SCIENCE, INNOVATION AND THE ECONOMY

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It may not have been a great Summer for football but it has certainly been a great Summer for science. The Royal Society has celebrated its 350th anniversary in great style with a display on the South Bank that showcases pioneering British science. The BBC has been doing a fantastic job, from Martin Rees's Reith Lectures on radio to Michael Mosley's "The Story of Science" and Brian Cox's "Wonders of the Solar System" on television. Exciting and accessible science books are spread out across the tables at Waterstones. And here, at the Royal Institution, you've been highlighting the potential of nanotechnologies – as well as holding lectures on the measurable shortcomings of the England football team.

So to be science minister is an extraordinary privilege for me. Indeed, so much is going on that it's not possible for me to cover every significant issue in science policy in this, my first major science speech. There are areas which we can only really advance once the comprehensive spending review has been concluded. I can assure you of my commitment to the dual support system and the Haldane principle, and I hope to reflect further on both in another speech. I do believe in concentration on excellent research – and excellence is to be found in individual departments. To take this particular debate further we have to be clear about the conditions in which excellence actually thrives and how much research funding we will be able to distribute.

Most importantly, I recognise my deep responsibility to the scientific community in these austere times. Good things were achieved over the past decade and I salute the achievements of David Sainsbury, for example. But the Government was borrowing too much, even before the Crash. It was a debt-driven boom. It never was sustainable but, as so often, it took a recession to reveal the uncomfortable truth. Whichever party won the last election would have had to face difficult decisions. The previous Government left no long-term spending plan – only a commitment to save £600m from the Higher Education, Science and Research budgets by 2012-13, without specifying where these savings came from.

I recognise that countries like the US, Canada and France have reacted to recession by spending more on science. But their public finances are in much better shape than ours. The US government's deficit as a percentage of GDP in 2009 was 10.2 per cent. Canada's was two per cent, France's six per cent, Germany's 1.6 per cent. Ours was 11.1 per cent. And when I meet ministers from other governments at the EU Council on Competitiveness and Research, they are just as preoccupied with saving money as we are. That is why the cost of the ITER programme for nuclear fusion was the top concern of fellow minsters at the last meeting. These are austere times for us all. But this Government wants science to emerge from this period to be strong, sustainable and effective. Vince Cable and George Osborne both understand the key role of science, technology and innovation in rebalancing the economy.

I am an optimist about science's capacity to do this, because the deep forces driving its growth and popularity are as powerful as ever. A very important stimulus for scientific

advance is, quite simply, technology. We talk of scientific discovery enabling technical advance, but the process is much more inter-dependent than that. For example, imaging technology is driven by the demands of astronomers, and then enables those same astronomers to make new discoveries. It's because of this process that we've been able to view this week those awe-inspiring images of the oldest light in the cosmos, gathered by the Planck space telescope. Meanwhile it allows medical imaging to advance along the way, almost as a by-product of our age old desire to look into the heavens.

In my speech at Birmingham University in May, I spoke of links between the academic and the vocational, the conceptual and the physical. We are not always good at this – we have world-class particle physicists at the Large Hadron Collider but sadly not many British engineers helped to build it. But there are other areas where these links between British science and technology are stronger. We not only have distinguished astronomers, but it was scientists and engineers at Cardiff University who produced the Spectral and Photometric Imaging Receiver for Herschel and Planck. This combination of scientific research and technological advance creates extraordinary dynamism, both intellectual and commercial. I see it as one of my tasks to strengthen these links. That is why one of my ambitions is to try to ensure that the exciting intellectual advance of nuclear fusion – we are world leaders at Culham – also drives British technological and industrial development.

This does not just apply to the natural sciences but to social sciences too. Howard Davies is right to remind us of their importance. I'm encouraged by the progress we're making in understanding human behaviour. Understanding social mobility, individual well being, stable families: these are challenges where strong social science can really contribute. My own recent book, *The Pinch*, on fairness between the generations drew on insights from neuroscience, evolutionary biology and game theory. The birth cohort studies of 1958 and 1970, reinvigorated by the millennium cohort study, have fundamentally shaped the debate about social mobility in Britain. Well being is a hot topic in Whitehall at the moment. We just held a valuable seminar in my department, with contributions from health experts, social scientists, psychologists and economists.

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More broadly, as society becomes more diverse and cultural traditions increasingly fractured, I see the scientific way of thinking – empiricism – becoming more and more important for binding us together. Increasingly, we have to abide by John Rawls's standard for public reason – justifying a particular position by arguments that people from different moral or political backgrounds can accept. And coalition, I believe, is good for government and for science, given the premium now attached to reason and evidence. We have already offered a science induction for new MPs, and ensured that the principles of scientific advice to government are referred to in the new ministerial code. In addition the Government's Chief Scientific Adviser, Sir John Beddington, has updated his guidelines on the use of scientific and engineering advice in policy making.

You might say that science is doing so well in the public sphere that the greatest risks it faces are complacency and arrogance. Crude reductionism puts people off. Scientists can morph from admired public luminaries into public enemies, as debates over nuclear power and GM made clear. And yet I remain optimistic here too. The UK Research Councils had the foresight to hold a public dialogue about ramifications of synthetic biology ahead of Craig Venter developing the first cell controlled by synthetic DNA. This dialogue showed that there is conditional public support for synthetic biology. There is great enthusiasm for the possibilities associated with this field, but also fears about controlling it and the potential for misuse; there are concerns about impacts on health and the environment. We would do well to remember this comment from a participant: "Why do they want to do it? … Is it because they will be the first person to do it? Is it because they just can't wait? What are they going to gain from it? … The fact that you can take something that's natural and produce fuel, great – but what is the bad side of it? What else is it going to do?" Synthetic biology must not go the way of GM. It must retain public trust. That means understanding that fellow citizens have their worries and concerns which cannot just be dismissed.

Transparency is part of the answer. In the Coalition Agreement, we have undertaken to create a new right for the public to request government-held datasets – information which will be published in an open and standardised format for ease of use. The controversy over climate change data at the University of East Anglia has really highlighted the importance of this measure. We must, of course, have due regard to personal privacy, the opportunity

to commercialise research, and national security – but, otherwise, scientific enquiry depends on practitioners being able to test and challenge both methods and results. I have already had some fascinating discussions with Tim Berners-Lee and Nigel Shadbolt about how we might boost data sharing.

This argument for transparency and openness is actually the best protection for science. We cannot, for example, have writers facing libel charges because they offer a scientific critique of other people's claims. This is an issue which I have raised with Ken Clarke, the Lord Chancellor, and which his department recognizes they must address.

So science is an ever stronger voice in the national conversation. For the rest of this speech, I want to focus primarily on the economic case for investment in science and research. In trying to link these grandiose arguments with economic returns, I'm reminded of a rather pompous Oxford don who recommended the study of Greek literature to his Victorian undergraduates, because it "not only elevates above the vulgar herd but leads not infrequently to positions of considerable emolument." And especially when money is tight, emolument matters. Public spending on science, just like everything else, has to stand up to rigorous economic scrutiny. Let's consider some of the most frequently used arguments.

The first relates to the benefits – often unanticipated – which accrue from blue skies research. Few scientists are as sure of their purpose as that man encountered by Gulliver, who was "eight years upon a project for extracting sunbeams out of cucumbers, which were to be put in phials hermetically sealed, and let out to warm the air in raw inclement summers." The man had no doubts about impact. As he told Gulliver, "he did not doubt, that, in eight years more, he should be able to supply the governor's gardens with sunshine, at a reasonable rate", and was desperate for additional funding "as an encouragement to ingenuity, especially since this had been a very dear season for cucumbers."

Margaret Thatcher was more circumspect when she wrong-footed sceptical Cabinet colleagues with her defence of public spending on the Large Hadron Collider. "Yes, but isn't it interesting?" was enough to stifle their objections. And her interest in the work at CERN was rewarded by Tim Berners-Lee establishing the groundwork for the World Wide Web. I've seen the original computer server with a note from Tim attached, instructing fellow scientists not to switch it off. Our lives have truly been revolutionised by his inventiveness.

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The surprising paths which serendipity takes us down is a major reason why we need to think harder about impact. There is no perfect way to assess impact, even looking backwards at what has happened. I appreciate why scientists are wary, which is why I'm announcing today a one-year delay to the implementation of the Research Excellence Framework, to figure out whether there is a method of assessing impact which is sound and which is acceptable to the academic community. This longer timescale will enable HEFCE, its devolved counterparts, and ministers to make full use of the pilot impact assessment exercise which concludes in the Autumn, and then to consider whether it can be refined.

We can also learn from elsewhere. For instance, there are some interesting developments underway in the United States, where the Star Metrics initiative is seeking to track the science dollars pumped into universities through the recovery programme and will then trace their impact on the broader economy. My department and the Research Councils are monitoring progress on this front.

But let's go back to those arguments for science. The previous government appeared to think of innovation as if it were a sausage machine. You're supposed to put money into university-based scientific research, which leads to patents and then spinout companies that secure venture capital backing. The mature business provides tax revenues for the Government, jobs for the local area, a nice profit for the university, perhaps with Porsches in the departmental car park. It sounds very attractive and it does happen – Imperial Innovations has been a great success. But it's too neat and tidy an account of scientific and commercial progress. The world does not work like this as often as you might think. And that is not our failure – it is a gap in that whole picture of innovation. Indeed it may actually have had the perverse effect of an exaggerated focus on IP and spinouts. On average the amount that universities generate from commercialising their IP (through licenses and selling stakes in spinouts) is less then 3 per cent of their total income from business and charities. Two Cambridge firms, ARM Holdings and Autonomy Corporation, are now in the FTSE100, but their route was more via mobility of researchers than via conventional spin outs. There are many other ways of harvesting benefits from

research. But the benefits are real.

For example, I'm a firm believer in clusters – best defined as a low-risk environment for high-risk activity. I think of places like Dundee, where, according to the city council, some 350 computer game and creative industries companies are based around Abertay University. The area around Dundee is now home to about three quarters of all British jobs in computer game development. At the same time, Dundee has made a name for itself in life sciences, where first-rate research has attracted significant investment from multi-national businesses.

But that's not the end of the story. There are other issues as well. Consider the spur of national pride – the pride, so to speak, of planting our flag on Everest first. There are, of course individuals – whether Olympic medallists or Nobel prize winners – whose achievements can be regarded as a vivid reflection of the health of the country that produced them. We all take pride in them. There's certainly nothing wrong with wanting to achieve something for your country. And fame, competition and pride are human motives that we find in every walk of life. But none of this is an economic argument for being the first person to make a scientific discovery. Why does it matter **economically** that we should be first or that something should be discovered by a Brit? What exactly is the **economic** problem if the next scientific discoveries originate overseas, rather than here?

I think that the answer is that we need enough good science so we have the capacity to tackle a new problem, to react effectively to scientific breakthroughs however or wherever they may arise, and to capitalise on those breakthroughs via research programmes and business initiatives of our own. Some 95 per cent of scientific research is conducted outside the UK. We need to be able to apply it here – and, in advanced scientific fields, it is often necessary to conduct leading-edge research in order to understand, assimilate and exploit the leading-edge research of others. It is this absorptive capacity which is crucial. Indeed, Griffiths, Redding and Van Reenen have shown that higher domestic business R&D spend also leads to greater productivity being generated at home from foreign R&D spend as well. And there are powerful feedback mechanisms on top of this – foreign companies cite the quality of the public research base as one of the main reasons for locating their own internationally mobile R&D here.

Now, this is, of course, something that we do already – yet the widespread notion is quite different; that the British invent and then fail to execute. On the contrary, the first model for computer tomography arose in South Africa, but the first CT scanner was made here in the UK. The ozone layer was discovered by French physicists, but UK scientists devised a way of measuring it, while members of the British Antarctic survey found a big hole in it.

Government backing for research does make economic sense. I was particularly interested to read the recent Imperial College Discussion Paper by Jonathan Haskel and Gavin Wallis, *"Public support for Innovation, Intangible investment and Productivity Growth in the UK Market Sector"*. It shows particularly strong spillover benefits from R&D spend on research councils. It shows a positive return from other forms of R&D too, but the spillover benefits seem to be greatest from the research councils. This is interesting evidence that research council spend is doing the job it should be doing – generating wider benefits across the economy as a whole. And the fact that one of the authors is a Treasury official only adds to its value!

These arguments about clusters, about absorptive capacity and the importance of basic research have already led me to a number of conclusions about the role of government in supporting science and innovation. I can't talk about levels of investment – that must await the CSR – but I do want to share my thinking on policy direction.

First, it makes sense for government to back shared facilities – research platforms if you like – which private companies could not develop on their own. So I'm delighted that a state-of-the-art laboratory is opening today at the Harwell Science and Innovation Campus in Oxfordshire. The new £26million lab is next to the Diamond Light Source, the ISIS neutron source and the Central Laser Facility. It will allow researchers to work side-by-side with beam line experts in fields ranging from drug development to novel materials. (They might even find that the most important room on the site is the coffee bar, as at the Hauser forum in Cambridge.) To date, experimentation at Diamond alone has helped firms like Rolls Royce to apply synchrotron techniques for aerospace and energy applications; Pfizer and GlaxoSmithKline on drug discovery and development; Johnson Matthey on improved

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emissions control catalysts. This is how publicly backed R&D boosts economic performance – one OECD study found that a 1 per cent increase in public R&D increased overall productivity by 0.17 per cent.

I'm similarly keen on pursuing further programmes along the lines of Skynet, the UK's single biggest space project system and the provider of secure satellite tele-communications for Britain's armed forces. With Skynet, the Ministry of Defence purchased a service, and requests further capability as necessary, but does not own the hardware. Instead, Astrium can sell spare bandwidth to other government departments and friendly states, thereby reducing MoD costs. Skynet is an example of smart public sector procurement. Instead of buying a satellite, the MoD bought a service and created a commercial opportunity at the same time. Spending about £220 billion pounds annually, it's vital that the public sector uses that purchasing power effectively. There is a lot more that we can do here both to back SMEs and to back innovation. A purchasing contract can be as effective a way to get money to an innovative small business as a grant or a capital investment: this is particularly important at times when banks are so reluctant to lend.

The economist Daron Acemoglu has shown how demand is sometimes aggregated or mediated through Government, as with defence or (in the UK) healthcare. In these cases the procurement decisions of Government can have important intended or unintended consequences for innovation. ARM Holdings, whom I mentioned earlier, started life as a collaboration between Apple and Acorn, the makers of the BBC micro computer. A BBC contract was crucial in its expansion to become producer of the world's most widely-used 32-bit microprocessor family. We must get better at stimulating businesses through this route so that other small firms can be helped on the road to similar success.

So far I have identified publicly funded research facilities and better public procurement. A third option worth exploring is public competitions for new technologies. Many of you will recall the stir caused by John McCain during the 2008 US presidential race, when he proposed a $300 million prize for battery technology to bring plug-in hybrids & fully electric automobiles into commercial use. It was criticised at the time in the *New Scientist* and elsewhere because it did not reflect the lessons that had been learnt on the best design of such prizes. Economic analysis can teach us a lot here. His idea has impressive antecedents in this country. As we know from Dava Sobel's bestseller *Longitude*, inventors earned more than £100,000 through terms set out in the Longitude Act of 1714, including £14,000 to John Harrison for his work on chronometers over the course of three decades.

In the early twentieth century, teams competing in the Schneider Trophy for seaplane development sometimes received money from the government, as well as RAF pilots on loan. Advances in aerodynamics and low-drag, liquid-cooled engines then contributed to the effectiveness of the Spitfire. A US firm, InnoCentive, runs what has been called an eBay for innovators in which companies set out problems which their network of 200,000 registered experts solve for a fee. One appraisal showed a third of problems which originators could not solve were solved by an outside expert who might be from a different discipline. And separately, the charity, the X Prize Foundation, identifies bigger challenges for which it sets a prize: it has driven innovation in sub-orbital space flight – including with our very own Richard Branson's Virgin Galactic. These sorts of networks are fundamental to a nation's innovative capacity and depend on a wide range of expertise. These prizes, if designed right, can be effective drivers of innovation. And it need not be Government which sets the prize or the challenge – it can happen in marketplaces on the web too.

The challenge we face is to make best use of our science base. Especially in a time of austerity, we inevitably think of the way it can contribute to economic growth. I strongly believe that contribution may come best if we encourage openness and innovation, not if we try to micromanage our universities, direct researchers or count patents. If we get the environment right, the evidence is overwhelmingly that scientific research can contribute to economic growth. A series of excellent recent reports have not just shown this but gone further and identified policy options for doing better in the future. I think of the report from the Council for Science and Technology, *A Vision for UK Research*; The Royal Society report, *The Scientific Century*; Herman Hauser's report on technology innovation centres; Nesta's recent work and, of course, James Dyson's very valuable report for my party, *Ingenious Britain*. There is lot of overlap between them and they provide the intellectual foundations on which we can set to work on the task of rebalancing our economy. The way forward lies in exploiting an evidently outstanding research capability with clear potential, under the right conditions, to drive sustainable economic growth.

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