead.

Trades Union Congress
Congress House
Great Russell Street
London WC1B 3LS

www.tuc.org.uk

contact:
Tim Page
020 7467 1202
tpage@tuc.org.uk

£ 10

For more copies of this title contact our ordering point on 020 7467 1294 or smills@tuc.org.uk. Bulk discounts may be offered.