House of Commons

Science and Technology Committee

Too little too late? Government Investment in Nanotechnology

Fifth Report of Session 2003–04

Volume I

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The Science and Technology Committee

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Contacts

All correspondence should be addressed to: The Clerk of the Science and Technology Committee, Committee Office, 7 Millbank, London SW1P 3JA. The telephone number for general inquiries is: 020 7219 2793; the Committee's e-mail address is: scitechcom@parliament.uk

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Summary

The scale of the impact of nanotechnology on the world economy and the "disruptive" nature of the technology fully merit Government efforts to stimulate industrial activity and academic research in this vital subject.

In this inquiry we find the DTI culpable of failing to build on an early successful nanotechnology programme in the 1980s in order to maintain the UK's prominent position in the field. The commissioning of a strategy report in 2001 by the then Director General of the Research Councils, Dr John Taylor, was a welcome, if belated, attempt to catch up with a commercialisation strategy for nanotechnology. However, the levels of investment planned are insufficient to match those of other major international competitors.

We regard the DTI's Micro and Nano Technology (MNT) Manufacturing Initiative to be an inadequate response to the Taylor Report. The £90 million over six years on offer from DTI would have been better spent on the establishment of one or two nanofabrication facilities, along the lines of those recommended by the Taylor Report. The DTI's decision to invite the Regional Development Agencies and Devolved Administrations to participate in the MNT Initiative succeeded in creating a bigger pot of funding for both research and the provision of facilities, but at the cost of a clearly focussed strategy, based on areas of existing UK strength. We believe that the pressures for short term financial returns and for a wide regional distribution of funding will result in a disparate range of microtechnology facilities being supported instead of the few world class nanotechnology centres necessary to raise the UK's nanotechnology profile. We do not have confidence in the RDAs' commitment to supporting or delivering a strategy that is best for UK interests as a whole.

Universities and academics have, in recent years, been generally slow to respond to the challenge of supporting nanotechnology research. The education and training strategy called for by the Taylor Report has still to be developed. We call for greater co-ordination between the Research Councils' funding decisions and the emerging priorities of the MNT Initiative. The Research Councils should also take the lead in the funding of research into any environmental and health issues identified as requiring further study.

We also looked at nanotechnology as a case study of innovation policy in the UK. Whilst we welcome the introduction of the R&D tax credits we have called for in previous Reports, we find that many of the barriers to successful innovation still exist. Venture capital is still a problem in the UK, as is the apparent reluctance of major companies to sink large sums into R&D: too often, it is SMEs and university spin–outs that are driving innovation forward. We call for the Government to increase the flexibility the RDAs have to use their venture capital funds so as to be more supportive in practice of suitable investment opportunities not only in nanotechnology but in high technology areas in general.

We conclude that Government investment in nanotechnology is at present insufficient, poorly focussed and by no means guaranteed to produce the overall levels of funding from the RDAs that are predicted. It is not too late though: the MNT Manufacturing Initiative

leadership can still produce a strategy that will maximise the impact of the UK's limited financial resources to make the UK the major player in nanotechnology that our early progress in this area should have produced.

1 Introduction

1. Nanotechnology is more than an exciting new technology. It represents a whole new method of manufacturing, which achieves control at the atomic scale. It is better described as a collection of technologies which are genuinely "disruptive" – that is, they will render many existing technologies and processes obsolete and create entirely new types of products. Over the coming years and decades, nanotechnologies are set to make an enormous impact on manufacturing and service industries; on electronics, information technology; and on many other areas of life, from medicine to energy conservation. Just how large this impact will be is not easily quantifiable, but some forecasts have placed the worldwide market for nanotechnology–related products at around £105 billion by 2005 and £700 billion by 2010.[1] Nanotechnology has been described as a new industrial revolution.

2. In June 2001 the DTI appointed an expert group to advise on the establishment of a strategy specifically designed to support the academic research and industrial capability necessary to allow the UK to benefit from the commercial potential of nanotechnology. The expert group set up by the Minister for Science and Innovation, Lord Sainsbury of Turville, led by the then Director General of the Research Councils (DGRC), Dr (now Sir) John Taylor, reported to the Department of Trade and Industry (DTI) in June 2002. The Government subsequently highlighted the importance of nanotechnology to the economy in its science strategy, *Investing in Innovation*, published the following month.[2]

3. A year later, on 3 July 2003, Lord Sainsbury announced a package of funding for nanotechnology worth £90 million over six years, along with the establishment of a Micro and Nanotechnology (MNT) Network to direct the spending of this money. The following day, we announced an inquiry into Government support for nanotechnology. Our aim was to examine how the Government had taken forward the recommendations of the Taylor Report and to scrutinise the planned expenditure of the £90m committed by Government. We did not attempt to repeat the comprehensive surveys of nanotechnology activity in the UK that have already been completed, but sought to establish whether the measures undertaken by Government are the right ones to support academic and industrial involvement and the full exploitation of nanotechnologies. We also looked at how universities are responding to the challenge of developing the right skills base to support such research and development. In the preface to his report, Sir John Taylor lays down a challenge: "in order to keep pace with competitor nations we need to recast the scale and nature of our nanotechnology activities".[3] We wanted to discover whether the Government is meeting this challenge.

4. In many ways nanotechnology is at a similar stage to the emerging biotechnology industry in the 1980s, a subject that was reported on at the time by Parliamentary Select

1 Department of Trade and Industry and Office of Science and Technology; *New Dimensions for Manufacturing A UK Strategy for Nanotechnology* (hereinafter referred to as the Taylor Report), June 2002, p 24

2 HM Treasury, DTI, Department for Education and Skills, *Investing in Innovation, A strategy for Science, Engineering and Technology*, July 2002

3 Taylor Report, p 3

Committees and has been revisited on a regular basis ever since.[4] We expect to follow progress on nanotechnology over the years. The wider issue of innovation has also been familiar territory for select committees. We used this inquiry to follow up the work of our predecessor Committee, and that of other select committees, on innovation and knowledge transfer: the translation of the fruits of scientific research into commercial and economic benefits. This has been a long acknowledged weakness in the UK and the subject of previous inquires we have carried out, and numerous studies commissioned by Government.[5] The Science and Technology Committee reported in the summer of 2000 on *Engineering and Physical Sciences Based Innovation.*[6] Although the science involved is largely different, the problem of turning the science into saleable goods remains the same. We have revisited some of the issues raised in that Report to see how much progress has been made. Our inquiry also coincided with a major re-examination by Government of the way it supports innovation and of the relationship between universities and business. Both the Innovation Report[7] and the Lambert Review[8] were published in December 2003. We were able to take account of the implications of these reports for the Government's nanotechnology strategy in the latter stages of our inquiry.

5. The focus of our inquiry was very much on the commercial exploitation of nanotechnology in the UK. We deliberately excluded from our remit the possible risks associated with nanotechnology: the potential social, environmental and health implications of the new technologies. The Government commissioned the Royal Society and the Royal Academy of Engineering to undertake a study of these potential risks in July 2003. This study is due to report in late spring 2004.

6. In the course of our inquiry we held five oral evidence sessions with Government, the Research Councils, the Regional Development Agencies, small and large companies, academic researchers and the scientific learned societies. The transcripts of these sessions are published with this Report, alongside the 18 written submissions we received. We also held an informal meeting with Sir John Taylor, after the end of his term as DGRC. We visited a small company, NanoMagnetics, in Bristol and held meetings at Bristol University with academics from a number of different departments active in nanotechnology–related research. We also undertook a visit to probably the biggest investor in nanotechnology in Europe, Germany, to see how support for nanotechnology works at both state and federal level, in Dresden and in Berlin. We would like to place on record our thanks to all those who contributed to this inquiry, by giving evidence or by assisting us on our visits. We would also like to thank our specialist advisers: Professor John Ryan, Director of the Oxford Interdisciplinary Research Collaboration in Bio–nanotechnology, Professor Paul Atherton, President of the European Society for Precision Engineering and Nanotechnology, both members of the National Strategy Advisory Group; and Professor

4 See, for example, the Trade and Industry Committee's Twelfth Report, Session 2002-03, *UK Biotechnology Industry*, HC 87

5 For example, First Report of the Science and Technology Committee, Session 1993-94, *The Routes Through which the Science Base is translated into Innovative and Competitive Technology*, HC 74-I; Second Report of Session 1999-2000, *Engineering and Physical Sciences Based Innovation*, HC 195-I

6 Second Report of Session 1999-2000, *Engineering and Physical Sciences Based Innovation*, HC 195-I

7 DTI, Innovation Report, *Competing in the global economy: the innovation challenge*, December 2003

8 HM Treasury, *Review of Business-University Collaboration*, Final Report, December 2003

Michael Elves, formerly the Director of the Office of Scientific and Educational Affairs at Glaxo Wellcome plc.

2 Background

Definitions: Micro and Nano

7. There is no strict, agreed definition of what constitutes nanotechnology and nanoscience. The terms refer to a range of technologies and processes used to manipulate matter at an extremely small length scale, usually taken to be in the range of 0.1 and 100 nanometres. (One nanometre is one billionth of a metre. Ten molecules of hydrogen side by side measure approximately one nanometre. A human hair is approximately 80,000 nanometres wide.) Broadly speaking, *nanoscience* refers to the study of the manipulation and assembly of matter at the atomic or molecular level, whereas *nanotechnology* is taken to be the application of nanoscience to create products and processes.

8. Nanotechnology is often categorised as either "top–down" or "bottom–up". Top–down nanotechnology involves the fabrication of nanoscale structures by machining processes carried out on larger structures, while bottom–up refers to the creation of organic and inorganic structures at a molecular level. At present nanotechnology is still mainly at the top–down stage. It is also, by nature, multidisciplinary: the potential applications span the sciences, medicine and engineering. The really exciting developments are expected to arise from the fusion of the engineering of increasingly small components with the biology and chemistry of assembling and manipulating structures, atom by atom.

9. Chemists are fond of saying that they have been practising nanoscience for many years.[9] This may be true, although they have not necessarily been practising it with those in adjacent disciplines. The Chief Executive of the Engineering and Physical Sciences Research Council (EPSRC) confirmed that "it is certainly true that many things that today would come under the heading of nanotechnology have been going on for a long time in some form or other without that label".[10] But it is the development of new tools capable of manipulating materials and substances at the nanoscale that has provided new scientific and commercial opportunities. As Patrick McDonald, the DTI official leading on the nanotechnology strategy, told us: "What has changed is an understanding of how we can manipulate things at molecular level. The rest of it we have been doing for a long time".[11]

10. Nanotechnology should be distinguished from microtechnology and microsystems, also referred to as microelectronic and mechanical systems or MEMS. One micrometre (or micron) is equivalent to one thousand nanometres or one thousandth of a millimetre. The application of microtechnology is generally far closer to the market and to a large extent it is already with us. It has been commercially exploited for many years, for example, in the production of ever smaller electronic devices and more powerful small computers.

9 Q 393

10 Q 99

11 Q 58

11. In establishing the MNT Initiative, Lord Sainsbury was keen to point out that the DTI drew no distinction between micro and nanotechnology. He told us that "when we are talking about nano here, we are talking really about nano and micro because it really does not make any sense commercially to make a distinction between them".[12] This is an important point. The boundaries between nanotechnology and microtechnology may be blurred—there is a degree of commonality in the techniques and equipment involved in micro and nanotechnology —but they are, in essence and in application, very different. It is at the nano not the micro scale that the physical and chemical properties of materials change and the scope for revolutionary advances in technology can be realised. There is some logic in combining micro and nano in order to maximise the potential of existing facilities and to avoid problems of definition. There is also a cost. **By making no distinction between micro and nanotechnology for the purposes of the MNT Network, the DTI is making no specific commitment to supporting nanotechnology itself.** We explore the consequences of using this definition in Chapter 3.

Applications of nanotechnology

12. Some of the benefits of nanotechnology are already with us. Nanoparticles and nanomaterials are used in the production of certain goods, such as sunscreens, carbon nanotube based tennis rackets, burn dressings and dental fillings. Other commercial applications are expected in the near future; still more are predicted for more distant horizons. Many of these commercial applications are predicted to stem from the interaction of several different disciplines and technologies at the nanoscale. The Prime Minister has said that "this kind of disruptive technology may create whole new industries and products we can't begin to imagine".[13] In recent months, newspapers and science journals have been reporting on exciting potential applications for the future, from the precise delivery of drugs to parts of the body to cables from earth to space capable of carrying small vehicles and producing energy.[14] Several examples of applications are included in Table 1.

Table 1: Present and future commercial applications of nanotechnology

Available now	1–5 years away	5–15 years away
Sunscreens Computer hard disks Semiconductor lasers for telecommunications Harder, stronger, lighter materials Self–cleaning windows	"Lab–on–a–chip" technologies Smart nano–coatings for packaging and minute tracking devices Better photovoltaic devices for renewable energy sources High density data storage	Targeted drug delivery & virus detection Anti–corrosion coatings Better medical implants and artificially created organs Molecular methods for disease diagnosis Non–invasive molecular imaging in medicine Better sensors, eg for pollutants

Source: Ev 35 (edited)

12 Q 465

13 Speech at the Royal Society, *Science Matters*, May 2002

14 http://www.nas.nasa.gov/Groups/Nanotechnology/publications/1997/applications/

Early years of Government support

13. The history of UK Government support for nanotechnology is perhaps surprisingly long. It began in 1986 when the National Physical Laboratory, in conjunction with DTI, launched the National Initiative on Nanotechnology to promote awareness. This was built upon two years later when the DTI launched the LINK Nanotechnology Programme (LNP). Over the ten years of its life, the LNP provided £23.6m in support of 28 projects involving 15 universities, 19 SMEs and 25 large companies. An evaluation of this programme concluded that its impact had been high, increasing sales for participants by £8–12m, and providing, for the majority of them, technical progress, increased R&D activity and spin–off benefits.[15] Three of the companies involved went on to become market leaders in their respective microsystems sectors: anti–judder automotive braking systems, fibre optics and semiconductor fabrication systems.[16]

14. The LNP came to an end in 1998, but there was no immediate attempt to build upon its apparent success. We sought to discover why. Patrick McDonald explained that, in spite of the large number of benefits produced "we did not find a particular large industrial engagement".[17] He told us that only two companies—Unilever and GlaxoSmithKline—had shown to the DTI any active interest in nanotechnology in the early schemes.[18] The DGRC told us that in the early days much of the UK funding came from the US defence laboratories and that "we were perhaps a wee bit late coming on–stream".[19] Patrick McDonald guessed that the main reason was simply money—the DTI's funding for technological support had been declining up until 2002 and there was "very little money to spend in this technology area".[20] **We have not been given a satisfactory explanation for the absence of a successor programme to the LINK Nanotechnology Programme.**

15. Since the end of the LNP the DTI's non–Research Council support for nanotechnology consisted of an assortment of small scale projects that included an element of nanotechnology rather than being explicitly focussed on developing the technology itself. These included LINK programmes in applied genomics, optics and biotechnology. It was only in 2000–01 that the DTI appeared to begin thinking seriously about providing significant levels of support for nanotechnology. The Foresight materials panel produced a report on nanotechnology in 2000 which led to three nanotechnology research projects costing around £5m. Then the Research Councils established two Interdisciplinary Research Collaborations in nanotechnology and announced a basic technologies programme including support for nanotechnology based projects worth £12m.[21] The department sought to learn lessons from the progress made in other countries by sending multidisciplinary missions to the US and Germany in 2001–02.[22]

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15 Ev 2

16 National Engineering Laboratory, *A review of the LINK Nanotechnology Programme* (NLP), May 2001

17 Q 2

18 Q 10

19 Q 493

20 Q 4

21 See below paras 76-86.

22 DTI, *The International Technology Service Missions on Nanotechnology to Germany and the USA*, March 2001; DTI, *The International Technology Service Missions on Nanotechnology Facilities and Centres, South and West USA*, October 2002

16. The failure to capitalise on this early work has proved costly. By 2001, the UK had fallen from a position generally regarded to be one of relative strength in nanotechnology research to one of relative weakness. The DTI sponsored mission to Germany and the USA concluded that "In 1986, the UK was on the threshold of opportunity; in 2001 we are on the threshold of a major challenge".[23] The independent review of the LNP reported that "There was a general feeling that the UK had fallen behind those countries that had continued to underpin the development of nanotechnology (US, Germany, Switzerland). It was also felt that the focus on nanotechnology in the UK had diminished after the support for infrastructure under the LNP was not continued".[24] The extent to which the UK has fallen behind in international terms is illustrated in Table 2. Although reliable comparable figures are not always available it is clear that the US and Japan have taken a very significant lead in investing in nanotechnology. We were interested that no-one we met on our visit to Germany complained about a lack of funding for nanotechnology. Far Eastern economies such as South Korea and Taiwan are also investing huge amounts in nanotechnology research.

17. Even with the money announced under the MNT Initiative, the UK is not competing in the same league as major international competitors and is significantly behind both France and Germany. This assessment was confirmed by the Taylor Report, which concluded that "the UK is indeed behind its major international competitors in the industrial exploitation of nanotechnology, and in the level of UK industrial support for R&D on nanotechnology applications".[25] **The DTI acted with commendable foresight in engaging industry and universities in a nanotechnology programme in the 1980s when few other countries had taken such steps. But the department's failure to build upon the LNP programme with something similar represents a very damaging failure, which has contributed significantly to the UK falling from a position of international strength in nanotechnology. This lack of foresight and ambition has left the UK in the position of having to catch up.**

23 DTI, *The International Technology Service Missions on Nanotechnology to Germany and the USA*; March 2001, p 4

24 National Engineering Laboratory, May 2001, p 15

25 Taylor Report, p 32

Table 2: Government support for nanotechnology (£millions)

Country	Past spending	Planned spending	Notes
Canada		50 between 2002–07	No national strategy
China	0.16 per annum (p.a.)	100 p.a.	Collaboration with Germany, France and S. Korea
Denmark	84 1988–97	5 p.a.	3 nanotechnology centres created in 2003
France*		536 over next 4 years	Priority given to fundamental research
Germany	173 in 2003	201 .in 2005	Nanotechnology strategy announced in 2003
India		3.4 p.a.	Collaboration with US, Japan, Germany
Italy	31 p.a.		Nanotechnology cluster created in 2002
Switzerland	64 between 2000–03		
Japan**	500 in 2003	200,000 in total by 2010	Focus on nanoelectronics and nanomaterials
USA***	423 in 2003	2,027 p.a. over next four years	National Nano Initiative announced in 2000. Creation of 6 new nanocentres.
S. Korea		80 p.a. over next 10 years	
UK*	30	45 p.a. 2003–09****	Nanotechnology strategy announced 2003

** Micro and nano expenditure*

*** Nano and materials*

**** Additional state funding varies (not included)*

***** Excludes £180m estimated funding from RDA/DAs over this period*

Source: FCO S&T Network; Institute of Nanotechnology. NB.Some figures are estimates of anticipated spending

The Taylor Report

18. When invited by the Science Minister, the DGRC assembled an impressive group of members from industry and from different academic disciplines to work on a strategy for nanotechnology in the UK. In addition to reviewing existing studies in the area the group conducted a comprehensive benchmarking study of UK nanotechnology capability in academia and industry and looked at the activities of leading competitor nations. The advisory group reported back to the Minister for Science and Innovation and the Report, *New Dimensions for Manufacturing: A UK Strategy for Nanotechnology*, was published in June 2002. The main findings and recommendations of the Taylor Report are summarised in Box 1.

19. To prepare its report, the advisory group commissioned a review of nanotechnology research in the UK. This review team formed the impression that the UK was not a world player in nanotechnology. It lacked "critical mass" in any one domain of the subject. Although the UK was strong across many areas the highest quality research seemed to be in electronics and molecular nanotechnology. The review suggested that if the UK wanted to compete on the international stage with a limited budget, a more focussed approach, possibly based on these two areas, might be a good strategy. The UK was found to have a good base of facilities of international standing which, given their wide geographic distribution, might benefit from a "more formalised high profile network".[26]

20. The Taylor Report recommended that companies needed to be convinced of the benefits of using nanotechnology and that steps had to be taken to guarantee both industry and academia access to appropriate facilities and to well trained staff. In order to guarantee access to the right facilities the Report recommended the establishment of at least two National Nanotechnology Fabrication Facilities where individuals and firms could fabricate and test potential products. It was argued that these centres should be focussed around particular applications rather than trying to cover too many, and that they should be able to support the incubation of new ventures.[27]

21. In addition to these main findings and recommendations the advisory group identified six key application areas (out of an initial list of 14) in which the UK has research strengths and industrial opportunities:

- Electronics and communications;
- Drug delivery systems;
- Tissue engineering, medical implants and devices;
- Nanomaterials (bio/medical/functional interface);
- Instrumentation, tooling and metrology; and
- Sensors and actuators.

The report set out a series of detailed targets designed to illustrate what success would look like in 2006 in each of these areas. The steps necessary to reach these targets were also outlined. The Report recommended that the Government take forward the establishment of the first two fabrication facilities "as a matter of urgency".[28]

22. **In our view, the Taylor Report provided a comprehensive, ambitious, affordable and achievable strategy for the development of UK nanotechnology capability: it provided a ready made blueprint which the DTI could have taken forward and implemented in full.**

26 Taylor Report, p 46

27 As above, pp 34-5

28 As above, p 35

Box 1: Findings and Recommendations of the Taylor Report

Findings

- Absence of a stable, visible and co-ordinated strategy for public support for nanotechnology applications in industry
- Fragmentation and lack of critical mass between our research and industrial capabilities
- The absence of a level playing field for Government support in international competition
- A lack of appropriate technology and business incubation facilities
- A need to give priority to the recruiting and training of skilled people

Recommendations

- The creation of an independent steering group to develop and oversee a strategy for accelerating the application of nanotechnology as widely as possible
- The immediate creation of at least two National Nanotechnology Fabrication Centres
- An awareness programme for nanotechnology
- A major training and education campaign to produce trained people
- Development by the DTI and RCUK of effective ways to facilitate access to the best R&D worldwide
- The promotion by the UK of national research capabilities and facilities abroad to encourage collaboration and attract inward investment

3 DTI Response to the Taylor Report

Survey of nanotechnology industrial landscape

23. The initial response of DTI to the publication of the Taylor Report was to commission a survey of the UK nanotechnology industrial landscape in September to "provide further evidence for a support initiative".[29] This study, led by the Institute of Nanotechnology, was intended to provide a clearer picture of the scale and scope of nanotechnology activity within UK industry and how it might look in 3–5 years' time. It also looked at the sectors of industry where the greatest interest lay, and the geographical distribution of interested companies. The group reported in February 2003. The main conclusion of the survey was that few large UK companies were using, or had any real strategy for adopting

29 Ev 80, para 6

nanotechnology. In the main, large companies regarded nanotechnology as somewhat peripheral to their core business, but expressed an increasing anxiety about their lack of information on its potential for product improvement or development. UK companies were found to be slow to identify or adopt "disruptive technologies" which require moving away from traditional approaches.[30]

24. Levels of industrial involvement in nanotechnology related areas were no secret in 2002. The Institute of Nanotechnology had already developed a comprehensive picture of UK nanotechnology activity in a report on *Nanotechnology in the UK* published in 2001.[31] The Taylor Report had already highlighted relatively low levels of industrial awareness of nanotechnology and proposed a detailed strategy to remedy this. **We question the need for the industrial survey commissioned by the DTI three months after the Taylor Report had been published: it did not add significantly to the body of knowledge that was necessary to inform the framework of future funding. The DTI could have responded to the Taylor Report without this unnecessary delay.**

Announcement of the MNT Manufacturing Initiative

25. On 2 July 2003 Lord Sainsbury gave what was effectively the DTI's considered response to the Taylor Report, 13 months after its publication. He announced a package of £90m over six years to help UK industry make the most of the commercial opportunities offered by nanotechnology and win a share of the global nanotechnology market. This sum was to be supplemented by spending from industry, the Regional Development Agencies and Devolved Administrations in excess of £200m. The £90m would be divided into two streams:

- £50m for an Applied Research Programme to support collaborative research and development projects between industry and the science base; and
- £40m to new and existing facilities that will make up the UK Micro and Nano Technology (MNT) Network to drive market development and the exploitation of nanotechnology by giving industry access to cutting edge research and resources.[32]

The whole package has now become known as the MNT Manufacturing Initiative.

26. To some extent, this initiative might be considered by some to be "implementing the Taylor Report." The Report did suggest that, in view of the scattered distribution of existing resources, the UK "might benefit from a more formalised and high profile network, focussing on better inter–institutional utilisation of these resources".[33] But the establishment of a MNT network was *not* the central recommendation of the Taylor Report. The urgent priority identified in the Report was the establishment of nanofabrication facilities, based on existing facilities, to enable UK industry to access the means by which to compete. Such facilities would form the start of a network. Sir John Taylor had reservations about the Government's response to his report, but did not believe

30 Ev 87, para 5

31 www.nano.org.uk

32 DTI Press Release, 2 July 2003

33 Taylor Report, p 46

that it had been rejected: "We wanted to see a rapidly established and evolving network–based programme to draw in industry R&D engineers, starting with at least two existing centres."[34]

27. The Government seems uncertain as to whether it is implementing the Report or not. Patrick McDonald told us, in relation to fabrication facilities, "I am not entirely sure we took a different view".[35] Later, the Science Minister explained to us why the thinking had changed on the establishment of such facilities, as we explore later in this Report.[36] **In our view, whilst the Taylor Report has not been completely rejected, there is no doubt that its central thrust has been lost: it is not being implemented in the manner recommended. Instead of the immediate focus being on the establishment of at least two nanofabrication facilities, the available money is being disseminated widely between supporting applied research and the further development of a number of existing small micro and nanotechnology facilities.**

Micro and Nano Technology

28. Whilst the DTI is developing a *Micro* and *Nano* Technology Network, the Taylor Report explicitly sought to develop a UK strategy for *nanotechnology*. Sir John set out the reasons for this in his evidence to us: "We intentionally focussed specifically only on the nanotechnologies because it is the nanotechnologies that are under–appreciated and under–applied in the UK. We recommended that microtechnology should be brought in alongside wherever appropriate, and that the strategy should develop accordingly".[37] This view is set out clearly in the Report too, so there could be no misunderstanding: it states that micro and nano facilities should not be merged "as this would destroy the explicit focus on nanotechnology which the Advisory Group believes is essential".[38] The DTI decided to have a different focus. The Department's evidence states that the MNT Network has as its objective "to raise the UK's core Microsystems technology capability to facilitate commercial research and development requirements whilst allowing for expansion into more speculative areas of nanotechnology as those requirements develop".[39] **It has focussed on micro, to enable nano to develop later, rather than getting the UK up to speed on nano as fast as possible.**

Behind the MNT Manufacturing Initiative

29. We sought to establish the reasoning behind the DTI's decision to establish the MNT Manufacturing Initiative rather than implement the recommendations of the Taylor Report as a whole.

30. The reaction to the Taylor Report, as far as we can judge, was positive. There seems to have been a consensus, at least among the Research Councils, that Taylor had identified the

34 Ev 139, para 18

35 Q 33

36 See below, para 40.

37 Ev 137, para 6

38 Taylor Report, p 10

39 Ev 83, para 33

right areas for further work.[40] The call for fabrication facilities certainly met the demands of industry, as identified in the Institute of Nanotechnology survey. But there appears to have been no immediate agreement in the DTI on how to take it forward. The announcement of the MNT Initiative was made just over a year after the Taylor Report was published. The Report was not implemented "as a matter of urgency" as its authors had demanded. There seem to be several underlying reasons for this. Funding was one issue. Sir John told us that he was given no indication of the sort of funding he could expect to be available for nanotechnology before he produced his Report, although he had a broad idea.[41] The £90m that the DTI provided was not earmarked in a Spending Review settlement and had to be found from somewhere. Sir John Taylor told us about the "chicken and egg" situation at the DTI, whereby there was a reluctance to commit funds in advance of any evidence that there was significant demand from industry for nanofabrication facilities. We believe that the DTI was too cautious. As Sir John points out, a key objective of the Report was to raise awareness and thereby stimulate demand from industry. Sir John also cites as a reason for delay a procedural debate within DTI over whether the Strategy Group that was recommended should be established formally as a Non Departmental Public Body (NDPB), with all the associated formal and lengthy appointment procedures.[42]

31. We suspected that the response to the Report was dictated in part by financial limitations. Lord Sainsbury rejected categorically the proposition that the decision to reject the main Taylor findings concerning fabrication facilities was financially driven. He explained that the DTI response was driven by two factors: first, "we had a wider view of the different technologies involved as we got into more detail on this; secondly, we saw that there were more opportunities to use current facilities and it made much better sense to do that rather than to just have two big centres for doing that. Those were the two things that changed it—it was not finance [...]".[43] However, he also told us that "I think it [the response to the Taylor Report] was framed in the context of the kind of funds which would be available. If we had implemented the Taylor recommendations as they were set out, we would have been very stretched to do that with the sort of sums of money that we had, even if we were able to get very substantial sums from the RDAs".[44]

32. We find it difficult to reconcile these two statements. The Minister seems to want us to accept that even though the DTI would have been hard pressed financially to implement the Taylor Report recommendations on fabrication facilities, the decision not to do so was taken, not on cost grounds, but on the grounds that the Report had got it wrong. The Minister's answers imply that the Taylor Report had somehow missed the fine detail of technologies that were available or the potential of available facilities. We totally reject this implication. Sir John Taylor conducted a very comprehensive analysis of UK capability in nanotechnology, with the help of leading experts in the field and technical consultants. To imply that in the year since the publication of the report things had somehow moved on, rendering the findings incomplete, is to stretch credibility and to diminish the work of the advisory group that the DTI had appointed to produce the report. Sir John Taylor certainly

40 Q 101

41 Informal meeting with Sir John Taylor, 4 February 2004

42 Ev 137, para 9

43 Q 510

44 Q 466

did not believe that his Report was ill informed about the nanotechnology activities going on in the UK.[45] The DTI strategy now includes not only nano—but microtechnology facilities: this, we can only assume, is what the Taylor Report is judged to have missed. **We find the DTI's immediate response to the Taylor Report wholly inadequate. We suspect that the initial decision to commission the survey of the UK micro and nano industrial landscape was taken in order to allow the DTI to broaden the focus from nanotechnology to include microtechnology, with its greater commercial potential and ability to attract matching funds. The decision to lump together micro and nano technology for the purposes of the MNT Initiative and to focus on the micro first will have serious adverse consequences for the successful commercialisation of nanotechnology in the UK.**

Funding

33. The £90m announced by Lord Sainsbury in support of the 2003 MNT Initiative is to be spread over six years from 2003. It will be used to lever in funding from other sources to support micro and nanotechnology research and development. Overall, the DTI expects £540m to be invested over this period. The breakdown of this projected funding is set out in Table 3.

Table 3: Government's estimated public and private funding for nanotechnology 2003–09

Funding Source	Funding (£m)
Research Councils	180
Government via MNT Initiative	90
Industry	90
Regional Development Agencies	180
Total	**540**

Source: Evidence Q 15

34. Applicants for DTI funding from industry will be expected to provide 50% matching funding for any project. The £180m from the Research Councils is based on current annual estimates of their funding for nanotechnology research.[46] The Regional Development Agencies (RDAs) and Devolved Administrations (DAs) are also expected to provide £180m of funding. We questioned the basis of this figure. Neil Mundy, Chairman of the RDA MNT Network Group,[47] told us "The £180 million is an aggregation of, I think, the DTI's view on the level of interest currently shown by the RDAs in a range of projects. The figure is an estimate by its nature; it is not capable of being tracked down to specific figures. It is an assessment given the number of projects in which the RDAs are interested as being a reasonable figure on which to assume the RDAs will contribute".[48] It is an educated guess,

45 Ev 137, para 2

46 See below, paras 63-70.

47 The RDA Network Group consists of representatives from the 9 English RDAs plus the 3 devolved administrations. For convenience, the term RDAs will hereinafter include the devolved administrations (DAs).

48 Q 333

not by any means a commitment. We have doubts about whether it is a realistic estimate. Clive Reeves from Scottish Enterprise told us: "I think that was only intended as an indication of the combined buying power of all the RDAs".[49] Neil Mundy added, "I think it is achievable but one must remember that the funding that the RDAs and the devolved administrations have are often tensioned against other requirements".[50] It must be true that the amount that RDAs are prepared to pledge will depend upon the nature and location of the projects to be funded and on other demands on their budgets. If the DTI could only find £90m to support this major initiative, then it could be argued that it has done well if it succeeds in levering in what might be a further £270m from the RDAs and from industry. There is no doubt that this extra money is welcome—£90m over six years would not go far. The DTI had to devise a strategy that would attract money from other sources. The consequent involvement of the RDAs has important implications for the direction and management of the MNT Initiative. We discuss this further in paragraphs 63-70 below.

35. The projected sum of £540m over six years should be seen in the context of the sums being spent in other competitor nations.[51] In France, Government federal funding alone for nanotechnology will be over £500m over a four year period; Japan has committed £500m for 2003–04 and South Korea has committed £80m per year for the next ten years. In the US, funding has been increased to $1bn per annum for 2003–06. Witnesses did not believe that the sums committed by the UK were in any way enough to help catch up with major competitors. Neil Mundy said that "I think we have expressed a view that, in the context of Dr Taylor's report about placing UK as global leader by 2007, those sums are insufficient".[52] The DTI made no pretence that the funding announced was going to put the UK back amongst the leaders in terms of levels of support for nanotechnology. Patrick McDonald told us "I think the best way of characterising our initial engagement is to get us on the road. It is not to get us to catch up […]".[53] **This lack of ambition is very disappointing.**

Other Government departments

36. It is disappointing that the DTI's funding for the Network has not been supplemented by contributions from other Government departments, many of which stand to benefit from the fruits of nanotechnology research. The Ministry of Defence (MoD) and the Defence Science and Technology Laboratory have contributed to two Interdisciplinary Research Collaborations established by the Research Councils. The Department of Health (DoH) has funded stem cell research, although this is not strictly nanotechnology and should not be included by DoH in their calculations of funding this area. Other Government departments have not contributed in the way that departments of state have done so in the US.[54] The RDA Network Group reports that many Government departments have not fully engaged with the MNT Network, including the Department for the Environment, Food and Rural Affairs (Defra), the DoH, and the Environment Agency

49 Q 335

50 Q 308

51 See above, Table 2.

52 Q 310

53 Q 15

54 See www.nano.gov

and that "further work is required" in this respect.[55] These departments have representatives on a DTI MNT officials group but such engagement does not seem to be translating into the commitment of funding for relevant research. The MoD has not itself carried out any work specifically on nanotechnology, but is conducting studies into the effect of depleted uranium nanoparticles.[56] It also has a number of research programmes with elements of nanotechnology, in areas such as chemical and biological weapon detection, protective clothing, precision munitions and molecular electronics.[57] In contrast, the DoH is "monitoring progress in nanotechnology and clinical applications in this field".[58] Whilst this interest in nanotechnology research may not have the same commercial focus that DTI has, there is nonetheless a case for the MoD, DoH, Defra and the Environment Agency at least to support policy related research in this area. The RDA Network Group say that "there has not been sufficient opportunity to establish that engagement which we believe is important".[59] This is unconvincing. **We recommend that the Government Chief Scientific Adviser liaises with the MNT Network and relevant Government departments to encourage the commitment of resources from departments to potentially useful nanotechnology research, as appropriate.**

The long term

37. We welcome the fact that the money committed under the MNT Initiative is for six years rather than the usual three year period of a spending cycle. However, if the UK is to be seen by industry and researchers as a serious player in nanotechnology the levels of funding will need to be significantly increased and guaranteed for the long term, at least the next ten years. Patrick McDonald was well aware of this. He told us: "All along in my dialogue with the Treasury, I have made it clear that this is a long term engagement and that what Lord Sainsbury announced was the first phase of a nanotechnology programme which would last probably ten plus years".[60] Such long term commitments do not sit easily with spending cycles. Patrick McDonald told us, very diplomatically, that "I have to acknowledge that there is a tension within the natural process in which I live and the natural timescale of some of these technology developments".[61] Nonetheless, he was optimistic: "It ought to be possible to put in place a long term programme within that structure".[62] We agree.

38. The DTI may be thinking long term but the Treasury is not noted for underwriting long term financial commitments. There are encouraging signs, however. Recent spending review settlements indicate that the Treasury recognises the economic benefits that scientific research can bring to the country. The Government announced a commitment to a ten year investment framework for science and innovation on 16 March 2004. One of the aims is to examine how to achieve the "better commercial translation of leading edge

55 Ev 124, para 53

56 Ev 146

57 HC Deb, 23 June 2003, col 542W

58 HC Deb, 10 June 2003, col 840W

59 Ev 132

60 Q 29

61 Q 29

62 Q 31

technologies into applications in business and the public sector". The consultation on the strategy seeks to identify technology-based sectors in which the UK has the potential to be competitive internationally over the next ten years.[63] **We welcome the long term view taken by the Government in its science and innovation framework consultation but question the need for yet another consultation on such well trodden ground.**

39. Nanotechnology would benefit enormously from a ten year strategy—it would provide the necessary encouragement for researchers and industry to become involved in nanotechnology R&D. Lord Sainsbury has been an advocate for nanotechnology for a long time. We hope that he is successful in arguing its case in the current consultation and in Government in the context of the 2004 spending round. It was the Treasury that highlighted the importance of nanotechnology in its *Investing in Innovation* strategy in July 2002.[64] Now is the opportunity for the Government to back up this vision with funding. **The sums of money currently committed by Government and other agencies, spent in line with current strategy, will ensure that the UK continues to fall behind our major competitors. We recommend that in its ten year investment framework for science and innovation the Government gives a clear commitment to funding nanotechnology research and development at least over the next ten years at levels significantly in excess of current spending plans.**

Fabrication facilities

40. One way of getting maximum value for the relatively low sums of money the UK has to invest would be to focus funding on a very small number of world class facilities to provide access to both top–down and bottom–up nanotechnology. The Taylor Report concluded that the absence of facilities where researchers and companies could work together to develop new products and incubate new businesses was one of the most important obstacles to the more rapid take up of nanotechnology in industry. It recorded that other countries provided public support for their nanofabrication facilities but that UK facilities are not easily accessible to industry. The establishment of accessible facilities did not fit comfortably with any existing DTI industrial support scheme. The Report recommended the establishment of at least two Nanotechnology Fabrication Centres, which should operate world–class facilities in which individuals and firms could prototype and fabricate potential products. The Centres would work with existing centres of excellence and Research Council facilities. The Report recommended that funding for the centres should start at £25m per year, rising to at least £75m per year within five years, provided that demand justified the increase.[65] The survey of the UK nanotechnology industrial landscape commissioned by the DTI seemed to support the case for such facilities. A nanotechnology fabrication facility was regarded by small and large companies as crucial to providing an impetus for nanotechnology in the UK.[66] Small start–ups in particular were thought liable to struggle when they outgrew existing facilities.[67] We found the arguments in favour of the

[63] HM Treasury, DTI, DfES, *Science and Innovation: working towards a ten-year investment framework*, March 2004, pp 8, 19

64 HM Treasury, *Investing in Innovation*, p 68

65 Taylor Report, p 35

66 Ev 81, para 13

67 Ev 88, para 10

establishment of such facilities to be strong. They could act as a focal point for both industrial and academic research and form the basis around which nanotechnology clusters could form.[68]

41. Lord Sainsbury explained the reason for the development of Government thinking on fabrication facilities: "the idea that two was the right number does not look right now. We will want a wider range of technologies involved in this, so I think the number will be more than two".[69] Patrick McDonald argued that "To build two new nanotechnology fabrication centres on green field sites, starting from scratch, would take at least five years".[70] This explanation does not stand up to scrutiny. By focussing on the establishment of two facilities, on green field sites, the DTI is misrepresenting the Taylor recommendations. Sir John sought to put the record straight in his evidence: "My report did not call for a strategy of two new Nanofabrication centres on green field sites. We recommended 'at least two centres' to be developed around existing research facilities to provide a base level of diversity both geographically and between life science and physical sciences applications".[71] These facilities were envisaged as merely a basis on which further activity could be built as the strategy developed. He lobbied DTI not to go for the green field site option which seemed to have gained credence. The Taylor Report envisaged that these facilities would be focussed around specific major areas of nanotechnology, such as biotechnology applications or nanoparticles.[72] Lord Sainsbury referred to "a wider range of technologies", but there is no reason why new facilities could not be multi–functional, and provide the range of capabilities which the DTI seems intent on supporting. This is the aim of the London Centre for Nanotechnology being established by Imperial College and University College London, due to open in autumn 2004, which will combine under one roof around 100 scientists with expertise in physics, chemistry, biology, electrical engineering, medicine, materials and geology. The Cambridge Interdisciplinary Research Collaboration is also establishing multi–functional facilities on site.

42. Other countries have chosen to develop one or several major world class facilities for nanotechnology research. France has Minatec at Grenoble and Belgium has the IMEC micro-electronics centre. These provide an international profile and focus for nanotechnology activity in Europe. In Germany six nanotechnology competence centres were established in 1998 and funding is strategically directed to building on existing areas of strength such as micro–electronics. Other countries have provided the long term continuous funding to give their centres the stability and confidence to expand their facilities and to attract the best scientists from all over the world. Lord Sainsbury told us "I think generally, for good reasons, people are moving away from the one kind of stand-alone centre on these things because I think it is increasingly seen that we need to put this kind of research into a university environment because so much of it is multidisciplinary and you want to have that interaction across the different disciplines".[73] We do not believe that the major centres are proving to be less popular now. Quite the

68 See below, paras 71-73.

69 Q 489

70 Q 33

71 Ev 137, para 1

72 Taylor Report, p 35

73 Q 480

opposite, in fact: we came across concerns that the best researchers would move abroad to work at such facilities. Indeed, one witness told us that it was difficult to obtain EU Framework Programme funding without being based at one of the big European facilities.[74] The Taylor Report stated that "unless the level of industrial R&D increases considerably and rapidly, the UK is likely to see a drain of talent to well rewarded work in leading edge industry labs overseas".[75] **The impact of a decision to develop world class centres in the UK on the number of top quality researchers remaining in or coming to the UK should not be underestimated.**

43. A decision to support two major facilities (in the first instance) would of course have led to difficult choices about their location. Such a decision would also have made it much harder to attract money from RDAs remote from the chosen locations. We recall all too clearly the bruising process of the decision to locate the Diamond synchrotron facility at the Rutherford Appleton Laboratory (RAL) in Oxfordshire and the repercussions for the alternative site at Daresbury in Cheshire. The Institute of Nanotechnology–led survey for the DTI on the industrial nanotechnology landscape indicated that at present the geographical balance of companies involved in nanotechnology is tilted towards the Midlands and the south of the UK.[76] There would, not unreasonably, be strong pressure from industry to ensure that any new facilities would be sited in this region. Indeed, there is still significant pressure in this respect. We were told by Patrick McDonald from the DTI that "it is essential to build on the critical mass we have at the moment, so Oxford and Cambridge, London. We have to build on those".[77] Professor Whitehouse, Director of the Engineering Department at the CCLRC told us "I still think there is a very important need for state–of–the–art technology centred in two or three centres".[78] One centre already exists at the Rutherford Appleton Laboratory. Professor Lawes from the Institute of Electrical Engineers told us that "there are three very large facilities there, which are absolutely world–class and which are, hopefully, to be employed in nanotechnology".[79] One such facility, the Central Microstructure Facility, had struggled to get funding and, he said, would have difficulties entering useful partnerships with universities and industry without further support.[80] No doubt RAL will be competing for MNT Network funds but it would be a failure of strategy if existing world class UK facilities were not to be fully utilised in the MNT Network. Indeed, there must have been a strong case for making RAL a first hub of nanotechnology activity on which the network could be built.

44. As we have seen, Lord Sainsbury maintains that the DTI would have been "very stretched" to establish two fabrication facilities. But this assumed the establishment of two centres on green field sites – a misinterpretation of the Taylor Report. The £90m could, according to the recommended levels of funding in the Taylor Report, be used to fund one such facility for at least three years without any additional support. Money attracted from industry and from relevant RDAs could have been used to provide support for other

74 Q 443

75 Taylor Report, p 30

76 Ev 80, para 9

77 Q 95

78 Q 109

79 Q 443

80 Q 433

facilities. **We are convinced that, had it wished to, the DTI had the necessary resources to sponsor at least one nanofabrication facility for the short term. We believe that the UK's industrial and academic strength and its international competitiveness in nanotechnology would have been better served by the establishment of one, if not two, nanofabrication facilities to give nanotechnology in the UK a distinctive focus. The rejection of this option appears to have been based more on regional political than economic factors. A geographically diverse network of small scale facilities is far easier to sell than one or two major centres built upon existing strongholds of research and development. The DTI displayed timidity and poor judgement in deciding against the immediate development of two nanofabrication facilities.**

The MNT Manufacturing Initiative and Network

Establishment

45. In January 2003 the DTI declared its strategy to support the formation of a Micro and Nano Technology Network and invited the RDAs to participate in the establishment of the MNT Manufacturing Initiative. They formed a Network Group comprised of representatives from the RDAs and the Devolved Administrations. This Network Group helped develop objectives for the Initiative. In line with the Taylor Report's recommendations, a National Strategy Advisory Group (NSAG) was then established to provide strategic direction to the Network. It met for the first time in June 2003 and is scheduled to meet four times a year.[81] It was not until January 2004 that a Network Director, Dr Hugh Clare, was appointed.

46. Instead of starting by appointing a strategic advisory group, as recommended by the Taylor Report, in order to advise on the development of a strategy, the DTI first decided to secure the participation of the RDAs, and their money. The objectives and goals of the MNT Initiative, and the division of the £90m into the two funding streams, were all agreed before NSAG had even met. From its first meeting in June 2003 it took a further six months to recruit a Network Director to actually drive the process forward**. The process by which the DTI established the MNT Initiative lacked logical coherence. The means were put before the ends, the broad strategy set before the strategic advisory group formed. The DTI is now left to try to make its strategy work around the constraints imposed by its original decisions.**

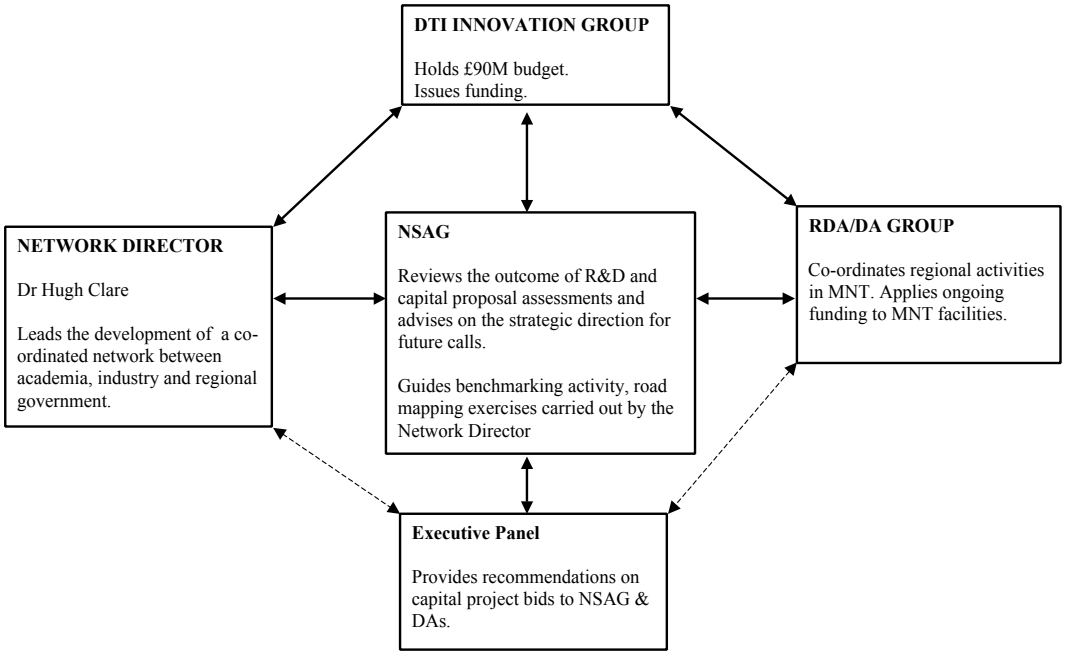
Structure and decision making

47. The decision making processes involved in the MNT Initiative are crucial to its performance. The bodies involved are set out in Figure 1 below.

81 Ev 122, para 5.1

Figure 1

DTI Micro & Nanotechnology Manufacturing Initiative Organisational Chart



Source: DTI, ev 140

The membership of NSAG consists of representatives from industry, academia, the RDAs and DTI. The Executive panel which provides recommendations on the award of funding on the capital projects funds to NSAG and the RDAs has a similar mix, and is led by the Network Director. The DTI holds the funding, and makes awards on the basis of the strategic recommendations from NSAG, but, as Figure 1 indicates, the RDAs have a direct influence on the DTI.

Role of Network Director

48. According to the recruitment advertisement for the Network Director, the purpose of the job is to:

- Provide input to the development of a national agenda for MNT and engage with all stakeholders across industry, academia and government to build an appropriate team and operational hub to deliver it;
- Act as the strategic and operational bridge between academia, industry and leading research bodies on all matters relating to MNT to ensure maximum impact and synergy;
- Unify existing facilities, and negotiate access to new facilities (both public and private) to fully meet the needs and demands of users of the Network; and
- Act as the authoritative UK voice and inspiration on MNT issues within the international community.

The Network Director will also "carry out benchmarking activity and road mapping exercises in micro and nanotechnology for the benefit of the network".[82] Lord Sainsbury told us "Clearly, he would be the person who would probably be putting forward the recommendations. That [decision] would be taken within the DTI, on the advice of the advisory strategic group we put together".[83] Looking at his formal role, the Director seems to us more of a champion, a facilitator and encourager, rather than someone who directs the Network or takes strategic decisions. **We are concerned that the MNT Network Director does not have the remit to give the Network the sense of direction and drive that it needs.**

49. The complicated decision making structure certainly confused witnesses, some of whom were not in agreement on who is driving the network forward. The Chairman of the RDA Group, Neil Mundy, told us that "we hope that the work of the network will not be seen as a RDA activity" and he aimed to let "industry actually be seen to be taking the lead".[84] When asked who would be responsible for running the Network, the DTI told us that "The DTI is going to take a back seat at this point".[85] However, the RDAs told us that the DTI would intervene to ensure that the Network would put national rather than regional interests first. Lord Sainsbury sought to clarify the picture: "There is no question of who is responsible for what. In terms of forming this network, we will make the decisions on that advised by the nanotechnology advisory group, which we have set up. We will decide which of the projects and make certain they are in a proper network and we will then have a network manager who will manage that."[86] The Minister also played down the role of the RDAs: "we are not doing it [allocating the £180m RDA money] on the basis of decisions being made by the RDAs. We have a national advisory committee and we will have real professionals who will assess the projects. All that the RDAs are doing is putting forward projects".[87]

50. It is clear to us that there has been considerable confusion over who is responsible for doing what in the MNT Network. The DTI are clearly *not* taking a back seat, but nor are the RDAs. The structure of the bodies forming the MNT Initiative indicates that the RDAs *will* have a significant role in determining how the money is allocated. This is hardly surprising. They could not be expected to commit money without retaining some control over its allocation. We deal later on with the impact of their involvement in such decisions.[88] It is far from clear to us who is taking full responsibility for the operation of the Network. The Initiative lacks an expert and authoritative driver. Sir John Taylor told us that if the MNT Initiative was not overseen by a "well informed and involved core group any significant levels of coherence and critical mass will be almost impossible".[89] The NSAG, which meets four times a year, is not in a position to provide such oversight and in

82 Ev 140

83 Q 513

84 Q 330

85 Q 48

86 Q 511

87 Q 474

88 See below, paras 63-70.

89 Ev 138, para 11

Sir John's view, was not "having much impact".[90] **We recommend that the DTI strengthens the leadership of the Network by giving real powers to the Network Director and by engaging the necessary expertise on a more established basis to inform decisions relating to the direction of the Initiative.**

Objectives

51. The Taylor Report set out in some detail what success would look like in each of the six technology areas studied in detail.[91] Under the heading What will success look like Taylor suggested what might be achieved in the development of each technology and which stakeholders should be engaged by given dates. The goals of the MNT Network are not so specific. They are as follows:

2007

- Cohesive MNT network;
- Adoption of MNT as an essential element of product development and innovation;
- Better supply of skilled MNT people to meet industry's needs;
- Recognition that UK has world class facilities – evidence of take–up;

2009

- Better environment to create spin–outs and inward investment;
- UK industry has captured and retained an increased level of high added value business;
- Preferred location for investment in MNT;
- Develop research/academic careers in UK;
- Establishment of recognised undergraduate courses in universities for MNT;

2012

- MNT takes over as a key driver of UK and global industry; and
- UK has increased its research base.[92]

Most of these goals are so vague as to be almost meaningless. They are not specific or measurable in any objective way. Nor do they provide a picture of where the UK might be in 10 years' time or a road map or levels of investment to get us there. **We recommend that the Network Director and NSAG devise specific and measurable targets covering levels of investment from the UK and abroad, the division of spending on micro and**

90 As above

91 Taylor Report, pp 47-69

92 Presentation by MNT Network Director at the NMT Manufacturing Initiative Information Day, 28 January 2004

nano technology, numbers of new companies, research outputs, collaborations, graduates and courses.

Applied Research Programme

52. One stream of the MNT Initiative is the Applied Research Programme, for which DTI has set aside £50m out of the overall sum of £90m. This will be awarded to industrial and academic research projects in micro and nanotechnology. The aims of the programme are to :

- Support and catalyse both industry/industry and industry/academic collaborations;
- Improve awareness, emphasising the commercial benefits of these technologies;
- Build a network of existing fragmented and commercially sub–critical academic and other nanotechnology centres; and
- Enhance existing facilities to enable them to provide services to industry, including supporting infrastructure.[93]

53. It was announced that the funding for the Applied Research Programme would be committed to projects of 2–4 years' duration over three years and spent over 6–7 years. The funding would be conditional on attracting at least match funding from industry. Grants would be allocated through a competitive bidding process using independent evaluators and a two stage application process would be used, with only the promising outline proposals being developed into full proposals. According to the guide for applicants, proposals will be assessed on the potential of research for commercialisation and alignment between market need and Government policy objectives.[94] An initial call for expressions of interest in September 2003 attracted some 615 submissions, around half of which involved industrial partners. After the finding of the earlier survey, this response left Patrick McDonald at DTI "quite staggered".[95] It certainly belied the apparent lack of industrial interest found in the 2003 industrial survey. This level of interest is perhaps partly due to the impact of DTI, the Institute of Nanotechnology and others, but also an indication of the stimulating effect of the prospect of a share in a £50m pot of money.

54. The aim was for this call for expressions of interest to be used to develop a picture of demand and technical themes for the first call for proposals.[96] Five main headings were identified for the proposals:

- novel materials;
- manufacturing/production techniques ;
- ultra precision engineering;
- micro systems; and

93 Ev 82-83, para 31

94 DTI, UK MNT Initiative, Applied Research Programme, *Guide for Applicants*

95 Q 14

96 Ev 83, para 32

- bottom–up nanotechnology.

Over half of the expressions of interest were in the area of novel material and microsystems. They covered a wide variety of potential applications, in different areas of economic activity, including chemicals, energy, food, electronics, health and automobiles. The first call for outline proposals was made on 2 February 2004 and closed on 26 March. Proposals had to include the participation of at least two UK businesses. This is a fairly short space of time in which to seek partners and put together a considered proposal. This first call was open in scope: no funds were earmarked for specific areas. In evidence Patrick McDonald acknowledged that "we can only focus on a few areas. We would probably end up spreading the money too thinly if we tried to address everything".[97] He expected NSAG to produce a strategy based upon supporting particular strengths and plugging any weaknesses. **There is at present no sign of such a strategy, or of any commitment to developing one. We understand that future calls for proposals may be more focussed, but this is by no means part of an established policy as yet.**[98] We note that a UK Roadmap is scheduled to be completed by July 2004, although the level of detail this will contain has not yet been indicated.[99]

The MNT Network (Capital Projects Programme)

55. The second stream of funding under the MNT Initiative is devoted to the establishment of the MNT Network. This is designed to provide access to academic and industrial facilities throughout the UK in order to drive forward the commercial exploitation of nanotechnology. The benefits and purposes of the MNT Network are summarised as follows:

- Improving access to a critical mass of world–class knowledge and facilities in the UK and overseas;
- Providing a catalyst to drive the specialist training and development of people to fuel growth in these emerging markets;
- Facilitating the integration of the complete supply–chain and better use of facilities, to take "blue–skies research" through to high–volume and high–value–added manufacture by UK companies;
- Identifying the demand for, and working with stakeholders to provide the new facilities needed to build the UK MNT capability;
- Encouraging a coordinated approach to applied research programmes and business support; and
- Providing a focus for information and advice to provide the support for UK business to drive innovation and new products.[100]

97 Q 26

98 Presentation by the Network Director, Hugh Clare at MNT Manufacturing Initiative Information Day, 28 January 2004

99 Ev 141

100 Ev 121

56. The £40m committed to the establishment of the Network is divided into two parts: £30m for initial set–up and capital costs plus £10m over five years towards running costs. The total set–up costs are estimated to be £120m. The balance is expected to come from partners and revenue generation. Capital Projects are defined as: "Industry/market facing UK based facilities which provide cost–effective open access for organisations and individuals to capabilities, processes and associated knowledge leading to marketable products, and services."[101] The money is to be distributed in three separate tranches. The first call for proposals, which ended in December 2003, resulted in 35 applications seeking a total of £81m. These focussed upon biomedical systems and sensors, optoelectronics and novel electronics.[102] It is expected that no more than half of the funds will be allocated in this first round, the results of which will be announced in April 2004. The second call for proposals will open in April 2004. Further calls will be made in spring and then winter 2004.[103] The following month, a register of existing nanotechnology assets will go live.[104]

Terms and conditions

57. The award of DTI funding must be matched by private sector funding. In awarding funds, the DTI has indicated that the emphasis is likely to be on building on existing facilities rather than constructing new ones.[105] Another factor to be taken into consideration will be the expected timescale for a financial return. Proposals will be expected to demonstrate the potential for additional revenue generation *within three years*. In addition to the anticipated return within a three year timeframe, projects must demonstrate the potential for significant further benefits on a longer timescale, of ten years. This longer timescale is necessary in order to identify the commercialisation opportunities for the more exploratory elements of MNT that are currently being researched.[106] We were disappointed to hear Patrick McDonald admit that the long term industrialisation of some facilities had not yet been thought through.[107] Professor Bates from the London Business School was not alone amongst our witnesses in thinking that a three year time frame was "probably not" sensible.[108] Clive Reeves from Scottish Enterprise explained the thinking behind this timescale from the RDA point of view: "Maybe three years is too aggressive, but maybe there are technologies that the UK will capture on that three–year timescale and do very well at and I think that by getting some early successes, we will be able to make the case to justify considerably more funding".[109] We formed the impression that the DTI was reluctant to expect too much by way of a return after three years but was obliged to provide some indication of financial monitoring. Patrick McDonald told us: "We will have to show some impact of this expenditure over a three year period. We are not likely to see much in terms of real revenue generated. What I have put down as a set of metrics for which to

101 DTI, UK MNT Initiative, Applied Research Programme, *Guide for Applicants*

102 Neil Mundy, Development Agency MNT Group Chairman, Presentation at MNT Manufacturing Initiative Information day, 28 January 2004

103 www.mnt.org.uk

104 Ev 141

105 www.mnt.org.uk

106 As above

107 Q 51

108 Q 274

109 Q 318

benchmark this programme is in terms of changes in behaviour, so more companies saying that they are aware of nanotechnology; more companies using nanotechnology in their experimental phases; more business/academic collaborations and hopefully an increase in the number of graduate and postgraduate employees working on nanotechnology related activities within the programme overall".[110]

58. We are concerned about the effect that the three year criterion will have on the award of funding. If financial returns are a requirement, funding would inevitably be directed at relatively well developed technologies which can make a return in this time scale. This would make micro a far more attractive option than nano technologies, with the likelihood that the money will go predominantly in that direction. Professor Lawes, who sits on the MNT Executive Panel on behalf of the West Midlands RDA, confirmed the danger: "the pressure is on them [the RDAs] to transfer the technology. The most likely things to be transferred are things which are pretty well mature".[111] This pressure should not be allowed to drive the strategy. **To spend the MNT Initiative funding on the establishment of a series of relatively mature microtechnology facilities would be to throw the Taylor Report, with its emphasis on developing the UK's nanotechnology capability, out of the window. We accept that both the DTI and RDAs need to show a return for their investment, but an insistence on seeing a return in three years for technologies in their infancy is liable to be counterproductive, and inhibit the development of the very technologies that the MNT Initiative is trying to stimulate. We recommend that DTI develop performance measures that are realistic in terms of revenue generation and are based on a longer time scale than three years.**

59. We also have concerns about the impact of the financial conditions governing the allocation of funds on their distribution. The DTI will fund at a maximum of 50% of total costs, decreasing to around 25% for those products nearer to market. We are not convinced that this 50% will, in practice, be sufficiently attractive to SMEs. Whilst universities can claim the full economic costs of their portion of the grant, the SME portion, once various deductions have been made, will be nearer to 30%. Professor Cass from the Biosciences Federation put the case very clearly:

> "If you do the figures, the universities have to recover 100 per cent of their costs, the SMEs can survive on recovering 50 per cent of their costs. If all that the DTI is going to put in is 50 per cent overall, it means they need a large company as the third arm that is prepared to do the work, or to enter the collaboration for only 30 per cent of its total true cost. It is proving to be very difficult to find large British companies which are prepared to collaborate on those terms, and so, while you can find lots of university departments keen to collaborate with industry, you can find lots of SMEs which are very keen to collaborate with universities, under the particular rules of the MNT programme it was proving to be very difficult to find the third leg, the large industry which had to come in to make the numbers balance."[112]

For small companies, the disadvantages are very significant. They may be discouraged by the burden of risk and potential return, particularly if other partners cannot be found.

110 Q 49

111 Q 431

112 Q 455

They may not be in a position to make the necessary level of financial commitment from their limited R&D budgets. Spin–outs and SMEs need low cost access to facilities and expertise. Where companies have been spun out of universities they certainly need to retain access to the relevant facilities. There are many factors which influence levels of SME R&D spending on nanotechnology, but the availability of financial assistance from the DTI with reasonable conditions is a major one. **We recommend that the proportion of funding available to SMEs is reviewed after the first round of funding, and amended if the take up is low.**

60. There is a further danger that, by adopting this policy on the proportion of costs that can be funded, the DTI is putting UK nanotechnology at a disadvantage compared to some counterparts on the continent. Lord Sainsbury did not believe this to be the case: "I do not believe that we have any difference in policy on near market support in this from other countries. We are all in roughly the same position."[113] We learnt in Germany that joint applied research programmes are usually state funded up to 50% of the eligible costs incurred by SMEs (this may be slightly higher in eastern Länder which are classified as developing regions) and up to 100% of the eligible costs incurred by public research institutes such as the Fraunhofer Institutes. Thus overall state aid may be considerably in excess of 50% for joint SME/institute projects, depending on how the work is divided. Although applicants for Capital Projects Programme funding may include other public sector partners, potentially taking total public sector funding over 50%, there is a tapering of such aid to make it less generous for projects at the near market end.[114] No such tapering occurs in Germany, as far as we are aware: the Fraunhofer Institute we visited in Saxony told us they had no hesitation in supporting projects which were very near to market. We noted in our renewable energy inquiry that the DTI's aversion to funding products close to market contrasts with that of major competitors, such as Japan.[115] The relatively cautious approach by DTI to state aid disadvantages UK companies and deters inward investment. Multinationals may choose to conduct their research in countries where there is more money available for nanotechnology research, with more generous conditions. It will take more imaginative incentives to meet the strategic objective to make the UK a preferred location for investment in MNT.

Responsive mode and strategic direction

61. We have reservations about the responsive nature of funding under the MNT Initiative. The DTI is aiming to stimulate demand from industry and then to follow its lead with the provision of funding. Neil Mundy from the RDA Network Group identified the need to focus the funding: "the philosophy is not to spread the jam thinly but to actually centre it in areas where there are key strengths".[116] Patrick McDonald agreed that "we can only focus on a few areas".[117] This view was supported by witnesses from industry.[118] It was also the

113 Q 525

114 DTI, UK MNT Manufacturing Initiative, *Guide for applicants*, p 4

115 Fourth Report, Session 2002-03, *Towards a sustainable non-carbon fuel economy: research, development and demonstration*, HC 55-I, para 93

116 Q 311

117 Q 26

118 Qq 177, 215

approach adopted by the German Government, which in 2002 identified four broad innovation areas in which it sought to build on existing resources. We agree that industry needs to play a prominent role in the determination of the most promising areas of nanotechnology to pursue but such strengths have already been identified. The Taylor Report identified six areas of nanotechnology in which the UK had a reasonable chance of making a mark. The DTI commissioned survey of industrial activity identified nanomaterials as the area of greatest activity in the UK.[119] Clive Reeves from Scottish Enterprise listed areas in which the UK has "huge research strength", even in comparison to the US.[120] **The areas identified by the Taylor Report could have formed the basis of six managed programmes for the applied research programme funding strand, complemented by the provision of relevant facilities.** The DTI has still not taken any decisions on where to focus.

62. The primarily industry driven and unfocussed approach adopted by DTI is not likely to help the establishment of the UK as a leader in specific fields. The absence of a national strategy was identified at one of the RA/RAE workshops on nanotechnology as being a brake on the successful application of nanotechnology in the UK.[121] The Network should retain some flexibility in order to respond to emerging patterns of demand and any exciting breakthroughs, but more guidance from the leadership of the MNT Initiative will be needed to ensure that industry is encouraged to work in areas of existing strength and maximum potential. Otherwise, research efforts are liable to be dissipated too widely to enable a critical mass to emerge in any one area. In our renewable energy Report, we concluded that "By repeating the not picking winners mantra, the Government has failed to take a lead".[122] The same applies to nanotechnology: the DTI needs to be brave enough to take decisions in order to give some definition to the UK's nanotechnology R&D efforts. **We recommend that future calls for proposals in the applied research and capital projects programmes are directed towards the meeting of strategic targets in specified areas that are devised by the Network Director and endorsed by the National Strategy Advisory Group.**

Role of Regional Development Agencies/Devolved Administrations

Engagement

63. The MNT Network represents a new approach to engaging RDAs and devolved administrations in national collaboration on investment in a particular industrial sector. If successful, it may form the working model for future sector–based DTI initiatives. We wanted to see how the new model would work in practice and whether the RDAs are up to fulfilling this new role in supporting micro and nanotechnology.

64. At the instigation of the DTI, the RDA Network Group was established in January 2003 to help drive forward the MNT Network. The Network Group comprises representatives of all nine RDAs and the three Devolved Administrations (DAs) and marks

119 Ev 80, para 10

120 Q 322

121 Royal Society Press Release, 10 November 2003

122 HC (2002-03) 55-I, para 218

the first time that they all have worked together.[123] We have already pointed out the prominent role that RDA representatives are to play in the decision making structures of the MNT Initiative.[124]

Nanotechnology activity

65. Before the establishment of the Network, some RDAs had already supported nanotechnology initiatives in their areas. Examples include a University Innovation Centre for Nanotechnology in Newcastle, a "Nanotech NI" centre in Northern Ireland and a Microsystems Packaging Centre in the North West (although this is micro rather than nano activity). The RDAs have also been working on the establishment of an asset register of nanotechnology capabilities in the UK, including both academic and industrial facilities, which is due to be completed in July 2004.[125]

Science expertise

66. Whilst there is evidence that awareness is rising, it would be wrong to give the impression that nanotechnology appears prominently on the horizons of many RDAs. It is clear that not all of them have been quick to help exploit the scientific potential of their regions. Witnesses to the 2003 inquiry by the House of Lords Science and Technology Committee into Science and the RDAs expressed concerns about their lack of scientific and innovation based expertise and that Committee called for RDAs to review their capabilities in this area.[126] Similar concerns in respect of knowledge transfer were reflected in the Lambert Review.[127] The evidence we heard from SMEs indicated that not all RDAs have been very proactive in making contact with local nanotechnology spin–out companies or supporting them financially. Professor Welland from the Cambridge IRC suggested that in some cases "the nano network is not high on their agenda and in some cases it is quite clear that they do not really understand the issue".[128] Neil Mundy acknowledged to us that "there is a range of capacities within the RDAs".[129] The Science Minister too seemed to accept that there are weaknesses, emphasising that "the main thing now is to make certain that they [the RDAs] move ahead on this and get very good people to run them".[130] There is evidence that RDAs are increasingly recognising the importance of science to their regional strategies. Some have now established Science Councils, linked together by a network to exchange best practise, and scientifically qualified people are being recruited.[131] Some are also playing an active role in seeking out companies which could benefit from collaboration with universities.[132] The North West Development Agency and One North

123 Ev 121, para 3

124 See para 50

125 HC Deb, 11 June 2003, col 894W

126 House of Lords, Fifth Report of the Select Committee on Science and Technology, Session 2002-03, *Science and the RDAs: SETting the regional agenda*, HL Paper 140-I, paras 3.43-44

127 Lambert Review, p 68

128 Q 360

129 Q 301

130 Q 480

131 House of Lords, Government Reply to Fifth Report of the Science and Technology Committee, *Science and the RDAs: SETting the regional agenda*; http://172.17.1.22/documents/upload/07%20RDAs%20response%20full%20text.pdf

132 Lambert Review, p 26

East have been active in supporting science in general and micro/nano initiatives in particular in their regions. RDAs are relatively new organisations but they have been running long enough now to have established the means of tapping into new technological developments and supporting commercial and knowledge transfer opportunities in their regions. **The patchy nature of scientific expertise in RDAs does not present a strong platform upon which to build participation in the MNT Network.**

Allocation of funding

67. We have already mentioned that the £180m predicted to come from the RDAs to support the MNT Initiative is no more than an informed estimate. The £180m includes commitments already made by the RDAs, such as the £30m funding for the North West Packaging Centre and the £11m for the nanotechnology equipment for Nanotech Northern Ireland. The £180m is not all new money. There is no agreed figure that each RDA will put into the MNT pot over the six years. Instead, the amount of funding to be provided by each RDA will be identified in response to the proposals submitted. The provision of funding, Neil Mundy told us, will be "easier in some regions than others".[133] So far, in the first call for capital projects, some £12m has been identified by the RDAs to contribute to capital projects.[134]

68. One of the disincentives for RDAs to invest is the timescales involved with nanotechnology research and development. The targets that RDAs seek to meet are not long term: they will want short term rewards for their investment that nanotechnology may not be able to deliver. A bigger concern is that the regions with the best nanotechnology facilities on which the Network may seek to build are not necessarily the ones with the money to invest there. If, for example, The East of England Development Agency is unable to fund the development of research and facilities around those that already exist at Cambridge, there can be no guarantee that, say, Scottish Enterprise, would do so, even if Cambridge is where the best projects are judged to be. Neil Mundy thought that "there is an understanding that the benefits from those investments are available to all regions in the UK".[135] We will be interested to see how this understanding applies in practice, particularly in situations in which two RDAs want similar facilities established in their regions. There is the added complication in regions with regional assemblies, which would have to be persuaded to support any RDA bid for a nanotechnology centre.[136] The Trade and Industry Committee has highlighted the dangers of the rivalry between regions undermining the success of the UK biotechnology industry.[137] The dangers apply equally to nanotechnology: a nanotechnology centre in every region would not be sustainable.

69. The RDAs have four out of 14 representatives on the Executive Panel which provides advice on the capital projects programme. Without the promise of RDA money, few capital projects will get off the ground. The reliance on RDA money brings an element of regional politics into the Network that is almost certain to drag it away from supporting the best

133 Q 309

134 Ev 140

135 Q 292

136 Ev 141

137 Twelfth Report of the Trade and Industry Committee, Session 2002-03, *UK Biotechnology industry*, HC 87

science towards more parochial goals. Patrick McDonald sought to reassure us: "I do not think we will end up with 13 [centres]. Already, a number of the RDAs have accepted that they are not going to have a physical fabrication facility. What they will have is perhaps a cluster of universities that are plugged into the network that can feed out into their region in terms of knowledge transfer for nanotechnology".[138] This seems to be some distance from the concept of building up facilities in existing centres of excellence that we understand is supposed to underpin the allocation of the capital projects funds. Rather, it suggests that many universities in different regions will be given a small share of the capital funds as their share of the cake. In our view, this would be the wrong outcome. The Government recognises the potential for conflict between regional and national strategies. In its consultation on the ten year science investment framework, the Government asks how science funding on a national basis can be integrated with regional economic strategies.[139] This is a pertinent question, which needed to be addressed before the MNT Initiative was devised. **We have severe doubts about the ability of the RDAs to agree to support, on the basis of scientific and commercial merit, the establishment of a small number of world class micro and nanotechnology centres built on existing facilities.**

70. If the emerging model of RDA and DA participation in nanotechnology investment is to be applied to other sectors in future, there needs to be an understanding that certain sectors will inevitably be more prominent in some regions and regional disparities should be an acceptable price for the delivery of greater economic benefits to the UK as a whole. **We recommend that all RDAs accept the advice of the National Strategy Group and commit themselves, if necessary, to support the development of a small number of facilities which will benefit the whole MNT Network, even though some RDAs would not enjoy the direct economic benefits of such centres.**

Clusters and focus

71. A cluster can be described as a collection of companies, research groups, facilities and service providers, in reasonable geographical proximity, that are concerned with research and development in a particular industrial sector. They are often focussed around universities or research institutes, which can provide a ready stream of skilled workers. The theory is that a cluster facilitates the easy mixing of ideas and people to create an environment conducive to knowledge transfer and innovation. As a reputation develops, the cluster can act as a magnet to companies and researchers in the sector, creating an expanding amalgam of associated companies and related specialist services, including venture capitalists. The biotechnology cluster around Cambridge is a good example in the UK. We saw in Germany the emergence of a nanotechnology cluster of small and large companies around Dresden. Grenoble and Silicon Valley are other examples. The role that clusters play in stimulating R&D and innovation has recently been reconsidered in a study commissioned by the DTI to examine ways to improve the UK's competitiveness. Professor Michael Porter from the Harvard Business School specifically looked at means by which innovation and enterprise could be stimulated.[140] The issue was also considered by

138 Q 74

139 HM Treasury, *Science and Innovation: working towards a ten-year investment framework*, March 2004, p 43

140 DTI, Economic Paper No. 3, *UK Competitiveness: moving to the next stage*, Professor Michael Porter, May 2003

the Trade and Industry Select Committee in its inquiry into the UK biotechnology industry.[141]

72. There is some blurring of the definitions of networks and clusters. The concept of a cluster in relation to nanotechnology was interpreted by Lord Sainsbury somewhat more broadly than we anticipated. He seemed to envisage the UK as a single cluster: a set of small facilities and companies linked together by the MNT Network :

> "I think there will be many more link projects and those will bring together the relevant players over wide ranges. They will not be just, as it were, geographic clusters, they will be linking people together across the UK and I think that also has to be right. Where we have a particular technological development, we do not want to confine it to one region of the country, we want to bring in all the relevant research institutes and companies across that particular area."[142]

This interpretation does not meet the concept outlined by the expert group that the DTI commissioned to advise on improving UK competitiveness nor does it match the concept as set out in the Government's *Investing in Innovation* strategy.[143] Professor Porter talks of clusters being "geographically proximate groups". Whilst he recognised that clusters can range in size—from single cities to Silicon Valley and even southern Germany—he emphasised that "proximity must be efficient to allow the efficient interaction and flow of goods, services, ideas, and skills across the cluster". The Trade and Industry Committee found that the workable boundaries of a cluster in the UK were related to commuting time. It needed to be small enough to be able to get around easily on a daily basis. In the US, the key factor in cluster travel was the avoidance of an overnight stay. It may be possible for clusters to operate over large distances in a nationwide network, but not as efficiently as a geographically tight cluster. The Lambert Review of Business–University Collaboration finds "proximity matters when it comes to business collaborations, especially for SMEs. Informal networks cannot easily be sustained over long distances, and even large companies may find it more efficient to work with research departments in their own locality".[144] We strongly believe in the beneficial influence of geographical proximity to the process of research and innovation. This is in line with Porter's version of a cluster. It was no doubt in part for this reason that the Taylor Report envisaged that fabrication facilities would be built on and linked to existing facilities.

73. We accept that it is not possible to impose clusters or create them through Government action alone. But it is possible to create a facility, near to existing related services and facilities, around which a cluster may form. Clusters need to be big enough to gain a critical mass and attract both commercial interest and the right skilled people. The Minister's version of a UK wide network of mini–clusters will spread the jam too thinly—just what the DTI is seeking to avoid. **In developing its MNT Network, the DTI is missing the opportunity to help create the conditions which might produce nanotechnology clusters with a sufficient critical mass to create an impact on the world stage. Indeed,**

141 HC (2002-03) 87, para 121

142 Q 476

143 HM Treasury, *Investing in Innovation*, July 2002, p 74, para 3.35

144 Lambert Review, pp 13, 70

the way the Network is to be run makes it very difficult for such clusters to be encouraged.

Conclusions on the MNT Manufacturing Initiative

74. **Once the decision was taken not to establish a small number of dedicated nanofabrication facilities, the establishment of an applied research programme and a network of enhanced facilities was the next best option. This network should have been a Nanotechnology Network rather than the Micro and Nano Technology Network that has emerged. We hope that the MNT Network will serve to generate industrial interest and collaboration in both micro and nanotechnology but we believe that adjustments need to be made to the structure if it is to have maximum impact.**

75. **We are left with a number of concerns. In principle, we question whether a network involving the exchange of ideas and information can operate effectively both at the near to market level that is envisaged and over the whole of the UK. We are still not convinced that the DTI has a clear idea of what the Initiative should achieve in which areas. There is still no road map and no clear strategy which sets out priorities and goals for forthcoming years. The DTI's decision to operate in responsive mode is not conducive to producing a coherent network of complementary facilities. We believe that a more directed approach is needed to build upon UK strengths. We accept that any strategy needs to be flexible enough to adjust to industry's response and any major breakthroughs in particular areas, but such flexibility needs to be built upon an initial strategy rather than forming the strategy itself. At present, the emphasis is on short term rewards at the expense of the long term strength. This is wrong. The strategy should give some indication of the emphasis to be given to both micro and nano, along with some guiding principles on the geographical distribution of funds and facilities. Above all, there needs to be strong leadership from the top if the efforts of those involved are not to be expended on the internal political wrangling involved in maintaining the network rather than the actual delivery of a coherent micro and nanotechnology infrastructure for the UK. We do not believe that the present structure lends itself to the exercise of such leadership and we have recommended improvements.**

4 Research Councils

History of activity

76. The Research Councils have been active in supporting nanotechnology in a strategic manner since 1986. A history of their activities is set out in Box 2. EPSRC has taken the lead in supporting research and facilities since it took over the original managed nanotechnology programme from the old Science and Engineering Research Council in 1994 but has worked collaboratively with other Research Councils, most notably in the establishment of three IRCs. It responded to the Taylor Report by developing further training, awareness raising initiatives and international promotion activities.[145] BBSRC and MRC have also been involved in managed programmes and cross council initiatives

145 Ev 106, para 2

relating to nanotechnology. In 2003, the Economic and Social Research Council produced a report on the economic and social impacts of nanotechnology.

Box 2: History of Research Council nanotechnology activity

1986	The National Initiative on Nanotechnology (NION) was launched by the National Physical Laboratory (NPL) and the Department of Trade and Industry (DTI) with the objective of disseminating information about nanotechnology in the UK
1988–1996	As a result of NION, DTI launched the LINK Nanotechnology Programme (LNP). The Science and Engineering Research Council (SERC) joined the LNP in 1989 followed by the Defence Research Agency in 1990;19881996-SERC launched an eight year Nanotechnology Managed Programme, subsequently managed by EPSRC
1999	BBSRC, EPSRC and MRC call for proposals for a Tissue Engineering Interdisciplinary Research Collaboration (IRC) subsequently awarded (2000) to the Universities of Manchester and Liverpool
1999	EPSRC held a Nanoscience and Nanotechnology Theme Day activity to evaluate its research portfolio in the area. The theme day concluded that the UK had research strengths in extreme nanotechnology, nanofabrication and molecular nanotechnology but that there was a need to pay more attention to research at the interface between engineering and biological/medical disciplines
2000	MRC held a workshop 'Nanotechnology in Medicine' to promote awareness of new developments in nanotechnology and discuss their possible application in biomedical research
2000	EPSRC, BBSRC, MRC and MOD call for proposals for Interdisciplinary Research Collaborations (IRCs) in Nanotechnology; 2 subsequently awarded
2001	MRC, BBSRC and EPSRC hosted the 'Taking a Small Look at Life' event which bought together key scientists, Government representatives and industry professionals to discuss how the fusion of skills across disciplines was yielding results that would impact on industry and society as a whole
2001	The IRC in Tissue Engineering, managed by BBSRC and jointly supported by EPSRC and MRC, is based at the Universities of Manchester and Liverpool was set up in 2000
2001	A cross-Council activity in Basic Technology was launched (currently 6 of the 15 Basic Technology awards are relevant to nanotechnology)
2002	Publication of the report 'New Dimensions for Manufacturing: A UK Strategy for Nanotechnology' prepared by the UK Advisory Group on Nanotechnology Applications
2003	Publication by ESRC of the report 'The Social and Economic challenges of Nanotechnology'

Interdisciplinary Research Collaborations

77. The main plank of Research Council activity has been the establishment of Interdisciplinary Research Collaborations (IRCs). The first IRC, in Tissue Engineering, was established at Liverpool University in 1999 with funding from BBSRC, EPSRC and MRC. It does not support nanotechnology specifically, but there are elements of bionanotechnology being funded within it. The second two IRCs were set up in response to a long term technology review by the Research Councils conducted in 1999. The two IRCs are centres of activity but are more virtual than physical: they are intended to be networks of excellence attracting a critical mass of researchers from different disciplines, and a

concentration of research and training activity. The IRC in Nanotechnology is led by the University of Cambridge with core partners including the University of Bristol and University College London. The main objectives of this IRC are: to fabricate complex 3-dimensional structures with molecular precision; to control growth and assembly of soft layers (such as human tissue) by directed self assembly on patterned substrates; and to produce architectures for new devices in biomedicine and information technology.[146]

78. The IRC in Bio–Nanotechnology is led by Oxford University with core partners including the University of Glasgow and MRC's National Institute for Medical Research. This IRC aims to investigate bio–molecular systems, from the level of single molecules to complex molecular machines, to establish their function; and to apply this knowledge to produce artificial electronic and optical devices. Funding for the Oxford and Cambridge IRCs is to be £18m over six years. Both groups have already attracted substantial additional funding from the participating universities and from the English and Scottish Higher Education Funding Councils through the Strategic Research Infrastructure Fund (SRIF). The IRCs aim to promote basic curiosity–driven research as well as research with applications for industry. Their success will be measured in terms of the research outputs and also the spin–out companies they help produce.[147] **We welcome the initiative and commitment shown by the Research Councils in establishing the two Interdisciplinary Research Collaborations specifically relating to nanotechnology and we hope that they will form a prominent part of the MNT Network. We recommend that, provided they perform satisfactorily, the Research Councils should guarantee the future long term funding necessary for them to be able to continue to attract the best researchers.**

Table 3: Total Research Council Expenditure (£Ks) on nanotechnology by Financial Year.

	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003
BBSRC	6,092	5,963	8331	11,101	14,499 35,000 (underpinning)
EPSRC	11,577	11,767	12,892	20,232	32,208
MRC	9,876	12,036	14,782	17,637	21,323

Source: Evidence from Research Councils; for notes on Table, see ev 96-97

Levels of demand

79. Funding for nanotechnology related areas has increased slowly over the last five years.[148] In spite of the success of the Link Nanotechnology Programme, nanotechnology did not rise rapidly in the priorities of all relevant Research Councils. It was not until 1999 that BBSRC recognised bionanotechnology to be within its remit and not until 2003 was it included in its 5 year plan. EPSRC estimates that it now supports 329 projects relevant to nanotechnology with a total committed value of £107m. However, it was only in the Strategic Review of 2003–07 that nanotechnology first featured as a key area. MRC has supported research which may help to underpin nanotechnology, for example, into protein

146 Ev 97

147 Q 112

148 See Table 3

structures, since the early 1990s. It only began to look specifically at the potential benefits of nanotechnology after the cross council review of future technology requirements in 1999 which led to the establishment of the IRCs. It has now contributed some £500,000 towards nanotechnology related projects in Discipline Hopping Awards since 2000. Interest in nanotechnology now appears to be increasing: of 220 applications received for Individual Discipline Hopping Awards since 2000–01, 51 were related to nanotechnology and half of the six new Institutional Discipline Hopping Awards were similarly orientated to nanotechnology.[149] In addition, six out of nine projects receiving some £22m under a recent round of the Research Council's Basic Technologies programme are in areas related to nanotechnology.[150]

80. The evidence we received about levels of demand for funding nanotechnology research was mixed. Professor White from BBSRC told us that demand in the priority area of nanotechnology had been "moderately buoyant as opposed to extremely buoyant".[151] However, there were a good number of exciting proposals, mainly in the drug delivery and technology areas.[152] Professor Whitehouse from the CCLRC told us that demand for the central microstructure facility had been flat and the number of projects had remained fairly uniform.[153]

81. The Taylor Report concludes that much nanotechnology research in the UK can claim to be "up with the world's best".[154] No doubt such research will continue to be funded by the Research Councils and others but the amount of funding going into this area has not risen dramatically until very recently. Research Councils respond to the levels of academic interest and excellence in different areas, both in the awarding of individual grants and in the selection of priority areas. Our view is that academics have been slow to get into nanotechnology research and secure more funding in responsive mode applications. Part of the reason for this may be the lack of appropriate and available facilities in the UK. We hope that the MNT Initiative will have the spin–off effect of stimulating interest in nanotechnology and increasing grant applications in this area to the Research Councils.

Funding strategy

82. The Research Councils seek to maintain "a balanced portfolio of basic, strategic and applied research" through grant awards, industrial collaborations and knowledge transfer partnerships.[155] Apart from their funding of the two IRCs, Research Council support for nanotechnology is now provided largely through responsive mode.[156] BBSRC has prioritised nanotechnology since 1999 and its spending on bionanotechnology has increased from £1.6m then to £4.5m in 2002–03. EPSRC in particular has supported the growth of the UK nanotechnology community with an increase in funding from £11m in

149 Ev 144

150 RCUK Press Release, 1 March 2004

151 Q 123 [Professor White]

152 Qs 124, 130

153 Q 137

154 Taylor Report, p 26

155 Ev 99, para 22; Q 128 [Professor O'Reilly]

156 Ev 107, Q 105

1997–98 to £32m in 2002–03. MRC has contributed significantly to the funding of the two IRCs and supported research in areas such as molecular motors. It has sought to stimulate research in tissue engineering and received £26m in the 2002 Spending Review for stem cell research, although to include this research in nanotechnology funding figures is somewhat questionable.

83. We support the Research Council's balanced approach to nanotechnology funding but we would like to see it being linked explicitly to the goals of the MNT Initiative. At present, we are not convinced that such links are secure. Professor Miles from the Institute of Physics told us "I think it is obvious that we are not getting that co-ordination with the IRCs. We are getting essentially Research Council funding but no DTI funding, and other centres are getting DTI and not Research Council funding, so these need to be co-ordinated".[157] The Research Councils state in evidence that they "will explore routes to collaborating, where appropriate, with DTI in its planned collaborative R&D programme".[158] This seems very vague. Representatives from EPSRC and BBSRC sit on NSAG, but this meets only infrequently and there is no formal co-ordination with the Research Council's strategy making bodies.[159] The Research Councils make their funding awards on the basis of the best science, without regard to the priority areas of research which may be identified under the applied research programme as having the most commercial potential. **The Taylor Report stressed that in any more focussed strategy, the balance between funding on the basis of quality and encouraging focus was a key issue to be faced by the Research Councils. We do not believe that this issue has been adequately addressed.**

84. Given the limited resources earmarked for nanotechnology related research, there is a case for the Research Councils encouraging applications in the priority areas identified by the applied research programme, as they emerge. Indeed, a managed cross–Council programme in the 2004 Spending Review might be seen as desirable. At present, there is no adequate mechanism in place to marry up the two streams of support for nanotechnology research. Without any linkage, we risk scattering the UK's research effort thinly across the whole breadth of micro and nanotechnology. Whilst the research itself may be excellent, this approach would not make the best contribution to the UK's overall competitive and research strength in nanotechnology. **We recommend that the Research Councils balance their responsive mode funding equally with managed mode funding in nanotechnology areas which complement priority areas established under the MNT Network applied research programme as they emerge.**

85. The Research Councils—mainly EPSRC—also support major facilities used for micro and nanotechnology research. We have already referred to the facilities at the Rutherford Appleton Laboratory and the difficulties faced in attracting industrial use of the Central Microstructure Structure (CMS) facility. The CMS facility produces next–generation devices based on semiconductors, polymers and biological materials in support of the UK university and industrial research communities. It has become a recognised national centre of expertise for the "top–down" fabrication of devices at the nano scale. This facility has

157 Q 448

158 Ev 98, para 18

159 www.mnt.org.uk

been very well supported by EPSRC, other Research Councils, the DTI and UK industry for the past twenty years and has become a recognised national centre of expertise. Indeed, we were told that "a significant fraction" of the 615 expressions of interest received by the DTI for the applied research programme involved collaboration with CCLRC.[160]

86. We will be examining levels of industrial access to facilities at RAL in our scrutiny inquiry into the CCLRC.[161] The Lambert Review recommended that Research Councils could do more to build collaborative links with business and found that the councils' efforts to develop multi–disciplinary research projects had not gone far enough.[162] Nanotechnology requires just such a multi–disciplinary approach. Whilst we recognise that some Research Councils, particularly EPSRC, have been seeking to raise the profile of nanotechnology for many years, levels of industrial awareness and sponsorship of research should by this stage be much higher. Sir John Taylor referred to the need for a different "sign over the door" at the CCLRC in order to attract industry.[163] Certainly, a more imaginative approach to engaging industry is required. This should not be left to the DTI alone. The CCLRC, along with some of the other Research Councils, has a great deal more to do in terms of industrial outreach. We have raised this issue in our scrutiny Reports on each of the Research Councils and there is some evidence of a more proactive approach. Research Councils are currently working on ways of increasing rates of knowledge transfer together with appropriate performance measures of success.[164] We look forward to seeing the outcome of this work. **We recommend that relevant Research Councils liaise with the MNT Network Director on a cross–Council initiative to improve industrial awareness of Research Council activities and facilities relating to nanotechnology.**

5 Skills

87. A nanotechnology strategy in the UK cannot succeed without the human resources to support it. Facilities require skilled technicians to operate them; companies will seek out skilled researchers, technicians and engineers; and universities will seek to attract the best scientists. The Taylor Report cites the availability of trained people as a key requirement for achieving the scenarios of success he envisaged. He calls for a "major campaign in training and education" to be part of the nanotechnology strategy.[165]

88. It is up to universities, in concert with industry and the Research Councils, to provide teaching and experience in the sorts of skills that will be required by the economy. Many of Britain's leading universities are now becoming engaged in MNT related research.[166] New facilities are opening, such as the nanotechnology centres in London, Bristol University and Southampton University. Other micro and nano technology facilities exist at the universities of Newcastle, Birmingham and Glasgow, to name but a few. There are an

160 Q135

161 A Report will be published in summer 2004

162 Lambert Review, p 85, para 6.33

163 Ev 137, para 3

164 Research Fortnight, 14 January 2004, p 6

165 Taylor Report, p 37

166 See http://www.nano.org.uk/

estimated 1500 researchers working in nanotechnology centres and universities throughout the UK.[167] The Taylor Report confirmed that there were "internationally leading individuals" in nanotechnology but that these people were spread thinly across the spectrum of nanotechnology research. The UK lacked a "critical mass" in any one domain of the subject.[168]

89. The absence of this critical mass is due in part to the poor levels of awareness of nanotechnology in the academic community. Professor Cass from the Biosciences Federation told us that life scientists are "not entirely sure what nanotechnology is or what it can do for them […] For hardcore practitioners of the individual disciplines, I think they are still struggling, in many cases, to see the relevance of this nanoscience, nanotechnology, to what they do".[169] It was depressing to hear from Professor Sir Harry Kroto of the Royal Society of Chemistry that he did not believe that university teachers actually knew what nanoscience and nanotechnology are.[170] Some universities are beginning to offer teaching and training in nanotechnologies, although we found no clear consensus as to how this could best be achieved. Part of the problem is that universities are not set up to cater for interdisciplinary subjects such as nanotechnology: graduates are usually trained in a single discipline.[171] In amending the way in which the Research Assessment Exercise operates, the university funding councils are now seeking to improve the degree to which research collaboration between different disciplines is rewarded in the Research Assessment Exercise. There is a great deal of departmental cultural resistance to multidisciplinarity to be overcome. Professor Lawes of the Institute of Electrical Engineers thought that this was changing: "we are slow but there are signs" and he highlighted engineering as an example.[172]

90. At present, only ten universities offer courses with nanotechnology highlighted as a specific element in the title. They range from a BSc in Chemistry with Nanotechnology at Hull to a MSc in Biomedical Nanotechnology at Newcastle upon Tyne and an MSc in Microsystems and Nanotechnology at Cranfield. Four nanotechnology related courses are at undergraduate level.[173] These are all relatively new. Witnesses were sceptical about the value of specific nanotechnology undergraduate courses. The Institute of Physics said in evidence that the subject lacks the coherence or maturity to be treated as a separate discipline and that "dedicated nanotechnology (or nanoscience) course runs the risk of superficiality".[174] Other witnesses from universities shared the view that it was better for students to gain a deep knowledge of a single discipline before specialising in nanotechnology at post graduate level.[175] Professor Aeppli from the London Centre for Nanotechnology told us that "once you make nanotechnology into its own discipline you lose the interdisciplinarity on which it thrives."[176] In contrast, it was the strong view of the

167 Figures from the Institute of Nanotechnology; http://www.nano.org.uk/

168 Taylor Report, p 46

169 Q 417

170 Q 407

171 Taylor Report, p 30

172 Q 416

173 This includes a BSc in Quantum Information and Computation at Loughborough

174 Ev 127

175 Q 396 [Professor Miles]

RDA Network Group that greater numbers of undergraduate degree courses with an MNT–relevant focus were needed.[177]

91. There was more of a consensus on the value of postgraduate courses. The Institute of Physics argues that Masters courses could also provide the means of retraining industrial researchers in nanotechnology but that a number of such courses offered in the last few years have been "fragmented and competitive between universities rather than providing a coherent set of programmes".[178] It is also concerned that the UK is not training enough technicians to provide support in production, instrumentation and operation of equipment. This is supported by the Taylor Report, which refers to anecdotal evidence that some nanotechnology centres have experienced difficulties in recruiting PhD students and researchers of UK origin.[179] The poor supply of science graduates was highlighted by Sir Gareth Roberts in his 2002 review, SET for success.[180] The issues he identified are still being addressed. We have some sympathy with the view expressed by the Acorn Link programme that industry needs more financially attractive and flexible courses to benefit from training which will enhance innovation.[181] In our 2003 Office of Science and Technology Scrutiny Report, we commended the Institute of Physics for offering means–tested bursaries for physics undergraduates.[182] There is no reason why this principle should not be extended to other disciplines that are suffering shortages, including courses with an element of nanotechnology.

92. We sought to discover whether there was a clear understanding of what was required in terms of relevant courses run by universities and if steps were being taken to provide a strategic framework for the provision of the right skills. Patrick McDonald from the DTI told us:

> "Hopefully we will be able to do something about the supply of skilled manpower. Primarily, this is a responsibility for OST and Research Councils to figure out. What I need to do is get a much clearer locus for them, as to what the training requirements are of business because at the moment it is all over the place."[183]

The Research Councils are still "figuring it out". They say in evidence that "Requirements from the user base as to the type and nature of trained personnel in nanotechnology are still emerging".[184] That is not to say that they have done nothing. EPSRC in particular has funded training in nanotechnology for a number of years.[185] It has provided some 80 "masters training packages" to give training in nanotechnology at selected universities. It

176 Q 388 [Professor Aeppli]

177 Ev 123, para 5.2

178 Ev 127

179 Taylor Report, p 30

180 HM Treasury, SET for success: *The supply of people with science , technology, engineering and mathematical skills.* (Report of Sir Gareth Roberts' Review), April 2002

181 Ev 94

182 Fourth Report, Session 2003-04, *The Office of Science and Technology: Scrutiny Report* 2003, HC 316, para 75

183 Q 81

184 Ev 98, para 19

185 See EPSRC Briefing: Nanotechnology, http://www.epsrc.ac.uk/website/commonpages/downloads.aspx?CID=7430&ZoneID=6&MenuID=119

plans to train 250 students over the next five years.[186] Since 1996 EPSRC has supported 337 PhD studentships, 125 project students and 88 Collaborative Awards in Science and Engineering (CASE) studentships in areas concerning nanotechnology. Twenty nanotechnology researchers have so far taken advantage of the public communications training being offered. EPSRC has recognised the need for interdisciplinary training at the interface between the physical and biological sciences, and has established a life science interface doctoral programme to promote research at the interface of the physical and life sciences. BBSRC has prioritised bionanotechnology and has consequently increased the number of studentships in this area from eight in 1998–99 to 28 in 2002–03.[187] MRC has ring–fenced certain awards for nanotechnology: it awarded three studentships in 2000–01, with a further two in each of the subsequent three years.[188] **It is up to the Research Councils to provide a measure of coherence in the provision of research and training opportunities in nanotechnology related fields and to promote interdisciplinarity. We commend the lead that EPSRC has taken. We recommend the Research Councils work closely with the MNT Initiative, RDAs and Sector Skills Councils to identify and address any skills shortages in this area.**

93. It is difficult to judge the success of the courses provided so far because of the absence of statistics on the subsequent employment of students in nanotechnology related areas. We were told that the Higher Education Statistics Agency uses standard occupational classifications in recording information on first destination employment which does not include nanotechnology.[189] Until such records are kept, manpower planning and policy making in the provision of education and training on nanotechnology cannot be evidence based. **We recommend that the Higher Education Statistics Agency collects and publishes information on the subsequent employment of students in sufficient detail to record in a meaningful way the career paths of those engaged in nanotechnology research and development.**

94. Even in the absence of the raw material with which to evaluate the effectiveness of nanotechnology training thus far, it is clear to us that the major campaign in training and education in nanotechnology called for in the Taylor Report is simply not happening at the moment. **Both universities and academics, with a few notable exceptions, have been slow to react to the development of nanotechnologies. That is now changing, with the provision of some nanotechnology related courses, although there has been no strategic attempt to meet the needs of UK research community and industry. It is our view that undergraduate courses in nanotechnology are more of a desperate scheme to attract people into science courses than an attempt to provide the right skills for subsequent employment. Universities should be providing these skills at postgraduate level in an interdisciplinary environment. In future, nanotechnology elements should increasingly form a part of standard physics, chemistry, biology, medicine and engineering undergraduate courses. We recommend that any dedicated nanotechnology courses should be given a kite mark by an appropriate body of nanotechnology experts approved by the Institute of Nanotechnology.**

186 Ev 107, para 14

187 Ev 102, para 15

188 Ev 109, para 7

189 Ev 133; Q 7

95. More specialist postgraduate courses should be provided for those seeking a career in nanotechnology related areas. Such students will provide the scientists, technicians and engineers required to staff the new or expanded facilities which the MNT Initiative should deliver. A more detailed picture of requirements in terms of skills and training should emerge as the MNT Initiative develops and the needs of industry are more clearly articulated. A conscious effort will be needed to link these needs with the training provided. There is no sign of this as yet. **We recommend that the Network Director reports back to the DTI, the Research Councils and DfES on the types of skills being demanded by industry and that universities are encouraged to reflect these in the courses they provide.**

6 International collaboration

96. The EU's Framework Programmes (FPs) provide considerable sums of money to the European research community in managed and in responsive mode. The Fourth Framework Programme (1994–98) supported some 80 projects involving nanotechnology. Although there was again no programme specifically dedicated to nanotechnology in the Fifth FP (1998–2002), an estimated €45m was awarded to nanotechnology related projects over its lifetime.[190] Some €17.5bn is available under the Sixth Framework Programme, which runs from 2002–06, with €1.3bn allocated to a programme on Nanotechnology, Materials and Production Technologies (NMP). The proportion of UK funding going towards this programme can be calculated to be around £110m of the funding of this programme. The aim is to get at least this sum in grant awards (*just retour)*.[191] The DTI evidence states that UK academics have been "very successful" in obtaining funds from the EU Framework Programmes, particularly in medical and bionanotechnology areas.[192]

97. The first call for proposals in the NMP programme was announced in December 2002, with funding of £191m available for Integrated Projects. The UK represented 11% of the participants in the proposals submitted, second only to Germany.[193] However, UK industrial participation in proposed projects amounted to only 5.5% of the total funding available. This seems rather slight set in the context of the UK's performance in FP5, when the UK obtained around 15% of total available funding, the joint highest return alongside that of Germany, with almost a third of UK participants coming from industry.[194] The Institute of Physics complained about the lack of industrial participation in FP6, which contrasted with the active UK academic involvement and the industrial participation from France, Germany and Italy. As a result, it claimed that "UK science is being exploited and developed elsewhere in Europe".[195] Unilever told us that they had been successful in two out of six proposals in FP6.[196] EPSRC funded grants of around £100,000 in the first call

190 www.cordis.lu/nanotechnology

191 Ev 84, para 42

192 Ev 84, para 44; ev 29, para 29

193 Ev 100, para 30

194 Sixth Report , Session 2002-03, *UK Science and Europe: Value for Money?*, HC 386-I

195 Ev 129

196 Ev 135

under the nanotechnology programme.[197] In addition, EPSRC has contributed £2m to UK participants in a European Science Foundation programme in "Self–organised nano-structures". Of the 16 projects recommended for funding, seven had UK participants.[198]

98. Information we obtained from FCO posts about the extent of collaborative ventures on nanotechnology suggested that it was the US, Germany and Japan which were the preferred choice of partner when it came to collaborative ventures. Many UK companies are looking abroad for partners: Unilever runs only four out of its 11 university collaborations with UK universities.[199] We received evidence from one research collaboration programme that although some effort has been made to co-ordinate a UK response, this "has not been planned particularly well" and that the French and German Governments were better at supporting national groups.[200]

99. Although too early to make a proper assessment on FP6, the DTI estimates that Germany leads in terms of participation, with France and the UK on similar levels. The DTI acknowledges great problems in encouraging UK industrial participation in the Framework Programmes.[201] We looked at UK participation in Framework Programmes in our inquiry into UK participation in the Framework Programmes and called on the Government to streamline its fragmented support to FP applicants.[202] The Government has now done so, establishing FP6UK in November 2003 to provide a central point for all potential applicants.[203] The Government also agreed with our call for a clear strategy to identify areas of strength in the UK and accepted the need for a more proactive approach from Government to encouraging bids in these areas.[204] The MNT Initiative provides an excellent framework within which to promote collaborative bids. The Network itself should be linked to other European nanotechnology networks that exist. No such links exist on its website at present.

100. If the UK does not manage to develop the facilities and centres that are required, or foster industrial engagement, international collaborative ventures on nanotechnology, with the skilled people and investment that they bring, will be increasingly scarce in the UK. **We recommend that the Network Director takes a proactive role in promoting bids from academics and industry to the nanotechnology and materials programme of the EU Sixth Framework Programme. We further recommend that the MNT Initiative provides clear links to other European nanotechnology networks.**

197 Ev 83, para 39

198 Ev 135

199 Ev 135

200 Ev 94

201 Ev 83, para 41

202 HC (2002-03) 386-I, paras 44 and 48, para 150

203 See www.//fp6uk.ost.gov.uk

204 Eighth Special Report, Session 2002-03, Government Response to the Committee's Sixth Report: *UK Science and Europe: Value for Money?*, HC 1162, paras 18-9

7 Health and environmental concerns

101. Most new technologies attract excitement about their potential but also fears about potential adverse impacts, both in the short and longer terms. Nanotechnology is no exception. In the recent past the prospect has been raised of self–replicating "nanobots" creating a "grey goo" taking over the whole planet and science fiction books have depicted intelligent swarms of nanoparticles intent on destroying life.[205] One Canadian environmental group has called for a moratorium on nanotechnology research until its potential risks are more clearly known.[206] In this inquiry, we deliberately did not invite evidence on the potential adverse impact of nanotechnology. Such evidence is being gathered by the Royal Society/Royal Academy of Engineering study commissioned by the Government in June 2003 to analyse the state of scientific knowledge in this field and to examine the need for regulation. It is expected to report in the late spring of 2004. The Government's efforts to engage the general public in debate about the consequences of scientific developments has been of long standing interest to this Committee.[207] In this context, we examined how the Government is dealing with concerns arising out of nanotechnology issues and to what extent these wider concerns have an impact on the Government's strategy to promote nanotechnology to industry.

102. It is difficult to assess the extent to which industry has been discouraged from investing in nanotechnology R&D by the potential risks associated with it. We suspect that ignorance is a bigger factor than fear. Patrick McDonald from the DTI gave us his view of the response from the private sector: "They have seen nanotechnology as a science fiction thing. They have read about the grey goo and they cannot figure out how this might or might not impact their business. It is a very typical response for a UK company to new technologies. They are a bit slow in picking up where it might factor in their business model."[208] From the point of view of attracting venture capital, we were told by John Mackie of the British Venture Capital Association (BVCA) that the ethical and environmental issues associated with nanotechnology were no more difficult to address than similar issues in the life sciences.[209]

103. The Health and Safety Executive has already carried out some work on the health effects of nanoparticles. In 1999–2000 a limited study in industries where nanoparticles could be produced found that exposure levels appeared to be kept to a minimum. A review of the possible health and safety risks was started at the beginning of 2003, part of which was subsequently subsumed by the RS/RAE study. Later phases of the HSE study will commence after the RS/RAE study.[210] The two separate studies have now apparently been untangled, but policy seems to have been joined–up only after the event. The Economic and Social Research Council (ESRC) published in 2003 a report on *The Social and*

205 See, for example, *Prey*, Michael Crichton, HarperCollinsPublishers, 2002

206 The "Action Group on Erosion, Technology and Concentration": see Chemistry World, *It's a small world*, February 2004, p 35

207 See for example, First Report, Session 1998-99, *Scientific Advisory System: Genetically Modified Foods*, HC 286, and Third Report, Session 2000-01, *Scientific Advisory System: Advice on Climate Change*, HC 14

208 Q 86

209 Q 277

210 Ev 144

Economic Challenges of Nanotechnology. This outlines current concerns and draws attention to the need to consider whether existing regulatory regimes are sufficient to deal with any unique qualities that nanostructured materials may have. The report also flags up areas in which further social science research is required.[211]

104. Similar studies have been undertaken in other countries. We heard in Germany that the Bundestag had commissioned its office of science and technology to conduct such a study. It reported in October 2003, concluding that "political decisions on the need for nanotechnology specific regulations will have to be made in the foreseeable future."[212] It also emphasised the scarcity and inadequate nature of research in areas such as the effect of inhaling nanoparticles and their impact on the environment, particularly in the long term.[213] This is echoed by the HSE's finding that there are deficiencies in the available knowledge on the hazard posed by nanoparticles.[214] In the US, the Center for Biological and Environmental Nanotechnology at Rice University in Texas is leading research on toxicological issues.

105. In evidence to us, and in advance of the results of the RS/RAE study, Lord Sainsbury told us "it may be necessary to do more work" on nanoparticles, although he emphasised that "The Health & Safety Executive's view at this current point is that it is well covered by the current regulation system".[215] Indeed, he was confident enough to say that "I think it has already emerged that the grey–goo scenario and self–replicating nanobots is far in the future, if it is at all possible, and is certainly beyond current technology and one does not need to give any serious thought about that."[216] The Minister believed that research on the health and environmental risks associated with nanotechnology should be the job of the HSE and the Research Councils and that such research should be done "earlier rather than later".[217] We agree. Neither the IRCs nor the Research Councils are supporting specific research on the health and environmental impact of nanotechnologies, although EPSRC has done some work in identifying potential research challenges in this area.[218] The RS/RAE study should also help to identify any future areas of necessary research. Any such research would need to be multidisciplinary and properly funded. **We recommend that the Research Councils examine the need for further research on the health and environmental impacts of nanotechnology in the light of the RS/RAE study and, if necessary, develop an appropriate cross council managed programme, with appropriate funding. Any such programme should be co-ordinated with similar research being undertaken internationally.**

106. It would be hugely damaging for nanotechnology research if the public debate on the subject was dominated by apocalyptic scenarios or, at the other extreme, the miracle cures that make such good newspaper headlines. We have consistently stressed the need for

211 Economic and Social Research Council, *The Social and Economic Challenges of Nanotechnology*

212 Summary of TAB working report No. 92, *Nanotechnology*, p 21, www.tab.fzk.de/en/projekt/zusammenfassung/ab92.htm

213 As above, p 18-19

214 Ev 145

215 Q 530

216 Q 529

217 Q 531

218 Ev 145

scientists to engage in and inform such debates. There is a growing understanding of the importance of this activity, partly reflected in the proportion of grant awards that some Research Councils are now earmarking for public communication. More and more academics are willing to put their heads above the parapet. We fully agree with Professor Miles from Bristol University on the correct response to the more exaggerated stories that appear in the press from time to time: "I think we have to engage with the media to put over the really positive, exciting aspects of the true nanotechnology and not just sit back and say 'This is Nonsense' but give the real story".[219]

107. We have criticised the time it took the scientific community to engage fully in the GM food issue.[220] As a result, those wishing to conduct research found themselves on the back foot as public opinion had already been coloured by opponents of this technology. We were pleased to hear Lord Sainsbury tell us in evidence that "we are trying to learn the lessons of these particular incidents".[221] In the absence of a public communications strategy, we are not convinced that this has happened. Nonetheless, **we welcome the establishment of the RS/RAE study into the need for regulation in the field of nanotechnology**. It should contribute to a rational debate of the wider health and safety issue surrounding nanotechnology. There are frequent public debates on nanotechnology organised by learned societies, the Institute of Nanotechnology and others. A report commissioned by Greenpeace into the potential danger of nanotechnology recognised the potential benefits as well as risks of the new technology.[222] A recent opinion poll carried out for the RS/RAE study found that while public awareness of nanotechnology was low, a majority of those who knew something about it thought that its impact would be positive.[223] These are encouraging signs. But more work will be needed to ensure that any legitimate concerns about nanotechnology do not foster an over–cautious approach and unnecessarily hinder the conduct of both commercially important and basic research. The Director of the MNT Network has a role to play in engaging with industry on these issues. The Research Councils also have an important role in public education, one which is perhaps more independent than that of DTI, with its interests in commercialisation. **We recommend that the Research Councils take the lead in co-ordinating a pro-active strategy to promote the dissemination to the public of accurate information about the potential benefits and risks of nanotechnology.**

8 Innovation

Nanotechnology as an example

108. Innovation can be defined in broad terms as the translation of new ideas into commercial applications. It is at the heart of any competitive economy. The Science and Technology Committees of previous Parliaments have undertaken major inquiries into the

219 Q 402

220 Third Report of Session 2003-04, *The Work of the Biotechnology and Biological Sciences Research Council*, HC 6, paras 63-65

221 Q 529

222 Greenpeace; *Future technologies, today's choices, Nanotechnology, Artificial Intelligence and Robotics: A technical, political and institutional map of emerging technologies*; July 2003

223 Royal Society Press Release, 15 March 2004

process of innovation in general, and into innovation performance in particular sectors.[224] The Trade and Industry Committee has also monitored UK innovation policy closely, notably in its recent inquiry into the UK biotechnology industry.[225] The DTI has reorganised its innovation policy over the last year. In March 2002 it established the Innovation Group, headed by David Hughes, and in December 2003 it published its Innovation Report, setting out its strategy and policy for innovation over the coming years. In this inquiry we did not seek to undertake a comprehensive review of the Government's policy in this area. We took nanotechnology as an example of an emerging area of scientific advancement with great commercial potential to test how far innovation is still being constrained by some of the barriers that have already been identified.

R&D activity in nanotechnology

109. The DTI–commissioned survey of the nanotechnology industrial landscape found that "nearly all commercial nanotechnology developments in the UK are being driven by university spin outs and SMEs. However, large companies, due to their vastly superior financial resources, once they get organised, are likely to provide the greater impetus to the UK economy".[226] The Taylor Report found that the high cost of experimenting with unfamiliar technology covering a wide range of disciplines made it hard for large companies to establish what nanotechnology could do for them, so they tended to rely on monitoring academic research rather than engaging in exploratory research themselves. Without further Government funding for fundamental research the risks to companies of sinking money into nanotechnology research were seen as too great.[227] The Taylor Report concluded that the UK is "considerably behind its major international competitors in the industrial exploitation of nanotechnology, and in the level of UK industrial support for R&D on nanotechnology applications" and that "a considerably higher level of successful industrial activity is both achievable and desirable if the UK is to retain a globally significant manufacturing base".[228] The survey found that large companies in the UK "are being hindered by adhesions to the traditional approach, and have yet to put in place adequate platforms for product development through nanotechnology".[229]

110. There is no definitive picture of the actual amounts that large companies are putting into nanotechnology R&D in the UK but there is no doubt that levels of private investment in some other countries are high: an estimated £2.18 billion over the last ten years in China and around £15bn in major companies alone in Japan over the last 10 years.[230]

111. We have little doubt that levels of private sector investment in nanotechnology in the UK are nowhere near those in Japan. QinetiQ have invested "seven figure numbers" into

224 See First Report of the Science and Technology Committee, Session 1993-94, *The Routes through which the Science base is Translated into Innovative and Competitive Technology*, HC 74-I; Second Report, Session 1999-2000, *Engineering and Physical Sciences Based Innovation*, HC 195-I

225 HC (2002-03) 87

226 Ev 80, para 9

227 Taylor Report, pp 7, 45

228 Taylor Report, p 32

229 Ev 87, para 6

230 Figures provided by FCO posts; not printed

QinetiQ Nanomatierials Ltd.[231] Among large UK corporations Unilever is more aware than most. They told us in evidence that total R&D spend at Unilever was "in the high hundreds of millions" but that even its investment in cutting edge nanotechnology was "relatively low, probably we have got about five million in total invested at this point in time" although that could increase rapidly if a particular lead was found.[232] Evidence from surveys of industry indicates that many UK companies are active in MNT areas but few have developed large scale facilities of their own. There are notable exceptions: QinetiQ have developed their facilities for making nanomaterials and Unilever have a centre for molecular informatics.[233] Dr McKinnon from Unilever did not believe that his company or the UK was necessarily late in pursuing nanotechnology research.[234] He told us that "we have reached the point, really over just the last two or three years probably, where we have begun to realise that the technology worldwide is at a stage that it is going to become increasingly important for us".[235] We heard from Patrick McDonald that private companies were "a bit slow in picking up where it [nanotechnology] might factor in their business model."[236] This point is supported by other surveys, which suggest that the finding of suitable commercial applications for nanotechnology is the major obstacle to progress in nanotechnology and nanoscience.[237] Professor Miles echoed this: "I think there are not many big industries out there engaging in nanotechnology, there are a few exceptions, the Pilkingtons and Unilevers, and so on, but I think most of the industries have a watching brief and want to interact at a level where they can follow what is happening in universities and research centres".[238]

112. UK companies tend to follow different strategies to those pursued by major companies in some other competitor countries, such as Germany and Japan, where it is common to drive the R&D process forward by contracting small companies to do the research. For example, Henkel, a company with a similar product base to Unilever, has created a joint venture with the university of Darmstadt to give it access to those technologies developed which will be of use to it, and a financial benefit from the commercialisation of other technologies. In the US, in some sectors, such as pharmaceuticals, a common strategy is for large companies to buy in services from smaller companies, letting them take the risks of research. In the UK, there is a culture of expansion by acquisition rather than by collaborative venture with a smaller partner. In Bristol, the Committee heard how large companies can seek to use defensive patenting to stop others gaining a foothold in a given specialist area. QinetiQ say that "a key objective for the company [Nanomaterials Ltd] is the generation of an extensive intellectual property portfolio covering the manufacturing processes, formulation of the materials for range of applications, as well as specific applications utilising nanometric materials".[239] They see the securing of intellectual property in nanomaterials as essential to the UK gaining a

231 Q 219

232 Q 225

233 Q 249

234 Q 223

235 Q 229

236 Q 86

237 3i White Paper, *nanotechnology – size matters*, July 2002

238 Q 419

239 Ev 118

competitive advantage. Unilever thought that this traditional attitude to intellectual property was shifting a little and appeared more ready to license technology from other sources.[240] However, they also thought that large companies might expect Government to help.[241]

113. It is regrettable that only a relatively small number of large companies in the UK are involved in nanotechnology research in any meaningful way. Few companies have the financial muscle to establish their own substantial R&D facilities. If such companies in relevant sectors do not take the lead in developing R&D programmes – either individually or in collaboration with universities or smaller companies – the UK economy will struggle to reap the benefits of the new technology. SMEs and university spin–outs should not be left to carry the flag. The DTI has a responsibility to intervene to stimulate UK industry when a hugely disruptive technology emerges, in which the necessary research and development is unlikely to be funded by the market. **We welcome the recent, if belated, attempts of DTI to raise awareness and encourage nanotechnology R&D. It is big business more than SMEs where most impact can be made and this is where DTI's efforts should be concentrated. A judgment on the success of such efforts will be made when we see the rates of participation in the MNT Initiative and evidence of a step change in investment in nanotechnology by major companies.**

Venture capital

Availability

114. The relatively low level of availability of venture capital in the UK has been identified as a significant barrier to innovation, which affects nanotechnology start–ups like those in any other field. It is difficult to assess the amount of venture capital funding going into nanotechnology at present. The figures collated by the BVCA are broken down by industry sector and region and so do not provide a ready indication of investment in nanotechnology related business. However, all technology sectors, bar electronics related companies, experienced decreases in investment in 2002: nanotechnology will no doubt have suffered too. It has been estimated by JP Morgan that venture capital companies invested $500m in nanotechnology start–ups in 2002 worldwide.[242] Another estimate puts this figure at above £3bn.[243]

115. Our predecessor Committee cited two reasons for the reluctance of venture capitalists to invest in high tech start–ups: the poor quality of management of these companies and the poor economics of investing in the relatively small sums of money required.[244] Since then, of course, the bursting of the dotcom bubble has had a negative impact on investment in high tech companies.

240 Q 257

241 Q 253 [Dr McKinnon]

242 Information provided by FCO posts; not printed

243 Daily Telegraph, 18 September 2003,

244 HC (1999-2000) 195-I, para 53

116. We did not form the impression that the availability of venture capital had eased in the last four years, at least not for small nanotechnology companies. Dr Matthews from Oxonica told us that "The venture capital community is predisposed very much at this current time to not investing in pre–revenue companies, so they are looking for companies which have revenues and have demonstrated market acceptance to some degree […] There comes a point for many companies […] where they struggled to get the necessary financing to move from a "proof of concept" position to a viable business."[245] We heard from the Chief Executive of NanoMagnetics in Bristol about the difficulties of obtaining venture capital without having secured financial support from Government. The venture capital company 3i agreed with Dr Matthews on pre–revenue companies, describing those deals as "fewer across the industry than they were two or three years ago".[246] Other venture capitalists accepted that there was a cautious approach regarding nanotechnology. The Chief Executive of the BVCA, Mr John Mackie, said that any investments in nanotechnology had been in "very, very small amounts".[247] He summarised the position: "Pure nanotechnology, the general theme that is coming back from our membership is, it is too early, it is too high risk, it is too long term, and at this stage most of it is in the area of pure research rather than applied research, therefore it is very difficult to see within a sensible timescale what the commercial returns might be."[248] The issue of timescales was seen as highly significant. Dr Matthews told us that "The financial venture capitalists are looking for a fairly rapid return".[249] 3i told us that "The typical VC runs a fund and the fund has got a ten–year life on which you have got to return the money to the investors".[250] As we discussed earlier, nanotechnology does not lend itself to those seeking a fairly short term gain. As Professor Bates confirmed, "If you are going to play this game, you have got to play it for the long term".[251]

117. We detected a strong suspicion that that relative lack of competition in the European venture capital market hampered efforts to secure funding on good terms in the UK. Compared with their US counterparts, European venture capital companies were held to be risk averse and short-termist in outlook. Mr Mackie thought the UK to be no less risk averse than other European countries and he questioned whether the significant sums of money being made available in Germany to biotechnology companies had actually led to commercial success. However, he acknowledged that the Americans had a more generous and long term approach to venture capital funding, chiefly because they managed much larger funds with the consequent greater leeway for taking risks.[252] Because of the often long term nature of their R&D, nanotechnology companies will tend to stand at the riskier end of the venture capitalists' spectrum and thus have to work harder than most to attract funding.

245 Q 159

246 Q 269

247 Q 278

248 Q 271

249 Q 159

250 Q 266

251 Q 274

252 Qq 285-6

118. These views are familiar. Our predecessor Committee called for venture capital industry to adopt a more long–term approach to its investment strategy.[253] We see no sign that UK venture capitalists have done so. They seem to want Government to fund research which will take the product far enough towards commercialisation to make venture capital funding viable.[254] Yet, as we have seen, the Government is not prepared to fund very close to market.[255] **We do not see any realistic prospect of UK venture capitalists changing their relatively cautious approach to high tech companies in the near future. Ministers rightly promote the UK as a good place to base manufacturing industry but they need to be supported by a more favourable climate for obtaining venture capital. If that is not immediately achievable in the UK, the DTI and RDAs should examine the practicalities of providing more structured routes into venture capital sources abroad.**

The Funding Gap

119. The cost to venture capitalists of managing relatively small investments has contributed to what has become known as the equity or funding gap: the range of £250,000 to £1m needed for proof of concept work in which it is difficult for small companies to attract capital. This was certainly the experience of the small nanotechnology companies which we heard from.[256] We were told that Government funding can be obtained up to £250,000 but venture capitalists are not inclined to deal in sums below £1–2m. The UK venture capitalists, 3i, said that the equity gap had been increasing from half a million to one or two millions.[257] However, venture capitalists are not convinced about the existence of such a gap. Mr Mackie of the BVCA told us that "a number of my member firms would say there is no funding gap at all, and certainly it is the case that a number of my member firms would say the far greater problem is a shortage of propositions that are what we would call investor–ready".[258] It is no doubt a difference in interpretation of what constitutes "investor–ready" that accounts for this difference of view. Nonetheless, the Treasury has long acknowledged that there is a problem. A variety of initiatives throughout the 1990s led to the establishment of regional funds and venture capital trusts and other schemes, none of which have resolved the problem. The Treasury again consulted upon mechanisms to bridge this gap during 2003.[259] As a result, the Treasury has announced new measures to stimulate investment. These include:

- Changes to Venture Capital Trusts that will improve fundraising
- Proposals to increase the Enterprise Investment Scheme threshold for income tax to £200,000;

253 HC (1999-2000) 195-I, para 54

254 Ev 117

255 See above, paras 59-60.

256 Q 159 [Dr Matthews]

257 Q 282 [Mr Lowery]

258 Q 283

259 HM Treasury, Bridging *the gap: a consultation on improving access to growth for small businesses*, April 2003

- Launching a "pathfinder" round of Enterprise Capital Funds which will adapt the US Small Business Investment Company model for the UK by investing a mix of public and private sector capital in business with growth potential; and
- A review of the Small Firms Loan Guarantee Scheme to ensure that it is working effectively in helping small businesses overcome the obstacles when raising debt finance.[260]

The 2004 Budget contained measures to increase tax relief for investments by venture capital trusts.[261] We welcome these initiatives, which should go some way to making capital easier to obtain for small companies. However, they stop short of filling the financial gap that hinders progression from the development to demonstration stages of a new product. Mr Mundy from the RDA Group told us: "We have tried and I know other RDAs have tried to make a point about the market failure being above half a million. I think at present that has not been responded to by Government".[262] We found a consensus that the DTI's University Challenge Funds have been successful in providing significant capital for early stage financing, but these grants are awarded up to a maximum of £250,000. They have not succeeded in filling the gap.

RDAs and venture capital

120. The RDAs have been seen by some to be the right organisations to fill any gaps in the provision of venture capital funding. They have Regional Venture Capital Funds totalling £270m to invest in SMEs, supported by a further £80m provided by Government.[263] In evidence, Mr Mundy accepted that they had a role to play: "the venture capital industry has come through a very bruising period and that understandably they are perhaps reluctant to invest in these areas of technical spin–outs and I think that is again where the regions and devolved administrations have to try and encourage the provision of those funds".[264] But we found little evidence that RDAs are seen as an option for venture capital funding. In fact, no investments have yet been made in nanotechnology spin–outs from these regional funds.[265] Dr Matthews perhaps understated the position: "I think it is a fair statement of fact that the RDAs are not necessarily recognised as being venture capital options".[266] He told us that he could not see a clear mechanism to allow companies to submit business plans to them in order to obtain funding.[267] Even if the funds were available, the RDAs are restricted in using their Venture Capital Funds to investments of up to £250,000, with the possibility of a further £250,000 after six months.[268] RDAs cannot at present solve the

260 House of Lords, Government Reply to Fifth Report of the Science and Technology Committee, *Science and the RDAs: SETting the regional agenda*, http://172.17.1.22/documents/upload/07%20RDAs%20response%20full%20text.pdf

261 HC Deb, 17 March 2004, col 327

262 Q 345; This evidence was given before the Treasury's announcement on *Bridging the Gap* in December 2003

263 *Investing in Innovation*, p 84, para 6.26

264 Q 320

265 Ev 143

266 Q 187

267 Q 188

268 Innovation Report, p 66, para 3.46

problem at the £500,000 – £1m range, although they are certainly in a position to support start–up companies.

121. The House of Lords Select Committee on Science and Technology has recommended that the RDAs should work with the Treasury and DTI to fill the exploitation gap for early–stage financing of high–tech enterprises.[269] The RDAs have now established a working group to address this issue and have been asked by the Treasury to suggest measures for the 2004 Budget to improve access to finance for SMEs.[270] Some RDAs have now established their own venture capital organisations to support start–ups, but they are only just becoming active. **We welcome the fact that RDAs are beginning to address the issue of the funding gap, but we are not convinced that they all currently have the funding or political will to provide the investment required by small start–ups, including those in the high tech and nanotechnology sectors. We recommend that the Government remove current maximum restrictions on the operation of Regional Venture Capital Grant Funds to enable them to be used more flexibly. We further recommend that RDAs earmark a significant proportion of their venture capital funds for investment in small high tech companies.**

122. The 2004 Budget contained measures to increase tax relief for investments by venture capital trusts. Nanotechnology is a classic example of a high tech area in which investment of between half a million and a million pounds is likely to be required. We have recommended that the RDAs play a bigger role here, but they are limited in how they can distribute their funds. Universities should be encouraged to focus on the proof of concept activity which is a pre—requisite of commercialisation. We agree with the Lambert Review that "The rationale for using public funds to support proof of concept activity is much stronger than for early stage investment in spin–outs".[271] Notwithstanding the DTI's purge of its various business support schemes announced in the Innovation Report,[272] we believe that there is a strong case for a new fund to provide this early stage support. **We recommend that the DTI establish a substantial dedicated proof of concept fund to be allocated in loans of up to £1m to high tech companies seeking to move to the next stage of innovation.**

Management

123. The other problem identified by our predecessor Committee was the quality of management of small start–up companies. This of course is an issue that goes wider than attracting venture capital and is vital to the success or otherwise of start–ups and university spin–outs. Professor Bates told us "I think our view is that there is not so much an equity gap but a management chasm".[273] Our impression is that universities have taken great strides forward in providing commercial advice to academics on the establishment of spin

269 House of Lords, Fifth Report of the Select Committee on Science and Technology, Session 2002-03, *Science and the RDAs: SETting the regional agenda*, HL Paper 140-I,

270 House of Lords, Government Reply to Fifth Report of the Science and Technology Committee, *Science and the RDAs: SETting the regional agenda*, HL 140;
http://172.17.1.22/documents/upload/07%20RDAs%20response%20full%20text.pdf

271 Lambert Review, p 61

272 See below, paras 130-1.

273 Q 288 [Professor Bates]

outs. Even five years ago, it was often difficult to obtain advice from universities about commercialisation. Now many universities boast their own Enterprise Centres to provide advice and training to would–be entrepreneurs. The third annual survey of higher education business links reports that there has been a significant "cultural change" in the higher education sector with institutions adopting a more entrepreneurial approach in their dealings with business.[274] The turnover of UK spin–outs as a whole increased from £212m to £289m during 2001–02. In nanotechnology related areas, there have been successful companies spun out from a number of universities, including Glasgow, Nottingham, Newcastle and Bath.[275] However, we note that the views expressed from both universities and business in the Lambert Review that there is now an undue emphasis in commercialisation activities on the establishment of spin–outs.[276] Licensing arrangements and collaboration with big business should not be under valued.

124. In our contacts with universities, we have noticed an improvement in the willingness of universities to engage with business, but this is not across the board and there is undoubtedly still plenty of work to be done. Ottilia Saxl from the Institute of Nanotechnology reported a mixed picture at universities: "some are very good at supporting spin–outs, others are a complete turn–off".[277] The Lambert Review also refers to the "variable quality" of technology transfer offices.[278] Dr Matthews acknowledged that there may be a problem: "I think there may be a lack of marketing intelligence within universities and an ability really to step out from the research end of things to the applications end of things".[279] Many potentially successful companies never get off the ground. The Taylor Report indicates that the risk involved in leaving an academic position was a significant deterrent to establishing spin–out companies and consequently, licensing was seen as a better option. Proposals to improve university and business collaboration have been put forward in the Lambert Review and we support the attempts to simplify and clarify the position on ownership of intellectual property, as well as the increase of third stream funding to support knowledge transfer. We look forward to the Government's response, which is expected in summer 2004. **We welcome the improvements that are being made to the provision of commercial advice and liaison with business in many universities and the attention the Government is giving to finding ways to improve the knowledge transfer process. We recommend that RDAs liaise closely with university enterprise centres in their regions to ensure that opportunities to tap into RDA and DTI funding via the MNT Initiative and other sources are maximised.**

R&D tax credits

125. Although the performance of UK business in investing in R&D has improved in recent years, it still lags behind Germany and France, is still no better than the EU average overall and is significantly worse that that of the US, as indicated in Table 4 below.

274 www.hefce.ac.uk/pubs

275 Ev 142

276 Lambert Review, p 50

277 Q 152

278 Lambert Review, pp 53-57

279 Q 156 [Dr Matthews]

Table 4: Expenditure on business R&D as a percentage of GDP, 1992–2002

	1992	1997	1998	1999	2000	2001	2002
Finland*	1.21	1.79	1.94	2.20	2.41	2.42	
Germany	1.55	1.54	1.57	1.70	1.75	1.76	1.75
France*	1.49	1.39	1.35	1.38	1.37	1.37	
UK	1.39	1.16	1.17	1.23	1.19	1.23	1.24
EU average*	1.18	1.13	1.14	1.19	1.22	1.24	
US	1.90	1.91	1.94	1.98	2.04	2.10	2.06
OECD*	1.49	1.48	1.49	1.53	1.56	1.62	

**Most recently available figures for 2001*

Source: OECD/ONS

The Government has turned to using R&D tax credits to stimulate higher investment in R&D by UK companies. The 2000 Budget introduced changes to improve tax incentives for SMEs. Our predecessor Committee welcomed these changes and called on the Government to look again at extending this credit to large companies.[280] The Government did this in the 2002 Budget, extending R&D tax credits to companies other than SMEs. The 2003 Budget sought to improve availability of these tax credits further by lowering minimum expenditure thresholds and extending their coverage.[281] The Treasury also undertook to consult on improving the definition of R&D to ensure that it remains up do date with technological developments and is competitive internationally.[282] Further clarification was much needed: we found in our renewable energy inquiry that tax credits were too complex and hence poorly understood by companies.[283] In this inquiry we heard concerns that awareness of tax credits is not universally high. We note that the Lambert Review called for the marketing of tax credits to be improved.[284] As a result of the consultation, the DTI published new guidelines on the definition of R&D tax credits on 5 March. They simplify the qualifying criteria and also emphasise that the tax credits apply to development work as well as straightforward research. The new guidelines come into force from April 2004.[285] **We welcome the publication of the simplified guidelines on R&D tax credits. We recommend that the MNT Network Director takes the necessary steps to publicise them as part of his awareness raising activities.**

126. There are many factors to be considered in accounting for levels of R&D in the UK. The Innovation Report states that the new tax incentives for R&D are comparable with, or more generous than, those in other OECD countries and suggests that the long term weakness in R&D investment is partly cultural: UK firms appear to place less emphasis on

280 HC (1999-2000) 195-I , para 92

281 Ev 135

282 HM Treasury, *2003 Budget Report*, para 3.71

283 HC (2002-03) 55-I, para 92

284 Lambert Review, p 29

285 DTI Press Notice, 5 March 2004;www.dti.gov.uk/support/rd_guidelines.htm

creativity. This is reflected in an index of European creativity, which ranks the UK eighth out of the 15 EU member states in terms of talent and technology.[286]

127. It is a feature of UK R&D investment in nanotechnology that the majority of work is being undertaken by SMEs. If nanotechnology is going to be fully exploited by the UK economy the engagement of large companies is crucial. In general terms, the indications of levels of investment by large companies are not necessarily encouraging. Table 5 indicates that the amount being spent by large companies in all sectors has increased by 11% from 1995 to 2001, well below the rate of increase in most categories of smaller companies.

Table 5: Expenditure on R&D performed in UK businesses by total company employment size-bands (£ million)

	1995	1996	1997	1998	1999	2000	2001
0-99 employees	624	709	567	579	..	955	1,041
100-399 employees	1,431	2,029	1,557	1,577	1,569	1,390	1,544
400-999 employees	1,774	1,757	1,837	1,692	1,878	1,610	1,743
1,000-4,999 employees	3,727	3,443	4,271	4,649	5,161	5,954	5,001
5,000-9,999 employees	711	531	301	629	390	271	1,603
10,000-19,999 employees	234	355	296	330	758	..	1,066
20,000 employees and over	615	472	726	677	..	..	684
Total	**9,116**	**9,297**	**9,556**	**10,133**	**11,302**	**11,510**	**12,682**

Source: HMT, evidence p135

128. Statistics provided to us by the Treasury suggest that take up of the SME R&D tax credit in 2001–02 cost £150m, exceeding the projected figure of £100m.[287] Some 6000 companies have so far benefited from R&D tax credits. In the last two years for which comprehensive figures are available, 2001 and 2002, the numbers of companies claiming the tax credit remained fairly static but the amount claimed more than doubled.[288] This is perhaps an early indication that existing companies are beginning to invest more in R&D. Expenditure on R&D by UK businesses has been increasing slowly since 1995, as indicated in Table 5 above. Although there are signs that the rate of increase is itself increasing, they have not occurred disproportionately in SMEs. All the representatives we saw from large and small companies in the nanotechnology area welcomed the recent changes. Indeed, Dr Matthews told us that tax credits were probably responsible for the survival of his company, Oxonica.[289] There is no conclusive statistical evidence as yet that the R&D tax credits have contributed significantly to overall UK R&D spend but there is no doubt that they have made a difference, to some SMEs at least. We agree with the Lambert Review that

286 Research Europe, 4 March 2004, *The Demos Euro-creativity index*, p 2

287 Ev 135

288 HC Deb, 19 January 2004, col 1045W

289 Q 201

the impact of the R&D tax credits needs to be assessed before any further measures are proposed.[290] **We fully support the introduction and further extension of R&D credits since 2000. It is too early for a meaningful evaluation of the impact that tax credits have had on levels of R&D. We recommend that the DTI wastes no opportunity to publicise the reforms and conducts periodic surveys of awareness to supplement the collection of statistic on take up.**

Innovation Report

129. The DTI supports the commercialisation of new technology and university spin–outs by a number of mechanisms. As part of support for small businesses, it provides (in England) the following help:

- **Micro Projects** are simple low cost development projects lasting no longer than 12 months. The output should be a simple prototype of a novel or innovative product or process. A grant of up to £20,000 is available to businesses with fewer than 10 employees;
- **Research Projects** typically involve planned research or critical investigation lasting between 6 and 18 months. The result of the project could be new scientific or technical knowledge that may be useful in developing a new product or process. A grant of up to £75,000 is available to businesses with fewer than 50 employees;
- **Development Projects** involve the shaping of industrial research into a pre–production prototype of a technologically innovative product or industrial process. A grant of up to £200,000 is available for businesses with fewer than 250 employees.
- **Exceptional Projects** involve technology developments which have higher costs. These projects are likely to generate much wider economic benefits and must be recognised as of strategic importance for a technology or industrial sector. A grant of up to £500,000 is available to SMEs with a qualifying project;
- **Foresight LINK Awards** are for the support of innovative, high quality, pre–competitive research projects in areas of commercial potential that address Foresight priorities. LINK projects involve collaboration between participating companies and academic researchers Three nano projects were supported under latest round in July 2001 with a combined value £5m;
- **SMART awards** provide grants to help individuals and SMEs to develop technologically innovative products and processes; and
- **University Challenge Funds** provide seed funding for universities to access funds to assist the transformation of research into good business.

The DTI's Small Business Service has developed a cross–Government national strategy for start–up businesses to encourage an enterprise culture and find ways of reducing risks for individuals undertaking business start–ups.[291]

290 Lambert Review, p 14

291 HC Deb, 6 October 2003, col 1082W; DTI, *A government action plan for small business*, January 2004

130. The Innovation Report was published in December 2003 by the DTI. The Report concludes that the UK's innovation performance (judged by patents and business R&D) is only average compared with our international competitors. The main steps to be taken to improve performance are as follows:

- The development of a Technology Strategy with business, the SET base and RDAs to provide a medium to long term framework for setting policy priorities;
- DTI will bear some of the risk in taking new technologies through to the market;
- DGRC to develop for each Research Council plans and goals for increasing the rate of knowledge transfer and interaction with business;
- Establishment of a "visionary" new programme of Measurement for Emerging Technologies, such as nanotechnology and the biosciences;
- Funders to work together to identify measures to take to improve access to finance for entrepreneurs;
- DTI to look at barriers to innovation in key public sector markets such as the NHS;
- Closer links between DTI and RDAs to align national and regional policies;
- The rationalisation of around 180 schemes to support technological innovation worth around £200m into five key products; and
- The launch of application programmes, worth £150m over their lifetimes, starting in areas such as nanotechnology, renewable energy, sustainable technologies, life sciences and ICT.

131. **The rationalisation of an incredible 180 different support programmes into five, providing around £200m, is very welcome.** The endless of array of schemes was proving to be a source of confusion and frustration to would–be applicants, and, as the Report notes, they have been expensive to administer.[292] The five products that DTI has chosen to focus upon all build upon successful existing schemes such as the Faraday partnerships and the Smart awards, both of which have consistently been praised in evidence to us in a number of inquiries.[293]

132. In terms of additional money, the Innovation Report puts relatively little new money on the table. Of the £150m committed, £90m is to be devoted to the MNT Initiative and had already been announced. The DTI has at least been up front about the double counting but this is symptomatic of the *ad hoc* way in which the DTI has developed its thinking on innovation and the forging of links between universities and business. The money for nanotechnology was earmarked before the DTI had agreed on a technology strategy which prioritised certain technologies. It is pleasing that the nanotechnology money was not delayed further until the conclusion of the Innovation Report, but the timing of the announcements suggests to us that there is no requirement for new technology boards for rational decisions about future priorities and strategy to be made. We suspect that the

292 Innovation Report, p 61, para 3.30

293 As above, see p 62 for details of five products

announcement of the new technology strategy and board are merely formalised versions of existing decision making processes and established to give an otherwise thin Innovation Report some more substance.

133. Whatever the merits of the new Technology Strategy and Technology Board, there are signs in the Report that the DTI is moving towards a more strategic and longer term approach. We asked Lord Sainsbury whether the Innovation Report represents a new approach for the support of innovation. He replied "I hope there is a different approach: one which focuses on certain priority areas rather than the ad hoc response to proposals from sectors of industry that had been made in the past".[294] As the Report acknowledges, a more selective strategy for technologies and research areas is in line with the approach of other competitor countries.[295] Once priority areas have been identified, the DTI will work with the industries concerned to fund strategic technology platforms to support future development.

134. The Minister explained that support would be based upon technologies of benefit to important segments of British industry and ones which could help to give that industry a competitive advantage.[296] The Minister talked about using public money to drive forward the demand from industry. In the case of nanotechnology, although the DTI was initially reluctant to do this, the response to the first calls under the Applied Research Programme would seem to indicate that this approach has paid dividends. The intention for DTI to bear some more of the risks in taking new technologies through to market is also welcome, although it has still to be seen how this will work out in practice. **We welcome the fact that nanotechnology has been identified as a priority industry and has benefited from the majority of the £150m made available by the DTI to support the new innovation strategy. Whilst we are sceptical of the need for new decision making structures in this area, we believe the DTI is right to focus a medium term technology strategy on technologies which may give UK industries a competitive advantage.**

9 Conclusion

135. The commercialisation of nanotechnology research in the UK in many ways presents a depressingly familiar picture of excellent research that is not being translated to the country's commercial benefit to the same extent as it is in other competitor countries. The story is all the more dispiriting because the UK was recognised to be ahead of the game when a nanotechnology research programme was started in the mid–1980s. The DTI and the scientific community lacked the foresight and leadership to drive forward this advantage. A commercially valuable trick was missed. The benefits of nanotechnology were too uncertain and far off for industry to get involved without Government stimulation of interest and help with the provision of expensive facilities. The DTI belatedly commissioned an advisory group to develop a commercialisation strategy, but cast aside the main tenets of the subsequent recommendations in the Taylor Report.

294 Science Question Time, Minutes of Evidence, 9 February 2004, HC 315-i, Q 2; http://www.publications.parliament.uk/pa/cm/cmsctech.htm

295 Innovation Report, p 61,para 3.28

296 HC (2003-04) 315-i, Q 2

136. Instead of taking a lead on nanotechnology, the DTI has followed on microtechnology. We believe that the £90m could have been better spent. The DTI has chosen to develop, not a focussed strategy for nanotechnology commercialisation and applied research, but funding streams that are likely to be based upon existing microtechnology research and facilities that are dispersed around the country. This strategy has evolved in order to meet the short term interests of the RDAs which are providing a large proportion of the financial muscle. It is a muddled strategy that seeks to reconcile the conflicting long term interests of the DTI's science and innovation policy with the development of regional policy. In respect of the commercialisation of nanotechnology, the conflation of the two policies has served to undermine the UK's position. If the involvement of the RDAs is envisaged as a template for innovation in other sectors, a better way of resolving this fundamental conflict needs to be found.

137. It is not too late for the DTI to take steps to avoid the UK falling further behind our major competitors. The MNT Manufacturing Initiative needs to be given strong leadership and a sense of direction, with the right facilities to support nanotechnology research and development in areas in which the UK can make an impact. A skills strategy to provide the people required to support these facilities and industry will need to be co-ordinated between the Research Councils, the DTI and the universities. Even with the availability of the right facilities and people, companies using and exploiting nanotechnology need, like any others, the right incentives to persuade them to operate in the UK. Recent measures taken by both the DTI and the Treasury should improve the prospects for innovation, but a slow warming of the innovation climate will not be sufficient to make the UK the recognised stronghold for nanotechnology that it should now be.

Conclusions and recommendations

1. We have not been given a satisfactory explanation for the absence of a successor programme to the LINK Nanotechnology Programme. (Paragraph 14)

2. The DTI acted with commendable foresight in engaging industry and universities in a nanotechnology programme in the 1980s when few other countries had taken such steps. But the department's failure to build upon the LNP programme with something similar represents a very damaging failure, which has contributed significantly to the UK falling from a position of international strength in nanotechnology. This lack of foresight and ambition has left the UK in the position of having to catch up. (Paragraph 17)

3. In our view, the Taylor Report provided a comprehensive, ambitious, affordable and achievable strategy for the development of UK nanotechnology capability: it provided a ready made blueprint which the DTI could have taken forward and implemented in full. (Paragraph 22)

4. We question the need for the industrial survey commissioned by the DTI three months after the Taylor Report had been published: it did not add significantly to the body of knowledge that was necessary to inform the framework of future funding. The DTI could have responded to the Taylor Report without this unnecessary delay. (Paragraph 24)

5. In our view, whilst the Taylor Report has not been completely rejected, there is no doubt that its central thrust has been lost: it is not being implemented in the manner recommended. Instead of the immediate focus being on the establishment of at least two nanofabrication facilities, the available money is being disseminated widely between supporting applied research and the further development of a number of existing small micro and nanotechnology facilities. (Paragraph 27)

6. We find the DTI's immediate response to the Taylor Report wholly inadequate. We suspect that the initial decision to commission the survey of the UK micro and nano industrial landscape was taken in order to allow the DTI to broaden the focus from nanotechnology to include microtechnology, with its greater commercial potential and ability to attract matching funds. The decision to lump together micro and nano technology for the purposes of the MNT Initiative and to focus on the micro first will have serious adverse consequences for the successful commercialisation of nanotechnology in the UK. (Paragraph 32)

7. We recommend that the Government Chief Scientific Adviser liaises with the MNT Network and relevant Government departments to encourage the commitment of resources from departments to potentially useful nanotechnology research, as appropriate. (Paragraph 36)

8. We welcome the long term view taken by the Government in its science and innovation framework consultation but question the need for yet another consultation on such well trodden ground. (Paragraph 38)

9. The sums of money currently committed by Government and other agencies, spent in line with current strategy, will ensure that the UK continues to fall behind our major competitors. We recommend that in its ten year investment framework for science and innovation the Government gives a clear commitment to funding nanotechnology research and development at least over the next ten years at levels significantly in excess of current spending plans. (Paragraph 39)

10. The impact of a decision to develop world class centres in the UK on the number of top quality researchers remaining in or coming to the UK should not be underestimated. (Paragraph 42)

11. We are convinced that, had it wished to, the DTI had the necessary resources to sponsor at least one nanofabrication facility for the short term. We believe that the UK's industrial and academic strength and its international competitiveness in nanotechnology would have been better served by the establishment of one, if not two, nanofabrication facilities to give nanotechnology in the UK a distinctive focus. The rejection of this option appears to have been based more on regional political than economic factors. A geographically diverse network of small scale facilities is far easier to sell than one or two major centres built upon existing strongholds of research and development. The DTI displayed timidity and poor judgement in deciding against the immediate development of two nanofabrication facilities. (Paragraph 44)

12. The process by which the DTI established the MNT Initiative lacked logical coherence. The means were put before the ends, the broad strategy set before the strategic advisory group formed. The DTI is now left to try to make its strategy work around the constraints imposed by its original decisions. (Paragraph 46)

13. We are concerned that the MNT Network Director does not have the remit to give the Network the sense of direction and drive that it needs. (Paragraph 48)

14. We recommend that the DTI strengthens the leadership of the Network by giving real powers to the Network Director and by engaging the necessary expertise on a more established basis to inform decisions relating to the direction of the Initiative. (Paragraph 50)

15. We recommend that the Network Director and NSAG devise specific and measurable targets covering levels of investment from the UK and abroad, the division of spending on micro and nano technology, numbers of new companies, research outputs, collaborations, graduates and courses. (Paragraph 51)

16. To spend the MNT Initiative funding on the establishment of a series of relatively mature microtechnology facilities would be to throw the Taylor Report, with its emphasis on developing the UK's nanotechnology capability, out of the window. We accept that both the DTI and RDAs need to show a return for their investment, but an insistence on seeing a return in three years for technologies in their infancy is liable to be counterproductive, and inhibit the development of the very technologies that the MNT Initiative is trying to stimulate. We recommend that DTI develop performance measures that are realistic in terms of revenue generation and are based on a longer time scale than three years. (Paragraph 58)

17. We recommend that the proportion of funding available to SMEs is reviewed after the first round of funding, and amended if the take up is low. (Paragraph 59)

18. The areas identified by the Taylor Report could have formed the basis of six managed programmes for the applied research programme funding strand, complemented by the provision of relevant facilities. (Paragraph 61)

19. We recommend that future calls for proposals in the applied research and capital projects programmes are directed towards the meeting of strategic targets in specified areas that are devised by the Network Director and endorsed by the National Strategy Advisory Group. (Paragraph 62)

20. The patchy nature of scientific expertise in RDAs does not present a strong platform upon which to build participation in the MNT Network. (Paragraph 66)

21. We have severe doubts about the ability of the RDAs to agree to support, on the basis of scientific and commercial merit, the establishment of a small number of world class micro and nanotechnology centres built on existing facilities. (Paragraph 69)

22. We recommend that all RDAs accept the advice of the National Strategy Group and commit themselves, if necessary, to support the development of a small number of facilities which will benefit the whole MNT Network, even though some RDAs would not enjoy the direct economic benefits of such centres. (Paragraph 70)

23. In developing its MNT Network, the DTI is missing the opportunity to help create the conditions which might produce nanotechnology clusters with a sufficient critical mass to create an impact on the world stage. Indeed, the way the Network is to be run makes it very difficult for such clusters to be encouraged. (Paragraph 73)

24. Once the decision was taken not to establish a small number of dedicated nanofabrication facilities, the establishment of an applied research programme and a network of enhanced facilities was the next best option. This network should have been a Nanotechnology Network rather than the Micro and Nano Technology Network that has emerged. We hope that the MNT Network will serve to generate industrial interest and collaboration in both micro and nanotechnology but we believe that adjustments need to be made to the structure if it is to have maximum impact. (Paragraph 74)

25. We are left with a number of concerns. In principle, we question whether a network involving the exchange of ideas and information can operate effectively both at the near to market level that is envisaged and over the whole of the UK. We are still not convinced that the DTI has a clear idea of what the Initiative should achieve in which areas. There is still no road map and no clear strategy which sets out priorities and goals for forthcoming years. The DTI's decision to operate in responsive mode is not conducive to producing a coherent network of complementary facilities. We believe that a more directed approach is needed to build upon UK strengths. We accept that any strategy needs to be flexible enough to adjust to industry's response and any major breakthroughs in particular areas, but such flexibility needs to be built upon an initial strategy rather than forming the strategy itself. At present, the emphasis is on short term rewards at the expense of the long term strength. This is wrong. The

strategy should give some indication of the emphasis to be given to both micro and nano, along with some guiding principles on the geographical distribution of funds and facilities. Above all, there needs to be strong leadership from the top if the efforts of those involved are not to be expended on the internal political wrangling involved in maintaining the network rather than the actual delivery of a coherent micro and nanotechnology infrastructure for the UK. We do not believe that the present structure lends itself to the exercise of such leadership and we have recommended improvements. (Paragraph 75)

26. We welcome the initiative and commitment shown by the Research Councils in establishing the two Interdisciplinary Research Collaborations specifically relating to nanotechnology and we hope that they will form a prominent part of the MNT Network. We recommend that, provided they perform satisfactorily, the Research Councils should guarantee the future long term funding necessary for them to be able to continue to attract the best researchers. (Paragraph 78)

27. The Taylor Report stressed that in any more focussed strategy, the balance between funding on the basis of quality and encouraging focus was a key issue to be faced by the Research Councils. We do not believe that this issue has been adequately addressed. (Paragraph 83)

28. We recommend that the Research Councils balance their responsive mode funding equally with managed mode funding in nanotechnology areas which complement priority areas established under the MNT Network applied research programme as they emerge. (Paragraph 84)

29. We recommend that relevant Research Councils liaise with the MNT Network Director on a cross–Council initiative to improve industrial awareness of Research Council activities and facilities relating to nanotechnology. (Paragraph 86)

30. It is up to the Research Councils to provide a measure of coherence in the provision of research and training opportunities in nanotechnology related fields and to promote interdisciplinarity. We commend the lead that EPSRC has taken. We recommend the Research Councils work closely with the MNT Initiative, RDAs and Sector Skills Councils to identify and address any skills shortages in this area. (Paragraph 92)

31. We recommend that the Higher Education Statistics Agency collects and publishes information on the subsequent employment of students in sufficient detail to record in a meaningful way the career paths of those engaged in nanotechnology research and development. (Paragraph 93)

32. Both universities and academics, with a few notable exceptions, have been slow to react to the development of nanotechnologies. That is now changing, with the provision of some nanotechnology related courses, although there has been no strategic attempt to meet the needs of UK research community and industry. It is our view that undergraduate courses in nanotechnology are more of a desperate scheme to attract people into science courses than an attempt to provide the right skills for subsequent employment. Universities should be providing these skills at postgraduate level in an interdisciplinary environment. In future, nanotechnology

elements should increasingly form a part of standard physics, chemistry, biology, medicine and engineering undergraduate courses. We recommend that any dedicated nanotechnology courses should be given a kite mark by an appropriate body of nanotechnology experts approved by the Institute of Nanotechnology. (Paragraph 94)

33. We recommend that the Network Director reports back to the DTI, the Research Councils and DfES on the types of skills being demanded by industry and that universities are encouraged to reflect these in the courses they provide. (Paragraph 95)

34. We recommend that the Network Director takes a proactive role in promoting bids from academics and industry to the nanotechnology and materials programme of the EU Sixth Framework Programme. We further recommend that the MNT Initiative provides clear links to other European nanotechnology networks. (Paragraph 100)

35. We recommend that the Research Councils examine the need for further research on the health and environmental impacts of nanotechnology in the light of the RS/RAE study and, if necessary, develop an appropriate cross council managed programme, with appropriate funding. Any such programme should be co ordinated with similar research being undertaken internationally. (Paragraph 105)

36. We welcome the establishment of the RS/RAE study into the need for regulation in the field of nanotechnology (Paragraph 107)

37. We recommend that the Research Councils take the lead in co-ordinating a pro-active strategy to promote the dissemination to the public of accurate information about the potential benefits and risks of nanotechnology. (Paragraph 107)

38. We welcome the recent, if belated, attempts of DTI to raise awareness and encourage nanotechnology R&D. It is big business more than SMEs where most impact can be made and this is where DTI's efforts should be concentrated. A judgment on the success of such efforts will be made when we see the rates of participation in the MNT Initiative and evidence of a step change in investment in nanotechnology by major companies. (Paragraph 113)

39. We do not see any realistic prospect of UK venture capitalists changing their relatively cautious approach to high tech companies in the near future. Ministers rightly promote the UK as a good place to base manufacturing industry but they need to be supported by a more favourable climate for obtaining venture capital. If that is not immediately achievable in the UK, the DTI and RDAs should examine the practicalities of providing more structured routes into venture capital sources abroad. (Paragraph 118)

40. We welcome the fact that RDAs are beginning to address the issue of the funding gap, but we are not convinced that they all currently have the funding or political will to provide the investment required by small start–ups, including those in the high tech and nanotechnology sectors. We recommend that the Government remove current maximum restrictions on the operation of Regional Venture Capital Grant Funds to enable them to be used more flexibly. We further recommend that RDAs

earmark a significant proportion of their venture capital funds for investment in small high tech companies. (Paragraph 121)

41. We recommend that the DTI establish a substantial dedicated proof of concept fund to be allocated in loans of up to £1m to high tech companies seeking to move to the next stage of innovation. (Paragraph 122)

42. We welcome the improvements that are being made to the provision of commercial advice and liaison with business in many universities and the attention the Government is giving to finding ways to improve the knowledge transfer process. We recommend that RDAs liaise closely with university enterprise centres in their regions to ensure that opportunities to tap into RDA and DTI funding via the MNT Initiative and other sources are maximised. (Paragraph 124)

43. We welcome the publication of the simplified guidelines on R&D tax credits. We recommend that the MNT Network Director takes the necessary steps to publicise them as part of his awareness raising activities. (Paragraph 125)

44. We fully support the introduction and further extension of R&D credits since 2000. It is too early for a meaningful evaluation of the impact that tax credits have had on levels of R&D. We recommend that the DTI wastes no opportunity to publicise the reforms and conducts periodic surveys of awareness to supplement the collection of statistic on take up. (Paragraph 128)

45. The rationalisation of an incredible 180 different support programmes into five, providing around £200m, is very welcome. (Paragraph 131)

46. We welcome the fact that nanotechnology has been identified as a priority industry and has benefited from the majority of the £150m made available by the DTI to support the new innovation strategy. Whilst we are sceptical of the need for new decision making structures in this area, we believe the DTI is right to focus a medium term technology strategy on technologies which may give UK industries a competitive advantage. (Paragraph 134)

ANNEX A: LIST OF ABBREVIATIONS

LIST OF ABBREVIATIONS USED IN THE REPORT AND EVIDENCE

BBSRC	**Biotechnology and Biological Sciences Research Council**
CCLRC	**Council for the Central Laboratory of the Research Councils**
DA	**Devolved Administrations**
Defra	**Department for Environment, Food and Rural Affairs**
DGRC	**Director General of the Research Councils**
DoH	**Department of Health**
DTI	**Department of Trade and Industry**
EPSRC	**Engineering and Physical Sciences Research Council**
ESRC	**Economic and Social Research Council**
FCO	**Foreign and Commonwealth Office**
IRC	**Interdisciplinary Research Collaboration**
LNP	**LINK Nanotechnology Programme**
MNT	**Micro and Nano Technology**
MoD	**Ministry of Defence**
MRC	**Medical Research Council**
NDPB	**Non Departmental Public Body**
NSAG	**National Strategy Advisory Group**
R&D	**Research and Development**
RAE	**Royal Academy of Engineering**
RAL	**Rutherford Appleton Laboratory**
RDA	**Regional Development Agencies**
SME	**Small to Medium Enterprise**
SRIF	**Strategic Research Infrastructure Fund**

ANNEX B: VISITS MADE IN THE COURSE OF THE INQUIRY

Bristol: Tuesday 21 October 2003

Morning: NanoMagnetics

The Committee was briefed by Dr Eric Mayes, Chief Executive, NanoMagnetics, on the establishment of his company and held wider discussions on Government support for small companies, the availability of venture capital and of nanofabrication facilities. The Committee also toured the premises.

Afternoon: Bristol University

The Committee held discussions with Professor John Steeds FRS, Head of Physics Department, Professor Mervyn Miles, Head of Nanotechnology Group and others from the physics, chemistry and biology departments on a wide range of issues, including the nanotechnology centre at Bristol University, support for university spin-out companies and the inclusion of nanotechnology in university courses.

Germany: Sunday 16 - Tuesday 18 November 2003

Monday 17 November

Morning: Federal Government and Parliament

The Committee met with Dr. Gerd Bachmann of the VDI Technology Centre and Dr. Matthias Werner from the Deutsche Bank AG, Microtechnology Innovation Team to discuss scientific advice to government on nanotechnology and current research priorities.

The Committee received a series of briefings at the Federal Ministry of Education and Research on the Federal Government's nanotechnology funding strategy and allocation of funding.

A meeting was held with the Bundestag Committee on Education, Research and Technology Assessment, chaired by Ulrike Flach, MdB / FDP and representatives from the Office for Technology Assessment of the German Bundestag (TAB). Among the subjects discussed were public percipetions of nanotechnology, environmental concerns and the findings of the TAB report on nanotechnology published in October.

The Committee had lunch at the British Embassy, hosted by the British Ambassador, Sir Peter Torry, with representatives from science, industry and government.

Afternoon: Charité/Virchow Clinic

The Committee looked at the facilities at the clinic and was briefed by Dr Andreas Jordan on his work there. Discussions covered the availability of venture capital and support for small businesses.

Tuesday 18 November: Dresden

Morning: Fraunhofer-Institut for Materials and Beam Technology IWS; Infineon

The Committe was briefed by Dr. Andreas Leson, Deputy Director, and others. Discussions focussed upon levels of funding, the Fraunhofer network, collaboration with industry and levels of demand for facilities. The Committee also toured the facilities.

The Committee was briefed by Dr Alexander Ruf and Dr Jürgen Rüstig at Infineon Technologies and toured the facilities. Discussions centred on nanotechnology networks, levels of R&D and patenting.

Afternoon: Saxon State Ministry of Science and Fine Art

Over a working lunch, the Committee met with representatives from the Saxon State Ministry of Science and Fine Arts and the Saxon State Ministry of Economics and Labour. The Minister of State Dr.Matthias Rößler gave an overview of science and technology policy of the Free State of Saxony. Discussions were held on regional support for innovation and research, higher education and the supply of skilled workers and public understanding of science.

The Committee was briefed by representatives of the Saxon Materials Research Network and the Nanotechnology Competence Cluster "Ultra-thin functional layers".

Formal minutes

Monday 22 March 2004

Members present:
Dr Ian Gibson, in the Chair

Paul Farrelly
Dr Evan Harris
Dr Br Iddon
Mr Robert Key
Mr Tony McWalter
Bob Spink
Dr Desmond Turner

The Committee deliberated.

Draft Report (*Too little too late?* Government Investment in Nanotechnology), proposed by the Chairman, brought up and read.

Ordered, That the Chairman's draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 137 read and agreed to

Ordered, That the provisions of Standing Order No. 134 (Select committee (reports)) be applied to the report.

Resolved, That the Report be the Fifth Report of the Committee to the House.

Ordered, That the Chairman do make the Report to the House.

Ordered, That the Appendices to the Minutes of Evidence taken before the Committee be reported to the House.

[Adjourned till Monday 29 March at half past Three o'clock.

Witnesses

List of written evidence

Reports from the Science and Technology Committee since 2001

Session 2003-04

First Report	Annual Report 2003	HC 169
Second Report	Chief Executive of the Medical Research Council: Introductory Hearing	HC 55
Third Report	The Work of the Biotechnology and Biological Sciences Research Council	HC 6
Fourth Report	Office of Science and Technology: Scrutiny Report 2003	HC 316

Session 2002–03

First Report	The Work of the Particle Physics and Astronomy Research Council *(Reply HC 507)*	HC 161
Second Report	Annual Report 2002	HC 260
Third Report	The Work of the Medical Research Council *(Reply Cm 5834)*	HC 132
Fourth Report	Towards a Non-Carbon Fuel Economy: Research, Development and Demonstration *(Reply HC 745)*	HC 55-I
Fifth Report	The Work of the Natural Environment Research Council *(Reply HC 1161)*	HC 674
Sixth Report	UK Science and Europe: Value for Money? *(Reply HC 1162)*	HC 386-I
Seventh Report	Light Pollution and Astronomy *(Reply HC 127, 2003-04)*	HC 747-I
Eighth Report	The Scientific Response to Terrorism *(Reply Cm 6108)*	HC 415-I
Ninth Report	The Work of the Engineering and Physical Sciences Research Council *(Reply HC 169, 2003-04)*	HC 936

Session 2001-02

First Report	Cancer Research – A Follow-Up *(Reply Cm 5532)*	HC 444
Second Report	The Research Assessment Exercise *(Reply HC 995)*	HC 507
Third Report	Science Education from 14 to 19 *(Reply HC 1204)*	HC 508-I
Fourth Report	Developments in Human Genetics and Embryology *(Reply Cm 5693)*	HC 791
Fifth Report	Government Funding of the Scientific Learned Societies *(Reply HC 53)*	HC 774-I
Sixth Report	National Endowment for Science, Technology and the Arts: A Follow-Up *(Reply HC 276)*	HC 1064
Seventh Report	The Office of Science and Technology: Scrutiny Report 2002 *(Reply HC 293)*	HC 860
Eight Report	Short-Term Research Contracts in Science and Engineering *(Reply HC 442)*	HC 1046