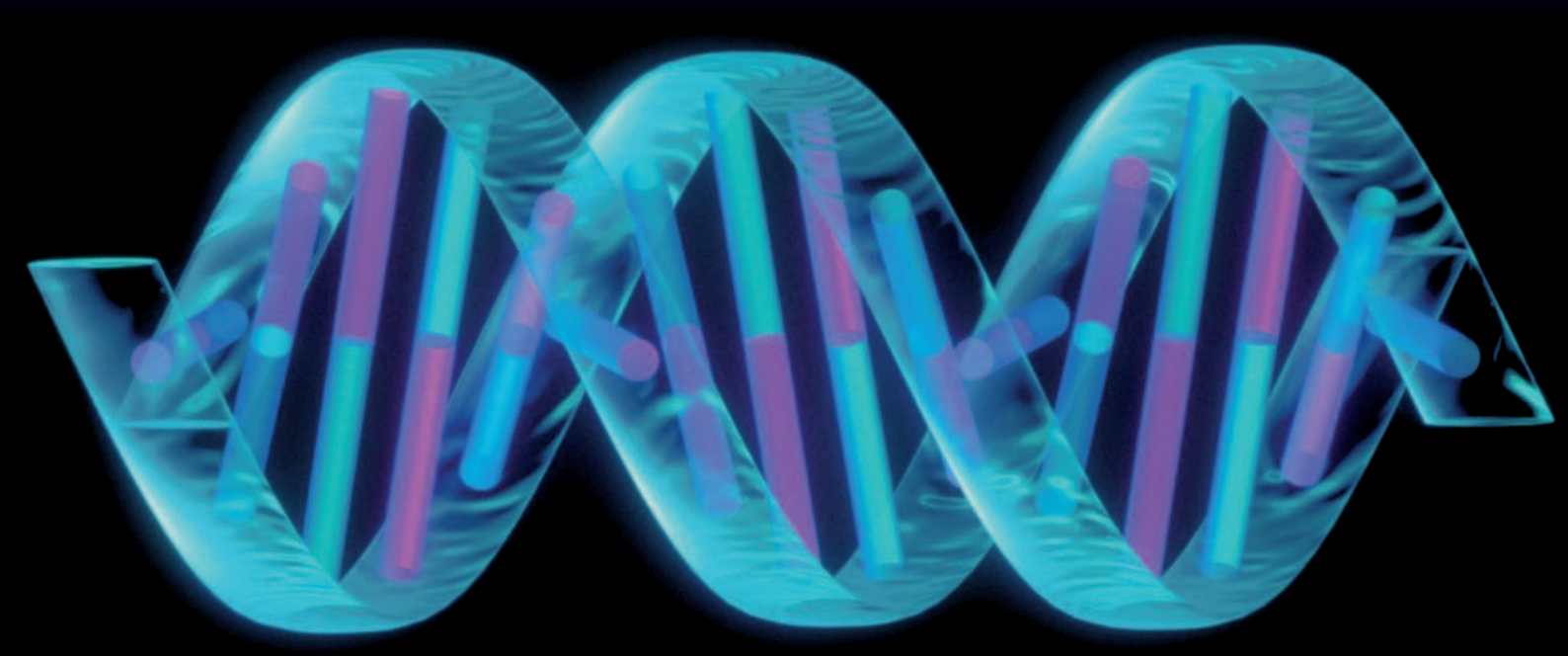
Strategy for Science, Technology and Innovation



2006 ~ 2013

Foreword

In the past decade, we have made great strides in growing our capability in science and technology. Government initiatives such as the Programme for Research in Third Level Institutions, Science Foundation Ireland, and investment in socially and economically vital areas such as Health, Agriculture, and the Marine, have built the foundations of a world-class base in research and innovation. This has been complemented by increased investment by the enterprise sector in R&D.

Progress has been significant, but it is essential that we continue the drive to build a truly knowledge based society. Such a society will offer new opportunities for employment and social advancement. It will harness our long tradition of creativity and our talent for communication. It will bring together researchers and innovators from all disciplines, including the physical and social sciences, arts and humanities, to meet the challenges and opportunities presented by an increasingly diverse and rapidly changing world.

People are at the heart of the knowledge society. Success in the future will be strongly dependent on growing the skills of our population and ensuring that levels of scientific and mathematical literacy increase. This places new demands on our education system, from primary level upwards, and requires us to build and expand a 'fourth level' of postgraduate and post doctoral research and education. Over the life of this Strategy we aim to see a doubling of postgraduate researchers, with significant numbers of these going on to take up employment in the enterprise sector. We also aim to ensure more effective commercialisation of the ideas and know-how being generated in our universities and public research institutions, and to forge new partnerships between these institutions and enterprise.

These ambitious goals will only be achieved through the concerted efforts of all those involved in the various areas and sectors identified in this Strategy. The Government is fully committed to the implementation of the Strategy and making the goal of a knowledge society, built on excellence in science, technology and innovation, a reality.

Bertie Ahern T.D.
Taoiseach

Introduction

Science, Technology and Innovation is vital to our economic and social progress. In an increasingly globalised world, it is recognised that high levels of investment in research and innovation are essential, both for economic competitiveness, and to yield innovations in areas such as healthcare and environmental technologies which make tangible improvements to our quality of life.

Growing research capability is a core component of the European Union's drive to become the most competitive and dynamic, knowledge-driven economy. Ireland has fully embraced that challenge and this strategy represents our comprehensive plan to guide us towards that goal.

The strategy is based on a shared vision of placing Ireland firmly on the global map in terms of the excellence of our research and its application for the benefit of society. The roadmap for achieving that vision has been developed by the Interdepartmental Committee on Science, Technology and Innovation, under the aegis of the Cabinet Sub Committee on STI and has benefited from the input of all major research performing Departments.

Our strategy encompasses the steps we need to take to develop a world class research system, building on the model of competitive excellence adopted by the PRTLI and SFI initiatives. It addresses key human capital investments across the education system and industry. It provides mechanisms to translate knowledge into jobs and growth and, in this context, it takes forward the recommendations of the Enterprise Strategy Group and the Small Business Forum. The strategy establishes agendas for public sector research in Agriculture, Health, Environment and Natural Resources. It also addresses the vital international and all island dimensions of research and innovation.

Strategy is the fusion of policy and action, and our plan sets out the mechanisms and overall resource levels which are required for implementation. The Government is providing the resourcing required to allow the new investments identified in the strategy to commence immediately, while the overall investment framework established by the strategy will be taken forward in the context of the National Development Plan. On behalf of the Taoiseach and my Government colleagues, I would like to thank all who have contributed to the development of this strategy. I am confident that the energy and enthusiasm which has driven its development will continue to fuel its successful delivery.

Micheál Martin T.D.
Minister for Enterprise, Trade and Employment

Table of Contents

Chapter Eight - Implementation

Executive Summary

Vision and Challenge (Chapter One)

"Ireland by 2013 will be internationally renowned for the excellence of its research, and will be to the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture."

The development of the knowledge economy is one of the key challenges and opportunities facing Ireland. The factors which contributed to our economic success to date will not be sufficient to achieve this vision. Competition is creating pressure for improvements in efficiency, quality and productivity and a growing need to innovate. These pressures are only going to increase. They are generating the need to take courageous forward looking steps that will achieve real strategic change, show tangible medium term results and shape the future.

There are very real challenges ahead. Science, Technology and Innovation (STI) in Ireland is still relatively underdeveloped. We now need to take a leap forward and move Ireland to an acknowledged leader in this field by means of this strategy. Success will be marked by increased participation in the sciences, increased numbers of people with advanced qualifications, enhanced contribution by research to economic and social development, transformational change in the quality and quantity of research, increased output of economically relevant knowledge, increased trans-national research activity, an international profile for Ireland and greater coherence and exploitation of synergies nationally and internationally. In summary, the strategy aims to deliver world class people and enterprises with the drive to succeed and the resources to do so.

World Class Research (Chapter Two)

World class research and world class people are at the heart of any National System of Innovation. Under the current NDP the Government made a strategic decision to develop a world class research system in Ireland. PRTLI and SFI investments fundamentally changed the scale and quality of research done here. However, a world class system requires dedication, persistence and sustained commitment.

The next phase of development will see significant increases in i) research capacity, quality and output, ii) investment in 4th level and the public research system, iii) reform in the universities and iv) better management of the research and innovation environments.

In striving to achieve world class research there are two overarching, interlinked goals. These are to build a sustainable system of world class research teams across all disciplines and to double our output of PhDs . Building critical mass in our research teams and maintaining the world class standards that we have fostered by competitive process under the NDP will be central to this task. Achievement of the goals will facilitate flows of researchers into and out of the country and from academia to enterprise.

While the PRTLI initiative made significant inroads in rectifying deficits on infrastructure,

there remains a shortfall which will be addressed through the upgrading of existing facilities and the provision of new ones. There is also an emerging need for a more structured approach to postgraduate formation to ensure effective development of our researchers, shorter PhD duration and increased completion rates. In addition, the development of career paths which will make science more attractive and has the potential to give Ireland a competitive advantage in the international market for top researchers will have to be examined.

Building the number of researchers will not be achieved by organic growth alone and a range of initiatives will be undertaken to remove obstacles from mobility of researchers. These measures, coupled with attractive funding opportunities, will make Ireland keenly competitive in the international talent stakes.

Capturing, Protecting and Commercialising Ideas and Knowhow (Chapter Three)

Transfer of knowledge from research organisations and higher education institutes into the market place has been identified as a key issue in the development of a world class research and commercialisation environment. Serious deficits exist in the Irish system in the areas of awareness, identification, evaluation, capture, protection and commercialisation of ideas; and these are addressed in the context of the strategy.

A two pronged approach is being implemented to upgrade our performance in the management and commercialisation of ideas from publicly funded and collaborative research. This will involve strengthening the IP/Commercialisation functions within the Higher Education Institutes and supporting this, where relevant, with a central source of specialist expertise. The mix of strong local action combined with central support for resource intensive and cross institutional tasks is a model which will deliver comprehensive assistance in this key area of the knowledge economy. This will be supplemented by the development of a range of measures supported by EI to develop collaborative links between industry and academic researchers.

Research and Development for Enterprise, Innovation and Growth (Chapter Four)

Manufacturing and international services have been and will remain the very significant drivers of economic growth productivity enhancement in Ireland. The development agencies are committed to working with companies to strengthen the RTDI base of the enterprise sector and have set clear targets to bring about transformational change in company attitudes to R&D and achieve the target of growing BERD to €2.5bn by 2013. Fully joined up thinking across the range of state support agencies will be critical to the achievement of these goals and Technology Ireland (TI) will be established as a virtual structure under the aegis of the Office of Science, Technology and Innovation (OSTI) to drive this. The skillsets of the agencies will be enhanced under the new approach. The key elements of the new approach will be i) raising awareness and increasing the number of firms doing R&D, ii) improving soft supports to develop technology strategies in firms, iii) achieving step increases in quality and quantity of R&D activity, iv)building in company technology capability, v)increasing inter-company and industry-HEI collaboration and vi) simplifying the administrative and operational procedures of programmes.

In addition, R&D grant supports will be made simpler; there will be increased support for technology transfer and the growth and development of industry led networks. Regional innovation will be supported in conjunction with the IoTs.

Industry-led research needs to be supported by appropriate infrastructure and to this end support for the development of competence centres will be important in translating advanced research into commercialisable technology. The development agencies will have a specific responsibility in respect of the development of competence centres and HE/Industry links generally and action in this area will form a critical part of the agenda of Technology Ireland.

The R&D tax credit is a central element of Government policy aimed at attracting more research intensive activity to Ireland. The operation and takeup of the tax credit will be regularly reviewed, monitored and modified as necessary, to support business R&D performance.

Science Education and Society (Chapter Five)

If we aspire to build a sustainable knowledge economy and become world leaders in STI we must build strong foundations in primary and second level education and our system needs to develop to make this happen. Interest in science must be stimulated at an early stage and fostered throughout the educational system.

At primary level, the reintroduction of science into the curriculum is a significant development which has been accompanied by in-service training of teachers. However, the link between the primary and secondary cycles needs to be strengthened. In the Colleges of Education more emphasis needs to be placed on science teaching methodologies and on awareness of scientific issues. These issues will have to be addressed in the context of the primary science curriculum review to be undertaken shortly.

At secondary level, where a revised syllabus was introduced recently based on a more investigative approach, some key concerns emerge relating to the uptake of science generally. More particularly these relate to the uptake of physics and chemistry. The strategy proposes to increase participation rates in the science subjects by:- i) reforming the science curricula for leaving certificate, ii) investment in continuous professional development and networks for teachers, iii) awareness promotion and the provision of guidance materials, iv) rebalancing the content of the science curriculum in the direction of problem solving and v) revisiting the issue of technical assistance for schools to facilitate practical coursework. All these proposed actions will be informed by a survey of pupil/teacher attitudes to be undertaken later in 2006.

In addition to the above, higher education institutes will be asked to consider the broadening of choice of subjects for matriculation purposes so as to give greater support to science. The issue of science graduates training as second level teachers will also be examined.

This will be supplemented by the work of Discover Science and Engineering (DSE) which will complement the developments in the school system through enhanced awareness measures, improved teacher training initiatives, enhanced internet based support materials, ca-

reers information and guidance, and pilot initiatives on awareness and teaching methodologies. In addition, DSE will develop a transition year programme designed to motivate pupils entering the senior cycle to continue to study science.

Research in the Public Sector (Chapter Six)

Across the sphere of Government there are important areas of civil and sectoral research which have a great potential to lead economic and social progress. Agriculture and food, health , environment, marine and energy are sectors which have the potential to yield innovations which make tangible improvements to our quality of life.

Agriculture and Food

The development of a sustainable food and agriculture sector is crucially important to Ireland's future development. RTDI has a key role to play in the sustainable development and competitiveness of the sector. In a rapidly changing business, economic and regulatory environment the current level of RTDI in this sector is low and the priority under this strategy is to build a knowledge economy in agri-food so as to provide a scientific foundation and support for a sustainable, competitive, market-oriented and innovative agriculture, food and forestry sector.

Health

A strong research culture is vital if the health service is to offer a world-class standard of care to patients and retain professionals of the highest quality. The system also needs to harness research to find better ways of improving the health of the population and delivering more efficient and effective healthcare. Problems that need to be addressed include the prevention and treatment of heart disease and cancer in the Irish population, controlling hospital acquired infections, obesity, managing neurodegenerative diseases in an ageing population and health service delivery. The Advisory Science Council is currently undertaking a review of key policy requirements of the health service with a view to strengthening health services research and policy research capacity nationally. The size of the healthcare industry worldwide is substantial and growing and opportunities for synergies across sectors are increasing in a range of domains. Ireland needs to develop its capacities in this sector and take advantage of the opportunities afforded by this growing market.

Environment

The future strategic direction of environmental research will be to anticipate and respond to changing circumstances and to engage in research to generate new knowledge of the environment and environmental technologies. Meeting international environmental obligations will demand continued engagement in such areas as climate change, biodiversity loss, environment and health, the urban environment, air pollution, waste management and water quality.

An environmental research centre is being developed as a centre of excellence within the EPA in close cooperation with the HEIs to build capacity in environmental data handling, modelling, assessment and guidance. This centre has the potential to become a key environmental component of the knowledge economy and will be the cornerstone of future environmental research.

Marine

The Marine Institute is finalising (2006) a marine research and innovation strategy for the period to 2013 with the objective of delivering an integrated research and innovation programme that will, through the use of research knowledge and technology, transform the sector to deliver sustainable, high growth, high value added, market led opportunities. The strategy is being built around measures to i) strengthen the competitiveness of traditional marine industries and their progression to higher value added activities, ii) push the frontiers of knowledge and explore the interfaces between disciplines and iii) deliver integrated scientific advice, policy and regulation to support environmental social and economic advancement.

Energy

The energy sector is characterised by exceptionally high dependency on imported fuels and international environmental obligations. These drivers require Ireland to develop a more competitive contribution from renewables together with improvements in energy efficiency. A recent strategic review of energy research development and demonstration activities concluded with the need for better coordination and alignment of energy, economic and innovation policies. Work on the articulation of national energy policy is underway and future strategic research will be geared to underpinning national policy priorities. The focus will be on improving security of supply, increasing the efficiency of energy use and bringing forward promising renewable energy technologies. Thematic areas to be covered will include:- i) Smart Grids, ii) rational use of energy, iii) wind energy, iv) biomass for heat and fuel and v) marine energy. An all-island approach to these issues will be adopted to take advantage of the obvious potential synergies in this area.

All-Island and International STI (Chapter Seven)

Transnational collaboration in the research area has brought real benefits to the Irish research effort over the last decade. Scientific excellence has been promoted and exacting international standards have become the norm. National priorities are being addressed effectively in a cost efficient manner and international mobility has enhanced the domestic quality of scientists. Collaboration has driven frontier research and helped avoid unnecessary duplication of effort, while affording access to international state of the art facilities for Irish researchers.

Ireland has benefited greatly from engagement in the international research arena under the EU Framework Programmes and from our involvement in the European Space Agency. Involvement with Intergovernmental Research Organisations (IGROS) has provided platforms to grow our own collaborative efforts. And more recently, enhanced research engagement with the US, India and China has brought benefits to scientists in both the academic arena and companies.

Increasing international competition will not allow for any let up in our collaborative efforts. Continued engagement with the EU institutions and appropriate international organisations will be pursued in a co-ordinated and strategic manner with Irish input being promoted in all areas to ensure the optimum return for our research sector. The EU Framework Programme will remain a central focus of our attention and in promoting Irish engagement particular

emphasis will be placed on working with our Northern Ireland colleagues. In addition, new Support Structures are being established under the aegis of EI to ensure maximum uptake of FP opportunities across all areas of the National System of Innovation.

Collaboration on an all-island basis will be a central tenet of this strategy ensuring that all potential synergies are harvested to the benefit of the population of the whole of the Island. At a policy level engagement and interaction has already begun and sectoral collaboration has been underway for many years. Collaboration was clearly evident in the establishment of the Ireland/US R&D partnership recently. All island STI programmes are up and running and very effective networks are promoting collaboration on a daily basis.

Implementation (Chapter Eight)

The strategy represents Ireland's first comprehensive strategic approach to developing STI on a whole of Government basis. For the strategy to succeed it will be necessary to ensure that joined up thinking is followed by joined up action. For that reason it is essential to design and implement feed back mechanisms which have the capacity to evolve over time in response to environmental changes.

The Interdepartmental Committee on STI, reporting to the Cabinet Sub Committee will have overall responsibility for driving the implementation of the strategy. To assist in this task, new implementation structures will be put in place. Two groups will be established: the Higher Education Research Group, and Technology Ireland. These will comprise representatives of key departments, agencies and other bodies and will have responsibility for ensuring coherence of approach and funding, a good fit between investments and linking HEI, sectoral and enterprise research in addition to having oversight of technology assessment and priority setting mechanisms. The key public research agendas and the important aspects of crossover between sectoral, academic and enterprise research will be addressed by these implementation groups and the IDC and Cabinet Sub Committee.

The existing evaluation competence in Forfas will continue to be utilised in assessing progress in conjunction with the input of the Advisory Science Council and evaluative capacities of the Chief Science Adviser. In addition, specific review mechanisms will be put in place in the context of the new NDP. Stakeholder bodies, including the science community and industry, will play an active role in this task.

The total level of expenditure on those areas of STI encompassed by the Strategy amounted to €658 million in 2005. Taking account of the allocations in the existing Capital Envelopes and Existing Levels of Service spending projected to 2013, the net additional resources required to implement the Strategy in full has been costed at €1.88 billion over the period to 2013. In order to ensure the immediate implementation of the Strategy, the Government is committing an additional €192 million (€66 million in 2007 and €126 million in 2008) over and above that being provided on the basis of existing levels of service and the multiannual capital envelopes for the period up to and including 2008. These resources are already significant and, when taken with this additional provision, will result in total Government investment in the strategy in excess of €2.7 billion in the period up to and including 2008. The Strategy will form a core component of the forthcoming National Development Plan, and decisions on funding for the remainder of the Strategy will be made in that context.

Summary of Key Actions and Outcomes

Chapter One - Vision and Challenge

- Increased participation in the sciences by young people;
- Significant increase in the numbers of people with advanced qualifications in science and engineering;
- Enhanced contribution of research to economic and social development across all relevant areas of public policy including agriculture, health, environment and the marine and natural resources;
- Transformational change in the quality and quantity of research undertaken by enterprise - both directly and in cooperation with third level institutions;
- Increased output of economically relevant knowledge, know how and patents from those institutions;
- Increased participation in international S&T cooperation and transnational research activity;
- An established international profile for Ireland as a premier location for carrying out world class research and development;
- Greater coherence and exploitation of synergies to mutual advantage in the development of STI policy on the island of Ireland.

Chapter Two - World Class Research

- Build on recent NDP investments to deliver a sustainable, world class research system across the spectrum of humanities, physical and social sciences;
- Deliver quality by increasing the number of research teams led by internationally competitive principal investigators;
- Upgrade existing infrastructure and develop new facilities to support research;
- Enhance postgraduate skills through a graduate schools mechanism;
- Develop sustainable career paths for researchers;
- Enhance the mobility of researchers;
- Double the number of PhD graduates by 2013.

Chapter Three - Capturing, Protecting and Commercialising Ideas and Knowhow

- Ensure that HEIs encompass IP management and commercialisation as a central part of their mission, equal to teaching and research;
- Strengthen institutional competence at TTO level and among researchers;
- Establish competitive fund administered by EI to assist strengthening of IP management function;
- Establish a new function in EI providing centralised support to HEIs thereby maximising the commercialisation of IP.

Chapter Four - Research and Development for Enterprise, Innovation and Growth

- Maintain commitment to strengthening manufacturing in Ireland into the long term;
- Achieve the target of growing BERD to €2.5 billion by 2013;
- Establish Technology Ireland as a virtual entity and mobilise practical structures required to make it work;
- Launch new EI awareness campaign including seminars and direct engagement with client firms;
- Continue IDA international promotional and marketing programme "Knowledge is in Our Nature";
- Increase absorptive capacity by strengthening technology skills in firms new to R&D;
- Rationalise and simplify enterprise R&D grant structures to make them more accessible to firms;
- Promote the formation and advancement of inter-company networks;
- Strengthen measures to assist firms with licencing in technology;
- Strengthen measures to increase interaction between firms and higher education institutions nationally and regionally;
- Develop additional competency centres in strategically important technologies, with significant expansion of industry linkages;
- Examine the operationalisation of the Forum on Small Business recommendations in respect of Innovation Vouchers and Knowledge Acquisition Grants;
- Review and modify, as appropriate, the R&D Tax Credit scheme.

Chapter Five - Science Education and Society

- DES to review the implementation of the primary science curriculum to ensure the new curriculum and teaching methodologies are stimulating interest in and awareness of science at a very young age;

- Science and awareness of scientific issues to be a core area of study for student teachers in Colleges of Education;

- Reform the maths and science curricula starting with physics and chemistry subjects in Leaving Certificate to ensure a continuum from junior cycle with the emphasis on hands-on investigative approaches and the completion and assessment of practical coursework;

- Invest in teacher professional development in collaboration between second level in-service providers, higher education institutions and the Discover Science and Engineering programme, as appropriate;

- At the Transition Year, the promotion of information brochures, guidance materials and resources and awareness initiatives in collaboration with the Discover Science and Engineering programme, and effective linking of this with school guidance services;

- Survey pupil attitudes to the revised junior cycle syllabus in 2006;

- Support the development of teachers' networks which will focus on improving teaching and learning, including the Continuing Professional Development of teachers;

- Further develop the full range of awareness raising activities under Discover Science and Engineering.

- Higher Education Institutes to consider the option of a science subject for matriculation.

Chapter Six - Research in the Public Sector

6.1 Agriculture and Food

- DAF will ensure that its public good competitive research programmes, (FIRM, RSF, COFORD) will be focused on the needs of the sector and will continue to increase collaboration and capacity building in Irish research centers;

- DAF will ensure that agricultural production research supports a competitive profitable farming sector that is sustainable in relation to soil, water, air quality and biodiversity, supporting a vibrant rural economy;

- DAF will build on existing R&D expertise and excellence to underpin the contribution of forestry to the sector;

- DAF will ensure that food research provides a base of knowledge and expertise in generic technologies to support a modern, innovative and consumer focused food industry, with attention to food safety and quality issues;

·Teagasc will restructure its research activities and resources into Centres of Excellence and will recruit 50 new researchers including fifteen Principal Investigators to underpin the needs of a bio-economy in agri-food;

• DAF, through Teagasc and its own competitive research programmes, will support the building and strengthening of a research capability in new technologies, and to exploit their application to natural resources including agriculture, food and non-food land uses;

• DAF will ensure that the new DAF Agricultural and Veterinary laboratories will operate as science based centres and will seek to collaborate and integrate them into the national research infrastructure;

• DAF will continue to strengthen co-operation with other Departments, State Agencies and Funding Bodies to avoid duplication and create synergies within agri-food R&D and contribute to building a knowledge economy in agri-food;-

• DAF will continue its links with Enterprise Ireland to achieve a strategic and seamless approach to food and forest products R&D funding, from the basic pre-commercial research funded by DAF to the near market research funded by EI;

• DAF will link with the Environment sector in carrying out research on agri-environment issues such as soil quality, nutrient efficiency and nutrient loss, air and water quality, biodiversity and ecology to enable the farming sector to operate in a sustainable manner in compliance with environmental requirements;

-DAF will link with the Energy sector on research into energy crop production at farm level and the use of existing forests for wood energy production;

• DAF and Teagasc will foster and build on the level of North/South Collaboration that already exists in agri-food and forestry research;

DAF will promote and assist participation by Irish researchers in EU research initiatives such as FP7, ERA-Nets and other collaborative arrangements.

6.2 Health

• Develop health research as a frontline health service to guarantee world class health care for patients, to resolve health problems facing the population, and to attract and retain health professionals of the highest quality and to improve efficiency and effectiveness to the health sector;

• A strong research culture to be built in the health services through targeted investments, on the basis of competition and peer review, and by a strong corporate commitment to research by the Health Service Executive and other health agencies;

• The R&D pillar of the health research strategy (MKWH) also needs strong support to ensure that the crucial 'population health' element of the Health Strategy has a sound research base to underpin appropriate disease prevention measures, redress social in-

equalities in health status and to ensure best practice in health service delivery and policy development;

• Develop a number of centres of world significance in translational health research, each of which has strong foundations in both academia and the health services and which will act as a magnet to the pharmaceutical and medical devices industry, nationally and internationally. Build these centres through strategic investment in research infrastructure, people and programmes by competitive, peer reviewed awards through the HRB and other funding agencies;

• Maintain the confidence of the public in health research by observing the highest ethical standards in research and provide for greater public engagement in relation to the benefits of health research and the complexities of undertaking such research.

6.3 Environment

• The research programme funded by DEHLG will be reviewed with the aim of maximising its value with particular regard to potential synergies between the different components of the programme.

6.4 Marine

• Conduct a survey of marine research and researchers on an all-island basis with particular emphasis on research underway outside of the Marine Institute (2006);

• Development of research discovery programme in Marine Biotechnology; Marine Biodiversity; Marine Technologies (2007-2013);

• Establish Ireland as an Internationally recognised centre for Ocean renewable research (See Energy research section) (2006-2013);

• Establish a SMARTBAY system for the observation, monitoring and management of coastal and ocean environments and the testing of new advanced technologies (2006-2008);

• Develop Ireland as a global monitoring centre for climate change assessments in the context of the North Atlantic Gulf Stream, unique marine and other ecosystems and SMARTBAY system, (2007-2012);

• Use the data derived from the Irish seabed survey and the new Infomar programme to place Ireland in a position of competitive advantage in a range of areas including participation in International research programmes (2006 –2013);

• Stimulate greater involvement by Irish seafood Industry in marine related research. Prioritise the development of marine healthfoods (2006-2013);

• Target a significant increase in FP7 participation and seek EU support for the Climate Change monitoring centre (possible European demonstration project (2006-2013).

6.5 Energy

• Establish, (2006) an Energy Research Council, which will advise on the setting of priorities

for Irish energy research to the year 2013. The Council will take a leading role in linkage with key national bodies (as well as EU and international programmes and bodies); coordinate existing RTDI; provide policy advice and analysis, and support strategic research initiatives and capacity building, complementary with existing initiatives;

• Take forward the key thematic research areas in relation to security of supply, rational use of energy, renewable energy technologies and national energy infrastructure;

• Establish an all-island inventory of energy research and researchers, (2006 and annually thereafter);

• Target significant levels of participation in FP7 and other international research programmes, (2007-2013);

• Develop all-Island initiatives and optimise collaborative proposals under FP7 as a practical means of furthering collaboration (2006-2013);

• Develop a range of cross sectoral research initiatives including climate change, enterprise, agriculture and transport, (commencing 2006);

• Progressively enhance the active engagement of Irish energy industries with R & D programmes (2006-2013).

Chapter Seven - All-Island and International R&D

• Strengthen and complement the national research infrastructure through linking the research system to centres of excellence internationally and foster partnerships through involvement in international research teams;

• Increase the access of the enterprise base to international leading edge technology networks and collaborations with leading companies and research centres in relevant sectors worldwide;

• Achieve scientific excellence, improved competitiveness and innovation through cooperation between researchers and industry and maximise Irish participation in EU Research Framework Programmes, including on an all-island collaborative basis;

• Implement a new National Support Structure for the Framework Programme;

• OSTI, assisted by Forfás, will continue monitoring and evaluating Irish engagement with international programmes. Key indicators of success will be the numbers of international collaborative engagements by Irish firms and institutions and the share of Irish research and development (public and private) supported by international sources.

• Data on promotion and collaboration of international programmes will be reported upon in agency annual reports;

• Links will be developed between the IDC and ASC and their Northern counterparts, to

ensure synergies and avoidance of duplication;

- Sectoral N/S cooperation in R&D will be supported and its further development will be encouraged.

- The full potential of US Ireland R&D Partnership will be realised;

- In promoting FP7, National Contact Points will make cross-border collaboration with NI a priority.

Chapter Eight - Implementation

- The key actions are contained within the text of this implementation chapter.

1 Vision and Challenge

1. Our vision:

Ireland by 2013 will be internationally renowned for the excellence of its research, and will be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture[1].

The development of the knowledge economy, including the factors that underpin it, is one of the key challenges and opportunities facing Ireland. There is widespread acknowledgement that the factors which led to Ireland's current economic success will not of themselves be sufficient to achieve our vision. Most of Ireland's recent employment growth has been driven by expansion in the services sector and construction. At the same time, Ireland's dramatic upsurge in productivity has been driven by technology based manufacturing industry[2]. Across the economy, global competition is creating pressure for improvements in efficiency, quality and productivity and a growing need to innovate and add value across all aspects of business. These pressures are only going to increase. Important social changes are also happening in Ireland. Two particularly notable aspects are the growing internationalisation of society and the changing nature of Irish demography. In addition, we have entered a period where economic cooperation with Northern Ireland is more possible, and given global competitiveness, more compelling, for both administrations than ever before.

These factors impact on the vision and on the kinds of strategies we pursue in building the knowledge economy. This Strategy has as its focus the period up to 2013. However, we fully understand the need to look beyond this. Key government decisions such as the introduction of free second level education and the ending of protectionism took years, or indeed, decades to fully bear fruit. The same need exists now; to take courageous forward looking steps that will achieve real strategic change, showing tangible results in the medium term, but also shaping the future in the longer term.

1.1 Where we have come from

Ireland began to consider science policy during the 1970s through the work of the National Science Council and, subsequently, the National Board for Science and Technology. These efforts had a broad purview at the policy level, encompassing areas such as energy and the marine, as well as policy on technological innovation exemplified by the formation of Ireland's first biotechnology programme. However, during this period there was a significant

1 National R&D Action Plan 2004
2 See Productivity: Ireland 's Economic Imperative. Tansey 2005

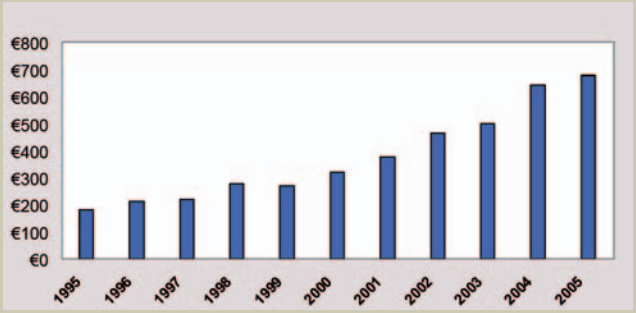
disjunction between the effort put into policy analysis and the programmatic funding which might have flowed from that analysis. It was only with the advent of EU structural funding for S&T, beginning with the 1989-1993 CSF[3], that substantive resources became available for S&T. These manifested themselves through the Operational Programme for Industrial Development which funded the first S&T development programme devoted to enhancing industrial R&D, higher education/industry collaboration, university research infrastructure; and the Community Initiative STRIDE, which focused on R&D in Natural Resources, including marine, forestry and agriculture. These programmes, though relatively limited in resources, provided much of the base in both policy thinking and programme design for current STI measures.

Perhaps the most notable feature was the almost total focus of activity in the period up to the start of the current National Development Plan, on applied research. It became apparent however through the national Technology Foresight exercise and analysis of international good practice, that attempts to build a system of applied research without a base of excellence in the underpinning sciences are not sustainable over time. In addition, as the Irish economy continued to develop and change, the human resources aspect of research policy came into sharper relief. There is a growing recognition that high level skills provide a key impetus to broad economic growth[4]. Put simply, society, economies and individual firms benefit from having a good supply of scientifically and mathematically literate people, even though all such people may not be directly employed in the sciences. The commencement of the PRTLI initiative in 1998 represented a pioneering move towards solidifying this view.

1.2 National Development Plan 2000-2006

A decisive shift in public policy and funding was initiated under the current National Development Plan (NDP), 2000-2006. The major initiatives involved the foundation and funding of Science Foundation Ireland (SFI) and the expansion of the HEA's Programme for Research in Third Level Institutions (PRTLI). Both of these initiatives have been the subject of review by panels of international experts, with very positive findings in regard to the rapid progress in building a base of world class research in Ireland. The graph below shows how Government investment in R&D has increased exponentially over the past decade.

Table 1. Government Expenditure on STI 1995-2005 in Public and Private Sectors (Constant Prices)



3 Community Support Framework
4 See Florida, Richard and Tingali, Irene Europe in the Creative Age, February 2004 (www.creativeclass.org)

These initiatives were complemented by increased resources for Marine, Agricultural and Health research, and the establishment of two Councils under the aegis of the Department of Education and Science: the Irish Council for Science, Engineering and Technology (IRCSET) and the Irish Research Council for Humanities and Social Sciences (IRCHSS), having responsibility for funding postgraduate research across a broad range of disciplines.

Within the current NDP, STI has become a major strand of government policy, underpinned by significant resources. The importance of ensuring greater coherence in the development of the overall national system of innovation has been recognized by government. The Cabinet Sub Committee for STI and its supporting structures are now in place.

1.3 The Lisbon Agenda and the National R&D Action Plan

The "Lisbon" agenda is aimed at making Europe more competitive and innovative on the world stage. As part of that process the Barcelona European Council concluded that Europe as a whole should aim to reach a target of spending 3% of GDP on R&D by 2010, with two thirds of that spend to come from industry. Some Member States such as Finland and Sweden are above that target, while many, including Ireland (at 1.6%) are substantially below it.

The National R&D Action Plan[5] proposed that Ireland should aim to reach 2.5% of GNP by 2010, with two-thirds of the increase coming from enterprise. Perhaps more crucially, the Action Plan represented the beginning of a more structured approach to building Ireland's National System of Innovation, which this strategy aims to fully realise.

1.4 The Role of Innovation

Innovation is about doing new things, or doing old things in new ways. Innovation can apply to all aspects of human endeavour: in the arts, the sciences and business. No single area of government policy has a monopoly on innovation. In the context of this strategy technological innovation has a vital role to play. By this, we mean the capacity to turn knowledge into new products and services. This is not simply a matter of industrial policy: it also has implications for our system of scientific and technological education, for the commercialisation culture within third level institutions, for fiscal policy and for public policy generally. The development of a fully realised innovation culture, however, transcends scientific and technological disciplines. This strategy, in assessing the need to develop advanced skills at Fourth Level also has regard to the potential of the humanities and social sciences, along with the natural sciences, engineering and technological disciplines. Thus the strategy aims to strengthen the National System of Innovation (NSI) across its many dimensions,[6] particularly with regard to the systemic aspect: forging more effective linkages and interactions among the different parts of the system. These issues permeate the strategy.

1.5 Building on Success – the challenges ahead

Much has been achieved in recent years, with especially notable progress under the current National Development Plan. However, there are very significant challenges ahead. Science, Technology and Innovation in Ireland is still underdeveloped by comparison with our key global competitors. An analysis of Strengths, Weaknesses, Threats and Opportunities[7]

5 Report of the Interdepartmental Committee, Building Ireland's Knowledge Economy, July 2004
6 See Appendix II for diagram of the NSI
7 Conducted at the commencement of the strategy formulation process, see Appendix I for summary

confirms that we have many strengths and opportunities to capitalise on, but also substantial threats and weaknesses to address and which are explored further throughout this strategy.

We now need to make the next leap forward to move Ireland from impressive latecomer to acknowledged leader. That in essence is the goal of this strategy. Our success will be marked by demonstrable achievement in a number of critical areas:-

- Increased participation in the sciences by young people;

- Significant increase in the numbers of people with advanced qualifications in science and engineering;

- Enhanced contribution of research to economic and social development across all relevant areas of public policy including agriculture, health, environment and the marine and natural resources;

- Transformational change in the quality and quantity of research undertaken by enterprise - both directly and in cooperation with third level institutions;

- Increased output of economically relevant knowledge, know how and patents from those institutions;

- Increased participation in international S&T cooperation and transnational research activity;

- An established international profile for Ireland as a premier location for carrying out world class research and development;

- Greater coherence and exploitation of synergies to mutual advantage in the development of STI policy on the island of Ireland.

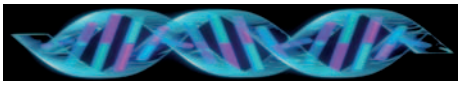
1.6 Why we need to act

Our economy has made great leaps forward in a relatively short time. This intensive growth can hide vulnerabilities especially when much of its foundations lie in domestic consumption and growth in public services and the construction sector. This type of growth has inevitable limitations. On the upside, it creates a window of opportunity to invest in the key factors that can allow the high living standards we currently enjoy to be maintained in a global competitive environment. It is no coincidence that those nations which have achieved long term competitiveness all have high levels of investment in research. They have universities and research institutions that produce world class talent and they have dynamic industries that make use of that talent by investing in the research and innovation that leads to world class products and services.

As with the economy, our progress in science in the past decade has been impressive. However, the foundations are weak. The countries that we need to benchmark ourselves against such as Sweden, Denmark and the USA have research systems whose roots extend back more than a century. At the other end of the spectrum, developing countries such as China and India are setting aggressive targets for catch up and have economies of scale on their side.

As a relatively small island, situated between the US and Europe, we have much to gain from enhanced all-island cooperation and pooling of resources in the STI arena, as is clearly evidenced by the experience to date in the sectoral research areas of health, agriculture and food, marine, energy and environment. In addition, there are wider possibilities for exploiting previously untapped potential cooperation under the umbrella of the EU Framework Programme.

World class research, world class people and world class enterprises with the drive to succeed, and the resources to do it: that is what our strategy aims to deliver.



2 World Class Research

2.1 Introduction

World class research and world class people are at the heart of the national system of innovation. Without scientific and technological talent, groundbreaking innovation is nigh on impossible. Organisations without the necessary talent are confined to adapting other people's ideas and technology: following, rather than leading. Incremental innovation is valuable, but of itself will not reshape our economy for the challenges of the twenty first century.

Under the NDP 2000-2006, Government made a significant strategic decision to develop a world class research system. Investments under the PRTLI initiative and SFI, in particular, have fundamentally changed the scale and quality of research in Ireland and the infrastructure supporting it. Independent evaluations of these investments have been uniformly positive, indicating that exceptional results have been achieved in a short period of time. Simultaneously, however, there is a widespread acknowledgement that building a world class research system requires dedication, persistence and sustained commitment. This strategy builds on what has been achieved under the NDP and maps out the next phase of development.

2.2 Importance of higher education

Higher education (together with key public research institutes such as Teagasc) is the engine room of Ireland's system of innovation. Our approach has been to develop the higher education system as the focal point for learning, scholarship, research and innovation. There are considerable merits in this approach. Talented, educated people are central to the knowledge society and the higher education system is the wellspring of advanced skills and learning. Advanced research and postgraduate and postdoctoral education have vital spinoff benefits for the quality of teaching and learning at undergraduate level. A higher education system which is strongly research and innovation oriented has the potential for mutually beneficial interaction with the enterprise sector.

The higher education system acknowledges the challenges it faces in meeting the demands of the knowledge society in the twenty first century and the need for reform and modernisation to meet those challenges. In the context of this strategy, there is consensus on the need to take the following specific actions:

- ·Significantly increase our research capacity, quality and output;

• Invest in the Fourth Level; to provide a new cohort of graduates at the doctoral and post-doctoral level, our future innovators and knowledge entrepreneurs;

• Reshape, reform and build capacity in our universities to support the development of the Fourth Level;

• Better manage the research and innovation environment within universities and ensure effective transfer of knowledge and technology.

At the broader level and also relevant to this strategy is the need to:-

• Renew and strengthen Third Level programmes, enhancing quality and delivering an even more flexible and adaptable labour force, with a lifelong capacity to react to change and innovation;

• Continue to focus on widening participation, lifelong learning and flexible educational provision, making the learning resources of the university available to a wider group throughout their working and professional lives;

• Establish mechanisms by which primary and secondary education is linked to the developments at 3rd and 4th level, providing an educational continuum with better public understanding of and interest in research and innovation, which will in turn ensure greater participation in these areas at 3rd and 4th level.

2.3 Current State of the Research Base

The impact of the research base on the economy is measured by its two key outputs – highly educated people and new knowledge. Taking the number of new doctorates (PhDs) produced per million of population as an indicator of trained researchers, table 2.1 shows the latest available data for Ireland and a number of comparator countries. While Ireland performs relatively poorly in terms of overall doctoral graduates, in the science and engineering disciplines Ireland is on a par with The Netherlands and Denmark, ahead of the US and Norway, but some way behind the three leading nations.

Table 2.1 Output of PhDs per Million Population (2001)

	Total PhDs	Science/Eng. PhDs
Switzerland	364	163
Finland	363	187
UK	239	144
Denmark	169	86
Netherlands	153	81
Norway	143	42
US	143	81
Ireland	**125**	**89**

Source: NSF Science and Engineering indicators 2004

As a result of the greatly increased funding for research post 2000, the Irish figures are expected to move towards the overall OECD average in coming years. Standard indicators of

knowledge output from the research system include publications in refereed journals and levels at which these publications are accessed ('cited') by other researchers in their own publications. Table 2.2 shows the latest available data for the same group of countries.

Table 2.2 Scientific Publications/Million Population (2002)	
Switzerland	1,757
Denmark	1,332
Finland	1,309
Netherlands	1,093
UK	1,021
Norway	972
US	926
Ireland	**647**
EU Avg.	673

Source: Eurostat Key Figures 2005

In terms of gross output of publications, Ireland was just below the EU average in 2002 and well behind the leading countries. Data on citations suggests that Ireland performs relatively better, but such data is distorted by lower citation rates for non English speaking countries. Using the more reliable comparator of US citations, Ireland's rate is 1.05 versus 1.64 for the US[8]

Studies undertaken in connection with the recent evaluation of Science Foundation Ireland provide an indication of the extent to which research quality in Ireland has improved since 2001. Analysis of the publication records of SFI-funded researchers, both before receipt of SFI awards and after such awards, indicates that their research performance is well in advance of average performance levels in Ireland in the past and is indicative of the success of government investment in upgrading the research base in a comparative international context.

These standard metrics, give some indication of our comparative position but they have limitations. "Per million population" data fail to account for economies of scale. In other words, the sheer volume of advanced researchers in the US will have a catalytic effect disproportionate to their representation within the population as a whole. In addition, citation data is a relatively crude measure to the extent that popularity and quality are not necessarily equivalent. However, it is the internationally recognised basis for assessing quality and therefore appropriate in the context of this Strategy.

It is essential, therefore, that small countries such as Ireland place a particular emphasis on quality - both in terms of the research work itself and also by achieving the critical mass of people and infrastructure to support that research.

A vital part of the strategic shift under the current NDP has been the building of a quality research base by supporting excellence, as measured by international peer review. This approach will continue and will be deepened under this Strategy.

2.4 Current R&D Performance

Exchequer funding for research in both the public and private sectors has increased significantly over the last five years, rising from €334 million in 2000 to over €680 million in 2005. These increases have supported a rapid expansion of the research system over the period.

8 Highly cited papers as a percentage of total publications

Based on Forfás surveys, in the Higher Education sector (universities, institutes of technology and the Royal College of Surgeons of Ireland), there were 2,650 researchers (full-time equivalents) engaged in research in the fields of science and engineering, and economic and social sciences in 2004, together with 950 research assistants. In addition, there were 360 technicians and 260 other research personnel supporting research activities. Total PhD students registered in the areas of science and engineering and economic and social sciences is estimated at 3,050. In the public research performing sector, which includes, for example Teagasc and the Health Research Board, on a full-time equivalents basis, there are 520 researchers, 290 of whom are at PhD level. These are supported by an additional 290 technicians.

2.5 Framework for development

Current efforts represent the first steps to building our research system. As a result of those efforts, we now have most of the components of a world class system. But much remains to be done to ensure that the system is truly competitive in terms of sustainability, scale, coherence and quality. In striving for excellence we have two overarching goals:

1. To build up a sustainable system of world class research teams in terms of people and supporting infrastructure;

2. To double[9] our output of PhDs.

These goals are interlinked. The quality of both research and postgraduate formation is dependent on access to world class Principal Investigators to lead teams of Postdoctoral and Postgraduate researchers.

2.6 Achieving the goals

In that context we need to continue to build the critical mass in our research teams and to maintain the world class standards that have been fostered by the competitive process instigated under the NDP. These students need to join research teams that are led by truly world-class Principal Investigators backed up by Postdoctoral researchers. This will be achieved by growing the number of Principal Investigators by 350 over the period to 2013 and Postdoctoral researchers by 1,050. To support these research teams, increases in the number of research assistants by 350 and technicians by 350 respectively over the period are required, as illustrated in Table 2.3. The structure and balance in research teams envisioned by this strategy is designed to ensure quality, consistent with national and international best practice as follows:[10]

Science, Engineering and Technology (SET) - 1 Principal Investigator: 3 Postdoctoral: 5 Postgraduate: 1 technician/research manager/assistant.

Humanities and Social Sciences (HSS) - 1 Principal Investigator: 2 Postdoctoral: 3 Postgraduate.

9 Relative to 2003 output levels

10 Includes all SET disciplines of Science, Engineering, Medicine, Informatics, Interdisciplinary/Interfaculty, Agriculture Science, Veterinary Science, Business/Commerce; excludes non-SET Humanities and Social Sciences, i.e., Humanities, Education, Arts/Philosophy.

Table 2.3 Cumulative Increases in S&E HE Researchers by 2013								
Total Net New Appointments	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Principal Investigators	40	80	120	160	205	250	295	350
Researchers (PhD+)	120	240	360	480	615	750	885	1,050
Research Assistants	20	40	60	80	103	125	148	175
Technicians	20	40	60	80	103	125	148	175
PhD Student Places	235	438	719	976	1,191	1,375	1,569	1,775
Total	**435**	**838**	**1,319**	**1,776**	**2,216**	**2,625**	**3,044**	**3,525**

Over the life of the strategy it is intended that this proposed structure be developed. It will allow researchers move from PhD training to Postdoctoral and PI positions. It will also facilitate a flow of researchers in and out of the country to gain international R&D experience and combine with a flow of skilled people taking up careers in the enterprise sector. Within this team based structure the overall annual output of top level PhDs will be effectively doubled by 2013 as shown in table 2.4 below. In summary, this will allow the annual output of PhD graduates be increased from 543 in 2005 to 997 by 2013, resulting in a total output of 6,546 PhD graduates over the period 2006-2013.

Table 2.4 Projections for Post Graduate Numbers									
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
SET PhD Graduates*	543	606	660	724	801	881	919	958	997
HSS Output* PhD Graduates/Postdocs	187	284	234	285	282	300	306	306	315
*In the same period, 1,815 additional postdocs will have undertaken four years of study in supported research teams									
** HSS data groups PhDs and Postdocs as Postdoc awards are an integral part of the completion cycle in HSS									

This is in line with the recommendation in the OECD's Review of Higher Education in Ireland (September 2004) that the number of PhD students should be more than doubled by 2010 when taking account of the vital requirement to maintain quality.

2.6.1 Importance of Humanities and Social Sciences

It will be noted that it is proposed to upscale research across all disciplines: both the physical sciences and the humanities and social sciences. This approach is founded in a belief in the intrinsic value of scholarship, both to democratic society and to the effective functioning of universities as communities of knowledge and discourse. It underscores the importance of scholarship and research in the formation of postgraduates, but also in its impact on the quality of undergraduate teaching.

In addition, there are compelling social and economic reasons to further develop our capabilities in the Humanities and Social Sciences. These include: better understanding of the very rapid changes taking place in the Irish economy and society; the importance of that

knowledge and understanding in better informing public policy making; and developing creative and analytical skills in the context of a global economy which is becoming increasingly dominated by knowledge based services.

2.7 Infrastructure

World class research requires first class people and also the supportive infrastructure within which to carry out that research. Much of that infrastructure is specialised: technologies such as nanotechnology, for example, require facilities which are very different from the general purpose labs provided for undergraduate education. The PRTLI initiative under the current National Development Plan, which benefited from substantial philanthropic support, made significant inroads towards rectifying long run historical deficits in research infrastructures in the HEIs. However, there remains a shortfall in provision for buildings, equipment and support services. Under this Strategy, it is intended that this shortfall be addressed both through the upgrading of existing facilities and the provision of new infrastructure. The implementation mechanisms outlined in Chapter Eight will, inter alia, ensure effective linkage between competitive research funding and the provision of associated infrastructure.

2.8 Graduate Schools

Graduate schools underpin research programmes in the world's leading innovative economies. In the context of this strategy's advancement of SET postgraduate training, the development of graduate schools can deliver:

· Quality-led training of early stage researchers in multi-disciplinary environments;

· Structured, relevant generic and transferable professional skills training enabling the PhDs produced to develop their careers in diverse sectors of the economy, including intellectual property management and commercialisation skills;

· Industrial placements and modular, transferable postgraduate courses, both practical and theory-based with built-in industrial expertise, and;

· Further training for industrial researchers requiring skills/knowledge upgrading.

There is an emerging consensus within the university system that a graduate school type mechanism is needed to ensure the most effective professional development of our researchers. The increases proposed in advanced researcher numbers and the aim to see a significant movement of advanced researchers to the enterprise sector, underscores the need for such a mechanism. The more structured approach to postgraduate formation also has the potential to reduce the time taken to complete a PhD and increase the completion rates of entrants to doctoral programmes, thus delivering both quality and improved value for money for the resources invested in PhD training.

In addition, it is recognised that a step change is also required to raise the levels of excellence in existing graduate schools in the humanities and business education if Ireland is to achieve its ambitions of developing knowledge-based enterprises that are highly innovative in world markets.

2.9 Researcher Careers

Human resources, in the form of sufficient numbers of suitably educated, high quality people, are essential to the achievement of the objectives for the research base. This has implications both for education at all levels up to and including undergraduate (to ensure a 'pipeline' of people interested in and qualified for a career in science or engineering[11]) as well as for the country's ability to attract mobile international research talent. One factor which impinges on both these issues is the availability of an attractive career structure for people interested in doing research. The development of more visible career paths will make science more attractive and has the potential to give Ireland a competitive advantage in the international market for top researchers.

The recent five fold increase in national investment in research, together with the progress that has been made towards the development of a state of the art infrastructure and the growing integration of higher education research with enterprise and sectoral research, provide the foundations to differentiate Ireland as a highly stimulating place to conduct research. However, overall Ireland does not yet have a sufficiently high profile as a location of choice for world class research. This makes the recruitment of the best researchers from abroad a continuing challenge.

Under this strategy we therefore need to further differentiate Ireland by developing attractive research career paths. Flexible career paths are required to reduce the reliance on two-year post doctoral contracts. Emphasis will be placed on sustainable career development rather than only focusing at early stage careers. Currently, little opportunity exists for systematic career development within the HE sector. The Advisory Science Council will be requested to examine, and come forward with proposals to the IDC on, this key issue.

In addition, this strategy places a heavy emphasis on growing business expenditure on R&D. As well as building strong HE based research teams, the movement of researchers from the HE sector to industry and the growth of collaboration between companies and research institutions through the development of industry led networks and competence centres are priorities.[12]

Within the HE sector, in the longer term, more of the top PIs will have to be incorporated into tenured posts in the universities. The wider programme of modernisation and reform of the higher education institutions and programmes of voluntary early retirement to provide for "new blood" will be especially important. The Strategic Innovation Fund announced in Budget 2006 will play a vital role in this regard.

2.10 Mobility of Researchers

Building up the required number of researchers will not be achieved by organic growth alone. Researchers will need to be attracted to Ireland in greater numbers than before.

Removing obstacles to the mobility of researchers has been identified as a priority for Ireland. Efforts to improve the mobility of researchers have been helped by the establishment of the European Network of Mobility Centres.

11 As discussed in Chapter Five
12 See Chapter Four for more details.

The Irish Universities Association is playing an important role in that regard, as operator of Ireland's national mobility centre and mobility portal. The Mobility Centre provides assistance to researchers wishing to pursue careers in both academia and industry.

In general, work permits for researchers are processed efficiently and without undue delay. A fast-track arrangement has recently been introduced by D/ETE for researchers in research-active organisations (including those to be employed in industry) who are supported by public funding - national, EU or international. However, there is a need to build on these national measures and the proposal for a new Green Card-type system for high skilled non-EEA nationals should facilitate the entry of researchers, within a particular salary range, and their family members.

In addition, it is proposed to move speedily to implement the recently adopted EU Directive and accompanying proposals concerning the entry conditions for third country researchers and their family members. In that regard, D/ETE is liaising with the Department of Justice, Equality and Law Reform (which has lead responsibility for the Directive) and other relevant parties to facilitate its early implementation.

These measures, coupled with attractive funding opportunities for researchers, will give Ireland a competitive advantage against larger, more established international funding agencies and research funding bodies.

Key Actions

- **Build on recent NDP investments to deliver a sustainable, world class research system across the spectrum of humanities, physical and social sciences;**
- **Deliver quality by increasing the number of research teams led by internationally competitive principal investigators;**
- **Upgrade existing infrastructure and develop new facilities to support research;**
- **Enhance postgraduate skills through a graduate schools mechanism;**
- **Develop sustainable career paths for researchers;**
- **Enhance the mobility of researchers;**
- **Double the number of PhD graduates by 2013.**

3 Capturing, Protecting and Commercialising Ideas and Knowhow

3.1 Introduction

The generation, capture, protection and exploitation of intellectual property is a central theme of any world-class research environment. Transfer of knowledge and technology, encompassing intellectual property, from HEIs and Public Research Organisations (PROs) into the market place is recognised as being of crucial importance in the establishment of a strong research environment and a knowledge-based economy, as are robust linkages between the third level and enterprise sectors. To operate at an internationally competitive level, serious deficits in the culture, process and funding in the area of IP in the Irish HEIs must be addressed. Consensus on this point has emanated from a number of groups whose recent reports have highlighted issues related to IP management in Ireland.

Under the current NDP, investment in R&D has rapidly expanded the size and quality of research in Irish HEIs. As a result, the number of discoveries and inventions in these institutions has increased. Aside from the commercial benefits to the inventors, institutions, and the economy in general, awareness of IP and its significance as an integral part of research is a crucial part of the education for any investigator, undergraduate or postdoctoral student involved in research. Clearly, before technology transfer and IP commercialisation can occur a number of important stages in the IP management process must be successfully completed, including the identification of IP, its evaluation and subsequent capture and protection.

3.2 Where we are now

Financial support for the development of new technologies has come on stream in recent years but constraints still exist to the creation of a dynamic exploitation system for IP. Each of the universities and the Royal College of Surgeons in Ireland currently has a dedicated Technology Transfer Office (TTO) responsible for these functions. Within the Institutes of Technology (IoT) sector, only DIT has a dedicated office of some scale. However, the TecNet alliance of the Institutes of Technology has considerable potential to address shared needs in this area across the sector[13]. The TTOs are staffed by between one and four full time personnel, supplemented in some cases by part-time employees. In almost all cases the offices are jointly staffed by university and Enterprise Ireland (EI) personnel, with EI staff providing commercialisation expertise in biotechnology and ICT related fields. In addition, the central EI Bio Research team of five provides expert support to the TTOs for IP protection and exploitation activities, principally in the biotechnology/life sciences area.

13 See Chapter Four

The TTOs can also access external legal and commercialisation specialists through the EI Bio team.

The TTOs also interact with staff in other areas of EI whose roles involve more general commercialisation related issues such as university-industry linkages. The SFI CSETs and the Tyndall National Institute also have business development managers, part of whose role is to work with the TTOs in managing IP arising from their research activities.

The underdeveloped state of IP within the HEIs is reflected in the absence of accurate data on patent filings and grants. The best available information suggests that the number of patents from HEIs to the Irish Patent Office has been increasing in recent years, but only 70 of the 1,056 applications received by the Office in 2004 came from HEIs. These 70 applications were received from seven HEIs with the remainder of HEIs recording no patent activity with the Irish Patents Office. High level analysis of return on research investment suggests that three of our universities are achieving returns on a par with those seen in the UK and the US, with one patent per approximately €3 million research investment so a clear gap exists between the best performers and the significant remaining majority of HEIs.

In terms of current funding for the IP Management function, the overall financial allocation to Technology Transfer (TT) activities in the universities amounts to approximately €11 million per annum. Of this, €10 million is used to support people, databases and commercial space for incubation and €1 million is used to cover patenting expenses.

3.3 Initiatives Proposed

Based on engagement with the HEIs and a review of IP Management practices in other selected countries, a two-pronged approach will be implemented to upgrade our performance in the management and commercialisation of intellectual property from publicly funded and public-private collaborative research. This involves strengthening the IP/ Commercialisation function within the HEIs and supporting this where relevant with a central source of specialist expertise.

3.4 Within the Institutions

Upgrading our IP performance requires a cultural shift in many of the HEIs. In particular, it requires that IP management and commercialisation should be seen as a central part of the institution's mission with equal standing alongside the traditional activities of teaching and curiosity driven research. Such a shift in culture could be underscored by having the head of the commercialisation function report directly to the institution's Vice President for Research.

There is also a clear need to strengthen institutional competence, both at TTO level and among the community of researchers themselves. A competitive fund administered by EI will be established to assist the institutions in strengthening their IP management functions. Grants from the fund will be made on the basis of competitive bids outlining the institutions' proposals in this area and the expected added value in commercialisation terms from increased investment. Activities to be supported by the fund will include:

• Recruitment of staff with appropriate expertise and experience of research and enterprise activities to staff the TTOs and deliver support to researchers;

• Training and support for researchers to ensure they are aware of the importance of technology transfer activities and understand the potential that exists;

• IP Scouting to monitor research and inventive activity that is being generated by the university;

• Better identification and selection of research inventions that are seen as valuable and worth protecting in terms of generation of future income;

• Measures to better implement the Codes of Practice on Publicly Funded and Public/ Private IP;

• Measures to ensure highly efficient processes that facilitate both patenting and publishing.

3.5 Central support unit in Enterprise Ireland

A 'Review of International Best Practice Pertaining to the Structure, Activities and Responsibilities of Industrial Liaison Offices' prepared for NUI Galway in 2004 suggests that to achieve globally competitive economies of scale in the management of intellectual property, there are strong arguments for a national, publicly-funded shared services facility, providing Irish institutions with access to pooled expertise in a number of resource-intensive areas. At the same time, it is clear that the HEIs need to continue with local level activities and to strengthen these as outlined in the previous section. A mix of strong local action with central support for resource intensive and cross institutional tasks is the model proposed in this strategy.

Building on EI's extensive involvement with the HEIs in this area to date, a new function will be put in place within EI to provide centralised support to the institutions and maximise the commercialisation of institution-generated IP. The services of the centralised commercialisation entity will include:

· Management of a newly established Competitive Fund for Technology Transfer in HEIs;

· Management of the Commercialisation Fund, Intellectual Property Fund and support for incubators and bio-incubators. The Commercialisation Fund was launched in recent years and includes three phases: proof of concept, technology development and commercialisation. An increased level of application is expected over the course of the strategy with particular emphasis being given to the final stages of support to ensure that transfer actually takes place to the benefit of the receiving company. Under the Intellectual Property Fund, 40 patents were supported in 2004 and this number is expected to double over the next few years;

• Diffusion of information on IP Management to all HEIs and sharing of good practices;

• Provision of expert and specialist TT support to all HEIs – legal expertise, license negotiation, spin out creation, IP marketing, international promotion, staff training, technology assessment evaluation, provision of patent protection and infringement costs; and,

• Provision of advice and seed funding to campus companies.

Key Actions

• Ensure that HEIs encompass IP management and commercialisation as a central part of their mission, equal to teaching and research;

• Strengthen institutional competence at TTO level and among researchers;

• Establish competitive fund administered by EI to assist strengthening of IP management function;

• Establish a new function in EI providing centralised support to HEIs thereby maximising the commercialisation of IP.

4 Research and Development for Enterprise Innovation and Growth

4.1 Introduction

Manufacturing and international services industry in Ireland have been the most significant driver of economic growth over the past fifteen years. In that period, the Irish economy tripled in size in terms of GDP, while goods and services exports grew eightfold. Foreign Direct Investment (FDI) was a large contributor to this expansion. The total stock of FDI in Ireland reached €168 billion in 2004, as the Enterprise Strategy Group noted, "...the highest in the world in per capita terms after Hong Kong".

In terms of Gross Value Added (GVA), manufacturing industry has been the principal engine of growth, with GVA in industry increasing almost twice as fast as in services since 1995. There is a clear correlation between technological intensity and growth. For example, in the period between 1997 and 2003, virtually all of the gain in real value added in manufacturing was attributable to four technologically intensive sectors, namely: software, chemicals, computers and instruments, and electrical machinery and equipment.

For a country whose performance is so dominated by high technology industry, there is a disjunction between this impressive overall performance and the level of R&D conducted by firms in Ireland. While business expenditure on R&D has improved considerably over the last decade, growing by 19.8 per cent in nominal terms between 2001 and 2003 for example, it still lags that of competitors. And the contrast is even greater when the level of spend in high tech sectors in Ireland is compared to broader global norms for those sectors, as Table 4.1 illustrates.

The four sectors of ICTs, Life Sciences (bio-pharma and pharma-chem), Medical Technologies and Food together account for the largest part of manufacturing output. Even within these technology intensive sectors, levels of R&D in Ireland are below that of competitor countries. These are also sectors where research has the potential to make a serious impact on productivity, growth and competitiveness. The four areas are also distinctly different and the level of R&D performance by companies within these sectors varies from low and non-performers to those that have high levels of R&D intensity.

The challenges for small and medium sized companies and multi-nationals in undertaking R&D are distinctly different, as are the strategies and solutions required. SMEs need to increase their research activity and technological capabilities. MNCs need to be able to secure research activities for their Irish operations against competition from other corporate loca-

tions globally. Similarly, the large base of non-R&D performing enterprises, both large and small, need to develop their research capabilities and capacities and to become research active.

Table 4.1. Business Expenditure on R&D (BERD) as per cent of Output, 2003				
Sector	**BERD *(€m)**	**% Output *Ireland**	**% Output **EU**	**% Output **OECD**
Electrical and Electronic Equipment	212.2	0.9	3.6	3.8
Pharmaceuticals	190.2	3.8	10.0	10.3
Medical Technology	115.9	2.0	4.9	7.8
Food, Drink and Tobacco	42.3	0.2	0.2	0.3
Machinery and Equipment	39.4	2.4	1.8	2.1
Other Manufacturing	72.1			
All Manufacturing	**672.1**	**0.7**	**1.9**	**2.4**
Software	378.3			
Others	25.2			
Total BERD €1,075.6				

* Data for Ireland is 2003 and estimated from the BERD survey and the 2003 Census of Industrial production. ** Latest data available for EU (21 countries) and OECD is 2000. Source OECD ANBERD series 2004.

The R&D Action Plan proposed challenging targets[14] for R&D performance by companies. While the increase in business expenditure on R&D of 19.5 per cent over the period 2001 to 2003 is encouraging, achieving the targets as set out in table 4.2 below will need a transformational change in company attitudes to R&D, supported by greatly enhanced efforts on the part of the state to support that change.

Table 4.2. R&D Performance and Targets, 2003 and 2013		
Year	**2003**	**2013**
Business Investment in R&D	€1.076 billion (0.93% GNP)*	€2.5 billion (1.7% GNP)
Number of Indigenous Companies with meaningful R&D activity (>€100,000)	462	1050
Number of Indigenous Companies performing significant R&D (>€2m)	21	100
Number of foreign affiliate companies with minimum scale R&D activity	213	520
Number of Foreign Affiliates companies performing significant R&D	60	150

The implications of these targets for policy are clear. While ultimately research and innovation is the responsibility of individual enterprises, the enterprise development agencies, Enterprise Ireland and IDA Ireland are committed to working with companies to strengthen the research and technological base of the enterprise sector. They will facilitate more companies in undertaking R&D and aims to support companies in moving from no or minimum scale R&D to more significant operations. If Irish industry is to grow, it needs to move progressively to undertaking research that will underpin products several generations forward and to complement the shorter term product and process development which is the focus of many current R&D performers.

14 This strategy has adopted those targets within the timeframe 2003 to 2013

4.2 Continued Commitment to Manufacturing and International Services

The Government remains fully committed to supporting the competitiveness and growth of manufacturing industry and international services through the full range of industrial and economic policy measures available to it.

In this context, support for research, development and innovation is absolutely vital. On the one hand, Ireland's economic success means that EU State Aids regulations will curtail many conventional grant based supports for firms, while on the other, lower cost competitors are putting pressure on traditional manufacturing throughout the developed world. Against that backdrop, the change in the performance and structure of industry in Ireland over the past two decades needs to be accelerated and deepened. Competitive industry in Ireland will need to be characterised by a much stronger base of home generated innovations (in both indigenous and MNC firms); by more indigenous technology based startups that make the transition to companies of scale; and by a multinational (indigenous and overseas) sector that builds on an already well established capacity for speed, flexibility and agility to become research and technology leaders within their overall corporate group.

4.3 Technology Ireland

If the demanding targets for enterprise performance are to be met, there needs to be fully joined up thinking and action among Enterprise Ireland and IDA Ireland across all facets of the science and technology agenda that impact on enterprise. This in turn needs to be supported by the research supports provided through SFI, HEA and sectoral agencies such as Teagasc. The report of the Enterprise Strategy Group called for a dedicated support structure for industrial research and development – Technology Ireland. The broad scope of this strategy requires that the potential for technological innovation is maximised throughout Irish enterprise. For this to happen, research and technological innovation needs to become a more integral part of agency strategies and actions, and this has fundamental implications for the agencies as detailed below.

4.4 Overarching Structure for Technology Ireland

Technology Ireland will be established as a virtual structure under the aegis of the Office of Science, Technology and Innovation (OSTI) at the Department of Enterprise, Trade and Employment. It will be a core component of the implementation structures for the strategy. These structures are described in detail in Chapter Eight. Within the framework of TI, IDA and EI will work together to ensure maximum complementarity and added value in their activities. This will be supplemented by more regular and structured interaction with SFI and with HEA, as required. A team of senior technology executives from each agency will meet regularly with the OSTI, supported by Forfás, to assess performance under this strategy and coordinate the activities of the agencies. The Group will have responsibility for overseeing the implementation of required actions to achieve the targets set out above, for ensuring coherence in programmes and initiatives among the agencies and for identifying areas for enhanced synergy in initiatives to promote enterprise R&D. The CEOs of the agencies together with the CEO of Forfás and the head of OSTI will meet periodically to oversee the joint actions of their agencies.

Both EI and IDA will need to enhance their skillsets to deliver on the challenging R&D targets under this strategy.

Work has already commenced in this regard. Under its strategy, "Transforming Irish Industry" EI has created two new technology divisions responsible for Technology Automation and Productivity, and Applied Research and Commercialisation. The latter division has three units, for ICT, Biotechnology and Industrial Products. Within this structure, EI is more directly linking its technologists into client facing roles.

IDA has established a new Research Collaboration and Commercialisation Group. This group will focus on key focus areas of relevance to IDA client firms: ICT Hardware and Software, Biology, Life Sciences, and Medical Technology. The group will work directly with IDA sectoral divisions and overseas marketing teams to support IDA clients to grow their R&D efforts.

4.5 Overview of Strategy for Enterprise RTI

The targets for increasing business R&D performance are challenging and require a new approach to the promotion of R&D in firms and the provision of State support. In that regard, the agencies will mainstream their R&D support offerings to enterprises as part of their overall supports to enterprise. The key elements of the approach under this strategy are as follows:

- Raising awareness and increasing the number of companies carrying out R&D;
- Improving soft support systems to secure the development of appropriate technology strategies by companies;
- Achieving step change increases in quality and quantity of R&D activity in existing R&D performers;
- Building in-company technology capability;
- Increasing inter-company and industry-HEI collaboration;
- Simplifying the administrative and operational procedures of R&D programmes.

4.6 Awareness and Technology Strategy Development

In light of the fact that significant numbers of indigenous and FDI firms do minimal, or no R&D, there is a clear requirement to raise awareness of the need for, and benefits of, technological innovation and research, and to encourage existing firms to do more. Specific additional initiatives will be implemented around R&D awareness, technology needs assessment and technical advice to develop and attract new R&D performers. Science & Engineering graduate and R&D management placements to support companies new to R&D will also be a priority to grow enterprises' capacity to absorb technology.

Awareness initiatives will also be complemented by supports to bring about more structured development of longer term technology strategies. These will improve the quality of research being undertaken by promoting in-company technology management development, R&D human resource recruitment and on-going interaction with expert agency executives.

Under the strategy EI is mounting a new awareness campaign. Some features of this campaign include:-

1. Learning by Example: a seminar series in which company speakers give first hand examples of the way in which R&D investment has worked for them and:

2. A system of personalised three-day consultancy support from a panel of approved consultants.

Through this process, companies can learn the realities of R&D from industry peers, get support to assess the relevance and scale of R&D, technology application or design improvement incentives appropriate to them and get practical advice on setting up R&D systems. Companies will also be alerted to the financial and soft supports available from the enterprise agencies and encouraged to make use of them. To drive this activity a group of R&D advocates will be formed of experienced R&D professionals from industry. EI is working in partnership with IBEC's Industry Research and Development Group in this advocacy process.

IDA Ireland will run a new international promotional and marketing programme targeted at both the existing base of multinationals in Ireland and at leading global enterprise R&D performers amongst key technology decision makers in MNCs in targeted markets. This will include substantive participation in trade fairs and technology conferences, trade press advertising, organised "technology" events and other promotional initiatives to specifically target research management levels and the research community in MNCs. The initiative will be promoted under the umbrella of the "Knowledge is in our Nature" theme.

4.7 Absorptive Capacity

A key step for many companies that do not engage in R&D or are low R&D performers is to increase their scientific and technological capabilities.

Capacity to develop an R&D strategy is critically influenced by the competence and experience of company personnel in the technology area. In addition to dedicated research staff, companies can also benefit from enhancing their capability to manage the entire process of research and technology development. The EI Innovation Management Initiative is being expanded to address this need. The programme caters for a wide range of needs, including four introductory courses, two for more sophisticated performers, two masters programmes (one at the National Institute of Technology Management and one by distance education), as well as activities to maintain best practice across the course providers.

As well as upgrading existing company skills, there is scope for assisting companies to bring in new talent in science and technology. In this regard, under the strategy, EI will develop coherent programmes for placing S&E graduates and R&D management, to support companies new to R&D and to introduce a capacity to absorb technology into firms. The Teaching Company Scheme which has been very successful for over 20 years in the UK is a model of how such schemes can be developed. It assists interaction between firms and higher education institutes, based on the placement of recent graduates in firms to develop innovation processes.

4.8 Simpler, more accessible financial support to firms

R&D is inherently risky, especially for small firms and for companies engaging in large scale projects, or research of an advanced nature. Financial assistance will continue to be important in supporting firms to become involved in R&D or to deepen that involvement, and to mitigate the risk inherent in research. Some €55 million is currently provided in funding to firms per annum. This funding has been instrumental in growing BERD, but there are indications that the way in which these grants are structured and delivered could be improved. Evaluations[15] indicate that there is some confusion among firms as to what supports are available and how to access them most effectively.

Currently, there is a shared "RTI Competitive Scheme" administered by EI. In addition, both IDA and EI operate separate "Capability" schemes for larger scale projects. These schemes were appropriate when the level of in firm R&D was lower and the agencies were more focused on grants to support expanding output and employment. R&D is now a much more central part of industrial policy and it is therefore time to look again at how grant support is structured.

The goal of promoting strongly increased investment in company R&D can best be reached by a simple, coherent scheme that can be accessed by firms at all stages of development. To achieve this, under the Technology Ireland umbrella, EI and IDA will implement a more holistic and systematic approach to providing R&D supports. The overall objective is to get more firms involved in doing research and development, to increase (where appropriate) the amount of R&D that existing performers are doing and, to raise the quality and sophistication of the R&D they perform. This should facilitate a planned progression for companies doing R&D, thereby improving in-firm technological capacity and capability over time. The range of supports will be set out in an easily understood package for promotion to companies.

This scheme will target firms in the three stages of R&D development already discussed – new performers, existing performers, and firms capable of more sophisticated research efforts. The criteria for the new scheme will be based on the scale and risk profile of the project and the R&D capacity and stage of development of the firm. As part of the process of promoting simplicity and accessibility, consideration will be given to removing the repayability element which is currently a feature of EI's existing schemes.

4.9 International Technology Transfer

Research and development is an important business function which helps companies to address the threats and opportunities of the market place. Technology transfer can play a complementary role as it allows companies in Ireland to locate partners in other countries and acquire new products. Licensing is a well established method of getting new products to market quickly. It builds on the availability of intellectual property which has been developed by a firm but which is not of immediate value to them. This is particularly the case with big companies where they may have large patent portfolios where value could be released if the technology were licensed. EI launched the TechSearch initiative in 2005. TechSearch works with companies to identify where technology licensing could play a role in their development, find suitable partners and guide them through the negotiation and contract

15 Technopolis, 2002

phase. This activity will be expanded and focused particularly on the needs of SMEs, while also working with MNCs and other large companies to access their patent portfolios. In many cases, these companies have generated intellectual property which is not core to their operations and which may be better commercialised by a smaller entity. Initial work by EI has shown that there is potential to expand this activity.

4.10 Support for HEI/Industry Collaborative Research

HEIs contain the largest pool of scientists and researchers within the national innovation system and it is a key policy aim in most countries to encourage industry to make more use of this resource. It is increasingly recognised that this is essential if significant increases in BERD are to be achieved. A range of current Enterprise Ireland programmes are the principal mechanisms for promoting such interaction, including the Innovation Partnerships scheme and more recently, the Industry-led Networks. The Innovation Partnership scheme aims to build links between companies and research groups to allow industry to access the expertise and facilities available. This programme will be modified to encourage larger projects and encompass additional activity created as a result of the Industry-led Networks.

4.10.1 Industry-led Networks

Continuous technological change and innovation are among the main determinants of productivity growth in firms and in the economy. As the processes that lead to technological innovations are exceedingly complex, firms rarely innovate in isolation. Increasing importance is now attached to interactions with other firms and with HEIs or public research organisations. The ultimate result of these interactions will be increased levels of BERD and of innovation. New approaches to developing and strengthening such networks will be implemented as part of this strategy.

Countries with fully developed national systems of innovation show higher levels of inter-firm cooperation than Ireland. Now that the number of R&D performing firms is increasing, it is important that firms begin to reap the benefits of knowledge sharing and risk mitigation that such cooperation can bring. Government incentivisation of such cooperation must of course take account of competition policy and avoid distorting the marketplace. As with the research supported by the EU Framework programme, this can be achieved by focusing assistance on the formation of networks and emphasising research which is some distance from the marketplace.

In 2005, Enterprise Ireland initiated a pilot programme to encourage the development of industry research networks in Biotechnology, ICT, and Industrial Technologies and Functional Foods. The purpose of these networks is to agree a research agenda between companies that focused on topics that were of emerging concern and interest. These topics invariably represented an opportunity for the firm but were too far from market to be justify direct investment. By supporting a co-ordinated programme of research it will be possible to generate new knowledge in these areas, training high quality graduates in the area and to build strong and enduring linkages between the companies and the research performers. For example, under the Industrial Technologies programme, the Power Electronics Industrial Group has presented an analysis of the current state of play in power electronics in Ireland and abroad, and has identified a range of areas on which they need to work in order to strengthen the industry in the medium to long term. The progress of these pilots so far

indicates that debate, and agreement, on a mutual research agenda is challenging for companies but it is a process that they find valuable and one that builds strong inter-company connections. The formation of additional inter-firm networks will be strongly promoted over the course of the strategy.

4.11 Regional Innovation and the Institutes of Technology

Given the concentration of scientific and technological resources in the major cities, companies in regional locations can find it more difficult to access support for innovation. Regional economic development is a key aspect of Government policy and within the broad framework set by this policy, regional innovation will have increasing importance in the future.

The Institutes of Technology (IoTs) represent an important resource in this context. Their multi-regional location and openness to working with industry provides a platform upon which real industrial impact can be built. It is clear that the IoTs can develop into an effective technology resources, focused on collaboration with local industry on the basis of applied research and technology development directed at the challenges facing the company.

A high quality response to these challenges will require the research community in the college to understand the science behind problems, be familiar with research processes and good research management practices, and be comfortable working in the context of an industrial environment. In that context, there is a continuing requirement to strengthen the IoTs' overall research capability, while ensuring that coherence is maintained within the higher education system. The advancement of the legislation to bring the IoTs under the ambit of the Higher Education Authority is an important step forward in that regard. The OECD Review of Higher Education recommended a specific role for Enterprise Ireland in developing a closer relationship between IoTs and regionally based enterprises focusing on applied research. Under this strategy, EI, in conjunction with the HEA, will work with the IoTs to develop that focus and to achieve the following goals:

- Build research strength in the IoTs that is of high quality and of relevance in a regional context;

- Enhance the networking across the IoTs through the mechanism of TecNet, which is a vehicle used by the Institutes to manage cross college collaboration;

- Create flexible processes to direct that expertise to local industry to help it address technology challenges and to access the benefits of new knowledge;

- Continue to support the development of the appropriate physical infrastructure to support this process building on the significant investment to date in incubator facilities;

- Strengthen the IP management and commercialisation function in the IoTs.

4.11.1 Building Research Strength

Enterprise Ireland piloted an initiative in the BMW region in 2004 to establish centres in the Institutes that would grow their applied research competence in areas identified as important for future regional economic growth. Based on an analysis of regional industry needs,

three projects were supported: Letterkenny Centre for Applied Marine Biotechnology; Sligo Applied Design Research Centre; Galway Technologies for the Marketing of Live Shellfish Products. Based on the experience of this pilot, a national campaign was undertaken in 2005 intended to broaden the base of technologies and regions supported, and further actions of this nature will take place during the course of this Strategy.

4.11.2 TecNet

TecNet is a company jointly owned by all the Institutes of Technology and it is co-sponsored by the Institutes themselves and Enterprise Ireland. Individually, the Institutes can make a marked impact on a region. In concert, they can draw on a significant pool of talent and facilities across a wide range of topics. Enterprise Ireland has supported TecNet on the basis that there are worthwhile gains to industry in the regions in facilitating the co-ordinated delivery of services across IoTs. In its early existence TecNet has sought to build a reputation within the IoT system as a facilitator and central resource, especially in the field of research. It is now focusing on enhancing its role as a central vehicle for cross college collaboration and this approach will continue to be developed through this Strategy.

4.11.3 Access for Local Industry

To ensure that the links between the expertise in the Institutes of Technology and local industry occur as a flexible and natural process, Enterprise Ireland will work with each Institute at a local level to agree common agendas setting out how the two organisations will work together to address local industry needs and to see where the commercialisation of research can bring benefit to the local economy. In line with the recommendations of the Enterprise Strategy Group, this engagement will cover technology and related business process needs, such as skills. Firms can benefit from a range of education and training support from short focused training to longer accredited courses. They need not only technology based material but also more directly business related subjects such as sales and marketing. The process of training by its nature also helps to build contacts across companies in the region and reinforces the networking which is vital to economic activity.

4.12 Competence Centres

Industry led research needs to be supported by an appropriate infrastructure. Along with investment in the science base, specific measures are needed to more closely couple scientific expertise with industrial needs and to build an infrastructural base in the research system that is closely linked with the express needs of enterprises. The closer coupling of higher education and industrial research will differentiate Ireland as a highly attractive environment within which to carry out advanced industrial research.

Some steps have been taken to date to achieve this, as reflected in the Centres for Science, Engineering and Technology (CSETS) established by SFI. These centres have a specific industrial orientation and involve direct linkages with an industrial partner. Under the HEA funded PRTLI programme, the Dublin Molecular Medicine Centre is another example of the development of shared competence in a specific field of science and technology.

There are international examples, particularly in the Nordic countries of more explicitly industry focused competence centres. Such centres have long term agendas which are strongly driven by express industry needs. There is a close relationship between competence centres

and technology programmes involving, for example, interfirm networks: competence centres aim to build critical mass in relevant technologies, and technology programmes aim to exploit that critical mass.

Initiatives which fit this competence model are the Tyndall National Institute and the National Bioprocessing Centre. The Tyndall National Institute at UCC is being developed as a multidisciplinary centre across several fields of ICT hardware and networking, with a strong science base and a specific industrial development mission. IDA Ireland is supporting the establishment of a National Bioprocessing Centre to provide scale up and training facilities to existing and new companies involved in this technology. The National Dairy Centre at Moorepark is also a significant competence centre with potential for further development. In addition, the planned National Digital Research Centre (NDRC) will support multidisciplinary research, innovation and commercialisation in the digital media area based on collaboration and robust linkages between enterprise and higher education.

The technology assessment and portfolio analysis process described in Chapter Eight will provide a basis for establishing a clear industrial input into the overall research agenda. The capacity to formulate and articulate industry-led research agendas will also be vital in this regard. Arising from this, further competency centres will be developed in strategically important technologies where a clear industry need is established. It is intended that these centres will, wherever possible, be built on university campuses to strengthen the overall innovation environment within the university and to create a strong linkage between industry needs and the research agendas of the colleges.

There is no single rigid structure that is appropriate to all competence centres, but experience to date suggests that the key issue to be addressed is that of building and reinforcing areas of strength within both industry and the academic sphere and ensuring that these are highly networked with one another. Measures that will be taken will include:

- greater industrial input to the research agendas of the centres: through the prioritisation process and through increased participation in the governance structures for the centres.

- Initiatives to ensure that companies can locate research staff at the centres working on company led research agendas – and particular efforts to attract company researchers at senior fellow level to the centres will also be pursued.

Enterprise Ireland, working with IDA Ireland, will have a specific responsibility for the overall requirement of linking sources of academic expertise with industry needs, both in the context of the development of competence centres and HE/industry links generally. This issue will form an important part of the agenda for the Technology Ireland related structures outlined earlier in this chapter.

4.13 Developing Innovation in Small Businesses

The recently published report of the Forum on Small Business makes two specific recommendations in relation to the development of innovation in small businesses. The report points out that the majority of small businesses are unlikely to have the scale or the resources to engage in in-house research. However, it notes that the stimulation of innovation (and

noting that much innovation is non technological) is important to the continued health and growth of small business. In that regard, the Forum recommends two specific initiatives: an Innovation Vouchers scheme, and a Knowledge Acquisition grants scheme, respectively. The Forum's thinking on the issue of knowledge acquisition grants is consistent with the proposals contained in this strategy for developing linkages between business and knowledge providers but brings a specific small business orientation to that issue. The Innovation Vouchers proposal has valuable awareness raising potential, in line with the overall thrust of this strategy to increasing the numbers of innovative and R&D performing companies. The resulting schemes should be designed to be administratively simple, effective and have minimum deadweight. These issues will be addressed, in response to the recommendations of the Forum, early in the life of this Strategy.

4.14 R&D Tax Credit

The R & D Tax Credit, introduced in 2004, marked a major step forward in government support for company R&D.

The scheme currently provides for a 20% tax credit available to companies for qualifying incremental expenditure on research and development. The tax credit applies to the full spectrum of R&D, from basic and applied research through to experimental development. In addition to supporting companies already based in Ireland, it is intended that the credit should play an important part in FDI strategy aimed at attracting more research intensive activity to Ireland.

The tax credit is structured as an incremental scheme operating on a rolling baseline starting from 2003. In practice this means that from the base point, the increase in a firm's R&D investment for each of the following 3 years is eligible for tax relief. In 2007, the credit is available for the incremental spend over the baseline of what the firm spent in 2004, and so on.

The credit was introduced in recognition of the fact that, internationally, similar fiscal incentives are widely used to stimulate private sector R&D. A number of OECD countries, however, operate a volume based R & D tax credit scheme under which the total amount spent on R&D in each year, rather than the increase on a base year, is eligible for the tax relief. However, comparison of the various schemes is not simple because while volume based schemes may seem to be superficially more attractive, restrictions on qualifying expenditure can mitigate this. These factors were taken account of in the design of the current scheme. Nevertheless, it is intended to keep the scheme under review, given its recent introduction, and to modify it as necessary in light of its operation and takeup with a view to supporting the BERD targets contained in this Strategy as effectively as possible.

Key Actions

- **Maintain commitment to strengthening manufacturing in Ireland into the long term;**
- **Achieve the target of growing BERD to €2.5 billion by 2013;**
- **Establish Technology Ireland as a virtual entity and mobilise practical structures required to make it work;**
- **Launch new EI awareness campaign including seminars and direct engagement with client firms;**
- **Continue IDA international promotional and marketing programme "Knowledge is in Our Nature";**
- **Increase absorptive capacity by strengthening technology skills in firms new to R&D;**
- **Rationalise and simplify enterprise R&D grant structures to make them more accessible to firms;**
- **Promote the formation and advancement of inter-company networks;**
- **Strengthen measures to assist firms with licencing in technology;**
- **Strengthen measures to increase interaction between firms and higher education institutions nationally and regionally;**
- **Develop additional competency centres in strategically important technologies, with significant expansion of industry linkages;**
- **Examine the operationalisation of the Forum on Small Business recommendations in respect of Innovation Vouchers and Knowledge Acquisition Grants;**
- **Review and modify, as appropriate, the R&D Tax Credit scheme.**

5 Science Education and Society

5.1 Introduction

A sustainable knowledge economy needs strong foundations – and these are to be found in first and second level education. The primary and secondary students of today are the potential star researchers of tomorrow. Although perhaps self evident, it has to be said that first and second level education provides the foundations for a knowledge-based society. In that context, if we aspire to being world leaders in science and technology, our education system needs to develop to make this happen and needs to support creativity in all its dimensions; technological, scientific and social.

5.2 Primary School

The reintroduction of science into the primary curriculum in all classes is a recent and significant development. From an early age, children are introduced to basic scientific concepts and methodology such as the observation of experiments and deductive reasoning. This has been accompanied by in-service training of primary teachers to equip them to teach the new science curriculum. The linkage between the primary and post-primary curricula should be strengthened to enable a gradual deepening and widening of science and scientific issues from one level to the other.

Given the introduction of science in the primary curriculum, more emphasis will be placed on science teaching methodologies in the Colleges of Education and through in-service training, particularly targeting the needs of those Education graduates who do not have a science background. In addition, a core area of study in the Colleges of Education will involve science and an awareness of scientific issues.

The implementation of the primary science curriculum will soon be reviewed. This review will include an examination of the effectiveness of teaching methodologies in stimulating interest in and awareness of science at a very young age. It will also examine how best pre-service training of teachers can address the ongoing needs of the primary science curriculum.

5.3 Second Level

At second level almost 90% of students study Junior Certificate science. A revised syllabus was introduced in 2003 and represents a significant change in the way science is taught at

junior cycle including in the area of teaching methodology and assessment, reflecting international trends towards a more investigative approach to science education. This approach provides for a move towards more practical and project work, with thirty practical experiments and investigations which can be carried out at different times over the period of the programme and presented for assessment as one of the components of the final examination. The reforms are seen as an important part of the moves towards making science more attractive, and encouraging students to continue the subject at senior cycle. The next round of OECD PISA (Programme for International Student Assessment) will allow progress to be internationally benchmarked as science is a major domain in the assessment.

At Leaving Certificate Level approximately 60% of students study at least one of the three science subjects. Currently, 14.7% of the cohort study physics and 13.6% study chemistry. The uptake of Physics and Chemistry has been a concern for some time. The numbers taking these subjects has declined substantially since the 1980s, and although the downward trend has been arrested, there is a critical need to achieve increases in the take up of these subjects over the coming years. This problem is not just an Irish problem, other countries are experiencing the same types of difficulties.

A critical concern is to increase the numbers who continue to study these subjects at senior cycle. The objectives will be to increase the percentage taking Chemistry and Physics subjects at Leaving Certificate generally to 20% of the overall cohort by the conclusion of this Strategy. As part of this approach, concerted efforts will be made to encourage a better gender balance in the take up of Physics, where females are under–represented at both ordinary and higher level and to increase the proportions of students generally who study these subjects at Ordinary level. Increased participation will be achieved as follows:-

• Reform of the science curricula in Leaving Certificate, particularly physics and chemistry subjects, to ensure a continuum from Junior cycle with the emphasis on project-based hands-on investigative approaches and the completion of practical coursework, and assessment of these as part of the overall examinations, allied with embedding of key skills and ICT; a more applied focus, and an emphasis on the inter disciplinary nature of science in society.

• Investment in teacher professional development in collaboration between Second Level in-service providers, higher education institutions and the Discover Science and Engineering programme, as appropriate.

• Promotion of information brochures, guidance materials and resources and awareness initiatives in collaboration with the Discover Science programme, and effective linking of this with school guidance services, targeting in particular transition year students.

Crucially, there is a widespread belief that physics, maths and chemistry are subjects in which it is difficult to score high grades, and the choices made by students are inter alia, influenced by the need to get points for courses such as medicine and other health sciences courses, rather than the pursuit of the 'pure sciences'. In line with proposals generally for reform of senior cycle, the science subjects will be reviewed with a view to re-balancing of content, greater emphasis on problem solving, and modernisation, to the extent feasible in order to allow a better embedding of key skills and an applied focus. It is important that the examination of new models leads to the development of new approaches and examplars.

In addition, there will be a need to ensure the availability of appropriate and suitably qualified personnel to undertake the associated assessments.

In the context of the plans for assessment of science practical coursework as part of the overall examination, the issue of technical assistance for schools will be revisited. A range of models will be explored in collaboration with other actors to see how best the work of schools in this area can be supported and enhanced.

Developments at senior cycle science will be informed by a further survey of pupil/teacher attitudes to be undertaken in 2006 in the light of the first cohort of students completing the revised junior cycle syllabus. This will focus on their experiences of the revised syllabus and assessment arrangements and the factors which influence their decision making in relation to the take up of the physical sciences at senior cycle. This will inform the ongoing process of curricular reform at Senior Cycle being undertaken by the NCCA.

There are also concerns regarding the numbers of students who choose science options at third level. Ireland in 2002 was above the EU average in terms of the numbers of students enrolled in maths, science and technology courses as a percentage of students in tertiary education. Despite this positive appearance, two problems underlie the statistic. First, the number of science graduates is now decreasing and secondly the demand for science graduates is increasing. A critical part of the overall strategy will be to encourage more students who perform well in science in senior cycle to choose science options in third level and to pursue careers in this area.

In the engineering and technology areas at second level, the revised syllabi in Architectural Technology, Engineering Technology, and Design and Communication Graphics with Technology have been developed. These, together with a new syllabus in Technology, are important in providing for an increased emphasis on investigative approaches, problem solving and entrepreneurial skills, CAD/CAM and control technology. These revised syllabi also provide a strong emphasis on practical project work for which 50%-60% of the marks are available. Implementation of the curriculum reforms in this area, allied with improved performance in maths, is necessary to provide the appropriate foundation on which the success of the higher education initiatives in science, technology and engineering depend.

To achieve the target of increased participation in the sciences, it is recommended that HEIs should consider the option of a science subject for matriculation.

The number of science graduates training as second level teachers will also be examined with a view to increasing the numbers of teachers available in science and maths, and establishing "quotas" for specific subject areas as necessary to ensure that the subject needs of the curriculum are adequately met. In addition, the coverage of science and maths in Higher Diploma in Education programmes and the concurrent BSc (Education) degrees will also be reviewed.

This work will be further strengthened through enhanced in-service training, promoting the development of Teacher Professional Networks and increased collaborative links between industry and schools and colleges.

An initiative is planned where direct financial support will be provided to Teachers' Professional Networks involving all teachers of a particular subject, including those who may be members of an existing subject association. This support will be used to encourage the development of teachers' networks. These will focus on improving teaching and learning, including teachers' own Continual Professional Development, along with capacity building of 'expert' teachers in regions based on the twenty one Education Centres. It is intended to prioritise science subjects and maths for this financial support, stressing the need for collaborative working with the curriculum support services and HEIs, as well as industry and Local Authorities.

5.4 Science Awareness

The Government's integrated awareness programme, Discover Science & Engineering (DSE), established in 2003 and managed by Forfás, has brought together and built on existing awareness activities and expanded these in a way that provides a focused and effective communications strategy. This is aimed at increasing the numbers of students taking SET as a career and raising the general level of awareness of the physical sciences amongst the public. The programme is intended to act as a catalyst in attracting a much higher level of private investment in awareness activities.

The Discover Science and Engineering programme will have a particular role to play in complementing the developments in the school system through:-

- Continuing awareness measures with primary schools, accompanied by enhanced supports for second level schools;

- Increasing the number of participating primary teachers/schools in the DSE teacher training initiative;

- extending the reach of this initiative to the second level sector in line with curricular reforms in collaboration with the second level school support service and higher education institutions as appropriate;

- providing enhanced internet based support materials and resources for teachers at both levels of the system;

- provision of information and guidance on careers in science, which will feed into school guidance programmes;

- supporting pilot initiatives with schools in disadvantaged areas promoting innovative approaches to awareness initiatives and teaching methodologies in science. Experience in this area will also inform the development of further modules and short course options in science in the Transition Year Programme.

A greater awareness among students of career opportunities in science, engineering and technology is needed. The development of information brochures, guidance and resource materials and effective linking with school guidance services in this area will be promoted, allied with a continued strengthening of school industry links.

There is a clear need therefore to find ways to stimulate interest in science before students enter senior cycle, so that they will be motivated to continue to study the subject and to choose it as a third level option. The Transition Year Programme has great potential in this regard, given its flexibility and emphasis on community, workplace and experiential learning.

A range of initiatives will be implemented which will optimise the interaction between the Transition Programme and relevant industries and third level research sites, through school visits, work placements and other measures. The scope for students to pursue short courses in science, as envisaged in the NCCA's proposals for senior cycle reform, should also be explored.

Where students are following a transition year programme, the choice of subjects they wish to take for the leaving certificate should be delayed until the end of Transition Year.

The continuing outreach and awareness activities and programmes of SFI, the Royal Irish Academy (RIA) and the Irish Council for Bioethics will make a major contribution to the achievement of this goal.

Key Actions

- **DES to review the implementation of the primary science curriculum to ensure the new curriculum and teaching methodologies are stimulating interest in and awareness of science at a very young age;**

- **Science and awareness of scientific issues to be a core area of study for student teachers in Colleges of Education;**

- **Reform the maths and science curricula starting with physics and chemistry subjects in Leaving Certificate to ensure a continuum from junior cycle with the emphasis on hands-on investigative approaches and the completion and assessment of practical coursework;**

- **Invest in teacher professional development in collaboration between second level in-service providers, higher education institutions and the Discover Science and Engineering programme, as appropriate;**

- **At the Transition Year, the promotion of information brochures, guidance materials and resources and awareness initiatives in collaboration with the Discover Science and Engineering programme, and effective linking of this with school guidance services;**

- **Survey pupil attitudes to the revised junior cycle syllabus in 2006;**

- **Support the development of teachers' networks which will focus on improving teaching and learning, including the Continuing Professional Development of teachers;**

- **Further develop the full range of awareness raising activities under Discover Science and Engineering;**

- **Higher Education Institutes to consider the option of a science subject for matriculation.**

6 Research in the Public Sector

6.1 Introduction

Chapter Two describes our strategy for growing advanced research at Fourth Level as the hub of the national system of innovation, with Chapter Four setting out strategy for research in the enterprise sector. Successful development of the national system of innovation depends on developing the capacity of all elements of the system and the interactions and linkages between those elements. Thus, Chapter Three described how commercialisation activities within the HEIs needs to be developed to build the bridge between the knowledge created there and the development needs of firms.

A fully developed national system of innovation has the capacity to contribute not just to economic progress, but also to the overall welfare of society. Across the sphere of government, there are important areas of civil and sectoral research which have a great potential to contribute to economic and social progress. This chapter outlines strategies for each of those areas within the context of our overall strategy and the national system of innovation.

The following key areas of research are addressed in this chapter:-

Agriculture and Food
Health
Environment
Marine
Energy

6.1 Agriculture and Food

6.1.1 Introduction

The development of a Food and Agriculture[16] sector which is sustainable from an economic and social point of view is crucially important to Ireland's future development. Research, development and innovation have a key role to play in the sustainable development and competitiveness of the sector.

The agri-food sector is one of Ireland's largest indigenous industries, employing approximately 170,000 people. It accounts for 9% of GDP, employment and exports. Irish owned agri-food firms account for 36% of employment and 57% of exports from indigenous industries. The majority of agri-food companies are located outside Dublin and this is of key importance in urban/ rural balance.

The business, economic and regulatory climate in agri-food is rapidly changing. Reform to the CAP and the upcoming WTO Agreement will result in Food and Agriculture operating in a more open market driven economy without support from traditional EU subsidies. Agricultural production systems must also be sustainable and are subject to compliance with increasing environmental legislation and wider demands from consumers and society. Regulation of food products is increasingly driven by food safety requirements as well as more sophisticated and complex regulations regarding health and well-being claims attributed to food products.

Ireland has a high rate of self-sufficiency in most of its agricultural produce and is very dependent on export markets. Over 80% of beef and dairy products are exported. The majority of Irish agri-food exports are commodity products but greater emphasis is being placed on development of more knowledge intensive and higher value added products. R&D and innovation is an essential prerequisite to drive this change in product portfolio. The current level of R&D is very low. On average, the sector spends 0.2% to 0.3% of sales on R&D. This low level is explained by the large incidence of SMEs in the sector, which do not have the resources, background or culture to engage in R&D. A small number of large Irish-owned companies have extensive R&D activities, but much of this is sited outside Ireland and attracting it back is predicated on having R&D support and capability here.

6.1.2 Research Infrastructure

The publicly- funded agri-food R&D system is well integrated. Agri-food research is carried out collaboratively in Teagasc, universities, some Institutes of Technology, and DAF Agricultural and Veterinary Laboratories.

Teagasc - Teagasc research spans the entire agri-food chain, from farm production to food processing and innovation. It also provides a comprehensive agricultural education, advisory and training service.

Research Capacity - Teagasc has a researcher capacity (PhD+) of 212, and it also supports 130 PhD and MSc level students based in its own research centres and in the universities.

16 The Sector includes Forestry

This graduate capacity has been nurtured for many years through the Walsh Fellowship Scheme, which Teagasc operates to support development and training of young graduates.

Research Centres - Teagasc is currently developing its research resources and activities into Centres of Excellence, which are strategically located around the country. Research in Animal Production is centred at Grange, Co. Meath, Moorepark, Co. Cork and Athenry, Co. Galway, Crop research is at Oakpark, Co. Carlow, Horticulture at Kinsealy, Co. Dublin, Agri-Environment research at Johnstown Castle, Co. Wexford and Rural Economy research at Athenry, Co. Galway. Food research is carried out at Moorepark Dairy Products Research Centre, Fermoy, Co. Cork and Ashtown Food Research Centre, Co. Dublin.

New Technologies – Teagasc has established a new Plant Molecular Centre at Oakpark and a Food Biotechnology Centre at Moorepark. The Alimentary Pharmabiotic Centre (APC)[17], also at Moorepark and UCC , is carrying out research in the Pharma-food area and is a joint undertaking between Teagasc, UCC and industry. These new Centres provide world-class facilities for application of Biotechnology research in the Biosciences.

Industry Link - Moorepark Technology Ltd. (MTL) is a pilot plant facility at Moorepark which facilitates food companies to engage in scale-up R&D. It is operated as a subsidiary company of Teagasc, with Teagasc and most of the main Irish Dairy Product processors as shareholders. It has the potential to greatly enhance the adoption of innovation in food companies.

DAF Laboratories - New state-of-the-art Agriculture and Veterinary laboratories were recently established by the Department of Agriculture & Food (DAF) at Backweston. They include the Central Veterinary Research Laboratory (CVRL), Central Meat Control, Dairy Science, Pesticide and Biocide, and Seed Testing and Plant Health laboratories. This complex has two associated experimental farms and access to national monitoring data related to health of the national livestock herd, food hygiene and safety, plant health and the safety and quality of seeds, animal feeds and pesticides.

Universities/Institutes of Technology - Agri-food research is also under way in the Universities/IoTs with strong collaborative linkages to Teagasc, particularly in Food research. For example, UCC is active in human health and nutrition research. The UCD Schools of Agriculture, Food and Veterinary Medicine, and Biological and Environmental Sciences research many aspects of agri-food in the broadest sense. TCD has developed a considerable research capacity in nutrition, UL in vegetables and packaging, while DCU has built capability in sensor technology research. Some IoTs have relevant activity in food safety and biotechnology. Forest related research is carried out in most of the universities.

6.1.3 Agri-Food Research Funding

DAF is the primary funding agency for agri-food research, and it uses a variety of funding mechanisms, both competitive and core grant-in-aid.

Core Funding - DAF provides core funding to Teagasc and to its own Agriculture and Veterinary Laboratories. Teagasc earns additional funding through commissioned research and

17 Funded through SFI CSET Initiative

through EU Framework and national public competitive research programmes, such as DAF, EPA, SFI etc.

Competitive Funding - DAF operates three NDP competitive programmes, under which Teagasc and the HEIs compete for funding:-

FIRM - The Food Institutional Research Measure funds basic to pre-commercial research aimed at providing scientific support to underpin the food industry as well as food safety and quality.

RSF - Research Stimulus Fund is aimed at research and development in production agriculture, animal and plant health, agri-environment and rural economy.

FORESTRY Fund – provided through COFORD, is aimed at "public good" and sustainability research aspects of forests and research and development of forestry products with a view to increasing the overall competitiveness of the sector. COFORD also funds company based R&D in collaboration with Enterprise Ireland.

Building and developing the Knowledge Economy in Sustainable Agriculture, Food and Forestry will require an increased level of funding as outlined in Chapter Eight.

6.1.4 Future Strategic Direction

The priority under this Strategy is to build a knowledge economy in agri-food, so as to provide a scientific foundation and support for a sustainable, competitive, market oriented and innovative agriculture, food and forestry sector.

Agriculture is now seen as having a multifunctional role, that is, it encompasses other functions besides producing commodities, such as maintenance of the rural landscape, protection of the natural and cultural heritage, support of rural economic viability and enhancement of food security. It will be required to operate as a sustainable economy based on renewable resources. Forestry has a significant role to play as a supplier of renewable products and energy, and increasingly, providing public goods such as recreation space for an increasingly urbanised population, carbon storage and sequestration, and biodiversity conservation and enhancement. This Multifunctional Model of Agriculture requires the development of a knowledge-based agriculture, with the technological, innovative and business capacities to be internationally competitive and environmentally sustainable. Environmental quality and food safety, combined with other quality-orientated dimensions, including concern for nutritional value and animal welfare, are now central to the longer-term international competitiveness of the agri-food sector.

There is scope to optimise linkages between Irish publicly-funded research and industry. Many Irish companies have underdeveloped R&D infrastructure and are therefore dependent on the public research system. At the same time markets and the environment in which the agri-food and forestry industries operate are rapidly changing and it is vital that the public research system is in a position to assist the sector to adapt and meet the new challenges.

Teagasc recently finalised a National Strategic Implementation Plan for Agriculture and Food, with a focus on research in the new biosciences, and with the aim of increasing the flow of new knowledge, systems, products and processes to the agri-food and forestry sectors. Increased support for agriculture and food research, including the competitively funded research programmes, will be necessary. These competitively funded programmes are focused on the development of collaborative linkages and virtual centres of excellence between the Universities, Teagasc and IoTs.

The new DAF Agricultural and Veterinary laboratories will operate as science based centres. This complex, with its associated farms and access to national monitoring data on food safety, will seek to collaborate and integrate into the national research infrastructure. Linkages with the Universities, Teagasc and other Institutes will be fostered through core and competitive research funding.

Strategy for the agri-food sector will be focused as follows :

Research in Sustainable Agriculture Production - The priority in Ireland is to support and develop a competitive, profitable, market oriented farming and forestry sector, operating in the new post CAP/ WTO era, in harmony with the environment. DAF will support research programmes focused on key aspects of sustainable production;

On Farm Production. Enhanced research programmes in animal and plant sciences, environment and rural economy will be developed, with emphasis on the development and adoption of new systems and technologies to support productivity, efficiency, competitiveness and environmental sustainability;

Non-Food land Use - DAF will also support research to exploit the potential to diversify land use into non-food crop production. Renewable energy, such as biomass and industrial oils and fuels are the most immediate options, but there is also potential for novel products (e.g. pharmaceutical), while in the longer term, crops and technologies for the production of fibre, biodegradable plastics, and other chemicals may become more feasible. Non-food crops offer a particular scope and possibility for biotechnology applications;

Forestry - As Ireland increases its forest acreage, a strong knowledge and R&D base is increasingly necessary to position wood production and processing as an internationally competitive sector, as well as to assess and value the public good provision of forests.

Research in Food - Food research will emphasise Food Quality, Safety and Nutrition, with a focus on Food for Health and Product Innovation. The Action Plan[18] recognises that there is scope for improved performance in the Pharma, Health and Food Sectors.

Food For Health – Health concerns are now a major influencing factor on consumers, as lifestyle related illnesses such as heart disease, obesity, cancer and diabetes become more prevalent and consumers seek healthy alternatives. The strategy is to increase R&D in Functional Foods, which are forecast to be one of the key drivers in the sector, and in which Ireland has already built a strong capability through the public funded programmes

18 Building Ireland's Knowledge Economy : An Action Plan for Promoting Investment in R&D to 2010

Teagasc aims to seek SFI competitive funding for a second CSET with UCC, to research functional foods that impact positively on obesity and colon cancer, and which will link to the existing SFI funded Pharma/Food CSET – The Alimentary Pharmabiotic Centre at Moorepark.

Teagasc plans the establishment of a department for Nutraceutical[19] research, which will fill a major gap and create opportunities for innovative product development.

Teagasc also plans to establish a clinical trials facility at its pig research unit at Moorepark, in anticipation of a change in the regulatory climate and to facilitate research in functional foods. Clinical trials are essential in order to validate health benefit claims related to functional foods.

Product Innovation – Future Research and Development will emphasise the need for innovation in the food sector so as to move Ireland's position up the value chain from commodity and ingredient supplier to product innovation and licence ownership. Driving industry up the value chain is a major challenge and is predicated on greater industry R&D involvement, which will require the support of public funded knowledge generation and expertise.

DAF and Enterprise Ireland already work closely together to achieve a strategic approach to food and forest product R&D funding, from the basic pre-commercial research funded by DAF to the near market research funded by EI. EI plays an important role in catalysing technology adoption and change to higher value-added products in industry. It is intended that this strategic approach to funding will engender a multidisciplinary approach to agri-food research, which increasingly interfaces with the environmental, pharmaceutical, biotechnology and timber processing and building industries.

New Technologies - Further development of new and emerging areas of science and technology such as Bio and Nano technology, applied to renewable bio-product research, will have a critical role to play in fostering a Knowledge Based Bio-Economy. These new technologies have a horizontal application across all the agri sectors and there is a need to build a capability in them in order to assess, harness and adopt new technological innovations. Potential areas for application include animal and plant sciences, food innovation, forestry and wood chain and other non-food crops, as well as risk evaluation of GMOs and their implications for agri-food. A strong base in bio and nanotechnologies is vital to building and profiting from the bio-economy.

Rural Economy - Research in Rural Economy will provide analysis of the impact of new policy initiatives and changes in Irish society on the economic well being of rural areas. Many of the issues are complex, involving trade-off between economic, environmental and social goals, and there is a need to seek answers to these rural related questions to assist both policymakers and rural communities.

Collaboration - Significant collaboration already exists with Research Bodies in Northern Ireland through Teagasc, DAF and COFORD competitive programmes, and there is potential to build on this. DAF will also promote participation in EU collaborative initiatives such as ERA-Nets and other Collaborative Groups, and will also continue to promote and assist active participation by Irish researchers in the EU FP7 programme. FP7 now includes sustain-

19 Functional Foods are based on bio-active cultures (Probiotics) and physiologically active ingredients (Nutraceuticals)

able agriculture and food and non-food crops, including application of new technologies to natural resources. The emphasis on excellence, collaborative links and multidisciplinary research in the competitively funded programmes in Ireland will continue to build capability and equip Irish researchers to co-operate and compete in the EU Framework and other International Programmes.

Key Actions

• DAF will ensure that its public good competitive research programmes, (FIRM, RSF, COFORD) will be focused on the needs of the sector and will continue to increase collaboration and capacity building in Irish research centres;

• DAF will ensure that agricultural production research supports a competitive profitable farming sector that is sustainable in relation to soil, water, air quality and biodiversity, supporting a vibrant rural economy;

• DAF will build on existing R&D expertise and excellence to underpin the contribution of forestry to the sector;

• DAF will ensure that food research provides a base of knowledge and expertise in generic technologies to support a modern, innovative and consumer focused food industry, with attention to food safety and quality issues;

·Teagasc will restructure its research activities and resources into Centres of Excellence and will recruit 50 new researchers including fifteen Principal Investigators to underpin the needs of a bio-economy in agri-food;

• DAF, through Teagasc and its own competitive research programmes, will support the building and strengthening of a research capability in new technologies, and to exploit their application to natural resources including agriculture, food and non-food land uses;

• DAF will ensure that the new DAF Agricultural and Veterinary laboratories will operate as science based centres and will seek to collaborate and integrate them into the national research infrastructure;

• DAF will continue to strengthen co-operation with other Departments, State Agencies and Funding Bodies to avoid duplication and create synergies within agri-food R&D and contribute to building a knowledge economy in agri-food;

• DAF will continue its links with Enterprise Ireland to achieve a strategic and seamless approach to food and forest products R&D funding, from the basic pre-commercial research funded by DAF to the near market research funded by EI;

- **DAF will link with the Environment sector in carrying out research on agri-environment issues such as soil quality, nutrient efficiency and nutrient loss, air and water quality, biodiversity and ecology to enable the farming sector to operate in a sustainable manner in compliance with environmental requirements;**

- **DAF will link with the Energy sector on research into energy crop production at farm level and the use of existing forests for wood energy production;**

- **DAF and Teagasc will foster and build on the level of North/South collaboration that already exists in agri-food and forestry research;**

- **DAF will promote and assist participation by Irish researchers in EU research initiatives such as FP7, ERA-Nets and other collaborative arrangements.**

6.2 Health

6.2.1 Introduction

Policy on health research is outlined in the Strategy 'Making Knowledge Work for Health', (MKWH) which identifies two separate pillars of health research as follows:

Science for health - Laboratory associated research including microbiology, molecular biology etc; Patient oriented clinical research including clinical trials and patient care.

R&D for health - Population based research including aspects of public health, health promotion, environmental health and the determinants of health; Strategic health service delivery and policy research.

In the past, health research funding was principally directed at activity in the science for health pillar. While that has changed in recent years, the introduction of a R&D culture within the mainstream health service has been relatively slow, there is a need to strengthen considerably the health services research and policy research capacity nationally. The Advisory Science Council is currently undertaking a review of key policy requirements. This review will be completed during 2006 and will contribute to the further development of strategy in this area.

Some of the structural recommendations in MKWH relating to new R&D structures have been overtaken by the wider health reform programme, particularly the establishment of the Health Service Executive (HSE) and need to be reviewed. However, the underlying strategic requirement to build up both of the pillars of health research is unchanged.

The health service can contribute to the further development of the national research strategy. Clinician scientists can play a key role in identifying unmet medical needs and giving direction and support to life sciences research to allow Ireland to capitalise on the massive advances underway in human genomics, proteomics and cell biology. These advances offer tremendous potential benefits to patients.

The investment in research under PRTLI and SFI has increased the capacity of the university sector to undertake world-class research. Much of the investment has been in research with a health dimension, reflecting the national strategic focus on research linked to life sciences and ICT. There are now strong research teams in neuroscience, immunology, food and nutrition, bioinformatics, sensors/devices, cell biology and microbiology and a new programme is systems biology is being considered. However, the capacity of the health services to complement this research and to 'translate' it into new and innovative products and interventions has not developed to the same extent, notwithstanding enhanced funding from the HRB from 2001 onwards.

A key priority is to develop a small number of centres of world significance in translational health research, each with strong foundations in both academia and the health services. Investment in such centres of excellence in translational medicine is required to extract full value from the resources that have been invested in basic biomedical sciences and biotechnology.

In selecting the most promising areas for such translational research relevant criteria include:

Relevance to the health service, critical research mass and international competitive potential, potential economic relevance and the identification of natural advantages presented by an Irish population group. Possible candidate areas of focus for such centres include: diabetes and the metabolic syndrome; infectious agents, including prion disease and food safety; Neurodegeneration, including Alzheimer's disease, stroke and Parkinson's disease.

The new technologies relevant to health and enterprise needed to underpin such centres of excellence include: Biomedical and Health Informatics; Human Imaging; and, Biomarker discovery.

To achieve the goal of world class centres of excellence in translational research, investment is needed in research infrastructure, people and programmes in the health service, complementary to the investment that has taken place or that is proposed in the HE sector. The infrastructure deficits that need to be addressed urgently include the provision of clinical research facilities on the campus of major academic teaching hospitals to provide a supportive environment for translational research; imaging equipment to enable researchers in Ireland to benefit fully from the revolution in understanding of the human body that such equipment is providing; banks of biological material donated by patients and gene reference libraries to facilitate analysis and research; and ICT systems of the highest quality to interrogate the developing banks of patient information effectively.

The major deficit in relation to people is careers in research for clinicians within the health service and for other clinical professionals to enable them to focus on research. The capacity of health agencies to protect and develop intellectual property and to negotiate with the health care and ICT industry also needs to be enhanced by the appointment of professionals with the appropriate knowledge and understanding of health research. There is scope for cooperation between academic hospitals and the commercialisation resources of the associated university (see chapter four) in developing this expertise.

Programme support, offered in the form of time limited awards to Principal Investigators, following competition and peer review, is needed to nurture translational and clinical research over an extended period and to train the next generation of health clinicians and researchers to the highest standard.

In mid-2005, the Tánaiste announced the provision of €50m over five years to implement the Health Research Board's Investment Programme in Research for Health and Wealth. This funding has enabled the HRB to begin to address some deficits in translational and clinical research capacity and to support the emergence of a small number of world-class translational research centres. A joint call issued by the HRB and the Wellcome Trust for clinical research centres in July 2005 is designed to provide a protected resource for translational health research on the campuses of at least one academic hospital. However, the scale of the challenge of developing world-class facilities requires a higher level of investment over a longer period than envisaged in the resources made available to date and requires explicit support. This is a particular challenge in view of the current strains on both the capital and revenue resources available to the health services.

6.2.2 Addressing the Major Health Challenges

As well as helping to achieve national research priorities, research also contributes to attracting high calibre professionals to work in this country and to advancing the sectoral objectives of the health service including improving efficiency and effectiveness. There is a need to strengthen considerably the health services research and policy research capacity nationally. A strong research culture is vital if the health service is to offer a world-class standard of care to patients across a range of specialities and attract and retain professionals of the highest quality. A system as complex as the health service also needs to harness research to find better ways of improving the health of the population and delivering more efficient and effective health care. Problems that need to be addressed include the prevention and treatment of heart disease and cancer in the Irish population; controlling hospital acquired infections; the problem of growing obesity; managing neurodegenerative disease in an increasingly ageing population, and health service delivery. Health research in computational biology and health informatics is an additional area of major strategic importance for the development of an efficient healthcare system and a potential opportunity for Ireland's ICT sector.

It is difficult to quantify the total expenditure on research as it is an integral part of the expenditure of the HSE, statutory health agencies and many of the independently managed hospitals and agencies. This is in addition to health research supported by Government Departments, the Health Research Board and the charitable and private sectors.

However, notwithstanding difficulties in quantification, it is clear that the total level of funding for health research in Ireland is low by international standard at less than 0.25% of overall expenditure. In the UK 1.6 per cent of the total budget of the NHS relates to research. For 2006, the budget of the HRB is in the region of €45m, the majority of which is made available for health research through competitive, peer reviewed calls to researchers in academic institutions and health agencies. It has broken new ground with the funding of a cooperative network of hospitals to conduct cancer clinical trials as part of an initiative under the Ireland, Northern Ireland, US National Cancer Institute Cancer Consortium. It has appointed the first clinician scientists – medical consultants with a primary commitment to research – to strengthen clinical research. It has awarded funding for the first PhD training sites to attract postgraduates of the highest quality into health research. The HRB currently funds 600 people involved in research, of which over 200 are Principal Investigators and 100 are PhD students.

The HSE has a statutory mandate to support research. The HRB and the HSE are working together to develop this mandate. There is a vibrant charitable sector that supports health research. The major charities recently formed the Association of Medical Research Charities to give a greater focus to research for better patient outcomes. The Association and other patient groups are pressing for more investment in research to improve the health outcomes for those with a disease or disability. The public's support for health research was demonstrated in a recent survey of public perceptions of medical research conducted by the Royal College of Surgeons in Ireland. The survey found that over 90 per cent of respondents considered that medical research would lead to better healthcare. However, the survey also indicated a need for continual education and engagement of the public about health research and the complexities of research methodologies.

6.2.3 Enterprise potential

Healthcare is a €3.4 trillion industry worldwide and likely to grow with increasing life-expectancy and personal wealth. The pharmaceutical and medical devices industries' presence in Ireland has grown at a faster rate with a higher level of foreign direct investment than in other countries. These healthcare industries are increasingly dependent on high quality clinical research provided by specialists in well-equipped centres. Ireland has the potential to capture more industrial R&D activity if it can provide state-of-the-art resources in a range of domains, including basic biomedical sciences, information technology, and bioengineering and drug development. ICT companies are looking for engagement with the health services because the complexity of biological information and health care provide special challenges for the development of appropriate information systems. The UK and the Scandinavian counties have realised the importance of linking their health services to their science and industrial development priorities and are investing in initiatives to bring them closer together. Ireland should do likewise by building the R&D potential within the health service and linking this with its investments in basic sciences.

Key Actions

- **Develop health research as a frontline health service to guarantee world class health care for patients, to resolve health problems facing the population, and to attract and retain health professionals of the highest quality and to improve efficiency and effectiveness to the health sector;**

- **A strong research culture to be built in the health services through targeted investments, on the basis of competition and peer review, and by a strong corporate commitment to research by the Health Service Executive and other health agencies;**

- **The R&D pillar of the health research strategy (MKWH) also needs strong support to ensure that the crucial 'population health' element of the Health Strategy has a sound research base to underpin appropriate disease prevention measures, redress social inequalities in health status and to ensure best practice in health service delivery and policy development;**

- **Develop a number of centres of world significance in translational health research, each of which has strong foundations in both academia and the health services and which will act as a magnet to the pharmaceutical and medical devices industry, nationally and internationally. Build these centres through strategic investment in research infrastructure, people and programmes by competitive, peer reviewed awards through the HRB and other funding agencies;**

- **Maintain the confidence of the public in health research by observing the highest ethical standards in research and provide for greater public engagement in relation to the benefits of health research and the complexities of undertaking such research.**

6.3 Environment

6.3.1 Introduction

Ireland's investment in the environmental sector is of the order of €1bn annually with employment of 6,000 throughout the public and private sectors.

The Environmental Protection Agency (EPA) under the auspices of the Department of the Environment, Heritage and Local Government, funds environmental research to generate the knowledge and expertise needed to protect and manage Ireland's environment and to anticipate issues arising from EU legislation and international conventions, for example the Water Framework Directive and the Kyoto Protocol.

Under the current NDP, €32m was allocated to the EPA under the Environmental Research, Technological Development and Innovation (ERTDI) Programme which includes the Cleaner Greener Production Programme (CGPP), aimed at developing systems and technologies to reduce the environmental impact of the industrial and service sector.

In matters relating specifically to wildlife conservation, the National Parks and Wildlife Service (NPWS) undertakes and facilitates research on Ireland's wild plant and animal species and natural habitats, including their distribution and optimum management requirements. The research has two main aims: to support the implementation of national and international legislation and to positively facilitate best practice by incorporating conservation considerations into future development, thus reducing costs incurred through delays in the planning process and enhancing consumer confidence in the process.

Nationally, the EPA programme has developed cooperative funding links with other sectoral R&D agencies (COFORD, Teagasc, SEI and the Marine Institute), with the NRA and with HE based research. Internationally, the EPA programme has promoted participation in the EU Framework Programme; the EPA is linked to a number of EU environmental expert groups, to European Research Area Networks (ERANETS) and initiatives such as Global Monitoring for Environment and Security (GMES) and the Group on Earth Observations (GEO).

6.3.2 Current and future priorities

The EPA programme provides support to environmental policy in four key ways:

- Research on priority environmental issues such as air and water quality, climate change and aspects of biodiversity (in addition to biodiversity research done through the NPWS).

- Large-scale projects with the objective of guiding sustainable development are undertaken with key players in the different economic sectors such as agriculture, forestry and transport.

- Part-funding is provided for demonstration projects by SMEs in the area of cleaner production; this is promoted by IBEC, and projects have not only reduced waste and other emissions, but have also shown how such measures can aid profitability.

• An Environmental Research Centre being developed as a centre of excellence within the EPA in close cooperation with the HEIs, in order to build capacity in environmental data-handling, modelling, assessment, management and guidance – in support of national planning. This centre has the potential to become a key environmental component of the knowledge economy.

6.3.3 Future Strategic Direction

Greater understanding of environmental risk will lead to less precautionary legislation which will have an overall positive impact on the enterprise environment. Knowledge and better understanding from environmental research will better allow Ireland to negotiate norms/ limits in future international legislation and agreements.

The future strategic direction of environmental research will be to firstly, anticipate and respond to changing circumstances and, secondly, to engage in research to generate new knowledge of the environment and environmental technologies.

Meeting UN and EU environmental obligations will require continuing research. Existing and emerging issues to be addressed include climate change, biodiversity loss, environment and health, the urban environment, air pollution, waste management, and water quality.

In-depth research to prepare Ireland for the adverse effects of climate change and to reduce significantly greenhouse gas emissions over the coming decades will also be required. In addition, research to anticipate the resulting environmental impacts from changing conditions in sectors including agriculture, transport, tourism and energy will be needed.

Increased expertise is required in the areas of chemicals in the environment (e.g. ecotoxicology) and the links between environment and health. This will be developed.

Through the EU's Environmental Technologies Action Plan (ETAP) there will be an increased focus on environmental technologies that result in reduced environmental impacts.The Environmental Research Centre, mentioned above, will be the cornerstone of future environmental research.

Interactions with the main economic sectors will be enhanced through co-operative projects both top down and bottom up. In a growing market for environment technologies, environmental research can identify new opportunities and contribute to the knowledge economy and to sustainable development. It can also help support quality of life in Ireland as a key attraction for inward investment in a modern economy.

Key Action

• The research programme funded by DEHLG will be reviewed with the aim of maximising its value with particular regard to potential synergies between the different components of the programme.

6.4 Marine

6.4.1 Introduction

The marine sector in Ireland is valued at €3bn (2003) and supports 44,000 direct and indirect jobs. Some 22,000 people are employed directly in the marine sector, 1.2% of total Irish employment. The marine sector is characterised by SMEs and micro SMEs. While only about 10% of marine firms are actively engaged in R&D, firms do benefit significantly from R&D spill-overs and positive transfers associated with the research activity of public sector R&D performers.

The Marine Institute provides competitive R&D funding under the current NDP to SMEs and the marine research community. A combination of research and services have been provided to the Irish shellfish industry and is vital in the continued control of shellfish disease. Research services are also targeted at the shipping and transport sector, the offshore energy sector and the marine technology sector.

There is an active marine research sector in Ireland. Research and services are carried out by the Marine Institute which co-ordinates and works in partnership with marine research underway in the Higher Education Institutions and the Institute has established an active HEI liaison group. A national directory of expertise has been drawn up. There are approximately 500 researchers, 125 PhD students and 37 MSc students currently in place. Of the 800 highly active PIs nationally, 82 are engaged in marine research, reflecting the relatively high activity of the sector. There is also close interaction with the enterprise development agencies, particularly Enterprise Ireland, and with individual companies.

Investments under the NDP 2000-2006 have seen positive developments in the infrastructure for Marine Research. This includes a new world-class state-of-the art facility to house the Marine Institute in Rinville, Co Galway. There are also extensive facilities and activities underway at UCC, NUIG, and also in other Universities and IoTs. There are two research vessels for inshore and offshore work, which are active both in research and providing services. The vessels are key to Ireland's participation in international research programmes. The salmon research facility of the MI located in Newport, Co Mayo is a unique European research facility located adjacent to the Gulf Stream with fresh-water/sea-water facilities which monitors every salmon migrating from sea to fresh water. The resulting database with traceability over fifty years is a valuable and unique resource.

In addition to links with other HE-based research groups and industries, there is also interaction with Government Departments/Agencies in the areas of Environment, Energy and Natural Resources including climate change and biodiversity.

There is good interconnectivity with the USA and the EU and Ireland is well set up to participate in international collaborative projects. Key north-south collaborations are also underway and will continue in areas such as fisheries, wave energy, coastal zone management etc.

6.4.2 Future Research Programmes

The Marine Institute is currently finalising a National Marine Research and Innovation Strategy for the period 2007-2013. As part of this process the Institute undertook a major foresight exercise and extensive stakeholder consultation. The overall objective of the strategy is to deliver an integrated research and innovation programme that will, through the use of research, knowledge and technology, transform the sector to deliver sustainable, high growth, high value added, market led, opportunities. The strategy comprises three key measures:

I. Transition Measure: Strengthening the competitiveness of traditional marine industries and their progression to higher value added activities. Programmes include:

- Shipping & Maritime Transport;
- Offshore Energy (Wave & Tidal and Oil & Gas;
- Marine Food (Seafood Processing, Fisheries, Aquaculture, Seaweed);
- Water-based Tourism & Leisure.

As an example, under the Marine Food Measure a significant emphasis on the development of a functional seafood research programme is planned. This will focus on the potential use of marine products in the health area. It will build on significant institutional investment in functional foods research to date and will support a number of dedicated PI teams.

II. Discovery Measure: Pushing the frontiers of knowledge and exploring the interfaces between disciplines. Programmes include: Marine Biotechnology; Marine Biodiscovery; Marine Technology.

An important dimension of this measure will be the development of a SMARTBAY incorporating a range of advanced and novel marine technologies for the observation, monitoring and management of the coastal and ocean environments and activities. This will be a unique development internationally with significant potential to stimulate both national and international scientific and industrial activity.

III. Policy Support Measure: Delivering integrated scientific advice, policy & regulation to support environmental, social and economic advancement. Programmes include: Marine Environment; Seabed and Resource Mapping; Information & Knowledge Management; Socio – Economics, Policy and Legal.

The Marine Institute's new facilities at Oranmore and Newport, coupled with the world-class research vessels, databuoy network and the ongoing oceanographic, biological and environmental survey programmes (including the Newport based indicator programme monitoring salmon migratory patterns) represent a unique asset. These, together with integrated data and information management systems, offer the opportunity to develop Ireland as a global monitoring centre for climate change assessments through the medium of marine and freshwater ecosystems. A key objective will be to raise the profile and international standing of key Irish facilities (for example, Newport) and to raise substantial international funding for these unique facilities. This would represent a significant cross-Government initiative involving key partnerships among Departments (e.g., DCMNR and DELG); State Agencies (e.g., Marine Institute; EPA; MetEireann) and the Higher Education sector. It would also afford Ireland a major opportunity to play a lead role at the hub of global environmental research.

Key Actions

- **Conduct a survey of marine research and researchers on an all-island basis with particular emphasis on research underway outside of the Marine Institute (2006);**

- **Development of research discovery programme in Marine Biotechnology; Marine Biodiversity; Marine Technologies (2007-2013);**

- **Establish Ireland as an Internationally recognised centre for Ocean renewable research (See Energy research section) (2006-2013);**

- **Establish a SMARTBAY system for the observation, monitoring and management of coastal and ocean environments and the testing of new advanced technologies (2006-2008);**

- **Develop Ireland as a global monitoring centre for climate change assessments in the context of the North Atlantic Gulf Stream, unique marine and other ecosystems and SMARTBAY system, (2007-2012);**

- **Use the data derived from the Irish seabed survey and the new Infomar programme to place Ireland in a position of competitive advantage in a range of areas including participation in International research programmes (2006–2013);**

- **Stimulate greater involvement by Irish seafood Industry in marine related research. Prioritise the development of marine healthfoods (2006-2013);**

- **Target a significant increase in FP7 participation and seek EU support for the Climate Change monitoring centre (possible European demonstration project 2006-2013).**

6.5 Energy

6.5.1 Introduction

The energy sector directly employs 12,400 people. It has a turnover of €7.2bn and directly contributes €1.78bn to GNP. It is a vital, strategic sector – part of the necessary national infrastructure. The energy sector in Ireland is characterised by exceptionally high dependency on imported fuels and obligations arising from the Kyoto protocol and relevant EU directives. These drivers require Ireland to develop a more competitive contribution from renewable energy sources, together with major improvements in energy efficiency in transport, buildings and industry.

Energy research activities are undertaken in support of national energy policy objectives, which are concerned with the maintenance of secure energy supplies to support economic growth and competitiveness, while ensuring that energy supply and use is environmentally sustainable.

In total, about 130 energy research, development and demonstration (RD&D) projects are currently underway, with a total funded value of approximately €25 million. This is twice the level of activity and three times the value of work undertaken in the previous year.

Sustainable Energy Ireland (SEI), an agency under the auspices of the Department of Communications, Marine and Natural Resources (DCMNR) commissions significant energy research and studies, through programmes derived from the National Development Plan. These programmes currently support the full-time equivalent of 25 post-doctoral researchers, 10 PhD students and 10 MSc Students.

Other agencies, notably Teagasc, the Environmental Protection Agency, the Marine Institute and Enterprise Ireland also support relevant technical research, while the Economic and Social Research Institute also undertakes research work relevant to energy policy.

ESB/ESB Networks, Bord na Mona, Airtricity, Viridian and others undertake/support energy related research related to their businesses.

In 2004 DCMNR undertook a strategic review of energy RD&D activities in Ireland and concluded that current activities, while valuable, could be better coordinated and aligned with national energy, economic and innovation policies. This was in line with the findings of the International Energy Agency Review of Ireland in 2003. Current research activity has tended to be project based and this, together with the "stop-start" nature of support has not been conducive to developing and supporting national energy research capacity. Work on the articulation of national energy policy is underway and future strategic research areas will be geared to underpinning national policy priorities working with all the relevant national players.

6.5.2 Future Strategic Direction

The strategic direction for energy research will focus on improving security of supply

through making the national energy infrastructure smarter in order to manage the dynamic balance between supply and demand, increasing the efficiency of energy use in order to reduce energy demand, and bringing forward promising renewable energy technologies. (The current target for electricity production from renewable sources of energy is 13.2% by 2010. Currently only about 3 % of electricity is derived from renewables.)

The following thematic research areas, amongst others, will be pursued under this strategy with the related critical objective of building capacity across the energy research sphere.

6.5.2.1 Power Systems Research (Smart Grids)

The Electricity Research Centre (UCD) represents a collaborative effort between power systems researchers in UCD and a range of collaborators with interests in the Irish Electricity Industry. The Centre is internationally recognised and works closely with international partners including University of Washington, USA , Queens University Belfast, UMIST, UK and others. Work includes congestion management, flexible load control and large scale integration of wind power.

6.5.2.2 Rational Use of Energy

This area covers energy efficiency and combined heat and power (CHP).

In line with national and EU policy, work on energy efficiency will be a major priority. This will be reflected in the creation of a national energy efficiency campaign, promotion of the National Energy Awards and active implementation of the new Irish Standard in Energy Management. Research activities will include further work in the SEI "House of Tomorrow" programme, which will accelerate developments in the quality of energy features in Irish housing from planning to construction. There is a clear need for exemplar projects in high-profile public buildings, research and development into widespread application of power factor correction technology and essential pilot work in the transport sector.

In CHP, lessons will be drawn from the recently completed report from the DCMNR CHP Policy Group, and a small number of strategic pilot projects will be supported, to be followed by a programme of information dissemination to encourage appropriate take-up of the technology.

Ireland's expertise in magnetism could be harnessed in the approach to design high capacity electrical storage systems.

Photovoltaics, Fuel Cells /Hydrogen and Geothermal technologies will be assessed in view of recent significant international advances in these research sectors. This will be done in conjunction with relevant International bodies.

6.5.2.3 Wind Energy

There are technological development barriers which will have to be addressed with regard to wind generation. Advanced IT and control solutions and innovative technology will be required to address the problems of over and under supply, and connectivity.

Given Ireland's favourable geographical location with regard to wind supply (as confirmed by the European Wind Atlas), investment in research in this area is vital, not least since wind is currently the most advanced reliable source of renewable energy and crucial to achieving our national targets.

6.5.2.4 Biomass for Heat and Fuel

This is a sector which can benefit from an integrated research approach involving a number of agencies, industries and HE actors. The application of advances in plant genetics to select suitable fast-grow species (for example willow and others) coupled with engineering developments: for example wood, burning heating systems, designed/modified in an integrated fashion based on the crop characteristics, is a promising approach. The plant selection and growth conditions work will take place in Teagasc.

Feasibility studies in connection with various bio-fuels based on Irish climate and growth conditions are underway. These will examine economic feasibility, available transport system (important in large scale bio-mass projects) and other characteristics.

6.5.2.5 Marine Energy

Research approaches to ocean energy systems are underway, and the physical wave tank facility at UCC is an important piece of infrastructure and well recognised internationally. Feasibility studies based on Irish conditions are about to commence at the Marine Institute. The Institute has an objective to achieve international recognition as a Centre of Excellence for renewable ocean energy research by 2013. A number of prototypes are under test by the private sector in connection with universities (UL and others).

6.5.3 All Island

The Department of Communications, Marine and Natural Resources is working closely with the Northern Ireland Department of Enterprise, Trade and Investment and the regulators in both jurisdictions to advance an all-island approach to the energy sector. This is evidenced in the recently published Framework Document and the development of the Single Electricity Market. The Departments are also working to develop a similar approach to energy RD&D which will take advantage of synergies and opportunities for collaboration. This has already received practical expression through the joint undertaking of the first all-island inventory of energy RD&D projects as a key data base for enhanced collaborative research work.

The necessary structural supports and multi-annual Exchequer funding are being put in place to ensure the prioritisation, coordination and support of energy research activities and capacity building in line with national energy policy objectives.

6.6 Geoscience Strategy

Work is underway to develop a coordinated national geo-science strategy. This envisages a more structured multi-disciplinary approach to national geoscience activities carried out in the HEIs, the Geological Survey of Ireland (GSI) and other state organisations. Geoscience research and monitoring programmes contribute directly to the environmental, energy, marine and infrastructure sectors and significant synergies are already being developed. There is obvious potential for greater all-island collaboration in the geosciences.

Key Actions

- **Establish (2006), an Energy Research Council which will advise on the setting of priorities for Irish energy research to the year 2013. The Council will take a leading role in linkage with key national bodies (as well as EU and international programmes and bodies); coordinate existing RTDI; provide policy advice and analysis, and support strategic research initiatives and capacity building, complementary with existing initiatives;**

- **Take forward the key thematic research areas in relation to security of supply, rational use of energy, renewable energy technologies and national energy infrastructure;**

- **Establish an all-island inventory of energy research and researchers (2006 and annually thereafter);**

- **Target significant levels of participation in FP7 and other international research programmes (2007-2013);**

- **Develop all-Island initiatives and optimise collaborative proposals under FP7 as a practical means of furthering collaboration (2006-2013);**

- **Develop a range of cross sectoral research initiatives including climate change, enterprise, agriculture and transport (commencing 2006);**

- **Progressively enhance the active engagement of Irish energy industries with R & D programmes (2006-2013).**

7 All-Island and International STI

7.1 Introduction

In the modern global economy, it can no longer be expected that single teams or even Member States can provide the necessary scale and scope of resources required to conduct research. For example, the average research expenditure of an EU-25 country is just over €7 billion per year, which is no more than that of many individual large multinational companies.

Transnational cooperation brings together resources, disciplines, and scientific excellence, thus achieving a critical mass, which could not be attained at national level. Participation of different actors - from university, industry and public research laboratories – and the interaction between these actors enables those research teams wishing to develop their S&T capabilities to participate in top transnational teams and benefit from learning and synergies. Moreover, cross-disciplinarity of research is growing and no state can be expert in all fields, especially the emerging ones. Hence researchers must increasingly look beyond their own national boundaries if they want to find high-quality expertise in complementary disciplines.

7.2 Benefits for Ireland

Whilst there are real costs in engaging in international collaboration, transnational co-operation has a number of benefits to offer Irish efforts in the broad research area:

- International Competition for funds helps promote scientific excellence nationally as Competitive Scientific Research can be undertaken in an efficient, cost effective and successful manner;

- Through successful participation in research related programmes we can ensure that our research efforts are meeting the most demanding international standards;

- National priorities can often be more effectively addressed on a transnational basis. The establishment of and/or access to international science networks are desirable for the performance of the national research system;

- International mobility of scientists enhances domestic quality;

- Collaboration is necessary at a regional level to achieve the scale of research efforts to

make real progress with frontier research, given the complexity and scale of the questions to be addressed;

- Unnecessary duplication and fragmentation of efforts can be avoided;

- Enhanced engagement with, and access to, international state of the art facilities for Irish researchers.

Specifically, Ireland has benefited greatly over the last two decades from the focus of the EU on supporting research, so as to strengthen the competitiveness of European industry. Access to EU Structural Funds and participation in the EU's R&D programmes has done much to enable researchers in Ireland to access funds, collaborate with European partners in leading-edge research, develop a national system of innovation and upgrade the national S&T infrastructure. Over the period of Ireland's EU membership, funding under the Framework Programmes has been additional to government expenditure on R&D. Under the Fourth Framework Programme (1994-1998), EU funding approximated to three quarters of all state funding of R&D in the business sector and almost half of state contributions to R&D in third-level institutions. EU supports have been used, in addition to steadily increasing national supports, to lay the foundations for a knowledge-based economy.

7.3 Challenges to be addressed

Ireland is currently a participant in many of the key networks and programmes at European level including the EU Framework Programmes, Eureka, the European Space Agency (ESA) and the European Molecular Biology Laboratory (EMBL).

The models adopted in building our relationships with China under the Ireland China S&T Agreement and the US under the All-Island Ireland/US R&D Partnership, are useful in developing robust and effective scientific networks. In addition to China, and more recently India, we will examine the potential for enhanced cooperation with the other advanced scientific economies in Asia. Our engagements with Intergovernmental Research Organisations (IGROs) such as ESA, EMBC, COST and EMBL provide platforms on which to grow our international collaborative research efforts. Our engagement in the EU's Open Method of Coordination (OMC) system and the EU's Framework Programmes will also assist in this regard. It is very important for Ireland to move forward in building its international collaborative networks in science. However, it is also important to make these investments in a way that produces the greatest economic benefits to Ireland. Focusing on investments with the strongest payoffs to technology based business and economic development as well as benefits for researchers and the culture of science would appear to make most sense.

The involvement of enterprises in Ireland in international research networks is part of the 'staircase' approach of such firms developing their research and technological capacities. The primary responsibility for firm participation will rest with the enterprise development agencies.

International collaboration brings benefits to Irish scientists in both the academic arena and companies. Quality standards are driven upwards and engagement with best practice ensures that industries compete at the cutting edge of technology, ensuring optimisation of returns to investment.

The dynamic of international competition in the sciences has stepped up over recent years, in particular for leading researchers. At the same time, the inter-dependence of the various elements of the global science system is increasing, given the complexity of the problems being addressed, the scale of investment required and the pervasive mobility of researcher careers. The relatively small scale of the Irish science and technology base means that much of what is being achieved in terms of Irish research is relatively unknown internationally.

7.4 Steps to be Taken

In view of the ever-changing international environment, ongoing review of Ireland's relationships in Science and Technology with third countries and intergovernmental organisations is essential. In this regard, continuing consideration of Ireland's participation in additional IGROs or other large scale science infrastructures will be important.

In addition, Irish engagement in the European Strategy Forum for Research Infrastructures (ESFRI) under the auspices of the European Commission, to help identify and prioritise European infrastructural provision as well as ensure access for scientists from all EU member states will be important in the coming years.

Ireland will also continue to actively participate in the process of Open Method of Co-ordination of research policies at EU level, under the auspices of the European Council's STI advisory body of senior officials, CREST. This provides an important mechanism for mutual learning and the promotion of transnational initiatives to enhance our national system of innovation, to reduce fragmentation and enhance the competitiveness of the European research area for leading researcher and companies.

National programme managers also need to link internationally. Links to national programmes in other countries are particularly underdeveloped in Ireland, although there have been some exchange of experiences such as with Tekes in Finland and in thematic areas such as marine. Enhanced engagement in appropriate EU ERANETS programme and the new ERANETS+ programme under the Seventh Framework Programme (FP7) should help to address any deficiency in this respect.

Regular contact with the European Commission across a range of dossiers will also be important given the impact of all European legislation on industry and academia. To help anticipate such legislation and enhance links with the Commission, in conjunction with the Department of Foreign Affairs, the OSTI will undertake networking initiatives to ensure that the Irish nationals in the Commission are fully aware of the domestic agenda on science and technology and our efforts to achieve the Lisbon targets. The enterprise development agencies will also engage in these initiatives.

To raise the profile of Ireland's research base and to attract new researchers and investors to Ireland, a brochure highlighting our engagement and success in this key area will be produced for use by all in promoting Ireland.

In addition, IDA Ireland will also run a new international promotional and marketing programme over the first three years of the Strategy, to raise the profile of Ireland as a technology location amongst decision makers in targeted markets, as outlined in Chapter Four.

7.5 EU Research Framework Programme

The Framework Programme for Research is the EU's main research policy instrument and it funds transnational collaborative projects involving a mix of researchers and companies from three or more European states, on a competitive basis. Through successive EU Framework Programmes, Irish researchers have joined with organisations in Europe, and beyond, to compete for and win funding for specific research projects. The benefits for successful participants include access to funds, the sharing of risks and costs, access to project results and working with leading researchers, thereby gaining new scientific knowledge and research skills. A key benefit is the substantial contribution the Framework Programmes make towards the building of transnational research linkages. These linkages can, and do, form the basis for future collaborative partnerships between researchers across all sectors.

Ireland intervened early in the design of the Seventh Framework Programme (FP7), currently (2006) being negotiated by the Commission with the EU Member States and the European Parliament. The programme will be of major strategic importance and benefit to Ireland in achieving its goals in the science and technology arena, with potential for a substantial increase in funding in the new round. Ireland is satisfied that many of the priorities put forward in our national position paper on FP7 have been reflected in the Commission's formal proposals. FP7 will contain many of the existing components of FP6 and will continue to be based largely around transnational collaborative research in a number of thematic areas and initiatives to encourage the mobility of researchers across Europe (Marie Curie Actions). However, new initiatives are also proposed, the most significant of which is the proposed European Research Council (ERC) which will fund individual research teams (across all disciplines) based on the excellence of their research. The ERC will complement SFI initiatives and programmes which are focused on building a base of world class research in Ireland.

To optimise the return to Ireland from FP7, it is imperative that more firms are encouraged to participate in the programme. In this regard, we have sought to ensure the simplification of FP7 and its rules of participation and to make it more attuned to the needs of industry, particularly SMEs, through improved support, better information and less bureaucratic participation procedures. It will also be necessary to enhance and streamline our promotion of the programme, and improve the National Support Structure (NSS). Increased engagement with potential participants and adapted links with the Commission and other European institutions will ensure that industry and third level agendas are brought to the deliberative table. The OSTI, in consultation with stakeholders, has developed a revised model which will see the NSS headed by a national director and supported by a core unit and dedicated teams which, while building on the positive elements of the existing structure, will provide greater strategic direction, address the issue of strategic targeting and ensure that FP7 has high visibility across the national RTDI system.

In promoting FP7, particular emphasis will be placed on working with our Northern colleagues to maximise the potential for cross-border collaboration with NI, which we see as a significant competitive advantage for the island of Ireland. Our National Contact Points will make this a priority.

7.6 All Island

Collaboration between researchers on the island of Ireland has been proceeding in a mutu-

ally beneficial way. Given the proximity of the two parts of the island and the financial and research rewards that are to be gained from such collaboration, increased emphasis will be placed on working together in the future. Obvious synergies in the area of Centres of Excellence and the avoidance of duplication will be pursued, to ensure that the strong research message emerging from the island of Ireland is coherent, innovative and forward-looking.

At the policy level, engagement and interaction between the IDC on STI and the Advisory Science Council, with their Northern Ireland counterparts and colleagues will be actively promoted and developed. The Terms of Reference of both of these groups have been specifically designed to allow for and encourage such all-island relationships in the STI policy arena.

7.6.1 Sectoral North/South Cooperation

Significant collaboration in the sectoral areas of Agriculture & Food, Health, Energy and Environment is already taking place to good effect. Every opportunity will be taken to ensure that these initiatives continue to be developed to mutual benefit, as set out in detail in Chapter Six on Research in the Public Sector. Close links between these sponsor Departments will be built upon, with regular contact between officials, to ensure coherence of approach.

7.6.2 All Island STI Programmes, Networks and Activities

InterTradeIreland (ITI), one of the six cross-border bodies set up under the 1998 Good Friday Agreement, has undertaken the RTDI role outlined in its establishing legislation and is actively promoting links between industry and academia on an all-island basis. This is being achieved through the creation of knowledge-intensive, all-island trade and business development networks and the implementation of all-island trade and business development programmes. ITI's work in this area is underpinned by a research agenda that seeks to develop the understanding of the dynamics behind the emerging island economy and to inform policy choices.

ITI's future STI strategy is underpinned by the key principle of adding value through collaboration and aims to optimise the use of the island's knowledge resources. Activities in the establishment of knowledge-intensive networks, STI support programmes, and innovation research are as follows:

Networks BioMedIreland and the All Island Software Industry Network;

STI Support Programmes EXPERTISEIRELAND.COM portal sharing information on the expertise available across the island of Ireland;

INNOVA: an all-island collaborative R&D programme aimed at firms, with the support of public research organisations;

FUSION: an accessible all-island technology transfer initiative, giving companies access to expertise and facilities in universities and colleges ;

Continuous Professional Development NovaUCD/AURIL Continuing Professional Development (CPD) Programme for knowledge transfer on the island of Ireland.

US/Ireland R&D Partnership: this is an outcome of the US Ireland Business Summit held in Washington in 2002. The Partnership was concluded in January 2005. Four initial priority areas were identified: Cystic Fibrosis, Diabetes, Nanotechnology and Sensors and the partnership has added an additional priority area of Respiratory Disorders including avian flu to this list. It is open to the members of the Partnership to develop other areas in which collaborative research could usefully be conducted. A small, high-level Steering Group drawn from business, academia and the public sector in each of the three administrations is being supported by a facilitating mechanism with all-island capacity and is now driving the Partnership forward.

Key Actions

- **Strengthen and complement the national research infrastructure through linking the research system to centres of excellence internationally and foster partnerships through involvement in international research teams;**

- **Increase the access of the enterprise base to international leading edge technology networks and collaborations with leading companies and research centres in relevant sectors worldwide;**

- **Achieve scientific excellence, improved competitiveness and innovation through cooperation between researchers and industry and maximise Irish participation in EU Research Framework Programmes, including on an all-island collaborative basis;**

- **Implement a new National Support Structure for the Framework Programme;**

- **OSTI, assisted by Forfás, will continue to monitor and evaluate Irish engagement with international programmes. Key indicators of success will be the numbers of international collaborative engagements by Irish firms and institutions and the share of Irish research and development (public and private) supported by international sources. Data on promotion and collaboration of international programmes will be reported upon in agency annual reports;**

- **Links will be developed between the IDC and ASC and their Northern counterparts, to ensure synergies and avoidance of duplication;**

- **Sectoral N/S cooperation in R&D will be supported and its further development will be encouraged;**

- **The full potential of US Ireland R&D Partnership will be realised;**

- **In promoting FP7, National Contact Points will make cross-border collaboration with NI a priority.**

8 Implementation

8.1 Introduction

This Strategy represents Ireland's first comprehensive strategic approach to developing science, technology and innovation on a whole of government basis. The process leading to the formulation of the Strategy has demonstrated that the STI coordination structures put in place by Government have the capacity to formulate policy in this coherent, joined up way. For the Strategy to succeed, it is vital that joined up thinking is followed by joined up action. As with any form of developmental planning, it is also essential that feedback mechanisms are built in and that the strategy has the capacity to evolve over time in response to developments in technology and changes in the domestic and international environment.

This chapter describes the structures and approaches that will be put in place to implement the Strategy.

8.2 Portfolio Analysis and Research and Technology Assessment

Good progress has been made in a relatively short period of time in building up the research and technology base and areas of clustered research strength are now beginning to emerge. The evaluation of SFI has recommended that Ireland should continue to focus on excellence as the primary criterion in supporting research. It is intended that this will continue to be the case. However, it is important to ensure that our investment in excellent research also has regard to economic and social needs and that these should play a guiding role in where investments are made.

The Technology Foresight exercise, which underpinned the current NDP, prioritised ICT and Biotechnology. Focused investments in these areas have been more supplemented by specific sectoral investments in health, agriculture and marine etc., and more broadly based research support under PRTLI, the Research Councils, the SFI Research Frontiers Programme. It will be important over the life of this Strategy to gain a better understanding of how the balance between individual excellence and coherence/critical mass is evolving. This can be achieved by taking a portfolio overview of existing and planned future research investments. This overview can take account of quality and critical mass in the portfolio, the applications time horizon of the research (long, medium and short) and its relevance to Ireland's existing and future economic and social development.

The broad based portfolio analysis approach will be supplemented by more detailed exercises focused on specific areas of science and technology. A pilot Research and Technology Assessment exercise is currently underway focusing on Nanotechnology. This is assessing the field of Nanotechnology in Ireland based on the following principles: the potential for quality research and critical mass; the potential to create an international uniqueness for Ireland in the research area e.g. converging or emerging technologies; and relevance to Ireland's current and future industrial, economic and social development. The learning from this pilot will be used to further develop the role of Research and Technology Assessment in the planning and implementation of the strategy.

This capability will be built up under the aegis of the IDC supported by its Joint Secretariat and Implementation Groups (see below) and with input from the Advisory Science Council and the Chief Scientific Adviser.

8.3 Implementation Structures

In line with its central role in policy formulation, the Interdepartmental Committee will have overall responsibility for driving and monitoring the implementation of the strategy and reporting to the Cabinet Sub Committee on Science Technology and Innovation (CSC).

As part of this overarching framework under the aegis of the CSC and IDC, new implementation structures will be put in place. In summary, these comprise two distinct but interrelated groups, as follows: Higher Education Research Group, and Technology Ireland. Specific arrangements are also being put in place to ensure the effective management of sectoral research and its relationship with Higher Education and Enterprise Research. The functions of these elements are described in more detail below.

To ensure maximum coherence in implementation - and with particular regard to the centrality of the higher education/enterprise research interface to the success of the Strategy - D/ETE will Chair the IDC, and D/ES will act as Deputy Chair. The Higher Education Research Group discussed below will be chaired by D/ES and E/ETE will act as Deputy Chair.

The IDC and the implementation groups will be backed up by a Joint Secretariat comprised of representatives of D/ETE, D/ES, HEA and Forfás.

8.3.1 Higher Education Research Group

The Higher Education system plays a pivotal role in the National System of Innovation and the delivery of the Strategy. As part of that delivery, significant infrastructural investment will take place in the HEIs, and the numbers of researchers at PI, postdoc and postgrad level will be greatly increased. It is essential that investments in the sector take place in a way that balances the need for strategic coherence and competitive excellence, for both institutions and researchers.

The Higher Education Research Group (HERG) will comprise representatives of the main Departments responsible for funding HE based research - D/ES, D/ETE and D/Finance, along with senior executives from the funding agencies of those Departments.

The group will have responsibility for ensuring coherence among key funding initiatives such as PRTLI and the funding awards schemes of the relevant agencies and councils.

The group will have a particular responsibility for ensuring a good fit between infrastructural investments in the institutions and research and postgraduate education programmes. Ensuring an appropriate balance between collaboration and competition among the institutions will also be of concern to the HERG.

8.3.2 Technology Ireland

The Strategy sets out proposals for how coherence will be brought to the enterprise dimension in the context of operationalising Technology Ireland (TI). Commencing January 2006, the group of senior executives from SFI, IDA, EI and Forfas has been convened under the aegis of the Office of Science, Technology and Innovation to begin this process. As the Strategy develops, Technology Ireland (TI) will strengthen its management and monitoring/oversight function. All significant initiatives - for example, proposals for new competence centres will be assessed by the group, particularly with regard to coherence and alignment with national strategy. TI will take responsibility for monitoring the outputs and outcomes of all agency RTI schemes. In particular, the group will regularly assess the progress towards the BERD targets specified in the strategy. In addition, the group will have an advisory function in relation to the cross agency allocation of RTI budgets.

To ensure customer input, TI will establish an Enterprise Feedback group of stakeholder representatives. TI will discuss progress in delivering the strategy with this group and incorporate its feedback into the continuing development of policy and programmes.

8.3.3 Sectoral Research

Under the Strategy, sectoral research will take place in a number of different institutional contexts. This includes in-house research in bodies such as Teagasc, the Marine Institute and Sustainable Energy Ireland. Sectoral research is also funded in the HEIs by many of these bodies. In the health context, the teaching hospitals also have the potential to be the locus of a very significant volume of clinical research.

Insofar as the sectoral research agendas are distinct from one another, responsibility for their implementation will fall to the relevant member Departments of the IDC and their respective agencies. There are important linkages and relationships between sectoral, HEI and enterprise research. Ensuring that these linkages function effectively is discussed in the following section. In addition, there are a number of cross sectoral research linkages in areas such as agriculture and energy for example. The IDC will continue to overview cross cutting linkages in these areas.

8.3.4 Linking HE, Sectoral, and Enterprise Research

It is vital that investments in HE research translate into economic benefit. This will happen through the absorption of PhD and postdoctoral researchers into the enterprise sector and through the commercialisation of HEI research. To facilitate this, the IDC will ensure that key officials from the HERG, TI and relevant Sectoral Research funders will meet regularly to address cross cutting issues in the Research/Enterprise space. Among the issues to be addressed by this grouping will include:

· Analysis of links between the research portfolio and enterprise needs;

· Technology Assessment and other priority setting mechanisms and their role in prioritisation of research investments;

· Oversight of the HE/Sectoral Research and Enterprise linkages;

· Oversight of enterprise demand for advanced researchers and flows of such researchers from the HEIs and other Public Research Organisations to enterprise.

8.4 The Spatial Dimension

Science, Technology and Innovation policy has the potential to contribute to economic and social development throughout the island. STI is essentially a global enterprise and the research community works in a global context, with mobility of researchers playing an important part. The spatial dimension of this Strategy needs to be seen in that global context. This means that the key criterion of achieving excellence must continue to underpin Ireland's research drive. Excellence at an individual level must increasingly be backed up by critical mass in research teams and the continuing development of the overall quality and standing of Ireland's HEIs. This approach is consistent with the National Spatial Strategy (NSS) which emphasises building centres of critical mass. This Strategy will promote the development of the Universities, Institutes of Technology and other key research performers in both a national and regional context. In addition, the drive to increase Ireland's business expenditure on R&D will contain a strong emphasis on encouraging smaller, less research active companies, to become research active. This will be important in regions where the numbers of research performing enterprises is currently low. In addition, the development of key areas of sectoral research such as agriculture, energy and the marine will be of relevance in ensuring that RDTI activity does not become overly concentrated in urban centres.

Placing RTDI in the context of spatial development does however require a recognition that Ireland is a small country and needs to harness all its resources to be competitive in a global research context. Increasingly, this will require a combination of competition and collaboration among and between both firms and institutions respectively. For example, the intra-company research networks being promoted by EI contain both large and small companies from across the country. Similarly, it is desirable to see higher education institutions increasingly share facilities – through mechanisms such as the Tyndall National Institute access scheme. In addition, mechanisms such as TecNet can increasingly ensure that the Institutes of Technology develop a shared agenda that will strengthen their research and commercialisation performance. In conjunction with these approaches, there will continue to be a role for initiatives which address distinct regional needs and, especially where clustering of research active firms is evident.

8.5 Resourcing

The total level of expenditure on those areas of STI encompassed by the Strategy amounted to €658 million in 2005. Taking account of the allocations in the existing Capital Envelopes and Existing Levels of Service spending projected to 2013, the net additional resources required to implement the Strategy in full have been costed at €1.88 billion over the period to 2013. Of this, some €640 million is required for higher education infrastructure, €340 million is required for enterprise supports, and €900 million is required for research and commercialisation programmes in the Higher Education Institutions and the public research sys-

tem. It is anticipated that the cost to the Exchequer of implementing the Strategy will be reduced through funding from the EU Framework Programme, Research Foundations and Philanthropy. It is expected that some €380 million should be secured from these sources. [It should be noted that total receipts from the FP are projected to be higher but not all FP income is directly offsettable against Exchequer investment in the Strategy]. In order to ensure the immediate implementation of the Strategy, the Government is committing an additional €192 million (€66 million in 2007 and €126 million in 2008) over and above that being provided on the basis of existing levels of service and the multiannual capital envelopes for the period up to and including 2008. These resources are already very substantial and, when taken with this additional provision, will result in total Government investment in the Strategy in excess of €2.7 billion in the period up to and including 2008.

As regards future resourcing, the Strategy will form a core component of the forthcoming National Development Plan, and decisions on funding for the remainder of the Strategy will be made in that context.

8.6 Review, Evaluation, Targets and Indicators

Reporting to the Cabinet SubCommittee, the IDC and its Joint Secretariat will oversee the continuing review and evaluation of the Strategy, with input from the Chief Scientific Adviser and the Advisory Science Council. The well established STI evaluation capacity in Forfás will also play a valuable role in supporting the Joint Secretariat in this task. In addition, specific review mechanisms will be put in place in the context of the National Development Plan. In reviewing the development of the Strategy, there will be close liaison with stakeholder bodies including the research community and industry. A range of key indicators and targets for the strategy will be monitored as follows:

People

Target: Number of new doctorates in science, engineering and technology earned annually to nearly double from 543 in 2005 to 997 in 2013 and in humanities and social sciences to increase from 187 in 2005 to 315 annually by 2013.

Publications

Ireland currently ranks 12th in a table prepared by the European Commission (Key Figures 2005) showing the number of scientific publications per million population for a range of countries in 2003. The top six were Sweden, Denmark, Finland, Netherlands, UK and Belgium. The US is 9th. Indicator: Ireland will aim to significantly advance its performance in terms of the publications league table.

Citations

The relative frequency with which scientific publications are cited by scientific peers is a universally accepted measure of the quality of scientific output. The US National Science Foundation produces annual data on this indicator. The indicator measures citation performance in relation to the number of publications, providing a relative measure independent of country size. For 2003 the top performers were Switzerland, US and The Netherlands, with scores around 1.0. Denmark, UK and Sweden were next. Ireland ranked 12th (out of 45) with a score of 0.76. In a number of fields the Irish performance was even better (in Clinical Medicine

ranked 10th and in Engineering and Technology ranked 4th with a score of 0.92). Indicator: Ireland will aim to significantly advance its performance on the citations index.

Internationalisation

The share of higher education research (HERD) funded by foreign sources (including the Framework Programme) is a good proxy for the internationalisation of the research system. Between 1998 and 2004 the level of foreign funding remained roughly constant in money terms, declining as a percentage of HERD from 19% in 1998 to 10% in 2004. Target: share of HERD funded from foreign sources should return to 20% by 2013.

Support for Research Commercialisation

Each research performing institution will be required to set targets in the following areas based on their research orientation and norms in leading international institutions:

- Financial and human resources devoted to technology transfer, IP management and other commercialisation activities;
- Number of invention disclosures reported;
- Number of patents applied for and granted;
- Number of patents generating revenue;
- Number of licence agreements with companies;
- Total revenues from licencing and fees from royalties;
- Number of actively trading spin-off firms established and their survival rates;
- Private sector investments in public research spin-offs;
- Number and size of industry-commissioned projects.

Enterprise R&D - Targets

- Number of indigenous companies with minimum scale R&D activity (in excess of €100,000) to reach 1,050 by 2013;
- Number of indigenous enterprises performing significant R&D (in excess of €2 million) to reach 100 by 2013;
- Number of foreign affiliates companies with minimum scale R&D activity (in excess of €100,000) 520 by 2010;
- Number of foreign affiliates performing significant levels of R&D (in excess of €2 million) to reach 150 by 2010;
- Business Expenditure on R&D in foreign-owned companies to increase to €2.5bn in 2013
- Business Expenditure on R&D in indigenous companies to increase to €0.825 by 2013;
- Proportion of sales in indigenous enterprises from innovative products and processes introduced in the last two years to double by 2013.
- Number of companies participating in international R&D networks and funding achieved.

International and all island

Target: Return from EU FP Seven to all participants to reach €400 million 2007-2013

Appendix I

Strengths, Weaknesses, Opportunities and Threats

The SWOT analysis complements the analysis of Ireland 's RTI performance undertaken in the National R&D Action Plan. The analysis was carried out by four independent stakeholder teams convened under the aegis of the Office of the Chief Science Adviser.

Overview of Key Results of SWOT Analysis

. In summary, the following are the key conclusions of the analysis:

- the importance of a statement on science policy and strategy, endorsed by Government;

- the critical importance of the Science and Education system at all levels (primary, secondary, third and fourth levels);

- building research capacity, quality and coherence, particularly with regard to the growth required in order to achieve the Lisbon R&D target;

- achieving balance and connectivity between discovery research, development and commercialisation;

- complement existing priority research areas (ICT and Life Sciences) with more emphasis on certain strategic research areas (e.g. Sustainable Food and Agriculture and Health) and key disciplines (e.g. mathematics);

- participation in international research, collaborative agreements and networks.

The detailed list of strengths, weaknesses, opportunities and threats identified is as follows:

Strengths

· Government's commitment to driving Ireland as Knowledge Based Economy and strong Government commitment to Research

· Success in attracting high quality, high technology FDI

· Highly adaptive manufacturing base

· Importance of engineering and the quality of Irish engineers

· Government support for enterprise

· Positive fiscal environment

· FP7: Ability to organise ourselves and influence the make-up of FP7

· Government responsiveness to changing competitive environment

· Emerging whole of government approach to STI

Weaknesses

· Historic absence of a fully developed national strategy for STI, and integration of sectoral and socio-economic research within that framework;

· Research Capacity in Universities/ IoTs and Industry (numbers; quality; supervision) in context closing output/quality gap with competitors;

· Lack of Research and Technology absorption capabilities by companies and weak commercialisation structures

· Numbers studying science subjects to Leaving Certificate level

· Structural weaknesses in universities/institutions

· Lack of funding for research support disciplines

· Low availability of Seed Capital

Opportunities

· Potential to attract further inward investment based on our excellence in engineering/ manufacturing/process improvement & developing scientific environment

· Increased efforts to raise the profile of Ireland as a locus of world class research and development

· Whole of Government Approach e.g. Sustainable Food & Agriculture; Energy, Health and others

· Socio-Economic input to Optimisation of the Enterprise Environment

· Greater influence on EU RTI policy in line with Irish strengths and opportunities e.g. Sustainable Food & Agriculture, Stimulation of Research Careers

· Greater leverage of existing future investments in ICT and Biotech to leverage non Exchequer finance and

· Industrially lead R&D linking the priority areas of ICT and Bio

· Innovative IPR Policy could stimulate investment by multinationals and others in indigenous sector

· Shared Research Technology Industry (Demand Driven) Centres

· Potential of knowledge-based services
- Financial Services
- ICT
- Health (including genome services, clinical trials and eHealth)

· Good environment for clinical research

- high ethical standards; availability of patients and growing availability of good researchers; active medical charities.

· Greater emphasis on new mechanisms to increase research in or by Irish industry

Threats

· Complacency in abandoning commitment to manufacturing, particularly strategically oriented high value manufacturing would lead to misunderstanding and convey an inaccurate message internationally

· Competition for FDI & underestimating the maturity of developing economies

· Absence of a coherent immigration policy for skilled workers/researchers

· Little awareness internationally of Ireland as an established centre of science;

· Lack of attention to and likely consequences of "science in society" issues

· Achieve commitment to Lisbon/Barcelona at expense of quality

Appendix II – National System of Innovation