ECONOMIC DEVELOPMENT AND TRANSPORT COMMITTEE

Date: 2 March 2006
Time: 2.00 – 5.00
Venue: Committee Room 2, Assembly Offices, Cardiff Bay
Title: Institute of Physics

23 February 2006

Ms Christine Gwyther AM
National Assembly for Wales
Cardiff Bay
Cardiff
CF99 1NA

Institute of Physics

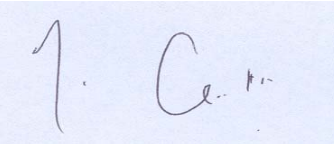
Dear Ms Gwyther

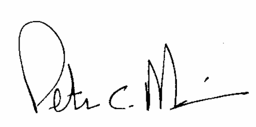
A Science Policy for Wales

The Institute of Physics is a leading international professional body and learned society, with over 35,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied. The Welsh Branch of the Institute, known as The Institute of Physics in Wales, has around 900 members. Our activities are summarised in Annex 1, including details of our support for physics education in secondary schools, in HE institutions and for outreach and public engagement.

The Institute welcomes the opportunity to respond to this important inquiry. The attached document highlights some key issues of concern to us and we look forward to discussing them further with your committee in our forthcoming meeting.

Yours sincerely





Professor Michael Charlton
Secretary,
Institute of Physics in Wales

Professor Peter Main
Director, Education and Science
Institute of Physics

Institute of Physics

An Institute of Physics in Wales Submission to the National Assembly for Wales EDT Committee Inquiry : A Science Policy for Wales

Introduction

The Institute is regularly asked for its views on aspects of government policy which impact on its role as a professional representative body. Three recent documents which the Committee may wish to consult are annexed electronically to this submission. The documents are entitled “Science and innovation: working towards a ten-year investment framework” (an Institute response to a joint HM Treasury, DTI and DfES consultation; 30th April 2004), “Strategic science provision in English universities” (an Institute submission to a House of Commons Science and Technology Committee Inquiry; 28th January 2005) and “Research council support for knowledge transfer” (an Institute response to a House of Commons Science and Technology Committee Inquiry; 16th February 2005).

The Institute is about to introduce new National and Regional Officers. The role of these new appointments will be to increase the activity, profile and influence of the Institute with national and local government and their agencies. The current budget is for a total of 6 full-time-equivalent staff across the UK, with one post for Scotland, a 0.5 post for Wales and 4.5 posts covering the English regions. The existing National Officer for Scotland works closely with the Scottish Parliament, and it is envisaged that the new National Officer for Wales would develop a similar relationship with the Welsh Assembly and the Welsh Development Agency.

Two Welsh Institutions (Cardiff and Swansea) participated in the recent International Review of UK Physics and Astronomy. This periodic exercise is co-sponsored by the Institute with the Royal Astronomical Society and the UK Research Councils which fund physics and astronomy research, EPSRC and PPARC. The visiting panel has recently reported, and two of their general remarks may be of interest to the EDT Committee:

> “Curiosity-driven research is important in its own right and attracts the most able people into physics and astronomy, but it is also the foundation for the improvement of the quality of life and wealth creation in a knowledge-based society. The Panel has noted that some of the new money entering the science base has been tied up with specific initiatives. Many of these initiatives may be of strategic importance to the UK. However, the Panel is concerned that this could be a creeping trend that could undermine the opportunities of physicists and astronomers to follow their instincts in research, and the UK’s ability to pursue curiosity-driven research at the highest level. *The Panel recommends that the research councils monitor the balance between targeted and curiosity-driven research to maintain a healthy balance between the two funding streams.”*
>
> “The Panel is of the view that physics has a unique place in a knowledge-based society, as a discipline that underpins the other core sciences and engineering. The Panel is deeply concerned that physics has ceased to be an identifiable discipline in a number of UK universities. A continuation of this trend would threaten the UK’s ability to produce the volume of physics graduates needed to compete on an international basis. *The Panel is disturbed to find that the financial health of university departments is to a significant degree dependent on undergraduate numbers, which themselves depend upon career choices of young people in the secondary system. This is not a good basis for strategic planning of the science base.”*

We concur. The physical sciences and, in particular, physics, mathematics and computer science are the strategic disciplines that fundamentally underpin technology and technological advances. Unfortunately, funding their activities within the current UK HE system is fraught with difficulties, which stands to jeopardize the national economy.

In future, inter- and multi-disciplinary research will be increasingly important in some areas (e.g. nanotechnology, nano-medicine) and in other areas generic new technologies will drive the science (e.g. visualisation and VR). The strengths that expert physical scientists can bring to these emerging areas must not be underestimated.

The Welsh Physics Scene – a Brief Summary

Physics in Wales has areas of significant strength, including particle physics theory and fundamental atomic physics at Swansea, materials physics at Aberystwyth, Bangor, Cardiff and Swansea, astronomy and astronomical instrumentation at Cardiff, solar system physics at Aberystwyth, gravitational physics at Cardiff and optoelectronics at Cardiff and Bangor. There is a healthy representation of what are loosely termed “pure” and “applied” physics here.

Wales has around 70 academic scientists working in identifiable physics and astronomy-based units in four HE institutions. This total is fewer than the number in several individual departments of physics in England and the total lags that in Scotland by a factor of about three.

Recent measures, in particular the HEFCW Reconfiguration & Collaboration fund, have begun to address some of these sub-critical mass problems in the Welsh system. For instance, a successful application has been made to this fund to establish the *Centre for Advanced Functional Materials and Devices* - a collaboration between the Institute of Mathematical and Physical Sciences, Aberystwyth and the Schools of Informatics and Chemistry at Bangor. This development explicitly cited the need for a sound base in science and technology, in an interdisciplinary environment involving researchers working at international level, for the success of the Welsh economy.

Wales has research stars in physics and astronomy, and in the wider physical sciences, engineering and mathematics. The prestige that these individuals bestow on our HE institutions is incalculable. Wales has too few of these stars across the board – this is an issue that the Science Policy should address.

Scotland – a Snapshot

Scotland's Physics Departments have recently formed a strategic alliance (SUPA, Scottish Universities Physics Alliance; see www.supa.ac.uk) which has received funding of £6.9M over a 4-year period from the Scottish Funding Council (SFC). An extract from the SUPA website is given below which encapsulates the aspirations of the initiative.

> "Six Scottish Universities have come together to form a research alliance in Physics. The aim is to place Scotland at the forefront of research in Physics through an agreed national strategy, an inter-institutional management structure, and co-ordinated promotion and pursuit of excellence. Adopting a coherent approach to staffing strategy, research training, research initiatives and funding opportunities, SUPA will pool and enhance Scotland's strongest Physics research areas and will develop as a world leader in Physics, creating the largest group of Physics researchers in the UK. It is also intended as a single "front door" for potential staff, sponsors, and industrial collaborators."

Note that SFC is promoting other alliances amongst its HE institutions (e.g. ScotCHEM, EaStCHEM, the Scottish Bioinformatics Research Network and the Edinburgh Research partnership in Engineering and Mathematics).

Science Policy – a Commentary

General

The formation of a creativity- and knowledge-led society in Wales is vital for the future of the nation.

It is well recognised that there are several problems facing the government and its agencies in achieving this aim. These have been eloquently set out in other submissions to the EDT Committee. They include the poor uptake of science in HE, the paucity of suitably trained secondary school teachers in certain areas (including physics), the lack of women entering science disciplines (particularly physical sciences) the endemic under-funding of many aspects of the activities of science and engineering departments in HE and the facilitating successful business-academia links.

Many of these problems are deep-seated and inter-related and some of them can be addressed by actions directed towards the funding of science, engineering and mathematics disciplines within HE institutions, the overlap of HE institutions with industry and HE outreach activities.

Wales urgently needs a Science Policy. Framing such a policy is a massive opportunity. It should be widely discussed, and engage and involve representation from all stakeholders in science in Wales. This should include industry, academia, education (both primary and secondary and those involved in ITT) and the general public. Expert advice from outside Wales should be sought as necessary.

The Science Policy should be bold – adopting best practice from elsewhere where appropriate and seeking imaginative ways forward otherwise. Broad support from all stakeholders and unanimous support from Wales Assembly Government is essential.

People

Our double-sided motto should be “train and retain”. And “retain and train”. The workforce needs to be re-educated and constantly refreshed with young talent. It is advisable that we import talent to drive standards higher. Some suggestions are made with regard to the HE sector below. Evidence presented by the Royal Society emphasizes the fact that Welsh school children are more likely to leave Wales for their HE experience – the consideration of measures to stem this tide are an appropriate Science Policy concern.

A workforce trained at many levels (technical, scientific and managerial) both to contribute to, and adapt to, the worldwide knowledge base is vital for Wales. It seems clear from the submissions of other bodies to the EDT Committee that Wales is lagging nationally and internationally. In the face of a rapidly changing world economy, this situation is potentially disastrous for Wales.

We offer the following suggestions to stimulate the thinking of those who will formulate Wales’ Science Policy.

> Consideration should be given to making student bursaries available to pay all, or a significant part of, the tuition fees, to talented students from Wales to study a scientific discipline at undergraduate level in a Welsh institution.

Offer, on a competitive basis, postgraduate scholarships to attract bright Ph.D. students to Wales, irrespective of their country of origin. Such an initiative could bring huge rewards since RCUK studentship funding does not have this flexibility.

Funds could be set aside to attract research stars to (back to?) Wales. Such a funding stream should be competitive and have a strategic focus, which should be reviewed. Universities might, for instance, bid on an annual basis.

Outreach
Consideration should be given to make funds available to support outreach and public engagement activities. Research scientists have neither the time nor the expertise to do enough of these activities to promote science. Dedicated local outreach officers could be established, with a clear remit and a realistic budget.

HE/Industry Interface
There are examples of excellence in Wales involving HE/ Industry collaboration. These include the Welsh Optoelectronics Forum. OpTIC Technium, Technium Digital and Technium CAST. There are also interesting physics-based initiatives underway across Wales in the micro- nano-technology areas which may eventually be commercially exploitable. These should be nurtured and best practice from elsewhere adopted in an effort to encourage academics to consider business and industry. Examples might be Business Fellow schemes (e.g. that operated by the London Technology Network). The Royal Society has recently introduced a scheme, in co-operation with the Tanaka Business School at Imperial College London, called “Leading in Science: Innovation and the business of science”. The aim is to introduce its young research fellows to the role of science in the economy and invite them to consider their own research and the potential for commercialization.

The annexed Institute document “Research council support for knowledge transfer” (a response to a House of Commons Science and Technology Committee Inquiry; 16th February 2005) makes important points of relevance to the interface between academia and industry. Though directed at the UK Research Councils, the suggestions made are largely generic.

The notion that academic researchers are sitting around ready to undertake short-term projects for industry is a myth. Mechanisms need to be found, though, to put industrialists in contact with scientists doing world-class work of relevance to their operations. It is the recruitment of people to support both industrial executives and research scientists, and the mechanism set up to deliver effectively at this interface, which is vital.

Annex 1: Summary of activities of IoP Wales

Currently, the Institute of Physics in Wales has around 900 members, who are distributed through Wales as follows: North (14%), Mid (8%), South West (16%), South East (36%). The remaining 26% of the membership reside outside Wales.

With such a spread out membership, it is increasingly important that we focus our activities and, where possible, work in partnership with other professional bodies and institutions on a local level. In practice, this means arranging joint talks with organisations such as the IEE, and local scientific and astronomy societies. It also means continuing to support activities that either promote the study of physics as a discipline, or that lead to an increased awareness of the role that physics has to play in the world that we live in.

Events for members tend to be organised on a regional basis by local co-ordinators based in Aberystwyth, Bangor, Cardiff and Swansea. Typically there are two talks per location each year.

Support for Secondary Education

There is an existing Physics Teachers Network in Wales which is run by three area co-ordinators, all of whom are members of the Institute of Physics in Wales. The Institute of Physics in Wales provides speakers for the annual Welsh Physics Teachers meetings that take place in Brecon and Dolgellau and provides local organisation for the Institute of Physics Schools' and Colleges Lecture, which is held at three venues in Wales each year. We organise the annual Paperclip Physics competition for schools, in which teams of 3-5 students have to demonstrate a physics concept in a novel way using only household items. Members of the IoP in Wales play an active role in the teacher-scientist network, with a number having developed on-going relationships with teachers.

Support for Higher Education

The majority of talks organised for members are hosted by the Physics Department at the local University, so the topics are often close to the research interests of the staff who work there. We provide support, where we can, for undergraduate student physics societies, and also provide bursaries to enable student members to attend conferences.

The Institute of Physics in Wales offer careers advice by calling on the services of a specialist careers adviser, who is based at Institute headquarters in London.

Support for Outreach and Public Engagement

The Institute of Physics in Wales aims to work in partnership with the organisers of national events in Wales, and members regularly contribute to the annual National Science Week, which takes place in March each year. We also contribute activities to both the National and the Urdd Eisteddfods.

Other events which we have supported financially in recent years include the Cardiff Science Festival (2006) and the North Wales Schools' Science Festival.

Individual members of the Institute of Physics in Wales contribute in many other ways, e.g. providing talks for the Science Cafes which have spread recently throughout Wales.

Institute of Physics

Annex 2

Strategic science provision in English universities

An Institute of Physics submission to a House of Commons Science and Technology Committee Inquiry

A full list of the Institute's responses and submissions to consultations can be found at http://policy.iop.org/Policy/public.html

28 January 2005

28 January 2005

Clerk to the Committee
House of Commons Science and Technology Committee
Committee Office
7 Millbank
London
SW1P 3JA

Institute *of* **Physics**

Dear Sir/Madam

Strategic science provision in English universities

The Institute of Physics is a leading international professional body and learned society, with over 37,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied.

The Institute welcomes the Committee's Inquiry, as we are extremely concerned about the future viability of a number of university physics departments in England. Recent high profile announcements about the Universities of Newcastle and Keele discontinuing their core undergraduate physics degree programmes have done little to allay fears of the Institute and its community.

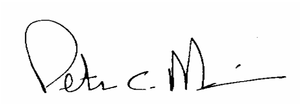
As the Committee may well be aware, since the turn of the new Millennium the Institute has been active in highlighting the emergence of 'physics deserts', regions in the country where there is no university provision for undergraduate physics. It was reported in the Institute's report of 2001, *the Undergraduate Physics Inquiry,* that since the removal of the binary divide, the economics of university physics departments has led to over 30% of them having either merged or closed. The current figure, following the merger of Manchester, and not accounting for Newcastle and Keele, is 48 in the UK, of which 36 are in England. If this pattern continues, we could be left in a position where many potential physics students are unable to study physics at their local institutions.

We are in the process of talking to HEFCE with regards to the demand side problem of getting more students interested in physics at A-level and undergraduate degrees. But this is a long-term solution, by which time the 'desert' could be encroaching into further regions of the country.

The attached annex details the key issues of concern to the Institute, in response to the main points issued in the call for evidence.

If you need any further information on the points raised, please do not hesitate to contact me.

Yours faithfully



Professor Peter Main
Director, Education and Science

Institute of **Physics**

Strategic science provision in English universities

Recommendations

The following issues need to be addressed as a matter of urgency in order to safeguard the provision of undergraduate physics in English universities:

- The HE market must take into account the needs of employers and the strategic need for more scientists and engineers. There is already capping of course entry in some subject areas, such as medicine or teacher training; it is not unreasonable that this level of control should be introduced elsewhere.

- The HEFCE funding model must be adjusted to provide appropriate funding for physics, as their teaching funding method from 2004-05 will lead to a 1% cut in funding for university physics teaching. If the Government is serious about its commitment to world-class research, more money needs to go into physics departments. Physics is a subject that links with industry on a long time scale; it is difficult to attract direct industrial funding, since companies are usually interested in a 3-5 year payback. However, the equipment and staff costs for running a physics department are as high as for any engineering department.

- A realistic solution to the problem of the missing part of FEC for charity and EU funding is required. The principle of transparency in use of funds argues against using funding from one area to subsidise work in other areas. Charity support is not equally distributed over all sciences, but is concentrated in medical areas. It is good that universities have some freedom in deciding how to use their HEFCE income for strategic developments, but it should not be the norm that QR income 'earned' by research excellence for example in a physics department could be used to fund the missing FEC for charity-funded medical research. The logical consequence of transparency is that if the Government wants to get the benefit of charity and EU funding, it should either work with those bodies to get them to pay the full FEC, or it should decide to provide explicit funds to top-up charity and EU grants.

- Schoolchildren must be provided with accurate careers advice at a sufficiently early age to allow them to make informed choices. Currently, careers advice tends to be reactive. For example, advisors will respond to a pupil's request on, say, how to become a doctor but they do not provide information on the relative career opportunities of different subject choices. If we are serious about persuading more students into science, we have to tell them explicitly that their career prospects will be better if they do. The Connexions initiative is useful in many ways, but does not provide any subject-specific information.

- We need more specialist teachers of physics. With only around 2,500 UK graduates in physics and astronomy each year, the shortage cannot be rectified from that source in the short to medium term. One small change that could help a little would be to allow physicists to teach mathematics as a second subject. However, we are faced with the situation that much of the teaching of physics will be done by people who do not have a background in the subject. There should be a subject-based, professional development obligation on all teachers of science operating outside their level of specialisation.

- The physics curriculum needs to be reviewed to ensure it is attractive and exciting, reflecting modern applications and advances. The Institute has developed an A-level, Advancing Physics, with this aim in mind (there are others). Although it is the second most popular A-level, many non-physicists find it too demanding to teach, due to the subject knowledge it requires.

- The solutions to the problems facing physics departments are of a medium- to long-term nature. However, if the situation worsens, then there may be a need for the Government to intervene with a short-term fix, by providing funds (possibly with strings attached to encourage change) to prevent several more struggling physics departments from closing.

The impact of HEFCE's research funding formulae, as applied to Research Assessment Exercise ratings, on the financial viability of university science departments

The Institute is extremely concerned about the level of funding for 4-rated physics departments in the RAE 2001, of which there are a significant number.

The Institute notes that HEFCE has recently announced that they will increase the average unit of funding by approximately 4% for 5 and 5* rated departments, and maintain funding in real terms for 4-rated departments. This is pleasing, as the Institute understands that the £118 million allocated by HEFCE through their present formula for 4-rated departments was not initially linked to inflation. However, 4-rated physics departments in England received only a little more than half of the QR funding they had anticipated from HEFCE for 2003-04, with the threat of even less in subsequent years. As a consequence, the Institute is concerned about their future viability and the marginalising impact this would have on physics if 4-rated departments were unable to continue to teach and produce distinct physics courses. Despite HEFCE's announcement, additional funds are needed for 4-rated departments; otherwise, by the time RAE 2008 is underway, it may be too late to prevent a number of 4-rated physics departments from closing, or at least cutting back severely on their research activity. The position of 3a-rated physics departments of which there are a few, is even more precarious.

HEFCE stated in its review of research funding consultation in 2003 that they propose to review the basis for subject weightings and to calculate new weightings to be used after the next RAE. This is something that the Institute would welcome, if it leads to an increase in the subject weighting for physics. The QR allocation per active staff member in physics in 2004/5 is: Grade 4, £10,376; 5, £28,981; and 5*, £34,886. Interestingly the QR allocations for physics are only marginally above the averages for all UoAs of £9,980, £26,346, £31,498, respectively.

The disparity in QR funds available to 4-rated departments relative to 5 and 5* means that 4-rated departments have been scrutinised closely by university managements with a view to either closure or investment to improve their grade. This was certainly the case with the University of Newcastle, which was constantly reminded of the strong correlation between their RAE grade and the size of its physics department. The average number of staff submitted by physics departments achieving a 5* grade in 2001 was 104, grade 5, 39 and grade 4, 19. We understand that it was then argued that with a Newcastle physics department submission of 14.5 staff achieving a 4B grade (which fell further following restructuring), the university could not afford the investment in physics staff and facilities required to achieve a 5 or 5* grade.

Physics is a research- and capital-intensive subject that is dependent upon up-to-date laboratories and new pieces of equipment, and has suffered from under-investment and a lack of sufficient infrastructure funding for some considerable time. This is demonstrated by the fact that, despite their success in the RAE 2001, even 5-rated departments (especially the smaller ones) are experiencing difficulties and are facing tough decisions with regards to the number of permanent staff they can retain. One of the reasons for this is that physics members of staff in 5-rated departments are being funded from the QR associated with their RAE rating at much lower levels than chemists, and up until recently biologists, in departments with grade 5 ratings. This state of affairs is a direct consequence of the closure of the smaller and, in some cases, weaker departments over the last decade or so. Other subjects have much longer 'tails' in their distribution of RAE grades. Paradoxically, the presence of a large number of weaker departments actually increases the funds given to the best, because it increases the size of the overall pot for the subject. Equivalently, even the strong physics departments are suffering from the closure of the weaker ones.

The desirability of increasing the concentration of research in a small number of university departments, and the consequences of such a trend

There is no doubt that HEFCE believes that there are too many research-based physics departments. However, the much quoted 'autonomy' of universities (the Government itself has created the environment that influences the decision making of many vice-chancellors) and the absence of any clear strategy in this area have meant that closures have occurred haphazardly, often resulting in regional deserts. It follows that there should be rational planning, identifying the number and location of the research departments. Undoubtedly, this will be a painful exercise but it should be done as openly and as fairly as possible.

The implications for university science teaching of changes in the weightings given to science subjects in the teaching funding formula

Recent changes in the weightings given to laboratory based science subjects in HEFCE's teaching funding formula have been disastrous; the funding provided was already seriously deficient, as a consequence of the overall support per science student having steadily decreased in real terms over many years.

Having continually argued for HEFCE to monitor and review the price groups allocated to the laboratory sciences, in order to maintain the existing high standards in undergraduate physics, the Institute believes that physics, as well as many other science and engineering disciplines, will suffer further under the new weightings. As of 2004-05, the weighting of 1.7 for price band B, which includes physics, will lead to a reduction in real terms of 1% in the teaching resource (confirmed in a response to the Institute from HEFCE, February 2004).

The rationale behind the new weightings is not clear. HEFCE initially recommended a split of price band B, to give five bands. The Institute understands that a decision was made not to split price band B, because the high unit costs of some laboratory-based sciences, including physics, were perceived to be a result of under recruitment. But this is far from obvious because:

- physics undergraduate numbers have not fallen (acceptances to undergraduate physics and astronomy were 3102 in 1994, and 3068 in 2003 (UCAS));

- departments have closed and large departments have become even larger leading to efficiency of costing, and

- deficit departments have severe limits on spending and so their spending will possibly have been lower than one might expect.

At a time when the Government is trying to encourage more students into science and when several physics departments are struggling to survive, it is hard to see why there should be an incentive for universities to recruit yet more students into arts and humanities degrees. The potential impact of top-up fees appears not to have been taken into account - the broadly 'flat' increase from fees could mean that HEFCE will need steeper bandings.

Physics is by its nature a resource-intensive subject to teach, in terms of both teaching staff and laboratory provision. As industry's demands for graduates with a high degree of technical knowledge and expertise increases, it is incumbent upon universities to have modern facilities and equipment. The cost of providing such equipment has risen at a faster rate than inflation. Universities are under pressure for resources for undergraduate teaching, and in the Institute's experience over the past few years, the majority of physics departments have been operating at a deficit.

The optimal balance between teaching and research provision in universities, giving particular consideration to the desirability and financial viability of teaching-only science departments

The Government's HE white paper hinted of the establishment of a two-tier university system, where research would be concentrated in a few centres of excellence. This would undoubtedly boost research effort, but at the expense of separating more strongly than at present those universities with a strong research base from others that might become teaching only universities. Any such move would have to be planned in an organised manner, and it needs to be understood that this approach may not provide the undergraduates that the country so clearly needs.

However, assuming that the Government decides to limit the number of research departments, there could be two models for producing the graduates. One would be simply to increase the intake for the remaining universities. This approach has several problems. It may not be possible to accommodate the students in laboratories and classrooms without substantial new build. In addition, it does not address the problem of regional deserts. The alternative is to create a new class of physics departments that do not carry out research competitive in the RAE but that can teach physics at the undergraduate level. The problem then would be to find a way of sustaining such departments. One way would be to make them teaching only, possible as part of a larger, multidisciplinary unit. Another would be to give them a role working with regional or national industry, with the support of the RDAs. In either case, these departments could offer three year Bachelors degrees in their own right, while acting as feeders for the students who wished to complete 4-year MPhys/MSci degrees at the research departments. Such students could spend the final two years of their programmes at the research departments. But, this model (and any other model that requires teaching-led departments) will have to be adequately sustained.

The US is an example of a successful mixture of types of institutions. There are several highly esteemed undergraduate colleges (e.g. Dartmouth, Swarthmore) where faculty may conduct some research in the summer months, but the emphasis is on teaching. Most universities do both teaching and research, with a range of weightings. The US example leads us to think that there is no one ‘optimum’ and it is preferable to let each institution determine its own balance. The current funding system in England doesn’t seem to allow such a choice, with departments dependent on research income for survival.

The importance of maintaining a regional capacity in university science teaching and research

Large areas of the population and industry now have no convenient access to a local university physics department offering teaching or research. As the proportion of students living at home increases (a THES survey undertaken in April 2004, revealed that a quarter of students live at home while studying, a higher proportion than estimated for previous years), and as industry becomes more dependent upon high-technology knowledge, these regions will suffer from a lack of proximity to university physics. The Government, rightly, is keen on increasing the number of women, ethnic minorities, lower social classes in science and engineering. Among these groups there is a greater likelihood of students wanting to live at home. But, if they live in the East Anglia region, where will they go to study physics? There is no undergraduate provision for physics at the Universities of East Anglia or Essex, and the University of Cambridge would not be a realistic proposition for many.

As another example, in the North East, there are substantial distinctions between the physics intake to the Universities of Newcastle and Durham, for example, in terms of geographical and social backgrounds. Newcastle has more locally-based students, many of whom perceive that they would feel socially less comfortable in Durham. Through a foundation year, Newcastle’s access has also been substantially broadened by admitting students whose background has contributed to entry grades that would prohibit direct entry to the first year. The withdrawal of Newcastle physics programmes will lead to a net loss of physics students in the region. It will send out a negative message to schools regarding physics and serve to degrade further the already weak science base in most regional schools.

The extent to which the Government should intervene to ensure continuing provision of subjects of strategic national or regional importance; and the mechanisms it should use for this purpose

To state the problem, physics departments are closing principally as a result of an inability to attract sufficient students to make ends meet, exacerbated by cuts in research funding in some cases. There are two reasons why some departments have found it difficult to attract enough students. One is that, although the number of physics entrants has not fallen dramatically in recent years, there has been no increase to match that of the total number of students in all subjects. The *relative* number of physics entrants, therefore, has fallen by around 40% in the last decade; the expansion in HE has largely been in subjects that do not require a specific skill or knowledge base on entry (e.g. psychology, drama, media studies etc). The second reason is that, without doubt, the HEFCE unit of teaching resource for physics is too low, as previously discussed. As a result, to maintain the level of their funding, the more popular departments have increased their student intake, sometimes by huge amounts, squeezing the smaller units, in many cases causing them to close.

One of the worst aspects of the closures is that they are occurring just at the time when analysts are predicting that the country will need an increase in science, particularly physical science, graduates. There is a need to stimulate a higher demand for physics degrees. Note that there is no shortage of demand from employers; indeed, that is part of the problem because so few of the graduates enter the teaching profession. In 2003, only 8% of the PGCE entrants covering science had physics degrees. But the HE market is not driven by employers, it is driven by student choice and there is no evidence to suggest that the choice is being made rationally. Somehow, careers advice to school students has to be made much more pro-active. The Institute would never want to prevent students from taking, say, history or media studies degrees, but it must be made clear to them that, by doing so, they will be severely hampering their career opportunities, both in terms of flexibility and pay. It would help enormously if the Government were to track graduates of various disciplines, possible via devices such as the census, to provide valuable, independent data on career prospects.

A recent report commissioned by the Institute and the Royal Society of Chemistry, *The economic benefits of higher education qualifications*, reported that the return of public investment for physics and chemistry graduates, and their earning potential was significantly greater than for a number of other, more popular subjects, and that only medics and lawyers are financially better off. The monetary value* of completing a degree level qualification in today's money terms stands at approximately £129,000. At the higher end of the scale, physics and chemistry graduates achieve additional lifetime earnings benefit (in today's money terms) of between £185,000 and £190,000. In addition, it currently costs the state approximately £21,000 to provide education to degree level for the average graduate. However, the value to the state in terms of tax and national insurance associated with earnings following qualification for an average degree is approximately £93,000 – for physics and chemistry, this figure is between £130,000-£135,000. Despite the fact that they are more expensive to teach (between £4,000-£6,000), the net income to the Exchequer is still much higher than for arts or humanities degrees. This message needs to be spread far and wide.

The shortage of physics teachers is undoubtedly already a matter of great concern and the situation will only get worse in the short term. The situation certainly won't be helped by the recent announcement that trainee teachers will be charged up to £3,000 a year in variable top-up fees from 2006, which will effectively reduce the £7,000 bursaries being offered to graduates who become teachers in physics, mathematics, etc. The Government should consider increasing the bursaries on offer to take account of the extra cost of training to become a teacher once variable fees are introduced, or give teachers help with their (tuition fee) loan repayments while they remain in teaching, so that the bursaries on offer remain as effective as possible in recruiting teachers into subjects, such as physics, that urgently need them.

Anyway, the number of trained physicists entering teaching will not be large enough to repair the damage for the foreseeable future. We have to live with the fact that the vast majority of people teaching physics at GCSE levels and below do not have physics degrees and need subject support.

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* The monetary value of a degree is defined as the difference in the present value of the after tax employment adjusted lifetime earnings of representative degree level holders compared to representative individuals in possession of 2 or more A-Levels. The monetary value incorporates earnings and employment effects in a five-year age band across the entire working life of graduates (as opposed to an overall snapshot). The monetary estimate is also discounted to provide an estimate of the value of a degree in today's money terms

The Government has recently introduced a number of initiatives to try to improve the situation with regard to the teaching of physics and the take up of university places in science and engineering. In the, *Science & innovation investment framework 2004-2014*, plans were unveiled for an increase to the aforementioned teacher training bursaries and golden hellos and, encouragingly, an intention to instigate a series of surveys to find out exactly who is teaching science in our schools. As the Smith Report, *Making Mathematics Count*, pointed out in the context of mathematics, this is an absolutely essential first step. One needs to know the full extent of the problem before one can solve it. Also on the teacher education front, the Teacher Training Agency, in collaboration with the Gatsby Foundation, has financed a scheme designed to encourage more teachers into certain shortage areas, including physics, mathematics and chemistry, by offering subject support to those who have the potential to teach but who do not have sufficient subject knowledge. In the physics scheme, the Institute is also involved, offering tutorial support and mentoring to the participants. In addition, there are various other schemes to help them, not least the Institute's own SPT Project, and the National Network of Science Learning Centres has put the infrastructure in place. What is now required is either a very effective carrot or an equally effective stick to ensure that the people most in need of this support actually take advantage of it. It is our experience, and that of comparable organisations in cognate disciplines, that the teachers most in need of help are the slowest coming forward. There is also a profound reluctance on behalf of head teachers to release staff for subject-specific INSET. Further Government intervention is absolutely necessary if we are to make a significant difference to the skills, knowledge and confidence of teachers of physics.

Finally, it is worth noting that, despite the recent decline, physics is still the third most popular A-level for boys. However, only 1 in 5 A-level students are female. Were we able to increase the number of female applicants to physics degrees, we would solve most of our problems immediately. Not least, it is known that women are more likely than men to become schoolteachers. On the other hand, an awful lot of people have tried to solve this problem; what is required is a hard-headed look at the problem based on solid research. The Institute is going some way along the road in this area but our limited resources place restrictions on the impact we can make.

The Institute of Physics is a leading international professional body and learned society, with over 37,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied

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Institute of Physics

Science and innovation: working towards a ten-year investment framework

An Institute of Physics response to a joint HM Treasury, DTI and DfES consultation

A full list of the Institute's responses and submissions to consultations can be found at http://policy.iop.org/Policy/public.html

30 April 2004

30 April 2004

Ten-year investment framework for science and innovation
Science & Industry Team
HM Treasury
1 Horse Guards Road
London
SW1A 2HQ

Institute of Physics

Dear Sir/Madam

Science and innovation: working towards a ten-year investment framework

The Institute of Physics is a leading international professional body and learned society, with over 37,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied.

The Institute welcomes the opportunity to respond to the consultation document, *Science and innovation: working towards a ten-year investment framework,* and the Government's clear recognition of the importance of science to the nation in the 2004 Budget, and its pledge for increased investment in future years.

The consultation document clearly highlights a number of key issues that the UK collectively will need to address in order to compete and interact more effectively with the US, Japan and the rest of Europe in terms of scientific excellence over the long term. The Institute will use this opportunity to highlight issues of concern pertinent to physics, a discipline whose strength and vitality, from school education through to industry, will be crucial to the Government's vision of making Britain "the best and most attractive location in the world for science and innovation." Physics is at the base of so much of modern society – spanning a broad range of science from blue skies research to many technological applications, such as in medical science, optics and materials – that investment in it is not only important for science, but for society as a whole.

The attached annex highlights the key issues of concern to the Institute which have been linked to the specific questions raised in the consultation document.

If you need any further information on the points raised, please do not hesitate to contact me.

Yours faithfully

Professor Peter Main
Director, Education and Science

Institute of **Physics**

Science and innovation: working towards a ten-year investment framework

Summary

Key issues of concern to the Institute relate to three areas in need of support from the Government:

School science teaching, and education in schools

- The Government must address the balance of specialisation of school science teachers. There is an extreme shortage of specialised physics teachers that is being masked by the overall numbers of graduates in other disciplines going into science teaching.
- A major concern has been the steady decline in the number of entrants to physics and mathematics A-level. Unless this is addressed, the number of suitable students in a position to apply for first degrees in physics and engineering will dwindle.
- Practical and experimental work are key to enthusing pupils in science subjects, and large class sizes and a lack of resources make it difficult to give pupils this experience.

Higher education and research

- Over 30% of physics departments have disappeared since 1994. At present, there are fewer than 50 UK universities offering a provision for undergraduate physics.
- The Government should reconsider the proposed allocation of HEFCE teaching funds planned for 2004/05. Physics departments already run at a loss, and the new proposals would mean a 1% cut in funding resource for price band B subjects, which includes physics. If the Government is serious about its commitment to world-class research, more money needs to go into physics departments.
- The proposed introduction of top-up fees may have a bearing on the number of entrants to physics under- and postgraduate courses. At present, no one knows how the market for fees and (more importantly) for bursaries will operate from 2006 onwards.
- It is imperative that an educated student market deciding what degrees to undertake is created. A significant problem facing science, and particularly physics, is that students are making ill-informed decisions about their careers at the age of 15. Teachers, parents, careers advisors should be in a position to highlight the benefits and the wide variety of career options that are available from science.
- The Government has made a fantastic commitment to science, by doubling the science budget. Blue-skies research, particularly in physics, is long term in its nature, and the Institute hopes that new money invested into the science base will continue to support this area of research through responsive mode Research Council funding.

Physics-based industry

- The Institute endorses the recommendation from the Lambert review that, the Government should create a significant new stream of business-relevant research funding, which would be available to support university departments that can show strong support for business. However, this additional support for research exploitation should not be at the expense of Research Council funding for blue-skies research.
- To enable the UK to reap more of the commercial benefits of its physics base, university physics departments and related groups should be encouraged to exploit more of their research in industry. RDAs should have a bigger role in facilitating links, but the Institute along with the Lambert review remain unconvinced that RDAs are the best channel for Government money to help business-university linkages.

Main response

Physics is an integral part of our culture, providing the foundations for many scientific disciplines. The increases in wealth, economic globalisation, living standards and quality of life have been largely based on technological progress, which in turn has relied heavily on innovative research in physics. In addition, physics education develops strong intellectual and practical skills, well matched to the evolving needs of employers, and also provides the foundation for all engineering and many scientific disciplines. However, as reported in *Physics – building a flourishing future*[1], the Institute's report into undergraduate physics in the UK, there are concerns, which are jeopardising the contribution that physics makes to wealth creation, innovation and economic growth. These include:

School science teaching, and education in schools

Physics teachers
[This section relates to question 10 in the consultation document]

There is a crisis in the teaching of physics in schools – a majority of the teachers of physics who teach to the under-16s do not have a physics-based degree. Only those with confidence and competence can teach their subject well, engaging and enthusing pupils and motivating them to pursue careers in science and engineering. Unfortunately, teaching is not seen as an attractive career option for physics graduates, which is an indication of their marketability, as they are in high demand in business and industry. The number entering teaching is low – there were 568 acceptances to PGCE courses in physics in 1993 and 323 in 2002 (GTTR). It is essential that the Government recognises and addresses this problem, and does not hide behind the fact that there have been increases in the number of science teachers, mainly in biology. The UK is desperately short of trained teachers in physics and mathematics.

The Smith report, *Making Mathematics Count*, highlighted issues of concern in the supply of mathematics teachers. A combination of physics and mathematics are pre-requisite for physics undergraduate courses. The Institute would urge the Government to take heed of Adrian Smith's recommendations for mathematics,

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[1] http://policy.iop.org/UPI/index.html

particularly those on the supply of mathematics teachers, and extend them to physics, without hesitation. In particular, the Institute fully endorses the recommendation that more must be done to address the issue of pay and other incentives to teachers of mathematics and other shortage subjects including physics. The Government could, for example, investigate differential salaries for shortage subjects, golden hellos, 5-year golden handcuffs, etc.

In addition to good teachers enthusing students, there is a need for good, well-paid teacher trainers to train them. It is proving difficult to attract good physics teachers to become trainers, because school salaries are often higher than those in universities.

The Institute was disappointed by the paucity of data that was contained in the last School Staffing Survey. At present, only the input of physicists into the teaching profession is known and not how many physicists are actually teaching in schools. Unless action is taken to collect better data on the backgrounds of teachers in schools, it will be very difficult to judge the success of recruitment and retention strategies.

The Institute notes that there is not a strong culture of professional development amongst teachers. Recent initiatives such as the KS3 strategy and the forthcoming Science Learning Centres are addressing this to some extent, but a culture change within the teaching profession is needed where all teachers feel obliged to engage in professional development. This will not to happen unless the Government makes more funding available to pay for teachers to participate.

A-level numbers
[This section relates to question 10 in the consultation document]

A major concern has been the steady decline in the number of entrants to physics A-level. Since 1994, there has been a 20% drop (AQA). In the same period, the number of entrants to mathematics A-level has dropped by 15%. Unless there is a reverse in this trend, the number of suitable students in a position to apply for first degrees in physics and engineering will dwindle.

A number of reasons have been suggested for pupils rejecting physics; including:
- a perceived lack of relevance;
- perceived difficulty;
- poor careers advice; and
- mathematical issues.

The Institute hopes that the 14-19 reforms will address the variability in the difficulty of subjects post-16. The 14-19 working group has echoed the concerns of the Roberts review (SET for Success) about the quality of careers advice. In particular, there is considerable anecdotal evidence that young people who might consider a career in science do not receive good careers advice – something which is touched upon in a later section.

The Institute is already working with the DfES to investigate how more girls can be persuaded to take A-level physics. The Institute hopes that there will be a positive Government response to the results of this initiative and a commitment to continue this work.

Curriculum
[This section relates to question 10 in the consultation document]

Although the National Curriculum for science was brought in under the banner of Science for All, it was originally intended for those students planning to continue their study of science. Recent developments such as 21st century Science and Applied Science have addressed this. But the Institute is concerned that the place of physics in these qualifications is much less secure.

One of the distinguishing characteristics of science education in the UK is the amount of practical work that is done. Practical has been in decline in recent years. A plausible explanation for this is the increase in class sizes. This is of a particular concern as the Institute believes that the more able students are those who are most likely to be in larger classes.

Despite welcome investment in school laboratories, there are still significant issues about school laboratories, resources for practical work and technical support. The announcement of a major rebuilding and refurbishment plan for schools is welcome, and it is hoped that within this there will be a priority for improving science laboratories and equipment.

Science communication
[This section relates to question 12 in the consultation document]

One medium that has been underused in communicating science has been public service television. There is a clear lack of science related programmes on the BBC. Exciting, topical science based programmes could provide a means to communicate the benefits and possibilities of careers in science, and help create a society that accepts and is excited by new technology. It is disappointing to hear that the annual Royal Institution Christmas lectures will no longer be shown on Channel 4 – and it is even more of a disappointment to hear that the BBC has not expressed an interest in buying the rights to show the lectures.

The Government should actively promote the representation of scientists amongst their ranks. This would improve the general quality of understanding and debate within Government, as well as improve links between Government and the scientific community, the quality of Government response to scientific issues and the level of public trust in Government on scientific issues.

Higher education and research

Health of physics departments
[This section relates to questions 1 and 6 in the consultation document]

Physics is, by its nature, a resource-intensive subject to teach, in terms of both teaching staff and laboratory provision. In the past 10 years, the university physics student/staff ratio has increased. The increase has been less dramatic than in some other subjects, as there were very few physics departments in the former polytechnics. As industry's demands for graduates with a high degree of technical knowledge and expertise increases, it is incumbent upon universities to have modern facilities and equipment. The cost of providing such equipment has risen at a faster rate than inflation.

The economics of university physics departments has led to the loss of several departments in the past ten years. Over 30% of physics departments have disappeared since 1994. At present, there are fewer than 50 UK universities offering a provision for undergraduate physics.

Larger areas of the population and industry now have no convenient access to a local university physics department offering teaching or research. As the proportion of students living at home increases, and as industry becomes more dependent upon high-technology knowledge, these regions will suffer from a lack of proximity to university physics. The Government rightly, is keen on increasing the number of women, ethnic minorities, lower social classes in science and engineering. For those in this under represented grouping living in the East Anglia region, for example, wishing to study physics, where would they go? There is no undergraduate provision for physics at the University of East Anglia and the University of Cambridge would not be a realistic proposition for many.

The Institute recognises that physics has a problem in recruiting from these under represented groups and is investigating the reasons behind the low-uptake.

The Institute understands that a survey conducted by the THES (23 April 2004) has revealed that more students are staying at home when they enter higher education. The survey found that a quarter of students live at home while studying, a higher proportion than estimated for previous years. If more and more physics departments are forced to close, regional deserts of physics provision are likely to appear all over the UK.

Teaching funding
[This section relates to questions 1, 6 and 7 in the consultation document]

Having continually argued for HEFCE to monitor and review the price groups allocated to the laboratory sciences, in order to maintain the existing high standards in undergraduate physics, the Institute believes that physics, as well as many other science and engineering disciplines, will suffer further under the new weightings, recently announced by HEFCE. As of 2004-05, the weighting of 1.7 for price band B, which includes physics, will lead to a 1% cut in the teaching resource.

HEFCE has argued that measured physics costs are too high due to falling student numbers but this is far from obvious because:

- physics undergraduate numbers have not fallen (acceptances to undergraduate physics and astronomy were 3102 in 1994, and 3103 in 2002 (UCAS));
- departments have closed and large departments have become even larger leading to efficiency of costing, and
- deficit departments have severe limits on spending.

The Institute urges HEFCE (and the other Funding Councils) to look more critically at the actual spend of university departments to determine what the ‘true’ price group weightings should be. At a time when the UK needs a more highly skilled and scientifically capable workforce to respond to today’s technology driven challenges and opportunities, physics departments are facing a crisis. With many departments already operating at a deficit, these further reductions in funding will have serious consequences.

Undergraduate intake
[This section relates to question 10 in the consultation document]

The future strength of the science base is crucially dependent on the flow of quality young people into it. As highlighted in *SET for Success*, the Roberts review:

"…graduates and postgraduates in strong numerical subjects, are in increasing demand in the economy – to work in R&D, but also to work in other sectors (such as financial services or ICT) where there is strong demand for their skills." Physicists fall squarely into this category.

SET for Success, reported that the 'disconnect' between the demand for skilled graduates and the declining number of physical sciences, engineering and mathematics graduates on the other hand, is starting to result in skills shortages. Furthermore, any attempt to address the issues associated with this decline requires action in schools, higher education, industry and the Government.

The proposed introduction of top-up fees may have a bearing on the number of entrants to physics under- and postgraduate courses. At present, no one knows how the market for fees and (more importantly) for bursaries will operate from 2006 onwards. In response, the Institute will introduce bursaries of £1000 per annum for physics undergraduates from less well off families. Whilst income from our reserves will provide the core of this, anecdotal evidence suggests that the potential for the flowering of a new philanthropy to support undergraduates in specific subjects is large and untapped.

It is also imperative that an educated student market deciding what degrees to undertake is created. A significant problem facing science, and particularly physics, is that students are making ill-informed decisions about their careers at the age of 15. Students at this age, irrespective of whether they are girls, from ethnic minorities etc., are not well-educated consumers. Teachers, parents, careers advisors should be in a position to highlight the benefits and the wide variety of career options that are available from science.

Research
[This section relates to questions 1, 2, 3, 6 and 18 in the consultation document]

The International Review of UK Physics and Astronomy[2], conducted in April 2000 by a panel of eminent international physicists on behalf of the OST, reported:

"That at its best, research in physics and astronomy in the UK is at the very highest level worldwide. Beneath the peaks of scientific excellence, however, UK physics research quality noticeably drops, largely due to a lack of adequate resources. For similar reasons, there are deficiencies in the breadth of coverage of some important sub-fields. As a result, the potential for seizing new opportunities and for maintaining the UK's overall excellent standing in international physics and technology research may be impaired. Physics research in the UK continues to suffer from a low level of funding. In fact, the field is currently in a state of slow recovery from a long period of chronic under funding. Substantial increases are now required in order to bring UK physics research up to international levels. Insufficient funding has caused the UK to miss important areas of opportunity. In particular, research infrastructure (both equipment and human resources) has been in decline for many years and may be reaching a critical point." The next international review of physics and astronomy is

[2] http://policy.iop.org/Policy/Intrev.html

expected to take place in 2005, and will be able to assess the progress that has been made.

A recent issue of concern to the physics community has been the low success rates for grant applications for curiosity driven research. The EPSRC, a major funder of physics research, has recently stated that there is a gap developing in the science budget – engineering and the physical sciences are being seriously under funded, and are on the wrong trajectory, in comparison with the biological sciences.

The Institute supports the views expressed in a letter to VCs and Principals, from the EPSRC where it reports that, "The UK's research capacity in engineering and the physical sciences is heavily dependent on the university sector. But the base of permanent staff is shrinking in these core subjects as is research income and research outputs such as the number of published papers. This partly results from a deliberate shift of resources toward new scientific opportunities in the life sciences. There is a need to sustain the UK's research capacity in important areas of the physical sciences and engineering by increasing the *quantity* of high *quality* research, and reducing the dependence of that capacity on student numbers."

In addition, the EPSRC report that, "The reduction in the UK's research capacity in engineering and the physical sciences has happened over a long period... This contraction will continue and could severely hamper improvements in competitiveness in the UK economy. The restored research capacity has to be in the UK; if it is elsewhere we will begin to lose the ability to understand and use developments elsewhere and will not maintain the research environments necessary to produce trained people. This will require concerted action by a number of bodies."

The Institute is of the firm belief, that the Government has made a fantastic commitment to science, by doubling the science budget, and of course after such a commitment it would expect an immediate return of investment. Blue-skies research, particularly in physics, is long term in its nature. Productivity won't be seen for many years, possibly decades. Money has been pumped into managed programmes, following a number of Spending Reviews, but the Government must be patient, and not continue this trend at the expense of blue-skies research. The UK should participate in the development of new knowledge (and, indeed, in its utilisation for wealth creation) by giving physicists the opportunity to follow their scientific instincts in research. Managed programmes should be used by the Research Councils with restraint.

Interdisciplinary research
[This section relates to questions 6, 7 and 18 in the consultation document]

While the conventional departmental structure in universities is fine for undergraduate teaching, it is very poorly adapted to the more interdisciplinary demands and opportunities in research. A much more flexible research structure, cutting across conventional departmental boundaries, is needed. It is a real challenge for universities to put this in place, as increasing transparency of costs makes collegiate strategic decision-making harder.

Furthermore, publications data show that research collaborations between individuals and groups in different universities are encouragingly endemic. It remains the case, however, that funding interdisciplinary research, whether within an institution or across institutions, is a challenge for the Research Councils.

Large facilities
[This section relates to question 8 in the consultation document]

For most large research facilities, at both national and international (European) levels to be competitive, there must be an element of international collaboration, not least because many existing and emerging effective infrastructures are of such a scale that they must now be funded at the supranational level. It would be advantageous to have a supranational body, probably at European level, with the specific remit of evaluating and funding proposals for such supranational large-scale facilities. Such a Research Council could co-ordinate national strategies and investments in facilities whilst also providing a single "letterbox" through which proposals for such facilities could be posted for review and evaluation.

Prioritisation of such facilities has to be carefully balanced between providing those facilities at the cutting edge which ensure the UK has a world lead, and those that provide adequate facilities to enable a large group of UK scientists to remain competitive. It could be argued that the former must take highest priority - but only in those fields in which the UK (either singly or collaboratively) is in a position to capture a world lead: there is little point building, for example, a new synchrotron just to allow more scientists to do more experiments, but there is a need to build a synchrotron that allows UK scientists to do experiments that can be done nowhere else in the world!

Further development of the UK science base
[This section relates to question 2 in the consultation document]

Caution is needed in basing a long-term strategy on existing areas of science. A consistent feature of UK research funding, relative to our main industrial competitors, has been the lack of flexibility in identifying new areas and responding to funding needs. In the physics area, two recent examples have been spintronics and nanoscience. In both cases, the science had been recognised as vital for the 21st century by our competitors before UK funds had been provided.

How funding mechanisms build on existing resources and research assessment reforms to reward excellence and underpin sustainability
[This section relates to question 5 in the consultation document]

The really big risk is that funding will become much less stable than it is now. Although there is a clear need to move to a full accounting procedure for research costs, if universities are dependent on the success of grant applications for the vast majority of their funding, there will be huge fluctuations in income that will make sensible management impossible. The Government needs to grasp the nettle and determine how many, and what type of research centres it wants and then fund them properly, with a balance of discrete and continuous funding to allow proper management and stability. Of particular importance is the stability of manpower and nothing is more likely to disrupt the retention of good people than uncertainties in funding.

Barriers facing business and the science base in effective engagement with EU research programmes
[This section relates to question 20 in the consultation document]

The problems with EU funding have included the massive amount of bureaucracy associated with the funding, the low level of overheads and the need to link the EU funding to other sources. In many physics departments, EU funding is used as a supplement to national funding but takes a disproportionate amount of administrative effort. In much of physics, there are natural and very strong European collaborations, particularly in areas where large facilities are required, such as astronomy and particle physics. However, there are also strong collaborations in other areas. The essential feature of successful European collaborations is that there should be genuine complementarity between groups. Perhaps the best way forward might be to link EU funding to national funding, to cover the full economic cost of the programme and to ensure that the European dimension genuinely adds value. Reducing the administrative burden would be a distinct advantage.

Physics-based industry

Physics-based industry
[This section relates to questions 9 and 13 in the consultation document]

The Institute's report, *The Importance of Physics in the UK Economy*[3], highlighted that physics underpinned 43% of UK manufacturing by 2000, and the percentage is growing. While "conventional" physics based industries (PBIs) are doing well compared with UK manufacturing as a whole, exciting new areas of industry are emerging based on developments in physics-based research over the past 20 years.

However, there are some worrying trends that threaten to hinder the performance of PBIs over the next decade. In particular:

- investment in PBIs does not match that of other manufacturing sectors and there is limited availability of venture capital for start-ups and small to medium-sized enterprises (SMEs); and
- commercialisation of physics-based research is limited, despite its potential for exploitation.

These issues require immediate attention if the UK is to maintain a healthy PBI base and UK PBIs are to continue to contribute to the growth of the economy. For instance, a modest increase in investment now could have a dramatic impact on the amount of physics-based industrial activity in the UK and the success of its commercialisation. University physics departments are starting to become more active in transferring technology to industry and their attitudes to entrepreneurship are changing. An acceleration of effort has to be encouraged, but it needs to be understood that it is not sensible to expect academics to become entrepreneurs on a large scale.

The Lambert review
[This section relates to question 9 in the consultation document]

The Institute welcomed the publication of the Lambert review of university-business collaboration and fully supports its conclusion that the main challenge for the UK is to raise the overall demand for research by business. A key recommendation from the review to enable this is that the Government should create a significant new stream of business-relevant research funding, which would be available to support university departments that can show strong support for business.

[3] http://industry.iop.org/pbireport/index.html

However, the Institute believes that additional support for research exploitation should not be at the expense of Research Council funding for blue-skies research. A careful balance is vital for the short, medium and long-term success of research in the UK. The Lambert review highlights the difficulty of encouraging such collaboration when resources are concentrated on a small number of "world-class" departments. The Institute strongly supports the conclusion that Government should take steps to fill the funding gap that exists between the research-intensive and the less research-intensive departments, with 'new' money.

The Institute agrees with the Lambert review recommendation that world-class excellence across all types of research should be recognised and rewarded by the RAE and Research Council peer review processes. Excellent research undertaken with industry or other users should be recognised as being of equal value to excellent academic research. An important issue here is the metrics used in the RAE to assess applied research. The issue of the difficulty of assessing multi-disciplinary activity and industry-linked research in a consistent way is a critical one. Appropriate recognition and credit to reward multi-disciplinary work and collaborative research with industry is vital. There is a view in the physics community that the RAE has driven ‘applied physics’ out of physics departments because elements of the RAE process, as applied to physics, favoured ‘pure’ science.

The Institute’s full response to the Lambert review can be viewed at *http://policy.iop.org/Policy/submissions.html#industry*

Regional Development Agencies
[This section relates to question 19 in the consultation document]

One of the challenges identified in the Institute’s report, *The Importance of Physics in the UK Economy*, is that, despite some high-profile spinout activity in the UK, there appears to be a low rate of commercialisation of academic research in physics compared with other disciplines. To enable the UK to reap more of the commercial benefits of its physics base, university physics departments and related groups should be encouraged to exploit more of their research in industry. There is significant potential for exploitation and the RDAs should have a bigger role in facilitating links, but the Institute along with the Lambert review remain unconvinced that RDAs, certainly as currently staffed and operating, are the best channel for Government money to help business-university linkages. Companies want to work with the universities with the most relevant skills and interests to support their business. In many cases these will not be in the same region. There needs to be a balance between innovative regional support for links and national support and co-ordination. DTI support and co-ordination of the major strategic and financial decisions would seem appropriate.

The Institute of Physics is a leading international professional body and learned society, with over 37,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied

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Institute of Physics

Annex 4

Research Council Support for Knowledge Transfer

An Institute of Physics response to a House of Commons Science and Technology Committee Inquiry

A full list of the Institute's responses and submissions to consultations can be found at http://policy.iop.org/Policy/public.html

16 February 2006

16 February 2006

Clerk to the Committee
Science and Technology Committee
House of Commons
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Institute *of* **Physics**

Dear Sir/Madam

Research Council Support for Knowledge Transfer

The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership (currently over 35,000) and is a leading communicator of physics with all audiences from specialists through government to the general public.

The Institute welcomes the opportunity to respond to the House of Commons Science and Technology Committee's Inquiry into Research Council Support for Knowledge Transfer.

General Principles of Knowledge Transfer Processes

The Institute aims to strengthen and support the health of physics based enterprises, in particular by promoting and facilitating innovation. The Institute operates its own knowledge transfer networks (the emerging technology programmes in nanotechnology, biotechnology and optics) with meetings often run in collaboration with Research Councils.

The Institute believes that knowledge transfer processes should follow a number of general principles. They should:

- Focus on stimulating and supporting demand pull rather than technology push. Demand-pull is crucial for effective knowledge transfer and should permeate all components of the knowledge transfer process.

- Focus on impact rather than activity per se. It is vital to build up a strong evidence base of what mechanisms have the most impact and in what circumstances.

- Be systemised and embedded in the culture of research departments and business R&D by linking directly to knowledge transfer metrics influencing assessment criteria.

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In addition, the Institute is of the view that:

- Mechanisms for collaboration must recognise the significantly different timescales to which industry and academia usually work.

- Intermediary bodies (e.g. Research & Technology Organisations, professional Institutes and knowledge transfer agencies) can play an important role in helping to reconcile the fundamentally different goals and objectives of academia and industry (e.g. the quest for knowledge vs. economic growth), by bringing the relevant people together. However, they must not be seen as a replacement for direct interaction.

- Intellectual Property needs to be managed sensibly by recognising that it is best owned and managed by the exploiting party, while ensuring that collaborating parties receive appropriate rights and returns that reflect their contributions.

- People-based schemes such as placements and secondments are an effective mechanism for knowledge transfer that could be more widely supported.

- Co-ordination across Research Councils is important and should extend to working with government departments so that all publicly-funded research reflects a coherent national strategy, rather than the fragmented set of strategies that we have at present.

- Care must be taken to ensure that any potential strategy is not directive, stifling innovation in research at birth.

- Within a competitive and global market for research, industry will place contracts according to where it can get the greatest value for money. The move to full economic costing in the science base may not be helpful to the UK if it used rigidly to set the price for work by academia for industry.

<u>Research Council Support for Knowledge Transfer</u>

The basic principle of funding universities to support knowledge transfer is excellent. An international panel of scientists, who recently undertook a review of the quality of UK physics and astronomy research, noted that the Research Councils have been promoting knowledge and technology transfer through their knowledge transfer schemes, and have many success stories such as the ‘Cambridge’ phenomena (e.g. Cambridge Display Technology) and within the SUPA collaboration. The international panel suggested that ‘UK plc’ would greatly benefit by having similar schemes throughout the country.

The recent statement made by the chief executive of PPARC to the Committee about PPARC requiring most grant applicants to provide plans for knowledge transfer activities, is a welcome development, and it is hoped that the other Research Councils will follow suit.

<u>Specific Areas of Concern</u>

There are a number of concerns that need to be addressed:

- **Stimulating Market Pull.** Knowledge transfer involves two bodies: the initiator and the receiver of that knowledge (as a simplification as the relationship is often more complex in practise). The Research Councils have struggled to get the initiators to make serious efforts at such transfer, and have no control over the intended recipients (usually industry). It is becoming increasingly rare for industry (except some of the very large multinationals) to have scientific staff with the experience and judgement to act as recipients, or even to decide what their needs are. The very poor record of research funding in UK industry is an illustration of this trend. The collapse of the large laboratories (whether government or industry) has made things worse.

  There is too much encouragement of technology push and not enough user pull at the start of research. This leads to scattered and fragmented activity without significant and complete outcomes. Users have their own priorities and will only respond to academic demands when there is mutual benefit and recognition. At present, collaboration happens more by chance than any strategic plan.

- **Distinguishing between applied and blue sky research**. It is important to recognise and support distinct funding streams for application of research and really innovative research where there is no application envisaged. At present there are attempts to show industry relevance for almost everything which can lead to weak and ineffective links across the board. Strong coupling where there is true benefit likely and no attempt to couple really original investigations would be more effective.

- **Acknowledging priorities**. The use of the term 'third stream' funding for knowledge transfer activities unfortunately reflects the view held by many universities on the relative priority and value of knowledge transfer activities compared to research and teaching. If knowledge transfer is to happen as a priority then alternative terminology to describe the different funding streams may be helpful.

- **Nurturing Relationships.** Improving management of expectations on both sides of the industry-academia interface are essential. Industry must be made aware that there are no researchers sitting around ready to do small, short term, projects. It is impossible to respond on the timescale expected in industry. Academics must realise that research in industry is more like development. The Research Councils could take a more systematically proactive role in supporting and nurturing these relationships.

- **Co-ordinated National Strategy.** The Research Councils need to identify strategic national user needs (with other stakeholders), and focus funding to achieve significant nationally relevant outcomes. The Technology Strategy Board has made a good start in this direction in its first year, but there is much more that can be done.

- **Effective Dissemination.** The Research Councils must add value by identifying and promoting integrated results of their investment. Research Council communication is limited at present – they need to evaluate, integrate and communicate the value of what they support through grants. Too much is left to the universities.

- **Centres of Expertise.** The Research Councils need to concentrate on and grow a small number of very much larger 'centres' of expertise – current fragmented funding of small projects leads to numerous sub-critical units that are not visible and competitive by international standards; the competition is global and not between UK universities.

- **Training.** New approaches need to be developed and Research Council and university staff need training – one cannot expect efficient knowledge transfer to just "occur on demand" if individuals are doing it untutored by trial and error.

- **Transferring People.** The transfer of people is the most effective mechanism for knowledge transfer. This should involve young students and recent graduates as well as operating between experienced Research Council staff, researchers and industrialists. Access to people-based schemes for companies of all sizes and sectors could be improved.

- **Remove cap on the Follow-on Fund.** The Research Council Follow-on Fund has been very successful in attracting good proof-of-concept proposals for initial funding to take research outputs to commercial propositions. There should be up to two calls per year and the financial cap on total proposal value from any university should be removed (EPSRC are the only Research Council to have such a cap).

- **Extended CRD Programme.** Collaborative Research & Development (CRD) projects are very valuable but restricted because of their focus on specific programme areas and their short term nature. There should be a general CRD programme capable of supporting collaborative research in any area over long time periods.

- **Knowledge Transfer Metrics.** Increased use of knowledge transfer metrics when assessing funding proposals would be welcomed. This should be combined, where appropriate, with more emphasis on post project reviews of successful exploitation activities. Success criteria should focus on meeting “market need”. However, care must be taken not to take such an approach to extremes and restrict creative blue skies research that questions commonly held beliefs. Distinctions may need to be made between R&D themes during assessments.

- **Engaging SMEs.** For small and medium sized companies it can be difficult to engage universities in collaborative high risk innovation projects. To this end there could be improved co-ordination of linked projects within the Research Councils together with better integration between the strategies of the Research Councils and government departments. More joint funding of long-term industry-led projects would be advantageous.

If you have any queries, please contact me or my colleague Dr Paul Danielsen at the Institute.

Yours faithfully

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Chief Executive

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