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COMMENTARY

Investing in science: securing future prosperity

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ABSTRACT. A meeting concerned with UK science and technology investment was held at Chatham House, London, in November 2010. The UK science and technology research budget has been preserved at a fixed cash level whereas other areas of government face significant reductions in their financial support. This is in marked contrast to some East Asian countries, such as China, where investment in science and technology is increasing. The UK needs to change many aspects of education at school level and beyond to preserve its status as a first rate scientific country. It also has to solve the long-term problem, with some notable exceptions, of being unable to translate basic research discoveries into manufactured products. This article discusses the impact of these issues along with some tentative suggestions on how to improve these, with particular reference to the radiological sciences.

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6 years ago the government presented its strategy for increasing science investment, a summary of which was published in the *British Journal of Radiology* [1]. At the time there was scant attention to radiation related research in healthcare, but since then the position has changed. Examples include large awards of basic technology funds for two new strategies for charged particle acceleration for cancer as well as partnerships between the Engineering and Physical Sciences Research Council (EPSRC) and Cancer Research UK (CRUK) on imaging research. Additionally, the Gray Institute was formed in Oxford to revitalise radiation research in oncology. Such developments may yield useful and interesting solutions to diagnosis and therapy of cancer.

Now, however, the financial situation has changed. The government has announced deep reductions in public spending, while retaining a constant cash level of funding for scientific research. ''Investing in Science: securing future prosperity'' was a 2 day meeting held at Chatham House, London, on 22–23 November 2010, and was attended by 137 delegates from academic, industrial, publishing and other disciplines with international participation. Fortunately, as the meeting was not subject to formal ''Chatham House Rules'', it is reportable.

The following account is a summary of the present state of science in the UK with some international contrasts. It is presented from the special standpoint of medicine and physics and their interactions in the radiological sciences. It is not possible to mention all of the excellent speakers and discussions on an individual basis, but further information is available from www.chathamhouse.org.uk/science/-/speakers/.

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Presentations

UK government policy

David Willetts MP, as Minister of State for Universities and Science, summarised the recent comprehensive spending review (http://www.hm-treasury.gov.uk/spend_index.htm) with full acknowledgment of the importance of scientific knowledge and research for the benefits to the economy and society. The high ranking of British science and its widely respected freedom continues to produce high quality output from a relatively modest financial input when compared with other advanced countries. Although the science research budget is effectively frozen for the next 4 years, it has fared better than many other branches of government. So, for state-sponsored science activities, much will depend on the effect of monetary inflation between now and 2015. The official and rather optimistic expectation that inflation will keep within a range that can be matched by efficiency savings was doubted by many of the delegates. In the words of Lord Rees, the process may yet prove painful but at least is potentially manageable.

The effects of the fixed funding rate each year will be harder to manage in some parts of the research councils than others, depending on our currency exchange rate relative to other countries. This is especially the case for our present approximate £80m contribution to the Centre for Nuclear Research (CERN), Geneva, which currently has a high public profile, yet is taking an increased interest in particle beam radiobiology and therapy of cancer [2]. The value added tax increase in January 2011 will not affect medical research, which is exempt, but a further uncertainty is what the allowed capital expenditure will be. There are some useful research overlaps with the National Health Service (NHS) research and development allocations, which fortunately are preserved but could be squeezed by other priorities.

The defence budget, as explained by the minister, Peter Luff MP, has been reduced by less than that of the remaining branches of government. It also has an important research budget, some of which overlaps with healthcare (*e.g.* the management of acute blast injuries, trauma and intensive care) as well as other spin-offs from cyber and security related projects, some of which involve imaging, as well as the usual radiation hazards.

Many government senior scientific advisors gave impressive presentations. It was interesting to learn that the only branch of government that does not contain such advice is HM Treasury. This is to be expected since its function is to raise taxes and curtail expenditure within reasonable limits, while attempting to expand the economy.

Further, heads of research and development of a variety of industries from the UK and other countries presented data about their large contributions to national and international research activities. The global aspect of business has yet to be matched by governmental global research funding initiatives, with some exceptions such as CERN and the World Health Organization, although it is fair to state that UK research councils have accepted long ago the need to fund research at laboratories and clinics abroad if necessary.

Most attendees agreed with Brian Cox (University of Manchester, UK) that the UK research and development budget should be at least restored to its 1986 level relative to gross domestic product, which amounts to around a doubling of what will exist in 2014. Innovations clearly should depend on a combination of fundamental research and more deliberate application of known basic science, taking into account the demands of potential customers. At least in healthcare, the general public are intimately involved in the process, although somewhat paradoxically they are rarely consulted formally for ''product-related'' advice.

The words of our scientifically trained former prime minister, Margaret Thatcher, were quoted only once: when strongly advised to discontinue all UK involvement in CERN, she then read a short summary of its research and defeated her advisors by saying ''that's very interesting isn't it?'' She probably did appreciate the eventual benefits that would accrue from such fundamental and curiosity-driven research.

Scientific publishing and education

There were important contributions from journal editors and prominent scientists concerned with public awareness and education. Two examples of areas in Britain were given where the availability of physics teaching in schools is limited (in the Blackpool area, with over 100 000 population, there is only 1 physics teacher in 5 schools, teaching physics at advanced level to only 5 pupils; around Coventry there are 3 physics teachers in 19 high schools). The Institute of Physics has already had to provide advice to biology graduates on how to improve physics teaching in schools. There is a similar problem in teaching mathematics. These situations augur badly for UK science and technology.

Worldwide aspects

In Europe, the Seventh Framework Programme (FP7) and special shared institutes like CERN continue, but there are new initiatives such as a single market for research and young principal investigator awards. It will be interesting to see if such consortia develop elsewhere in the world. France leads Europe in signing formal agreements for co-operative research with other countries, as explained partly in other *British Journal of Radiology* articles [3, 4], with the UK lagging far behind other European Union states.

Elsewhere, in China and India, for example, scientific publications will soon outstrip the western world, as will spending on science and technology, with the expectation of large future gains in prosperity. The Chinese government plans for a ''green'' economic expansion driven by innovation at low cost. One notable example of involvement within China is that of the pharmaceutical company Merck, who have established hepatitis B vaccination production sites and other facilities in China over the past 20 years; the incidence of hepatitis B has subsequently fallen from 10% to 1%. However, developing countries need to be careful about engaging with too much blue-sky research, which is initially parasitic of their resources, although capable of producing many benefits in the longer term; instead, concern about water purity, agricultural yields to relieve starvation and tropical diseases are a far greater priority. ''Science diplomacy'' is a possible way of improving communication between previously unco-operative countries, while providing friendly but pertinent advice.

Many countries have not so far excelled in interdisciplinary projects, where researchers need to have broad understanding of their collaborators' objectives. Western countries appear to maintain a lead in this respect. Examples are obvious, most imaging research in medicine is applied physics, while bio-informatics is heavily dependent on computer science. Broadness of training and ''discipline-hopping'' are important to make progress. More applications of systems engineering to biology and medicine are likely to improve efficiency of agriculture as well as the quality of healthcare.

Nearer to home, there were criticisms of UK research impact assessments. In the rather perverse case at Oxford University, the largest commercial output from a single researcher has been JR Tolkien, for his *Lord of the Rings* trilogy that, in a formal research assessment exercise (RAE), would imply that considerable resources should be diverted to the Department of Anglo-Saxon studies! However, the continued importance of the humanities must be respected and they have much to contribute alongside science.

Public involvement

Many speakers appealed for more public involvement in science and a greater appreciation of scientific methods; even recruitment to clinical trials might benefit from such engagement. The societal dangers of some pervasive pseudoscientific beliefs were also raised. Despite this, many presentations contained crude correlations that do not necessarily prove cause and effect, for example the observation that therapeutic abortions are associated with mental instability later in life. Such factual data should not be dismissed, but must be studied further. Quantitative social sciences research and good data sets are relatively sparse and are infrequently used by government at the present time. Another vexing problem is international law; scientists can face lawsuits drafted in other countries and protective legislation is indicated.

Nomenclature is another issue for public awareness and radiology in particular. The abrupt change of nuclear magnetic resonance (NMR) to MRI, in order to decontaminate the brand of any associated radioactivity, was highlighted by an Oxford astronomer (Katherine Blundell), whereas the CT scanner nomenclature denies radiation exposure when it actually exists. These two techniques were UK discoveries, which resulted in Nobel Prizes being awarded to Godfrey Hounsfield and Peter Mansfield. But the failure to develop these elegant discoveries into viable long-term products by British industry failed to realise economic advantages. It was paradoxical that the country of discovery could barely afford to purchase the evolving commercial products from abroad; the British public were highly dependent on purchases of scanners by charities and the shortage of such equipment must have contributed substantially to diagnostic and therapeutic delays, leading in turn to disappointing cancer survival in the UK.

Discussion

The present state of UK science reflects, at least partly, the provision made to schools, universities and other institutes over the past 20–50 years. More recent funding reductions *e.g.* during the 1990s may yet cause adverse effects. If quality of life is dependent on educational attainments, the UK has traditional strengths but many acquired weaknesses, which must be overcome. The past enthusiasm for replacing agriculture and downgrading industry in favour of financial and other services including information technology must now be accepted as having been a serious mistake; judicious combinations of all these approaches to economic benefits are essential. It is noticeable that if direct taxation is used to fund healthcare, then industry and the other sectors of the economy have to produce sufficient wealth to allow progress, but individuals are now spending more of their earned income directly on health-related services. However, any assumption that the latter route will grow with time depends upon an expansion in general economic prosperity.

Greater sharing of biomedical research costs is an attractive possibility. One immediate example is the recent finding that the low energy ion ring (LEIR), which supplies heavier ions to the Large Hadron Collider at CERN, is redundant for close to 80% of the year, which opens up the possibility of biomedical research *i.e.* rare isotope production, particle radiotherapy and space-medicine studies. This would be a sensible use of scarce budgets, by sharing between nations, during financially restricted times.

The present author, as an NHS cancer specialist for 22 years, has experienced considerable public interest in science during consultations with patients and relatives of nearly all ages. In contrast, teaching of medical students has become more difficult since many have poor scientific backgrounds and have never studied physics as a single subject. Some solutions to the problems faced by the UK are proposed:

- Our high-quality science journals might collectively produce a journal specially designed for schools where the coupling of an experienced teacher and a researcher is used to produce a range of articles targeted at pupils in the first few years as well as the middle years of the secondary school curriculum, perhaps concentrating on numeracy at the same time. One advantage of such an approach, if it is free at the point of delivery by internet downloading, might be that parents would also read such articles with interest and public awareness of science and scientific methods might improve.
- The settlement of the new UK Maxwell Institutes, designed to improve academic–industrial collaboration, might be used to persuade some of our older and most prestigious universities that doctorate courses of longer than 3–4 years might be allowed for industrially experienced students who could continue to work within their companies. This is at present a problem not only for industry, but also for NHS physicists, who need to resign from their posts in order to study for a PhD at some universities. This is in marked contrast to medical graduates, who in some instances are allowed up to 6 years to deliver a doctoral research thesis. There would be some advantages for longer-term developmental work between academia and industry if this were to be tolerated, but only if there were to be no reduction in academic standards.
- A greater acceptance that translational research in medicine is equally valid between the physics laboratory and the clinic in the same way as from the molecular laboratory to the clinic.
- Greater attention to numeracy and mathematical modelling within medicine should provide considerable advantages, for example in situations where clinical trials cannot be performed, or to eliminate combinations or temporal sequences of modalities that are unlikely to provide benefits, while indentifying those that have a high probability of being successful.
- The joint ''concordats'' in science and medicine with France must be encouraged.

There was no hint of any grand new projects, on the French pattern, apart from continuing with the Diamond Synchrotron Phase III and the St Pancras medical initiative. Other advanced countries are doing much more.

In terms of my own preference for charged particle therapy for cancer, the UK will by 2015 allow NHS tariffs at two or three specified hospitals that deliver proton therapy only and without an impressive research and development structure. This will mean that Germany, Italy, France and Austria within Europe, and Japan more distantly, will have more versatile beams using ranges of light ions and backed by ambitious research commitments. Unless the large cancer charities such as CRUK intervene, in partnership with a leading university and the Science and Technology Facilities Council (STFC) laboratories joined up with EPSRC and the Medical Research Council, the prospect of implementing the basic technology grants (referred to in the Introduction) seem remote and it must be questioned whether British industry retains sufficient expertise to manufacture and export such technology. Repetition of past failures to commercialise CT and MRI scanners may yet bring further national humiliation.

Many of these ideas involve relatively small amounts of money. Perhaps the time is ripe for parts of the financial services industry to be overtly associated with such developments for the benefit of the public. This might engage public opinion, heal recent rifts and lead to a more harmonious society. There is, as always, a role for large public and private benefactions from industry, including that of private healthcare.

Conclusion

To maintain its scientific reputation, the UK must use its intellectual freedom to innovate in order to address many of the demands of the present and future centuries. Within the medical sciences, the UK should aspire to change from ''catch-up'' to a more leading role. It is vital to engage the public more and improve education in science.

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