MAKING THE CASE FOR FUNDAMENTAL RESEARCH

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WHAT IS FUNDAMENTAL RESEARCH?

Some research is undertaken with very direct applications in mind. Recent examples of applied research in the field of physics include the development of high temperature alloys for use in aircraft, or the miniaturisation of computer chips. The case for funding this kind of research is clear. Commercialisation of the application is expected to lead to a healthy return on the resources required, and in most cases the research is likely to be carried out by private industry or to attract funding from private sector investors.

Some research is undertaken as part of a major programme directed at an area of national or international concern. The cross-cutting programmes announced in December 2007 by the Department of Innovation, Universities and Skills provide prime examples, addressing the challenges of an ageing population, environmental change, sustainable energy and threats to global security. Government has a clear duty to tackle these issues, and a commendable commitment to supporting the research required.

But some research is undertaken purely and simply to investigate the nature of our world, and to expand the frontiers of our knowledge. Sometimes this kind of research is called 'pure' or 'blue skies' or 'curiosity driven' research, but a better description is 'fundamental research' because this is the work which, throughout the history of science, has provided us with the insight to make sense of our environment, and underpinned the development of the technologies we take for granted in the modern world.

It is sometimes assumed that fundamental research in physics is concentrated in the fields of particle physics and astronomy. It is certainly true that research in these areas is almost solely fundamental in nature, and that they encompass a wide range of significant activities in which the UK has an outstanding reputation. Fundamental physics research, however, is much wider than that. From biological physics through nanotechnology to superconductivity, fundamental research is carried out in all of physics' individual branches.

MAKING THE CASE

Traditionally, the Research Councils have supported fundamental research in the UK. However, there is real concern among the science community that an increasing focus on potential applications, and the prioritisation of funding towards directed programmes, may put support for fundamental research at risk. At the present time in particular, increasing pressures on government funds inevitably increase the threat to continued investment.

In October 2008, the IOP hosted a roundtable discussion bringing together interested MPs, peers and physicists from academia and industry, to review the case for fundamental research. There was general agreement that a purely utilitarian view is wrong – that knowledge has a value over and above any reasonably predictable outcome. But there was also a recognition that significant sums of money are required to maintain current programmes, and that their value needs to be clearly articulated to justify continued government support.

Speaking from their own experience, the researchers illustrated the benefits to society which flow from fundamental research (in addition to the advancement of knowledge). Three clear benefits are the development of new technologies; the excitement and inspiration that attract young people into science; and the

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DEVELOPING NEW TECHNOLOGIES

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Examples quoted during the discussion included:

- X-rays, lasers and semiconductors are all technologies which are widely used in every aspect of our lives, and are enormously beneficial to society. They all stem from discoveries made through fundamental research, undertaken without any application in mind, and anything up to 50 years or more before commercialisation;
- The phenomenon of superconductivity was discovered as a result of fundamental research in 1911, but the practical deployment of superconducting magnets was only made possible in the 1960s with the development of alloys able to withstand the high magnetic fields involved. Now superconducting magnets are widely used in MRI scanners in hospitals, in mass spectrometry equipment for chemical analysis, and in magnetic separation processes, as well as in particle accelerators;
- Pioneering work on liquid crystals was undertaken at the Royal Radar Establishment in Malvern in the 1960s. Liquid crystal display technology was made practical by parallel research at Dundee University, 25 years ago, into amorphous silicon. Today, LCD's dominate the market for television and computer screens, and represent a worldwide industry worth hundreds of billions of dollars;
- Quantum Information Technology (QIT) developed from researchers asking fundamental questions, 20 years ago, about the manipulation of data according to quantum laws. QIT is currently at the interface of fundamental and applied research. It offers the potential for a second IT revolution with hugely enhanced manipulation of data and guaranteed secure communications. The UK is well placed to exploit QIT commercially, having been in the field from the very start;
- In atmospheric physics, research into the absorption of different wavelengths of radiation, circulation patterns, the effect of varying combinations of greenhouse gases, and the impact of solar activity is now being applied to modelling the impact of climate change, and has provided input to the work of the Intergovernmental Panel on Climate Change.

These and a myriad of other examples demonstrate how, over a long period, fundamental research has made dramatic technological advances possible, and is still doing so today. Such research may be a bad investment for any private individual – its benefits are unpredictable, may be very long-term, and cannot be exploited exclusively by any one company. But a 1991 report by University of Pennsylvania economist Edwin Mansfield, quoted in the discussion, indicated a 28% return on investment on basic science in the USA. Fundamental research has proved a wonderful investment for society – a classic case of public investment justified by a public good.

PROVIDING INSPIRATION

If the UK is to achieve its ambition of becoming a knowledge-led economy in the 21st century, it needs to attract the brightest and best young people into science. All the evidence suggests that it is the big questions that inspire young physicists – the fundamental building blocks of matter, the nature of black holes, or the origin of the universe.

Viewing figures for programmes like *Horizon,* averaging between 2.5 and 3 million, demonstrate that fundamental physics is popular, and is part of our culture. The continuing popular fascination with astronomy is demonstrated by the presence of an astronomical society in every major town.

There was general agreement at the discussion that another valuable side-effect of fundamental research is its ability to excite, inspire and attract young people into science.

BUILDING UK CAPACITY

Further along the educational pipeline, PhD students and post-doctoral researchers are also attracted into research by the excitement of addressing the big, fundamental questions. Most research funding goes into the salaries of post docs and post grads who go on to work in a wide range of fields including applied research and directed programmes.

Participants in the discussion identified the training of PhD students as the most vital element of knowledge transfer. PhD students were seen as the UK's most important asset – "the only thing we've got to keep us ahead of the rest of the world". As well as developing their own research skills, training research students builds "absorptive capacity", the ability to absorb and exploit the 95% of research done outside the UK.

Young researchers, with prepared minds able to recognise the potential applications of discoveries made through fundamental research, were identified as one of its most valuable byproducts. They will provide the cohort of scientific entrepreneurs who will start the next generation of innovative UK businesses, just as they are the magnet that attracts research-intensive industries to invest in the UK.

CONCLUSION

Physicists undertake fundamental research for one prime reason – to enhance our understanding of the world we live in. But over time their work generates other hugely significant benefits – the development of radical new technologies; the inspiring ideas that draw young people into science; the capacity of our industry to meet new challenges through innovation.

In making the case for fundamental research, IOP is not seeking to penalise applied research, or directed programmes. We believe it is possible to optimise the performance of both basic science **and** UK plc by striking the right balance of funding between applied research, for which private sector investment may be the most appropriate route, and fundamental science, for which public funding is generally the only support available.

Fundamental research is an outstanding investment for society. IOP urges policy makers of whatever party to recognise its value and commit to its long-term support.