BioPolis - Inventory and analysis of national public policies that stimulate research in biotechnology, its exploitation and commercialisation by industry in Europe in the period 2002–2005

National Report of IRELAND

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Summary

Since the mid 1990s, Ireland has had very high rate of economic growth (an average of 7% in 1991-2003), fuelled by large amounts of Foreign Direct Investment (FDI) in manufacturing industries. However, with the accession of new countries to the EU, the Irish government has perceived the need to improve productivity and to upgrade its position in the global value added chains in order to maintain its high FDI and economic growth. To this end, during the last 6 years, Ireland has been developing a new set of funding agencies and policy instruments to strengthen its basic research capabilities in strategic fields. Although in relative terms GERD is still low, at 1.4% of its GNP (or 1.1% of the GDP), in absolute terms it has grown at an annual rate of 9% in 1999-2003.

Given the strength of Irish manufacturing in the pharmaceutical sector, biotechnology was chosen as one of the strategic sectors of the National Development Plan for 2000-2006 and became a funding target. As a consequence, the Irish government effectively increased its expenditure by 6-fold in this field, from 9M EUR per year in 1994-1998, to 57M EUR per year in 2002-2005, mainly through two new programmes for strategic research and the continuation of its agency for the commercialisation of research:

- The Programme for Research in Third Level Institutions (PRTLI) for 2000-2007 awarded 22.4M EUR per year to universities and technology institutes for research centres and networks in areas related to biotechnology. Although a generic programme, the PRTLI followed NDP priorities and spent half its total budget in the area of life sciences.
- The funding agency Science Foundation Ireland (SFI), created in 2000 specifically for ICT and life sciences, allocated a total of 73.5M EUR to support outstanding scientists and projects in basic research in biotechnology. SFI is in rapid expansion, its biotechnology expenditure growing from 7M EUR in 2002 to 30M EUR in 2005.
- The funding agency Enterprise Ireland supported research commercialisation through a variety of policy instruments, including funds for industrial research, grants for academia-industry collaborations, aids to the creation of start-ups and seed capital funds. Its expenditure on biotechnology grew from 4.3M EUR per year in the mid 1990s to 6.4M EUR per year.

The proportion of specific and generic funding has remained stable since the 1990s at one third and two thirds of the total, respectively, but policies, which focused heavily on commercialisation in the previous decade, have widened to ensure a sound basic research base through the creation of research centres and human resources.

Besides the policy-directed instruments, the government has also devised new non-policy directed instruments that have played a complementary role (8M EUR per year or 17% of total biotechnology expenditure): a new research council supporting the broad knowledge base (IRCSET), the Health Research Board (HRB) supporting medical research and Teagasc establishing new biotechnology institutes of food and agro-biotech. Charities play a minor role, with only 0.7M EUR per year in health biotechnology.

Health biotechnology is the most important application area for policy-directed instruments, receiving more than half the total expenditure. The increase in funding for biotechnology research and commercialisation and the wide range of policy instruments used should enable Ireland to maintain or even strengthen its performance in the knowledge base, knowledge transmission and industrial development.

1. Introduction and background

1.1 General introduction

Ireland has been the fastest growing country of all the OECD countries for the last decade, with an annual GDP growth of 6.7% in 1991-2003 (OECD, 2005). After a slowdown in 2001-03, GDP growth is again over 5%. This growth is causing a major transformation of the country, with a dramatic decrease in unemployment rates and an income per capita much higher than one would expect given its innovation investment and performance (Innovation Policy in Europe 2004).

Ireland has a population of 4.0 million people with annual population growth rate of 0.8%, among the highest in Europe. This is the result of its traditional high birth rates together with new positive migration flows. Ireland has thus one of the youngest populations in Europe, which added to its good educational level, makes an attractive workforce.

The Irish economy had historically relied on agriculture, with beef and dairy products as major exports, while fisheries, forestry and mining had also been important sectors. The last decades of the 20th century saw the development of a strong manufacturing sector, and in the 1990s, the establishment of high technology industries, including microelectronics, software and pharmaceuticals. In 2003, chemicals and pharmaceuticals accounted for 43.5% of exports and machinery and transport for 28.5% (The Economist, 2005).

A major driver behind the development of high technology industries has been the establishment of manufacturing subsidiaries by foreign companies, bringing with them high amounts of Foreign Direct Investment (FDI). The net cumulative inflow for 1990-2003 was US$ 96 800M (OECD, 2005), the highest of the OECD, for a country that has a GDP of 149 000M EUR in 2004 (EUROSTAT). The ratio FDI inflow/GDP in 2003 was 19.4%. Ireland has been particularly successful at attracting US manufacturing firms. In order to remain an attractive country for investors, corporation tax was reduced from 20% to 16% in 2002 and then to 12.5% in 2003.

This concentration on manufacturing by foreign owned companies, representing 49% of manufacturing employment (OECD, 2005), has led Ireland to have a big trade surplus (US$89 600M exports vs. US$51 800M imports), but also an important deficit in the services and incomes account, with a small deficit, of 1.4% of GDP in the current account.

The rapid increase in GDP had not been matched up to 2001 by an equal growth in investment in R&D. As a result, gross R&D expenditure (GERD), in spite of its increase in the early 90s, was reduced in relative terms from a 1.32% of GDP in 1996 to 1.12% in 2002. The same pattern is observed for Business Expenditure in R&D (BERD), which achieved its maximum of 0.93% of GDP in 1996, and then fell back to 0.79% in 2004 (Source OECD, 2005). However, in absolute terms both GERD and BERD have kept increasing. These figures may underestimate the Irish efforts, since as a result of transfers within transnational companies established in Ireland, Irish GDP could be estimated to be 20% higher than Irish GNP. Thus, Irish government

estimates its R&D expenditure as 1.4% of its GNP – which still remains far below the EU mean.

1.2 Characteristics of national S&T and innovation system

The situation outlined above suggests that in Ireland there has been a growing mismatch between its highly productive industry and highly trained population, on the one hand, and its private and public level of investment in R&D on the other. This gap has been recognised by the Irish government, which has engaged since the late 80s in a major re-organisation of public sector research.

In 1987, an Office of Science and Technology (OST) was established by the Science and Technology Act within the Department of Enterprise, Trade and Employment (DETE). Under the OST, programmes in advanced technology (PATs) were devised, expenditure on R&D received a major boost in the early 90s and funding agencies for R&D were developed, including the Health Research Board (1987), Teagasc (1988) and the Marine Institute. The Culliton review (1992) and the Industrial Development Act that followed, resulted in the creation of Enterprise Ireland (at the time called Forbairt) for the promotion of technological development in industry, and Forfás as a board for the coordination of industrial, science and technology policy (Martin, 1999).

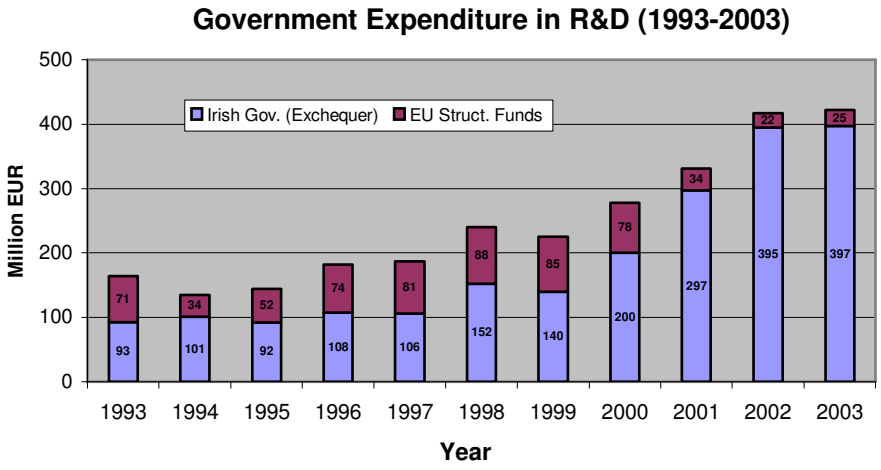
The White Paper on Science, Technology and Innovation of 1996 stressed the promotion of business investment in R&D as a key role of public policies for technology. In 1999 a Technology Foresight Exercise proposed that Ireland focus its R&D on two major national priorities: biotechnology and ICT.

Since 2000, the most important developments for science and technology have fallen under the umbrella of the massive National Development Plan (NDP), which aims to invest 57 000M EUR during its seven years of duration (2000-2006). It claims to be the most ambitious plan Ireland has ever embarked on. Its objectives include improving the infrastructure, developing a high-skilled workforce, enhancing competitiveness and promoting social inclusion. It is mainly funded by the Irish Exchequer (90%), with a significant contribution from the EU: 3 800M EUR from Structural and Cohesion Funds and 2 200M EUR from the CAP Rural Development Plan.

One of the focuses of the NDP is the creation of a "highly innovative, knowledge-based economy that is internationally competitive" in Ireland. Thus, Research, Technological Development and Innovation (RTDI) has been allocated 2 500M EUR (of which 1 500M EUR is reserved for industrial development activities) from the 7 300M EUR given to the Productive Sector Programme of the NDP.

This investment has allowed a doubling of GOVERD from 1993 to 2003, in spite of the reduction in EU structural funds, which were 40% of Irish GOVERD in 1993 and now only represent 5% of public R&D expenditure (see Figure 1.1).

Figure 1.1 Government Expenditure on R&D in Ireland – Irish Exchequer and EU structural funds contribution.



In spite of keeping the focus on R&D for strategic industrial interests that has characterised Irish S&T policy since the 80s, the NDP seems to represent an important policy change for its appreciation of the importance of nurturing a broader scientific and academic base in order to cater for the human resource and knowledge needs of the high-technology sector.

Thus, under the aegis of the NDP, the Science Foundation Ireland (SFI) was founded in 2000 with a budget of 646M EUR for the promotion of basic research in strategic technologies (ICT and biotechnology) and the Higher Education Authority developed its Programme for Research in Third Level Institutions (PRTLI), with a budget of 605M EUR for 2000-2006. The Irish Research Councils for Science, Engineering and Technology (IRCSET) and for the Humanities and Social Sciences (IRCSSH) came into existence in 2000 and 2001, respectively in order to provide competitive grant schemes for generic research.

Recent government developments since 2004 include the establishment of a Cabinet Committee on Science and Technology, supported by the Inter-Departmental S&T Committee and the appointment of a Chief Science Adviser, who will report to the Cabinet.

The upgrading of Irish basic science has also been expressed in the membership of Ireland in international scientific bodies. For example, IRCSET and IRSSH joined the European Science Foundation soon after their creation, and Ireland joined the European Molecular Biology Laboratory (EMBL) in 2004.

1.3 National support and framework conditions for biotechnology

The National Biotechnology Programme, started in 1987 as one of the PATs, led to the creation of the agency BioResearch Ireland (BRI), which was mainly devoted to the commercialisation of R&D. In the mid-90s BRI played the central role in the promotion of biotechnology in Ireland, representing 31% of the total funding for public biotechnology R&D in the period 1994-98. It was co-managed by Enterprise Ireland and the universities. Most of BRI activities revolved around biotechnology specialist centres that were established in the main five Irish universities to act as

linkages between academic and industrial research. BRI funded its own R&D and funded contract research in the different specific fields covered by each centre. In accordance with the needs of the national industry, they were mainly devoted to pharmaceutical biotechnology on the one hand, and to food, animal and plant biotechnology on the other (Martin, 1999). The other main source of public funding for biotechnology in the 90s was Teagasc, the R&D branch of the Agriculture and Food Development Agency, although only part of its research was clearly using molecular biology (Martin, 1999). In this case, the funds were spent within the 8 laboratories of Teagasc, although cooperation with industry was strongly promoted.

With the advent of the NDP, the policies and the organisation of funding agencies for biotechnology went through a major re-adjustment, with the development of programmes that support a wider spectrum of research, from basic to industrially oriented (Senker, 2003). Since 1999, BRI stopped performing R&D and focused on technology transfer activities and later it became the Biotechnology Directorate of Enterprise Ireland, whereas the funding of basic research received a major boost and was transferred to the newly created SFI.

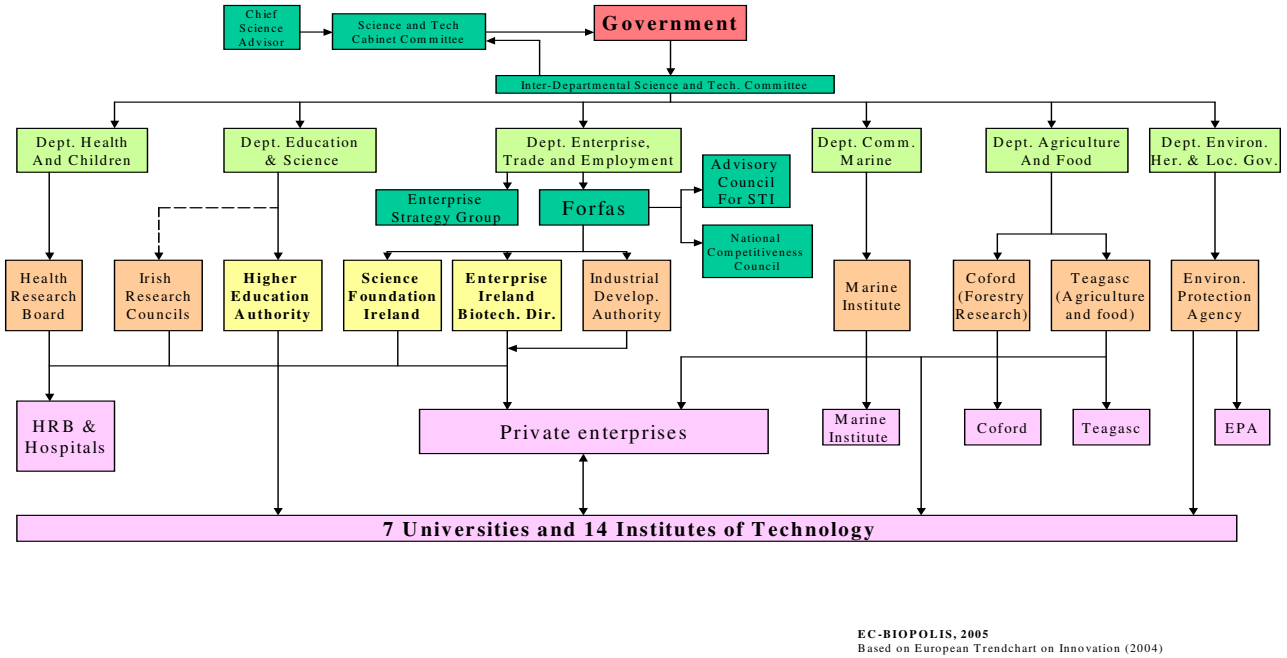
A survey of the public attitudes to new technology found that Irish respondents were quite positive in relation to the application of biotechnology to agriculture (75% of Irish respondents foresee a positive effect compared to 66% in the EU average), but mildly negative in generic terms (61% of Irish respondents foresee a positive effect compared to 65% of Europeans). In general, it appears that Irish perceptions on biotechnology tend to sit quite close to the EU average (EC, 2005).

Concerning regulations, Ireland transposed the directive 90/210/EEC on contained used of genetically modified micro-organisms into the national law under the Genetically Modified Organisms (Contained Use) Regulations, 2001 (S.I. No. 73 of 2001), whereas the directive 2001/18/EC on the deliberate release of GMOs to the environment has not been yet transposed. In 1998 and 1999 the Minister of the Environment held a public consultation concerning GMOs and the Environment, which led to a policy statement recognising the need for balance in terms of environmental protection and socio-economic considerations (Dept. Environment, 2005).

1.4 Main biotech policy and research actors

The policies for science and technology and innovation of the Irish government are organised on a sectoral basis, with each sectoral department taking charge of their sectoral research targets. Figure 1.2 presents an organisational scheme of the main policy bodies involved. However, in agreement with the main vision of research as a means of economic growth, the most relevant influential advisory bodies and funding agencies concentrate around the Department of Enterprise, Trade and Employment (DETE). This predominance is shown by the fact that the Inter-Departmental Committee for STI, responsible for setting priorities in RTI expenditure, is chaired by the Minister of DETE. As part of the NDP's new developments, the Dept. of Education and Science is playing an increasingly important role.

Figure 1.2 Actors in biotechnology policies in Ireland.



Colour codes: Light green: Government departments. Dark green: Advisory bodies. Yellow: main funding agencies for biotechnology R&D. Light brown: funding agencies with some research activities in biotechnology. Pink: research performers.

Within the DETE, the Office of Science and Technology is in charge of the development, promotion and co-ordination of the Ireland's STI policy. The appointment in 2005 of a Science Chief Advisor, with an advisory function at the cabinet level, highlights the growing importance of STI in Irish politics. Another recent development (2004) has been the creation of a new advisory group, the Enterprise Strategy Group, that aims to look at Ireland's world competitiveness.

Forfás: To date, the main advisory body in Ireland's STI has been Forfás, subordinate to the DETE. Besides advising the government, Forfás coordinates the agencies implementing the policies of industrial development, research and innovation of the DETE. Under Forfás, the Advisory Council for Science, Technology and Innovation (ACSTI), created in April 2005 as successor to the Irish Council for Science and Technology (ICSTI), is meant to work as the primary interface between stakeholders and public policy makers.

Enterprise Ireland (EI) is an industrial development agency under the DETE. It was created in 1998 as the merger of Forbairt (former development agency) and the Irish Trade Board. Its mission is to "help Irish companies to grow and sustain positions in global markets producing innovative, high value products and services". It focuses on 5 areas of activity of the national enterprises:

- Achieving export sales
- Investing in research and innovation
- Competing through productivity
- Starting up and scaling up
- Helping enterprises link with regional resources

Enterprise Ireland has a specific *Biotechnology directorate* which has taken over the role of BioResearch Ireland in promoting technology transfer in biotechnology and start-ups by Irish enterprises. Thus, although most of Enterprise Ireland's aid and services to firms are generic, biotechnology is set as one of the priority areas. Enterprise Ireland runs the majority of grant schemes that fund industrial research or support start-ups. Details of the programmes will be presented in section 2.

The **Industrial Development Agency (IDA) Ireland** aims to attract inward investment in manufacturing and internationally traded services, both through the establishment of new foreign subsidiaries or through the expansion of those already present. Although it has an important role, we will not consider it in this report because it does not directly manage any funding scheme.

Science Foundation Ireland (SFI), aims to fund excellence in basic research in those areas deemed of strategic importance, namely ICT and biotechnology. Founded in 2000 and established as a statutory body in 2003, the significant budget allocated to SFI illustrates a major change in Irish STI policies towards stronger support for basic research.

The **Higher Education Authority** is the statutory planning and development body for higher education and research in Ireland. It has both advisory powers and funding authority for the higher education sector. Under the NDP its role as a research funding agency has been re-inforced through the Programme for Research in Third Level Institutions (PRTLI).

The **Irish Research Council for Science, Engineering and Technology** (IRCSET) and for the **Irish Research Council for Humanities and Social Sciences** (IRCSSH) were created in 2000 and 2001 as funding agencies for generic, i.e. non-directed basic research. Their funding is significantly lower than that of the agencies presented above (10.5M EUR and 8.0M EUR in 2003 for IRCSET and IRCSSH, respectively). These research councils represent a new development in the Irish scientific system.

Finally, there are funding agencies linked with specific sectoral goals of other ministerial departments. In the case of Ireland, with a tradition in agriculture, fisheries and forestry, the other main actors are the funding agencies related to:

- Medical research: **Health Research Board** (HRB) dependent on the Department of Health and Children, with a budget of 24M EUR in 2003.
- Agriculture and food research (**Teagasc)** and forestry research (**Coford**), under the Department of Agriculture and Food.
- Marine research (**Marine Institute**) under the Department of Communications, Marine and Natural Resources.
- Environment (**Environment Protection Agency – EPA**) under the Department of Environment, Heritage and Local Government.

In conclusion, in broad brush, one may view the Irish National System of Innovation as benefiting from four types of public research funding (Hynes, 2004):

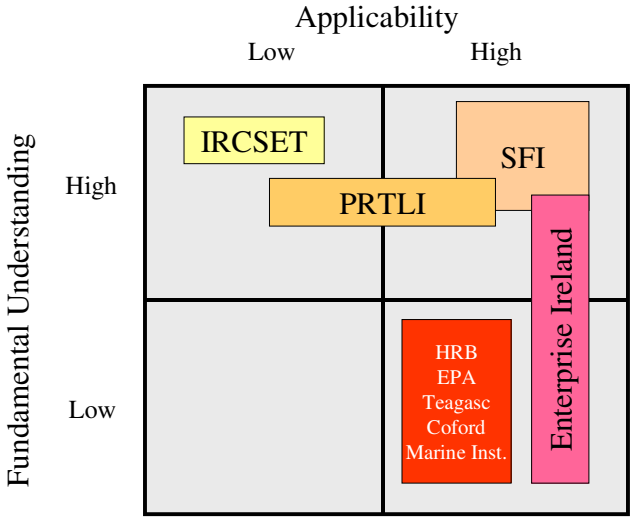
a) Block grants awarded to higher education institutions making the base of the system.
b) Generic competitive grants awarded to researchers (mainly through IRCSET and IRSSH, as well as the basic research grants of SFI) and the funding allocated by PRTLI to help third level institutions to formulate and implement strategic research goals.
c) Grants for applied research aimed at specific sectors with a specific socio-economic function (EPA, Teagasc, Coford, Marine Institute, HRB).
d) Competitive grants awarded to application-targeted research directed at the national strategic goals (EI, SFI and to some extent HRB as well).

A similar interpretation of the policies arises from the use of Pasteur's quadrant analysis (see Figure 1.3).

One of the aspects stressed by the NDP is the promotion of a more even distribution of economic activity among Irish regions (NDP, 2000). However, regional actors such as the regional development agencies (e.g. Shannon Development) do not represent a significant source of funding, in spite of their role in the creation of linkages between local players

of academia and industry, and we will not consider them in this report. Some of the instruments presented below incorporate regional policy aspects in two forms: higher percentage of government funds in industry grants for less entrepreneurial regions, and basic research matched to regional industrial strengths.

Figure 1.3 Analysis in terms of Pasteur's quadrant of the role of funding agencies in the Irish system of innovation.



2 Funding for biotechnology R&D, transfer and commercialisation

2.1 Introduction

This report reviews the funding of biotechnology research and commercialisation. In the report we make a distinction between policy-directed funding and non-policy directed funding of biotechnology.

Policy-directed funding includes funding which is directed by explicit policy decision making about installing a specific instrument, such as specific R&D programmes, programmes encouraging collaboration, industrial research grants, support for centres of excellence, support for commercialisation of research, support for start-ups, programmes encouraging mobility of researchers, programmes with open calls, etc. This policy-directed funding can include biotechnology specific policy instruments and generic policy instruments. Biotechnology specific policy instruments are instruments that have been specifically set up to stimulate biotechnology. Generic policy instruments are instruments that are not dedicated to a specific technology, but which in principle stimulate all technologies, also including biotechnology. In the BioPolis project, only those generic instruments are included if a reference is made to (the stimulation of) biotechnology activities in the policy of the funding organisation that runs the program, or of the ministry/government department that funds the funding organisations or that runs the program itself.

Non-policy directed funding of research includes funding which is part of the structural governmental support for scientific education, research and research infrastructure. This type of funding is mainly given through block grants to universities and (government) research institutes, the open-call system of research councils etc. Research councils, research institutes and government research institutes develop their own programmes through which biotechnology may be supported. In the BioPolis project only the funds for block grants to (government) research institutes and through the open-call system of research councils are included.

In this chapter the funding of biotechnology research through policy and non-policy directed instruments and of biotechnology commercialisation through policy-directed instruments is presented. Data were collected through desk research (publications, documents, websites of national public funding organisations and/or government departments), surveys completed by representatives of funding organisations that manage the generic and biotech specific programs, interviews with representatives of organisations that are involved in non-policy directed and policy-directed funding. The websites of the funding organisations and their programs and the names of contact persons that participated in surveys and/or who have been interviewed can be found in Annex 3 (List of Contact Persons), in footnotes and in Annex 4 (References). Section 2.2 presents the non-policy directed funding and section 2.3 the policy-directed funding. Charities also play an important role in funding of biotechnology research in some countries; they will be addressed in section 2.4. The final section provides a short

overview of the European funding of biotechnology research in Ireland through the 6th Framework Program.

2.2 Non-policy directed funding for biotechnology research

Table 2.1 summarises the funding organisations responsible for non-policy directed funding for biotechnology research. In the period 2002-2005 they allocated 39.9M EUR to this research. The biotech research activities of each of the organisations concerned is discussed in more detail below.

Table 2.1 Non-policy directed funding of biotechnology research

Funding organisation		Period	Funds M EUR
HRB	Response Mode	2002-2005	19.5
IRCSET	Response Mode	2002-2005	6.4
Teagasc	Public Research Institute	2002-2005	12.2
Marine Institute	Response Mode	2002-2005	1.3
Coford	Response Mode	2002-2005	0.4
EPA	Response Mode	2002-2005	0.2
TOTAL		2002-2005	39.9

Source: BioPolis Research

2.2.1 Irish Research Council of Science, Engineering and Technology (IRCSET)

After its creation at the turn of the century, the first initiative of the IRCSET was the "Embark Initiative", launched in June 2001 under the NDP umbrella to support students and early-stage researchers to pursue a full time career in their chosen research area. It is meant to address a relative lack of doctoral-level investigators in Ireland. It has 3 funding schemes, one at the postgraduate level, another at the post-doctoral level and a basic research grant scheme (part of which was given funds from EI, but have been managed by SFI since 2005 under the Research Frontiers Programme).

IRCSET had a R&D budget of 3.8M EUR in 2002 and 9.9M EUR in 2003, but it is scheduled to spend a total of 95M EUR by the end of the NDP. Assuming that expenditure will keep increasing in order to meet the NDP target, one can roughly estimate expenditure to be about 60M EUR for 2002-2005. Life Sciences were awarded one third of the grants in 2003, which extrapolated to the whole period yields around 20M EUR. However, since the Embark Initiative is generic and aimed at basic research, the proportion of expenditure in biotechnology is lower than in other funding agencies.

For 2002 and 2003, basic research grants totalling 1.4M EUR were allocated to biotechnology projects (10 three year projects per year) , whereas 29 projects received an average of 0.15M EUR per project for 3 years in 2005. On the other hand, the Embark Initiative is supporting postgraduate scholarships (in 2005 up to 13M EUR for 230 MSc and PhD for 3 years) and postdoctoral fellowships (in 2005, 4.8M EUR to 50 researchers for 2 years). Of these, an estimate of 1.2M EUR was awarded to research in

biotechnology in 2002-2005. From figures above, one can roughly extrapolate a total expenditure of IRCSET in biotechnology of 6.4M EUR for 2002-2005.

Since IRCSET is aimed at basic research, the projects funded can be mostly classified as basic biotechnology.

2.2.2 Health Research Board (HRB)

The Health Research Board is the body under the Department of Health and Children that promotes, funds and conducts medical and epidemiological research. Its research strategy comprises two strands: (a) one responsible for supporting researcher-driven investigations for developing new or improved therapies; (b) one responsible for creating an environment within the Irish health system that supports research. In this study, we will consider the funding under the first strand. In terms of policy goals, HRB supports both basic research and applied research, as well as the transmission of knowledge from academia to hospitals (as opposed to industry, as in EI).

It should be noted that, although among all the agencies funding R&D in Ireland, HRB is the only one that has not been included in the NDP, its budget for R&D increased dramatically from 6M EUR in 1998 to 21M EUR in 2002. Thereafter it has remained stable, amounting to about 87M EUR for the period 2002-2005, of which approximately 65M EUR was for research funding by competitive grants. One source of information in the HRB estimates that 54.5M EUR (63%) was spent on research related to biotechnology, with a steady increase from 12M EUR in 2002 to 16M EUR in 2005[1]. Data from an evaluation report for 2002 and 2003 (O'Donovan, 2004), suggests that 10% of the projects correspond to the area of Genomics, Proteomics and Human Disease, with another 30% from areas with an important biotechnological component such as Biomaterials, Microbiology and Molecular & Cell Biology (perhaps around one half). Thus, we put forward an estimate of about 30% expenditure in HRB for biotechnology, yielding 19.5M EUR for research funding.

Following PRTLI's strategy of allocating funds by means of open competitive calls, HRB has developed a number of funding schemes that are mostly allocated after peer-review processes. These grants include projects grants, postdoctoral fellowships, as well as dedicated posts for senior medical researchers, focusing on strengthening the links between basic biomedical research and clinical practice. Small infrastructure awards have also been created, totalling 3M EUR in 2004.

*Table 2.2Projects funded by different research committees**

Research Committees	**Projects Funded 2002-2003**	**%**
Biomaterials & Bioengineering	*6*	6%
Cancer Biology & Haematological Diseases	7	8%
Cardio-Respiratory & Renal Diseases	9	10%

[1] Given the ambiguities inherent with the definition of biotechnology, this might be an upper estimate in relation to the stringent definition we are using in the BioPolis project.

Dental & Digestive Sciences	6	6%
Epidemiology, Health of the Population & Primary Care	3	3%
Genomics, Proteomics & Human Disease	**8**	**9%**
Health Services Research & Practice Based Research	8	9%
Immunology, Pathology & Mechanisms of Disease	*11*	12%
Mental Health & Mental Illness	3	3%
Metabolism, Endocrinology & Reproductive Medicine	7	8%
Microbiology, Mechanisms of Infectious Diseases & Host Defence	*6*	6%
Molecular, Cell & Developmental Biology	*9*	10%
Neurosciences	10	11%
TOTAL	**93**	**100%**

*Genomics, Proteomics & Human Disease is the only committee with a clear biotechnology focus. We have also highlighted some other fields with an important biotechnology base (fields such as cancer biology and metabolism might also have been included).
Source: BioPolis Research

2.2.3 Teagasc (Agriculture and food development agency)

Teagasc is a semi-state body responsible for the provision of integrated research, advisory and training services for agriculture and the food industry. About 40% of the budget is devoted to research with the remainder split half and half between advisory and training services. Teagasc employs over 1,500 staff at over 100 locations throughout Ireland, with 550 advisors and regional specialists located at regional, county and local offices. Given that Teagasc receives block grants from the government, we have considered their biotechnology research expenditure as non-directed policy funding.

Currently it supports research in the areas of food processing (particularly dairy), agriculture, biotechnology and rural economics. In biotechnology the aim is the evaluation of the "the risks associated with new GM crops" and the production of "new fundamental knowledge to increase the efficiency of production of livestock, crops and innovative food products". Although Teagasc encourages collaboration with private enterprises and third level institutions, it performs most of its research in-house through 200 research scientists and 300 research technicians at nine dedicated centres. The eight colleges and local training/research centres are staffed by college lecturers, technicians and education officers.

For the period 2002-2005 Teagasc spent about 184M EUR (46M EUR per year, stable) in research of which only 12.2M EUR was specifically targeted to biotechnology in the following areas: Food (55%), Animal (20%) and Plant (25%). According to the estimate of our source, although the figures for research in biotechnology are small, they have increased substantially (300%) between 2002 and 2005[2], while Teagasc's overall R&D expenditure has remained stable since 2002.

Its research priorities within the area of biotechnology for 2004, stemming from the Food Institutional Research Measure (FIRM) devised in 2003, included (Teagasc, 2005):

- Product differentiation through the development of new flavours using biotechnology in dairy products.
- Food safety in the pasteurisation process.
- Development of probiotic cultures.
- A programme on genetic markers for beef and dairy cattle and establishment of a DNA bank for the Teagasc dairy herd.
- Assessment of environmental and biodiversity risks associated with the introduction of genetically modified arable crops in Ireland.

[2] Interestingly, for the period 1994-1998, the Inventory (1999) had estimated that Teagasc's expenditure in biotechnology to be about €17.6M, whereas for 2002-2005 we only find €12.2M in spite of a reported sharp increase! We believe that this disagreement is due to the more technical and stringent definition of biotechnology used in the EC-Biopolis project –which may leave many of the very applied practices of Teagasc outside biotechnology.

Part of the special government funding of 32M EUR over five years to improve Teagasc's research infrastructure has been used for the creation of two biotechnology centres:

- The National Plant Biotechnology Research Centre, at Oak Park Carlow, has been recently constructed with a capital investment of 3M EUR between 2002 and 2004. Its research focuses on genetic engineering in plants, including production, growth and risk assessment of GM plants. Its running costs for 2005 amounted to 0.6M EUR.
- The Moorepark Biotechnology Centre at the Moorepark Food Centre, which started in 2001 and opened new facilities in 2005, with a construction cost of 3.8M EUR and running costs of 0.7M EUR. This programme aims to provide "innovative technologies to the dairy, food ingredients, nutritional and beverage sectors", with about 75% of research aimed at food and 25% at animal biotechnology. Part of food research, however, touches the health area as well, since it looks at the health benefits of food (e.g. in probiotics). Thus, it has joined forces with University College Cork to create the Alimentary Pharmabiotic Centre, one of the CSET programmes funded by SFI.

2.2.4 Coford (National Council for Forest Research and Development)

The National Council for Forest Research and Development (Coford) is the agency for forestry research of the Department of Agriculture and Food. It was created in 1993 under the STRIDE Forestry Sub-Programme, an initiative of the European Commission. From 1994-1999, Coford supported research with the main goal of increasing the competitiveness of the forest industry.

Under the current NDP, Coford manages the Forestry Research and Technological Development and Innovation (RTDI) Measure, with a budget of 15M EUR for 2000-2006 (about 9M EUR for 2002-2005). This measure aims to support R&D that helps the forestry industry remain viable, internationally competitive and environmentally compatible with sustainable development. One of the priorities of the Forestry RTDI Measure is to encourages partnerships between third level institutions and industry.

Coford's main focus in terms of biotechnology is "investigating and developing the genetic resource of indigenous and exotic tree species to ensure that forest plantations are diverse ecosystems", which falls under the plant biotechnology area. This represents only about 3-5% of Coford expenditure, amounting to about 0.35M EUR for 2002-2005.

2.2.5 Marine Institute

The Marine Institute manages the RTDI (Research Technology Development and Innovation) Measure, which is of the one of the RTDI measures of the National Development Plan 2000-2006. Its main objectives are (i) To upgrade key national marine laboratories and facilities. (ii) To support and strengthen the RTDI capacity of Irish

industry in the marine sector. (iii) To support national marine RTDI capacity building in targeted areas.

As is the case in other sector-specific funding agencies, the Marine RTDI measure covers a broad range of policy goals, from high level research to academia-university knowledge transmission and adoption by industry of new industrial applications developed in academia. Thus, it has developed a diversity of sub-programmes that fund:

- Applied (industry) marine projects
- Strategic technology projects
- Postgraduate fellowships
- Networking
- Technology transfer.

Although the Marine RTDI has a significant budget of R&D of 52M EUR for 2000-2006, its expenditure in biotechnology is it estimated to have been 1 25M EUR out of the estimated 30M EUR available for 2002-05. In terms of areas, its main focus has been on Animal biotechnology (40%), with Health biotechnology following in importance (30%), then Environmental (20%) and Plant biotechnology (10%).

2.2.6 Environmental Protection Agency (EPA)

As part of the NDP, the Environmental Protection Agency (EPA, under the Dept. of Environment, Heritage and Local Government) was charged with the development of the Environmental Research and Technological Development and Innovation (ERTDI) Programme, which was allocated 32M EUR for 2000-2006 (about 18M EUR for 2002-05).

The EPA research programme provides funding for projects across a broad range of environmentally related areas and projects ranging in scale from desk studies and scholarships up to large scale multi-annual projects. ERTDI research issues include protection of natural resources, waste and eutrophication of inland waters. Grants are awarded on a competitive basis.

Up to now, there has been no significant expenditure on biotechnology, but EPA is currently planning to fund projects involving environmental biotechnology and possibly industrial biotechnology from late 2005. However, this will remain a small contribution – the open call of this programme will allocate 3M EUR over 3 years of which only about one fifth is expected to be environmental biotechnology.

2.3 Policy directed funding for biotechnology research and commercialisation

Policy directed funding in Ireland is carried out through three funding agencies: HEA for sustaining a broad base of research, EI for applied research and commercialisation and SFI for basic research focused on strategic and specific targets – one of which is

biotechnology. Table 2.3 summarises the instruments used by each agency and the funds allocated to them.

Table 2.3 National public policy-directed biotechnology stimulating instruments in 2002-2005.

Instrument	Funding organisation	Budget M EUR	% of total	Use of DF/SF
National				
Generic				
PRTLI	HEA	89.6	47.5	No
R&D Capability Initiative	EI	3.0	1.6	No
Innovation Partnerships	EI	1.5	0.8	Yes
RTI Initiative	EI	6.3	3.3	Yes
Comm. Fund - Proof Concept	EI	2.6	1.4	Yes
Comm. Fund - Tech. Dev.	EI	11.0	5.8	Yes
R&D Awareness	EI	0.2	0.1	No
Enterprise Platform Programme	EI	0.4	0.2	No
Technology Transfer Initiative	EI	0.6	0.3	Yes
Biotech specific				
Principal Investigators	SFI	50.4	26.7	No
Centres for SET	SFI	21.7	11.5	No
Industry Supplement	SFI	0.7	0.4	No
Workshops and Conf.	SFI	0.1	0.1	No
UREKA and STARs	SFI	0.6	0.3	No
Total		188.7	100.0	

Source: BioPolis Research

2.3.1 Science Foundation Ireland

The Science Foundation Ireland (SFI) is the funding agency charged with steering Irish science towards international excellence in those areas of strategic interest for economic growth, ICT and biotechnology. As a consequence, its policy instruments fund basic research in these areas but are aimed at the same time at producing socio-economic returns. The ultimate objective of SFI is to "assist in the re-positioning of Irish-based industry higher up the economic value chain, thereby ensuring its long-term competitiveness" by creating a base of research excellence that has strong collaborative links with local industry.

This combination of basic research with far-sighted technological ambition is best captured in the words of SFI Director General William C. Harris (www.sfi.ie): "We want to stimulate discovery and innovation and to help magnify the impact of good ideas. So we will choose among proposals based upon the assessments of scientists, who will consider the quality of the ideas and research record of the scientist or engineer—that is, the potential of the research to shape other fields and, where possible, to generate technological advances."

As outlined above, SFI was created in 2000 as a sub-board of Forfás, and in 2003 it was established on a statutory basis under the Industrial Development Act, 2003 (Science Foundation Ireland). In accordance with its dual basic-strategic research aim, its board combines leaders from academic and government bodies as well as from private enterprises performing research in Ireland and international authorities in ICT and biotechnology.

Under the NDP, SFI was assigned 646M EUR between 2000-2006. By the end of 2005, SFI had made commitments for 509M EUR, with an estimated expenditure for 2002-2005 of 320M EUR. This expenditure has been growing quickly as shown by Figure 2.1. The area of biotechnology represented about 40% of the commitments, with an estimated expenditure for 2002-2005 of 105M EUR[3]. However, the SFI definition of biotechnology includes research in life science that falls outside the definition of biotechnology used by the Biopolis project. We estimate that biotechnology represents about 70% of SFI Life Science expenditure (74M EUR).

Figure 2.1 SFI Expenditure per year

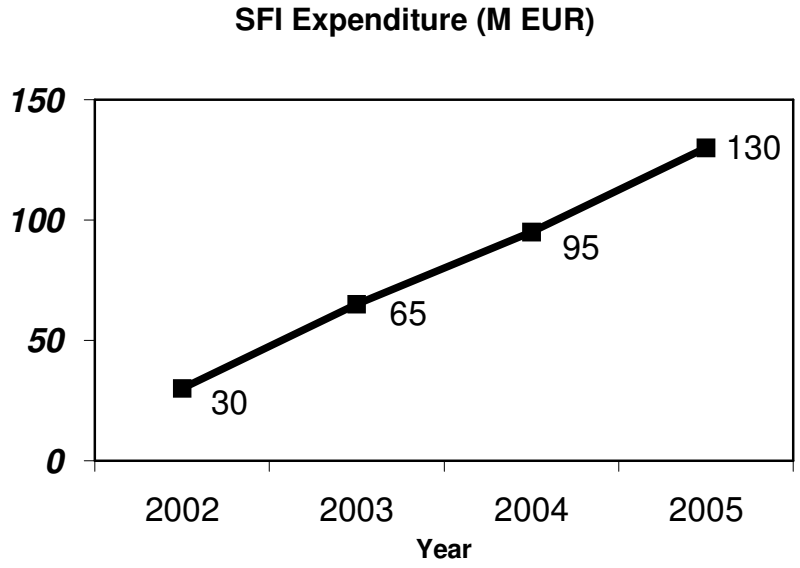


Table 2.4 Commitments of SFI to different research areas up to end of 2005

Area	Commitments (M EUR)	%
Life sciences	210	41
ICT	261	51
Frontiers (generic)	38	8
TOTAL	509	100

[3] Due to the very fast growth of the commitments, which cover a period of 3-5 years, actual expenditure is still much lower.

The difference between commitments (509M EUR) and expenditure (320M EUR) for the period 2002-2005 is due to the rapid growth of funding and the 3 to 5 years duration of most projects. Commitments have been made to many projects for expenditure after 2005. The above figure does not include Overhead Investment Plan figures.
Source: BioPolis Research

Policy instruments

In consultation with the research community throughout Ireland, SFI has established a flexible grants portfolio for investing in research that takes place within publicly funded research bodies in Ireland. The two main policy instruments of SFI are Principal Investigators awards for individual researchers and the Centres of Science Technology and Engineering Programme awards.

SFI awards portfolio for individual researchers has had a variety of grants during the period 2002-2005. We have included all the expenditure for the various individual grants under the SFI Principal Investigator instrument title in the tables. Currently the two main individual instruments are:

SFI Principal Investigator Programme: Grants for outstanding researchers. Normally ranging between 50,000 - 250,000 EUR per year for a three to four year period.

SFI Research Professor Awards: For outstanding researchers, with particularly distinguished international reputations. Awards normally range up to 2.5 M EUR over a five year period.

Other programmes to support research are the following:

Industry Supplements Programme: Collaborative projects with industry that are directly related to and enhance existing SFI peer-reviewed programmes. Normally ranging up to 50,000 EUR.

SFI Workshop and Conference Grants: Supporting significant international scientific meetings taking place in Ireland, involving Irish scientists and research bodies.

In order to achieve excellence, SFI policy instruments are strictly based on international peer review and provide generous grants. Since Ireland has traditionally exported some of its best researcher (in particular to the US and the UK) such generous conditions are designed to retain their researchers and to bring home those who have emigrated. Eventually, they hope these conditions will also attract foreign researchers to work in Ireland. For example Prof. Tim O'Brien recently returned to Ireland from the Mayo Clinic, Minnesota, US, to become director of the Regenerative Medicine Institute.

A small policy instrument of this type is the Walton Visitor Awards (about 1M EUR in 2002-2005), which were set up with the aim of bringing international researchers to

Ireland for periods of up to one year. Grants usually total 0.2M EUR per year, including salary, laboratory, and moving expenses.

The **Centres of Science Engineering and Technology** (CSET) Programme was established in 2003 in order to support the creation of clusters of research excellence by means of collaborations among researchers of different public research organisations (PROs) and between PROs and industry. Grants range from 1-5M EUR per year initially, for up to five years and support research partnerships linking scientists, engineers, and industry. Application is made by PROs and the CSET must be based on a university campus.

SFI currently funds seven CSETs, four in the ICT sector and three in Biotechnology centres, as outlined below:

- Alimentary Pharmabiotic Centre (at the University College Cork, 16.5M EUR committed in 2003) investigates the means by which intestinal bacteria influence health and disease.
- Regenerative Medicine Institute (REMEDI, at the National Univ. of Ireland, 15M EUR) is to develop a new and realisable paradigm for medicine, utilising minimally invasive therapeutic approaches to promote organ and tissue repair and regeneration, rather than replacement.
- Biomedical Diagnostics Institute (BDI) at Dublin City University was established is 2005 with a financial commitment of 16.5M EUR to develop the next-generation of biomedical devices. The diagnostic devices and sensors will aim to detect minute concentrations of disease related molecules in biological samples such as blood, saliva and breath.

Although the two programmes above are defined in terms of research agenda, the training of researchers (mainly postgraduate and postdoctoral students) is one of their main policy goals.

The fact that education is a priority is also shown by the following complementary instruments that represent a small percentage of the SFI budget, but illustrate SFI's resolve to connect the educational base to strategic basic research.

Undergraduate Research Experience & Knowledge Award (UREKA) Supplement and Sites (1.2M EUR for 2004-2005):
The purpose of the UREKA Supplement is to fund outstanding undergraduate students (from Ireland and abroad) to carry out challenging and meaningful research within a designated UREKA site for a duration of 10-12 weeks during the summer months. The research project should give the students an opportunity to extend themselves intellectually, unrestrained by the limits of their degree courses and to work closely with researchers, post-docs and PhD students. In parallel, SFI fund research groups at UREKA sites to provide UREKA students with a challenging research environment and events aimed at stimulating their interest in science or engineering and equipping them with the skills and knowledge needed to pursue a career in these areas It is expected that UREKA

Sites will become a powerful tool for attracting very highly motivated undergraduates who would provide a pool of high calibre potential PhD students.

Secondary Teacher Assistant Researchers (STARs) (1.0M EUR for 2004-2005)**:**
This programme is an initiative through which teachers can receive support to conduct research within SFI-funded research team during school holiday periods for up to eight weeks. Teachers receive the equivalent of up to two months' salary for their participation in the programme. The goal is to help teachers renew their interest in science as researchers, connect them with faculty in the universities and institutes of technology, and enhance the teaching of science across the educational system. The primary aim of the programme is to disseminate new skills and knowledge to teachers.

Application areas

SFI funds for biotechnology support basic research underpinning phenomena that may have applications in biotechnology. It has classified its investment per research area into the following categories:

Table 2.5 Breakdown of SFI investment in research areas in life sciences

Research Area	Commitments to end 2005 M EUR	%
Molecular/Cell Biology	48.8	28
Sensors, Devices	27.4	16
Neuroscience	23.5	13
Agri-Food	22.7	13
Bioinformatics – Systems Biology	25.7	15
Immunology	20.3	12
Microbiology	6.5	4
Nanotechnology (attributed to ICT expenditure)	n.a.	--
TOTAL	174.9	100

Source: BioPolis Research

Of these areas, *Neuroscience* is not included in Biopolis' more stringent definition of biotechnology, whereas a significant percentage of *Molecular/Cell Biology* may not be directly related to biotechnology. In consequence, we estimate that around 70% (between 60% to 80%) of SFI funding for life science can be attributed to biotechnology. This yields a total commitment of 174.9 M EUR for the period 2002-2005[4]. In terms of areas of research, SFI estimated that about 20% fall within Plant and Animal biotechnology, whereas the remaining 80% is evenly split among Health, Food, Basic, Non-technical and Industrial biotechnology.

[4] Part of these commitments are for projects that will end as late as 2008.

2.3.2 Programme for Research in Third Level Institutions (PRTLI)

The Programme for Research in Third Level Institutions (PTRLI) is the leg of the NDP aimed at strengthening the research capacity of third level institutions in key research areas – namely biosciences and biomedicine and ICT, in accordance with the NDP strategic goals. Whereas SFI funding is mainly directed to principal investigators, PRTLI supports the implementation of strategic planning by institutions with both capital and recurrent investment to improve infrastructure, research programmes, graduate output and conditions for interdisciplinary research. It was first launched in 1998 and is managed by the Higher Education Authority (HEA) under the Department of Education and Science.

Initially the PRTLI had total funding of 605M EUR between 2000-2006, with 404.3M EUR in capital investment (buildings and equipment) and 200.7M EUR in research programmes and people. However, capital funding was suspended between mid-2002 and the end of 2003, and the programme has now been extended until 2007. From these data we may estimate that for the period 2002-2005, the PRTLI has spent a total of 382M EUR, or 63% of the budget of the programme, with 232M EUR in capital investments (i.e. 57% of total capital) and 150M EUR in current expenditure (75% of total current). Following NDP priorities for ICT and biotechnology, almost half of its budget (295M EUR) is targeted at bioscience and biomedicine. Funding is allocated on a competitive basis among the universities and institutes of technology of Ireland.

Programmes with an important biotechnology component are listed in Table 2.6. For the 2002-2005 period we can estimate a capital expenditure of 45.5M EUR and a current expenditure of 44.1M EUR, making a total of 89.6M EUR. The programmes with higher funding are those related to biomedical activities – although a detailed inspection at the centres reveals that each of them has a more diverse range of research than one might presume from their names.

We should like to stress the approximate character of these data. Thus, some of the research performed in the centres included may be life sciences but not biotechnology, whereas many bioscience centres not listed have some activities in biotechnology. For example, we have not included the Dublin Molecular Medicine Centre (with 26M EUR funding), on the basis that it *exploits* biotechnology rather than developing it, in spite of its activity in pharmacogenomics.

Another aspect worth noticing is that 3 out of the 8 programmes (about 10% of funds) that have been classified as biotechnology are not part of the biosciences investment. Thus the National Centre for Sensor Research falls in the Chemical and Physical Sciences category and there are two small programmes in environmental biotechnology.

Table 2.6 Programmes supported by the PTRLI with an important biotechnological component (2000-2007).

Programme	**Capital (M EUR)**	**Curr. (M EUR)**	**Total (M EUR)**	**Application Area**
Institute for Bioengineering and Agroecology (National University of Ireland, Maynooth)	4.4	1.1	5.5	Plant 5.5 (4%)
Biotechnology and Environmental Science research (Institute of Technology, Carlow)	0.2	1.0	1.2	Environment 3.6 (3%)
Ecotoxicology Programme (Cork Institute of Technology)	1.2	1.2	2.4	
Polymer and Molecular Research (Athlone Institute of Technology)	1.3	1.0	2.3	Basic 13.3 (10%)
National Centre for Sensor Research (Dublin City University)	9.3	1.7	11.0	
National Centre for Biomedical Engineering Science (National University of Ireland, Galway)	23.4	8.9	32.3	Health 111.4 (83%)
National Institute of Cellular Biotechnology (Dublin City University)	18.5	15.8	34.3	
Programme for Human Genomics (Trinity College Dublin, University College Dublin and Royal College of Surgeons)	18.5	26.3	44.8	
TOTAL	**76.8**	**57.0**	**133.8**	
Total 2002-2005 (Estimate) (% respect of 2000-2007 expenditure)	**45.5 (59%)**	**44.1 (77%)**	**89.6 (67%)**	

Source: BioPolis Research

These programmes illustrate that, although this investment comes under the umbrella of the Higher Education Authority, the priorities of the PRTLI are improvement to the research capacity of the universities and support for interdisciplinary research rather than the creation of new educational programmes.

2.3.3 Enterprise Ireland

Enterprise Ireland (EI) is the state agency under the Department of Enterprise, Trade and Industry that is charged with assisting industry development. In consequence technology development it is one of its main goals. EI had a budget in 2004 of 226M EUR of which 107M EUR was for financial support to industry, whereas 66M EUR (estimated) was for science ant technology (EI, 2005a; Forfás, 2004). However, some of the programmes of EI are funded by other agencies, such as IDA Ireland or partly managed by regional agencies such as Shannon Development.

Although EI represents an important part of the NDP expenditure for R&D, its design has not resulted in an upsurge of funds as it is the case for PRTLI or SFI. EI has developed a number of policy instruments that cover the promotion of applied research, the transmission of knowledge from academia to industry and its adoption for new applications, as well as firm creation and business investment in R&D. Its new research priorities continue to be centred on the upgrading of Irish industry and its increasing

collaboration with Irish PROs, to make it a world-class technology player in key niches – this is presented in the report "Enterprise Ireland Strategy 2005-2007 : Transforming Irish Industry" (EI, 2005b).

As it is the case for the great majority of policy-directed programmes in Ireland, EI programmes are allocated on a competitive basis. The major programmes are described below.

R&D Capability Initiative
It provides R&D funding for investment in projects by industry that represent a significant "step-up" in the development of the firm's R&D function. Expenditure may be used for R&D staff, equipment and facilities, and EI also may acquire some shares of the firm being financed. In 2000-2004 it invested 47.7M EUR in equity and awarded 123M EUR in funds and facilities to 302 firms. We estimate that for the period 2002-2005, this will amount to 52.8M EUR in equity investment and 131.5M EUR in recurrent costs and facilities awarded to 303 firms. However, of this it is estimated that only 2.1M EUR in equity and 0.9M EUR in funds was spent by firms active in biotechnology during the period 2000-2004 (a total estimate of 3.2M EUR in 2002-2005). These low figures appear to be partly due to the fact that these grants have to be completed in 2-3 years after approval, which is considered a short time for a biotechnology firm.

Seed and Venture Capital Programme:
Under the 1994-1999 Operational Programme for Industrial Development, the EU Seed and Venture Capital Measure was established 'to provide early stage, small and medium-sized growth oriented enterprises with equity capital'. Between 1996-1999, this EU-funded measure allocated 43.9M EUR to 16 Irish funds, raising in total 78M EUR in Ireland by 1999 and 123M EUR by 2004. However, only 4.5% of this amount was invested in biotechnology firms.

Under the NDP for 2000-2006, Enterprise Ireland has committed 98M EUR (to be added to 310M EUR committed by private investors) to continue to develop its capital market for SMEs, with new funds that addressed the weak points of the former measure: need for early stage and small investments, greater regional perspective and promotion of sectors difficult to finance such as biotechnology. In this direction in 2001 and 2002, two funds dedicated specifically to biotechnology were established: the Irish BioScience Venture Capital Fund (20M EUR) and the European BioScience Fund I (12.7M EUR). Both funds have concentrated all their investment in the Seed stage, although half of the total investment made under this programme has been at the Early stage.

In 2001-2004 132.5M EUR were invested of which 25.1M EUR (19%) went to firms working in life sciences (for 2002-2005, we may estimate a total of 134.3M EUR invested, of which 25.5M EUR were for biotechnology). An inspection of the portfolio of biotechnology-specific funds yields 10 companies (77%) related to Health biotechnology (including one in probiotics that is also related to Food biotechnology) and 3 (23%) to Industrial technology (mainly sensors to be used in research institutions or industry).

Research Technology and Innovation (RTI) Initiative:
The RTI Initiative aims to bring about an increase in high quality R&D in business by supporting commercially focused, industry led projects in product and process development in a competitive basis. It concentrates on high quality, risk intensive R&D projects for SMEs and there is a maximum of 0.65M EUR for grants. There has been an annual spending of 31.3M EUR (2002-2004), from which we estimate a total expenditure of 125M EUR to 624 projects for 2002-2005. However, it is estimated that biotechnology represents only 5% of this expenditure, amounting to about 6.25M EUR for the period under study.

Innovation Partnership Initiative:
This initiative provides support for firms to undertake research projects with Irish universities or institutes of technology. Its aim is to foster or strengthen collaborations between industry and PROs. The companies have to contribute between 25-50% of the grant. Thus, the 11M EUR (1.5M EUR for biotechnology) of support given by the Irish government has resulted in projects with a value of 18.5M EUR (2.9M EUR for biotech).

Commercialisation Fund:
This fund introduced in 2003 has 3 separately funded stages:

Proof of Concept: The first phase is meant to support for 12 months individuals or small groups based on PROs to develop a product concept up to a stage where the route to commercialisation becomes clear. It has awarded grants to 163 projects for a value of 12.5M EUR in 2003-2005, of which 2.9M EUR (36 projects) were in the area of Life Sciences. By examining a sample of projects in 2004-2005, we have estimated that about 20% of all projects are related to biotechnology. 80% of the biotechnology projects fell under the Life Science category, whereas the remainder fell under other topic areas like Information Technology.

Technology Development: The second phase focuses on support to the development of technologies that in the medium term can become the basis of new business or generate licensing agreements. Consequently it funds projects where the underlying technologies are trustworthy and have a market. It allocates up to 0.35M EUR to each project for up to 3 years – an amount that will increase to 0.5M EUR in future calls. From the list of projects 2002-2005, we estimate that about 25% of the projects deal with biotechnology, yielding about 11M EUR of the total estimate of 44M EUR[5] allocated by this programme in 2002-2005.

Commercialisation of R&D: The third phase aims to bring new product ideas or business ventures with innovative technologies from PROs to the market. The funding is available for entrepreneurs based on a university campus for commercialisation activities such as

[5] Estimate: every year 40 projects at an average of €0.3M for 3 years, totals €12M per year. Since the programme started in 2001, 2002 expenditure was only €8M, making €44M for 2002-05.

undertaking market research, cost analysis and financial projections, or searching for potential joint venture partners. Grants are for a maximum of 38,000 EUR over 3 years[6].

Industry-driven Research Initiative:
This is a new programme that will start at the end of 2005. It incorporates two novelties with respect to other EI funding schemes. The first particularity is that the areas to be funded are decided after inviting representatives from industry to explain their research needs. The second novelty is that instead of an open call for competitive grants, this programme will be a tender aimed at fulfilling the specific needs identified by industry that EI considers to be in the national strategic interest. This research initiative will be open to both industry and third level institutions. As it is a fund dedicated to commercialisation, biotechnology will be one of the areas specifically targeted.

EI also has several minor initiatives:

R&D Awareness Initiative:
This instrument is meant to help firms with limited investment in R&D to understand their possibilities to do more. Enterprise Ireland offers 3 days technical consultancy to help:

a. Establish an R&D strategy and identify appropriate projects.
b. Develop a project plan.
c. Apply for funding.

Only firms with R&D spending of less than 65,000 EUR now or 130,000 EUR during the last 3 years are eligible.

The R&D Awareness Initiative has a cost of about 0.9M EUR per year (3.6M EUR for 2002-2005).

Enterprise Platform Programme:
This one-year full time training programme is aimed at supporting entrepreneurs who are about to establish a start-up firm. Participants are expected to have both some higher education and practical experience in the field of their innovative activity. Besides training, the programme includes a number of resources or support services such as access to incubation units, meeting facilities, or counselling. This programme is funded by the Higher Education Authority on the academic side, while EI provides additional funding to help a selection of these entrepreneurs to initiate their start-up projects. The EI contribution is approximately 2.2M EUR per year. Participants from the life sciences are estimated to represent only about 5% of participants. It is worth noting, that in the other training programme of Enterprise Ireland, the Innovation Management Initiative (not presented here), the participation of biotechnology industry is also considered to be marginal.

[6] No data is available concerning the total expenditure of this instruments. We estimate that it is negligible compared to other instruments.

Intellectual Property:
Enterprise Ireland gives advice on the protection, development and commercialisation of patentable technology. In appropriate cases, it may as well provide financial aid for the costs associated with patenting.

Technology Transfer Initiative:
This initiative aims to act as a gateway for firms by facilitating access to the expertise and resources of the universities that form the Atlantic University Alliance: University College Cork, The National University of Ireland, Galway and University of Limerick. Its objective is to develop the capabilities in local industries through the strengthening of industry-university links. In terms of specialisation Cork focuses on food, and Galway on health biotechnology. The initiative has annual funding of 0.4M EUR, of which an estimated 40% is devoted to biotechnology.

Application areas and priorities of biotechnology in EI programmes

Since EI programmes are generic to all sorts of industries, and not specifically targeted to Life Sciences (although there seems to be a bias towards supporting the government's strategic priorities), it is difficult to make an estimate for expenditure on biotechnology (which seems to vary between 15% to 30% for most of the programmes for which we have been able to obtain information). Given this fact, estimates for EI on the expenditure per specific area of biotechnology become even less reliable.

Having said this, it is possible, however, to make estimates extrapolating from the programmes on which we have information. According to the Advanced Technology Research Programme in 2002 (the precursor of the Technology Development part of the Commercialisation Fund presented above) its priority subfields in biotechnology for 2002 were:

a. Agricultural biotechnology
b. Food biotechnology
c. Environmental biotechnology
d. Vaccines and immunotechnologies
e. Novel Diagnostic technologies
f. Novel therapeutics
g. Bioinformatics
h. Functional genomics

From a sample of the projects funded by this third-level programme (2001-2004), we have found that its priorities were Health (55%, related to points d. e. and f.), Food (15%), Basic (10%), Industrial (10%), Plant (5%) and Animal biotechnology (5%). However, other EI programmes aimed at industry appear to have a higher proportion of Health biotechnology (estimated at 75%) and very small share of Basic, Plant and Animal biotechnology, whereas the Food (15%) and Industrial (10%) proportion remain unchanged.

The low percentage of participation of biotechnology companies in the generic programmes that do not have biotechnology as a specific targets (e.g. the R&D Initiative or the RTI Initiative), raise the question of the suitability of such policy instruments for this high-technology sector.

2.4 Charities

In 1998 a group of charities established the Medical Research Charities as an alliance to fund and promote biomedical research in Ireland. This group sometimes collaborates with the HRB, for example to fund research into rare diseases. Within this alliance, the two largest are the Irish Cancer Society (ICS) and the Irish Heart Foundation.

The Irish Heart Foundation focuses its activity on the prevention of heart disease by creating awareness of risk factors and encouraging healthier lifestyles. Thus its activities concern mainly dissemination of information, public talks, publication of educational resources, etc. It supports a small number of research projects using about 7% of its budget, and only a few have an important biotechnology component. For 2005 we estimate the expenditure related to biotechnology to be about 50,000 EUR, which is negligible within the context of the EC-Biopolis project.

The Irish Cancer Society (ICS) is a national charity for cancer care, dedicated to eliminating cancer as a major health problem and to improving the lives of those living with cancer. It funds grants on cancer research on a competitive basis through an autonomous body within ICS, the Cancer Research Ireland, which is responsible for grant evaluation. The grants are mainly allocated to projects undertaking applied cancer research (although research can sometimes be quite basic), usually to 12 new projects every year, renewable for another 2 years.

Research expenditure by ICS has increased from less than 0.5M EUR in 1998, to 0.9M EUR in 2002 and 1.8M EUR in 2004. We estimate total ICS expenditure on research in the period 2002-2005 to amount to 6.4M EUR, of which about 40% is related to biotechnology (2.6M EUR).

Table 2.7 Overview of biotechnology stimulating instruments by charities

Charity	Duration	Budget (M EUR)
ICS	2002-2005	6.4

Source: BioPolis Research

2.5 Participation in 6th FP and use of development funds

Table 2.8 Involvement of Ireland in biotechnology/life sciences programmes of the 6th Framework Programme

Sixth Framework Programme[1] Thematic priority	**Participations as coordinator(% of total)**	**Participations as members of project teams (% of total)**
1. Life sciences, genomics and biotechnology for health	0	77 (0.9)
2. Nanotechnologies, section bionanotechnology	1 (8.3)	3 (2.8)
5. Food quality and safety	1(1.1)	38 (2.4)

[1] First and second call, all types of projects
Source: BioPolis Research

Overall the participation of Ireland to the 6th FP in biotechnology-related areas is higher than its demographic weight, particularly in bionanotechnologies and in food quality and safety. Structural funds were extremely important in the early stages of Irish biotechnology in the 1990s, but have now become a complementary source of funding.

3 Performance indicators

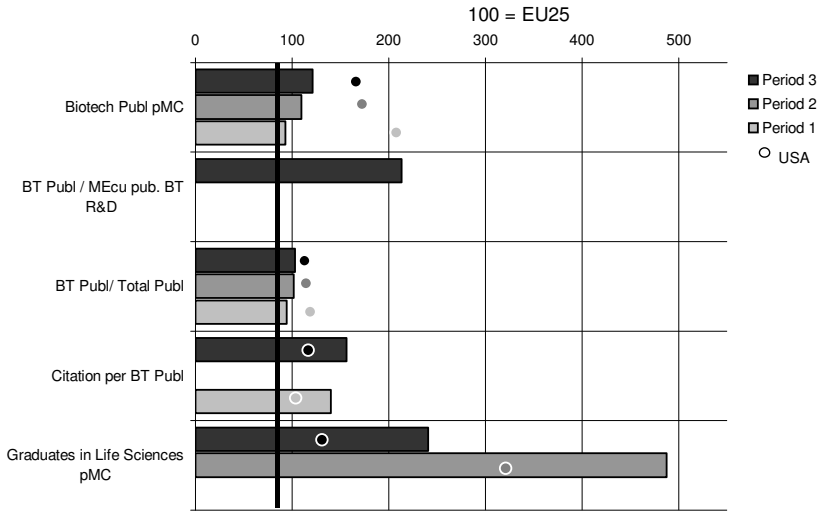
3.1 Introduction

This section analyses the performance of the Irish biotechnology innovation system for two or three time periods (depending on data availability) as shown by a range of indicators for scientific and commercialisation performance[7]. Each time period includes several years, to avoid capturing erratic trends. National trends are benchmarked against the performance of the EU25 Member States and the US.

For each area data are shown of a number of different indicators for Ireland, the USA and the EU25. The values of the EU25 have been chosen as a reference for each indicator. The absolute figures that are used to calculate the values for the indicators presented and the sources for the data can be found in Annex 5. In principle, for each indicator data are presented for three periods. The periods chosen can vary considerably between the indicators; table A.5.1 presents the specific years of each period for each indicator.

3.2 Performance in creating a knowledge base and supporting the availability of human resources

Figure 3 Performance Indicators. The knowledge base

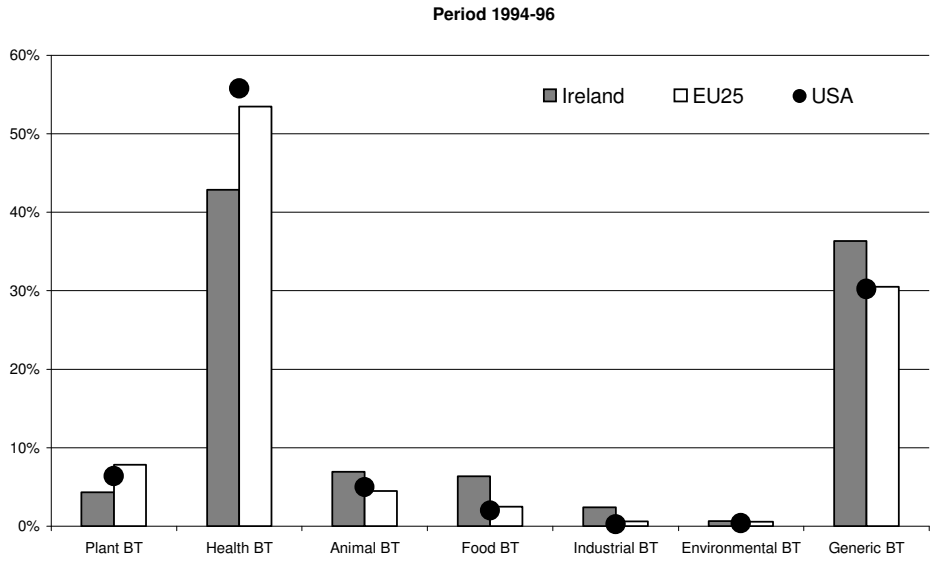


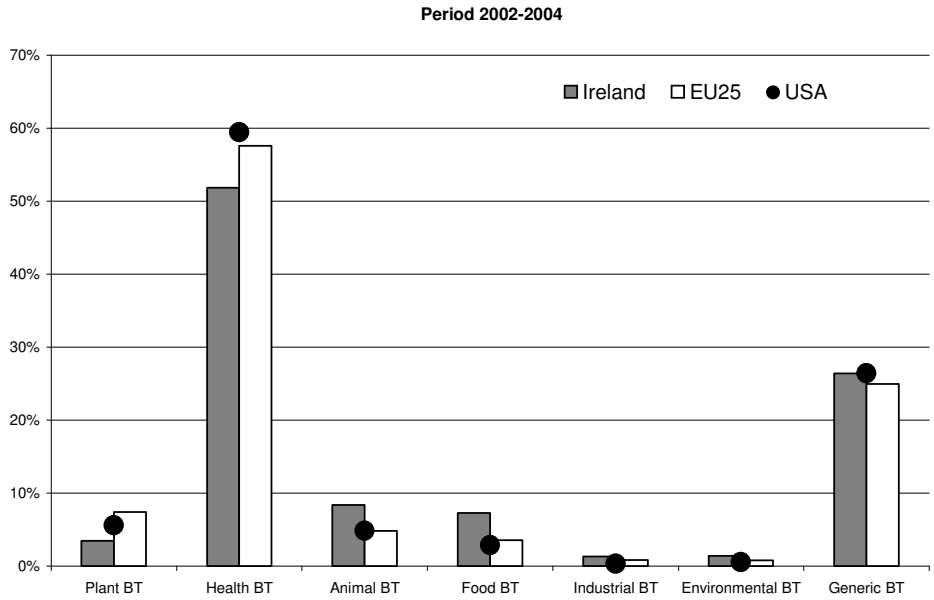
Source: BioPolis Research

[7] For a detailed discussion on the strengths and limitations of science and technology indicators see Moed et al (2004).

The Irish knowledge base has improved in the last decade in most indicators and particularly in relation to the biotech publications per million capita. The comments about the attractiveness of the youthful and highly skilled workforce made in section 1.1., are captured by Ireland's above average performance in graduates in Life Sciences pMC. Although still above the EU-25 and US average, it has declined significantly during the most recent period.

Figure 3.1 Share of biotechnology subfields

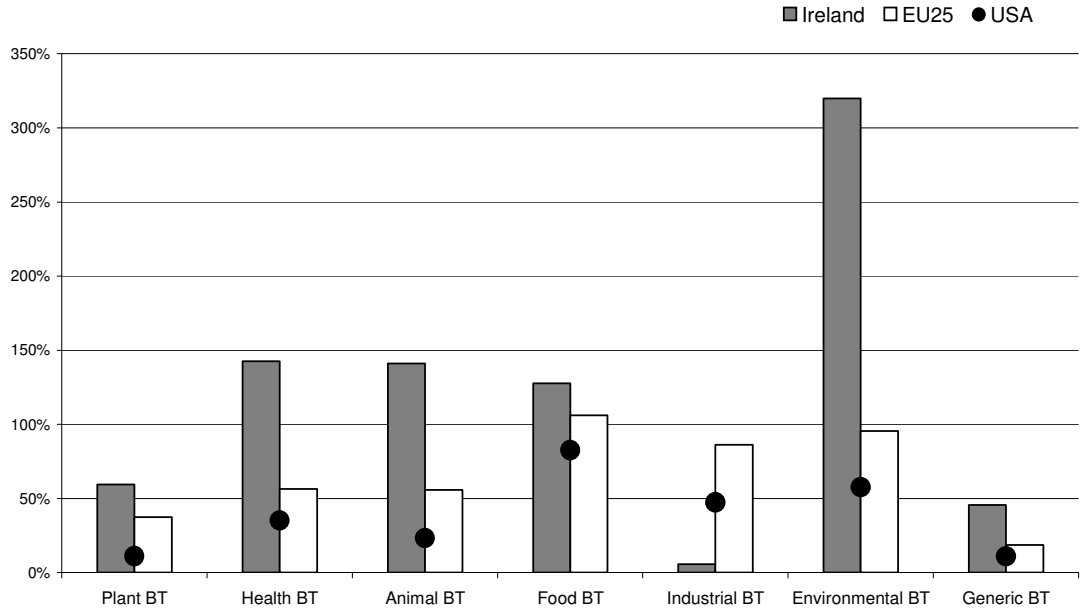




Source: BioPolis Research

Ireland's share of biotechnology fields is quite similar to the EU average, with a bit less health biotechnology and more animal and food biotechnology. This relative specialisation may be attributed to the weight of dairy products in Irish farming.

Figure 3.2 Biotechnology subfields: growth rates between 1994-1996 and 2002-2004

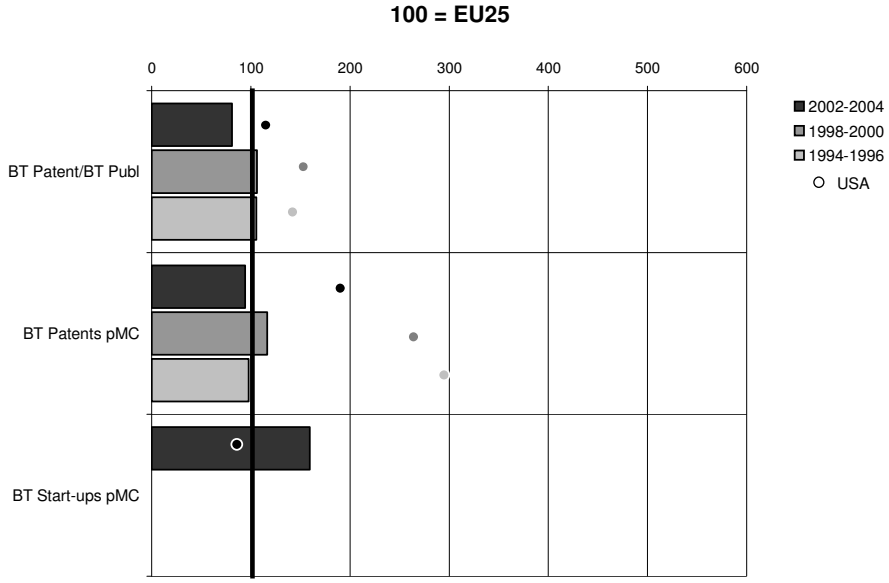


Source: BioPolis Research

In most fields, Ireland has showed a much higher growth rate than the EU average. Industrial biotechnology is the only field that does not present significant growth.

3.3 Performance in knowledge transmission and application

Figure 3.3 Performance indicators. Knowledge transmission and application

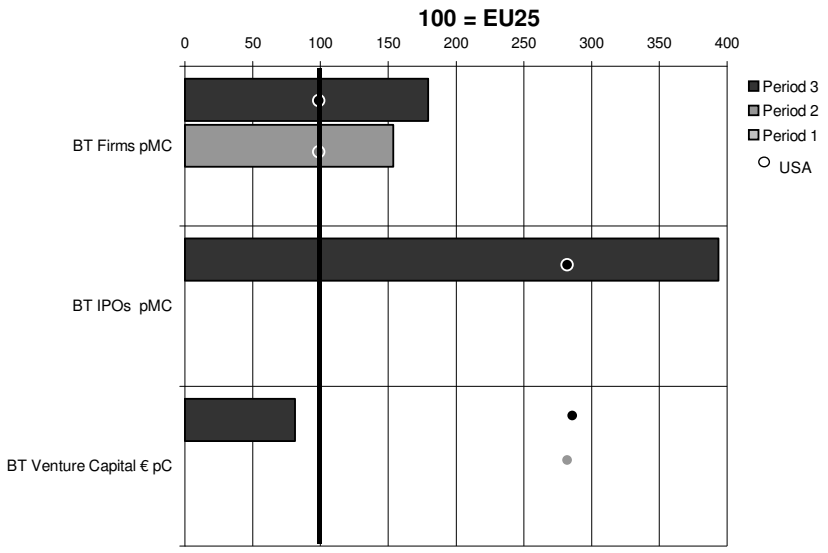


Source: BioPolis Research

Unlike many other European countries, which have a good knowledge base but low application indicators, Ireland has application base was already very good in the 1990s in relation to its scientific capabilities, considering its modest investment in R&D.

3.4 Industrial development

Figure 3.4 Performance indicators. Industrial development

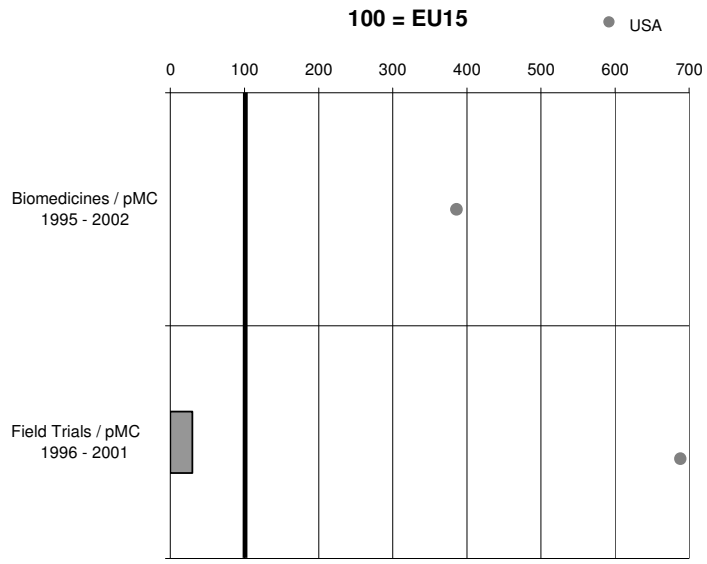


Source: BioPolis Research

Industrial development in biotechnology is also very good when compared with the low level of investment in R&D. This means that biotechnology is, together with ICT, a very important technological specialisation of Ireland.

3.5 Market conditions

Figure 3.5 Performance indicators. Market conditions



Source: BioPolis Research

Ireland has a low number of field trials for GMOs, in spite of a quite positive public perception to the use of biotechnology in agriculture.

4 Conclusions

4.1 Introduction

During the last 6 years, Ireland has been developing a new set of funding agencies and policy instruments in order to construct a solid national system of innovation that make it possible for the country to upgrade its position in the value added chain within the world economy.

Given the strength of Irish manufacturing in the pharmaceutical sector, biotechnology has been chosen as one of the strategic sectors and awarded a large amount of policy-directed funding through a new agency, the Science Foundation Ireland, whereas life-science research in general has supported through a programme targeting academic research (the PRLTI). This steep increase in funding for basic research is a complete change from the late 1990s, policies, which were orientated towards commercialisation.

Besides the policy-directed instruments, the government has also devised new non-directed instruments that have played a complementary role: the IRCSET supporting the broad knowledge base, the HRB supporting medical research and Teagasc establishing new institutes of food and agro-biotech.

4.2 Public funding of biotechnology through policy instruments

In the period 2002-2005, there is a clear trend signalling a major growth of policy directed instruments compared to non-policy directed may illustrate current developments. Within the policy-directed instruments, the increase over the years in the funding allocated to biotechnology specific instruments is due to the progressive development of the new agency SFI. Decreasing expenditure on generic policy directed instruments is mainly due to the concentration of PRTLI investments related to biotechnology to the early period of the programme (2000-2007) and should not be interpreted as a change in policy.

Table 4.1 Public funding of biotechnology through non-policy directed and policy-directed instruments in the period 2002-2005 (in M EUR)

	2002	2003	2004	2005	Total
RESEARCH					
1. *Non-policy Directed*					
Public Research Institutions	3.1	3.1	3.1	3.1	12.2
Response Mode	6.9	6.9	6.9	7.1	27.7
Total	9.9	9.9	9.9	10.1	39.9
2a. *Policy Directed Generic*					
National	28.0	28.0	18.8	14.8	89.6
2b. *Policy Directed Biotech-specific*					
National	6.9	14.9	21.8	29.9	73.5

COMMERCIALISATION[8]					
1a. *Policy Directed Generic*					
National	6.4	6.4	6.4	6.4	25.6
GRAND TOTALS	51.2	59.2	57.0	61.2	228.6

Source: BioPolis Research

4.3 Specific features of the instruments

Instruments of HEA and SFI cover PROs, whereas some of the instruments of EI cover various forms to promote PROs-industry collaboration, with grant to various combinations of the PROs, SMEs and Large Firms (LF).

Table 4.2 Participants/recipients and co-financing requirements of policy-directed programs that fund biotech activities in the period 2002-2005

Instrument	Funding agency	Participants/Recipients			Financial contribution required	
		PROs	SMEs	LFs	Recipients	Other Public authorities
National						
Generic						
PRTLI	HEA	√				
R&D Capability Initiative	EI		√	√	√	
Innovation Partnerships	EI	√	√	√	√	
RTI Initiative	EI		√	√	√	
Comm. Fund - Proof Concept	EI	√				
Comm. Fund - Tech. Dev.	EI	√				
R&D Awareness	EI		√	√	√	
Enterprise Platform Programme	EI		√		n.a.	
Technology Transfer Initiative	EI	√				
Biotech specific						
Principal Investigators	SFI	√				
Centres for SET	SFI	√			√	

Legend: PROs: Public Research Organisation. SME: Small and Medium Enterprise. LF: Large Firm.
Source: BioPolis Research

4.4 Policy goals

In accordance with the objective of upgrading Ireland's position in biotechnology research the goals of policies for biotech are biased towards basic research, collaboration among disciplines and availability of human resources. These policies are mainly implemented by the HEA in a generic way through the PRTLI, and through SFI instruments specifically for biotech. However, it is worth noting that some of SFI's

[8] The total for commercialisation policies is lower than that shown in Table 4.3 for commercialisation policy goals 5,6,7 and 9 because it reflects those instruments that were solely or mainly oriented towards commercialisation. However, many of policy directed research instruments had many policy goals, including some minor commercialisation activities.

instruments also target knowledge transmission. On the other hand, EI's generic instruments, which aim more at supporting industry and PROs-industry collaboration, represent a more modest contribution to biotechnology development in absolute expenditure.

Table 4.3 Coverage of policy goals and funding by goal by policy-directed instruments in the period 2002-2005 (in M EUR)

	Policy goals								
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
National									
Generic									
PRTLI (HEA)	√		√	√					
R&D Capability Initiative (EI)									√
Innovation Partnerships (EI)		√			√	√			
RTI Initiative (EI)					√	√			√
Comm. Fund- Proof Concept (EI)		√			√	√			
Comm. Fund - Tech. Dev. (EI)		√			√	√			
Comm. Fund –Commercial. (EI)					√	√	√		
R&D Awareness (EI)									√
Enterprise Platform Program. (EI)					√	√	√		
Tech.Transfer Initiative (EI)					√				
Seed & Vent. Capital Program. (EI)									√
Total for generic	**71.7**	**9.0**	**9.0**	**9.0**	**5.0**	**4.3**	**0.3**	**0.0**	**6.9**
Biotech specific									
Principal Investigators (SFI)	√		√	√	√			√	
Centres for SET (SFI)	√	√	√	√	√	√		√	√
Industry Supplement (SFI)	√	√	√	√	√	√			√
Workshop and Conferences (SFI)			√						
UREKA and STAR (SFI)			√	√					
Total for specific (SFI)	**33.8**	**13.9**	**9.5**	**10.7**	**5.3**	**0.3**	**0.0**	**0.0**	**0.0**
Grand Total	**105.5**	**22.9**	**18.5**	**19.7**	**10.3**	**4.6**	**0.3**	**0.0**	**6.9**

Note: The figures in this table should be read as merely indicative of the relative expenditure allocated to the various policy goals. Since many goals overlap in one instrument, the split of expenditure between goals is only a rough estimate and/or informed guess. On the other hand, it is important to bear in mind that instruments of some goals (e.g. social acceptance programmes) may require less expenditure than others even if they are set as a policy priority.

* Legend:
1 = High level of biotechnology research
2 = High level of industry-oriented (and applied) research
3 = Knowledge flow and collaboration among scientific disciplines
4 = Availability of human resources
5 = Transmission of knowledge from academia to industry and its application to industrial resources
6 = The adoption of biotechnology for new industrial applications
7 = Firm creation
8 = Social acceptance of biotechnology
9 = Business investment in R&D

Source: BioPolis Research

4.5 Biotech research application areas

The three agencies funding policy-directed instruments for biotechnology in Ireland do not target any specific field in particular. In consequence, it is very difficult to make an assessment of their areas of application and the figures in Table 4.4 should be read with caution. It appears that the research centres funded by the PRTLI are focused on health biotechnology whereas EI's instruments support commercialisation in health but also in food and industrial biotech. SFI instruments seemed to have a more diverse scope.

Table 4.4 Coverage of biotech application areas and funding through policy-directed instruments by biotech application area in the period 2002-2005 (in M EUR)

	Biotech application areas							
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**
National								
Generic								
PRTLI (HEA)	3.6	0.0	2.7	74.4	0.0	0.0	9.0	0.0
EI (all instruments)	0.7	0.7	0.0	16.6	3.8	2.5	1.4	0.0
Total for generic	**4.3**	**0.7**	**2.7**	**90.9**	**3.8**	**2.5**	**10.3**	**0.0**
Biotech specific								
SFI (all instruments)	√	√	√	√	√	√	√	√
Total for specific	**7.4**	**7.4**	**0.0**	**11.8**	**11.8**	**11.8**	**11.8**	**11.8**
Grand Total	**11.6**	**8.0**	**2.7**	**102.7**	**15.5**	**14.3**	**22.1**	**11.8**

Note: Figures in the table should be understood as rough estimates of expenditure in a given application area.

* Legend
1 = Plant biotechnology
2 = Animal biotechnology
3 = Environmental biotechnology
4 = Health biotechnology
5 = Food biotechnology
6 = Industrial biotechnology
7 = Basic biotechnology
8 = Ethical, legal, social aspects of biotechnology

Source: BioPolis Research

4.6 Stimulation of biotech activities through the instruments

Table 4.5 Coverage of biotech activities for the period 2002-2005 through policy-directed instruments

	Biotech activities															
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**12**	**13**	**14**	**16**	**17**	**18**	**19**
National																
Generic																
PRTLI (HEA)	√		√	√	√	√										
R&D Capability Initiative (EI)														√		
Innovation Partnerships (EI)								√						√	√	
RTI Initiative (EI)								√						√	√	
Comm. Fund- Proof Concept (EI)		√														
Comm. Fund - Tech. Dev. (EI)		√										√				
Comm. Fund –Commercial. (EI)											√	√				
R&D Awareness (EI)													√		√	
Enterprise Platform Program. (EI)												√				
Tech.Transfer Initiative (EI)															√	
Seed & Vent. Capital Program. (EI)											√					
Biotech specific																
Principal Investigators (SFI)	√	√		√	√	√		√		√						
Centres for SET (SFI)	√	√	√	√	√	√	√	√	√	√						√
Industry Supplement (SFI)	√	√		√	√	√	√	√		√						
Workshop and Conferences (SFI)				√		√							√			√
UREKA and STAR (SFI)	√	√			√	√										√

* Many different types of activities are supported by biotech instruments:

1 Basic research
2 Applied research
3 Centres of excellence
4 Research network
5 Mobility of researchers among disciplines
6 Biotechnology training
7 Mobility of researchers between academia and industry
8 Collaborative research between industry and public research organisations
9 Set up research institute/centre of industrial interest
10 Technology transfer office
11 Science and technology park
12 Protection of IPR in public research organisations
13 Financial support for start-ups
14 Non-financial support for start-ups
15 Creation of incubators
16 Awareness of biotech by companies not yet active in it
17 Grants for industrial research
18 Other incentives for business investment
19 Support for public discourse activities

Source: BioPolis Research

4.7 Dynamics: comparison with 1994-1998

Irish policies have made a huge leap forward in this last decade in its commitment to biotechnology, effectively increasing 6-fold its expenditure in this field. This figure has to be put in the context of a low initial figure and of the economic boom, which has allowed an increase of 70% of its GDP in 10 years. However, the leap in biotechnology funding is not the result of the moderate total increase in R&D funding, but a consequence of policies focusing on life sciences and biotechnologies.

Table 4.6 Comparison of biotechnology funding by agency in 1994-1998 and 2002-2005

Agency	2002-2005 (M EUR)	%	1995-1998 (M EUR)	%
SFI	73.5	31.8	0.0	0.0
HEA	89.6	38.8	0.0	0.0
EI	25.6	11.1	17.2	46.8
HRB	19.5	8.4	3.9	10.7
Teagasc	12.2	5.3	14.1	38.3
IRCSET	6.4	2.8	0.0	0.0
Marine Institute	1.3	0.5	0.6	1.7
Coford	0.4	0.2	0.5	1.4
EPA	0.2	0.1	0.0	0.0
ICS (Charity)	2.6	1.1	0.4	1.1
Total	231.2	100.0	36.8	100.0

Source: BioPolis Research

Table 4.7 Comparison of biotechnology research funding through non-policy directed funding and policy-directed instruments in the periods 1994-1998 and 2002-2005

Funding	Average total funding per annum for biotechnology research in 1994-1998 M Ecus	Average total funding per annum for biotechnology research in 2002-2005 M EUR
National	9.3	57.2
Total	9.3	57.2

This table combines total data for non-policy directed funding and policy-directed instruments.
Source: BioPolis Research

The proportion of specific and generic funding has remained stable at one third and two thirds of the total, respectively, but policies, which focused heavily on commercialisation in the 1990s, have widened to ensure a sound basic research base that supports the creation of research centres and human resources. On the market and industrial side, there have also been some new initiatives for social acceptance and firm creation, but without a major increase in the expenditure aimed at commercialisation. EI increased it average expenditure per annum from 4.3 M EUR in the 1990s to 6.4 M EUR in the recent period, whereas the programmes targeting basic research, SFI and PRTLI, that did not exist in the 1990s, had an average biotechnology expenditure of 18.4 M EUR and 22.4 M EUR each in 2002-2005.

Table 4.8 Coverage of policy goals by policy directed instruments in the periods 1994-1998 and 2002-2005

Presence of instruments					
Policy areas	**Policy goals**	**1994-1998**		**2002-2005**	
		G	**S**	**G**	**S**
1. Creation of knowledge base and human resources	1. To promote high level of biotechnology basic research	√	√	√	√
	2. To promote high level of industry-oriented (and applied) research	√	√	√	√
	3. To support knowledge flow and collaboration among scientific disciplines		√	√	√
	4. To assure availability of human resources		√	√	√
2. Knowledge transmission and application	5. To facilitate transmission of knowledge from academia to the industry and its application for industrial purposes	√	√	√	√
	6. To stimulate the adoption of biotechnology for new industrial applications	√	√	√	√
	7. To assist firm creation			√	
3. Market	8. To monitor and improve the social acceptance of biotechnology			√	
4. Industrial development	9. To encourage business investment in R&D	√		√	

Source: BioPolis Research

5 Future developments

To follow the National Development Plan (NDP) for 2000-2006, the Irish government is preparing a new Strategy on Science, Technology and Innovation for 2007-2013 which will be made public sometime in 2006. It appears that the government plans to keep the push towards a 'knowledge economy' initiated in 2000.

Annex 1: List of Tables

Annex 2: List of Figures

Annex 3: List of Contact persons

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Mr. John Fenessy, Coford
Dr. Mary Gillick, Enterprise Irelenad
Dr. Mary T. Kelly, Science Foundation Ireland
Dr. Lance O'Brien, Teagasc

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Annex 5: Performance

Introduction

This Annex includes the data that was used to develop the indicators discussed in Chapter 3. Chapter 3 describes four sets of indicators used to measure the performance of the national biotechnology system of innovation, in terms of:

1. Creating a knowledge base and supporting the availability of human resources: Charts 3.1, 3.2.1, 3.2.2 and 3.3
2. Knowledge transmission and application: Chart 3.4
3. Industrial development: Chart 3.5
4. Market conditions: Chart 3.6

The indicators aim to capture trends in performance and compare the national situation with that of a reference region. To present trends in performance, most indicators are provided for three or two different time periods, depending on data availability. To avoid capturing erratic trends, each time period includes several years, again depending on data availability. Information on which years have been captured for each period and comments concerning the index used can be found in the last two columns of Table A5.1.

Table A5.1. ..... Performance indicators, charts, comments and time periods

	Indicator	Chart	Comments	Time periods
Ind. 1	Biotech publications per million capita (pMC)	3.1	Index: Reference Region EU25 =100 and US data for comparison	(1) 1994-1996, (2) 1998-2000, (3) 2002-2004
Ind. 2	Biotech publications per BT public R&D expenditure	3.1	Only for those countries included in the inventory Index: Reference Region EU25 =100	T Pub. 2002-2004 / Total Pub. Expenditure 1994-1998 M Ecu
Ind. 3	BT patents / BT publications	3.4	Index: Reference Region EU25 =100 and US data for comparison	(1) 1994-1996 (2) 1998-2000 (3) 2001-2003
Ind. 4	BT publications / Total pub.	3.1	Index: Reference Region EU25 =100 and US data for comparison	(1) 1994-1996 (2) 1998-2000 (3) 2002-2004
Ind. 5	Citations to BT publications	3.1	Index: Reference Region EU25 =100 and US data for comparison Small country effect	(1) 1994-1998 (3) 2000-2004
Ind. 6	Graduates in life sciences pMC	3.1	Index: Reference Region EU17 =100 and US data for	(2) 1998 (3) 2002

	Indicator	Chart	Comments	Time periods
			comparison	
Ind. 7	BT publications in subfields, as % of total BT publications	3.2.1	Data in % EU25 and US data for comparison	1994-1996
		3.2.2		2002-2004
Ind. 8	Growth rate of BT publications in subfields	3.3	EU25 and US data for comparison Small field effect	Growth rate between 1994-96 (period 1) and 2002-04 (period 3)
Ind. 9	Biotech patent applications pMC	3.4	EU25 and US data for comparison	(1) 1994-1996 (2) 1998-2000 (3) 2001-2003
Ind. 10	Number of biotechnology companies pMC	3.5	European (data available) and US data for comparison	(2) 2001 (3) 2004
Ind. 11	Number of biotech start-ups pMC	3.4	European (data available) and US data for comparison	(3) 2001-2003 (only one period)
Ind. 12	Number of biotech IPOs pMC	3.5	European (data available) and US data for comparison	(3) 2002-2005
Ind. 13	Venture capital in € pC	3.5	European (data available) and US data for comparison	(2) 2002 (3) 2004
Ind. 14	BT acceptance index	No Chart - Discussed in text of chapter 3	Source: BT Policy Benchmarking 2005. The biotechnology acceptance index is a composite index and draws on questions Q.12, Q.13.1 and Q14.01 and Q14.09 of the Eurobarometer 58.0	2002
Ind. 15	Eurobarometer 225	No Chart - discussed in text of chapter 3	See section 3.3 and sections 3.4.1, 3.4.2, and 3.4.3 of the Special Eurobarometer 225[9]	2005
Ind. 16	Biomedicines	3.6	Source: BT Policy Benchmarking 2005 Index: Reference Region EU15 =100 US data for comparison	1995-2002
Ind. 17	Field trials	3.6	Source: Biotechnology Innovation Scoreboard 2002 Index: Reference Region EU15 =100 US data for	1996-2001

[9] http://europa.eu.int/comm/public_opinion/archives/ebs/ebs_225_report_en.pdf

	Indicator	Chart	Comments	Time periods
			comparison	

The following methodological issues are related to some of the indicators:

- Indicator 3 (Patent BT / Publications BT) replaces the indicator *BT publications basic research/ BT publications applied research*. Results of the EPOHITE project have shown that the original indicator does not differ significantly in the case of old EU member states. This might be the result of methodological problems associated with the indicator, since the definition of basic and applied research is based on a journal classification made by SCI. The explanatory power of this indicator is therefore questionable.
- To calculate the citation rate first the publications for the period 1994-1996 (set 1) were searched and all the publications in 1994-1998 that cited any publications in set 1 (set 2). Citation rate has been calculated by (number of publications in set 2) / (number of publications in set 1). However, many of the articles in set 2 cited not only one article in set 1 and these duplicated citations are not taken into account in our calculation. For example, if there are 2 articles in set 1 and they each has one citation but cited by the same article, there is only 1 article in set 2. The citation rate for the 2 articles in set 1 is 0.5 instead of 1. This depreciation is more obvious in countries with more publications such as USA and EU25 since the possibility to cite multiple articles in set 1 is large. Accordingly the citation rates of USA and EU25 are a bit underestimated.
- The indicator 'Citations to BT publications' seems to have a 'small country effect' bias. Small countries show a relatively large citation rate. A possible explanation might be that, as far as number of publications is concerned, larger countries usually have a larger 'middle quality' share of research results (in terms of impact) while smaller countries usually have a 'low in number but good in quality' publications impact. This can be explained by the concentration of resources allocated to selected research groups in small countries. Small countries may concentrate resources in outstanding research units. Accordingly, fewer publications may have greater impact.
- The EU25=100 index is applicable in the indicator 'Graduates in life sciences pMC' since data was only available for 17 member states.
- For those countries starting from zero in period 1 (1994/1996), the growth rate of BT publications in subfields was set to 100% if the number of publications in period 3 (2002-2004) was larger than zero. On the other hand, if the country reduced the number of publications to zero in the period 2002-2004, the growth rate was -100%.Given that a relative growth rate was used, small fields tended to have relatively larger growth rates.
- To benchmark each country we chose EU25 (or EU15 if data was not fully available) as the reference region. In those cases where data for EU25 or EU15 were not available, the reference corresponds to the sum of national data available. Moreover, to ease the presentation of indicators with different scales in a given chart, an index value was used.

Raw data for the Figures in chapter 3

Raw data for Figure 3.1. BT publications per million capita (pMC): absolute and indexed

	BT publications			Population (million)		
	94-96	**98-00**	**02-04**	**1996**	**2000**	**2004**
EU25	97521	128716	145646	447	451	457
Ireland	733	1182	1557	4	4	4
USA	119802	135508	154402	264	276	292
	BT Publications/pMC			**Index EU25=100**		
	94-96	**98-00**	**02-04**	**94-96**	**98-00**	**02-04**
EU25	218	285	319	100	100	100
Ireland	202	313	387	93	110	121
USA	454	492	529	208	172	166

Source: BIOPOLIS research
Publication data: Science Citation Index (through online database vendor STN International)
Population data: EUROSTAT and OECD

Raw data for Figure 3.1. BT publications per BT public R&D expenditure

	BT Publi-cations	**Non Policy Directed Funding**	**Policy Directed Funding**		**Total Public Spendin g on BT (Mecu)**	**BT Publicatio-na/ Mecu BT public expenditure**	**Index**
			Biotech Specific	**Generic**			
	2002-2004	**1994-1998**	**1994-1998**	**1994-1998**	**1994-1998**	**2002-2004/ 1994-1998**	
EU25	145646				n.a.		
Ireland	1557	12.2	14.5	18.75	45	34	213
USA	154402				n.a.		n.a.

Source: BIOPOLIS research
Publication data: Science Citation Index (through online database vendor STN International)
BT public expenditures in research: Inventory Project, Table 3.4 Executive Summary

Raw data for Figure 3.4. BT Patents per BT publications: absolute and indexed

	BT Patents			BT Publications		
	94-96	**98-00**	**01-03**	**94-96**	**98-00**	**01-03**
EU25	4924	8921	10119	97521	128716	140219
Ireland	39	87	83	733	1182	1422
USA	8590	14396	12348	119802	135508	148853
	BT Patents/ BT Publications			**Index EU25=100**		
	94-96	**98-00**	**01-03**	**94-96**	**98-00**	**01-03**
EU25	0,05	0,07	0,07	100	100	100
Ireland	0.05	0.07	0.06	105	106	81
USA	0,07	0,11	0,08	142	153	115

Source: BIOPOLIS research
Publication data: Science Citation Index (through online database vendor STN International)

Patent data: EPPATENT, WOPATENT (online database vendor Questel Orbit)

Raw data for Figure 3.1. Share of BT publications of Total publications: absolute and indexed

	BT Publications			Total Publications		
	94-96	**98-00**	**02-04**	**94-96**	**98-00**	**02-04**
EU25	97521	128716	145646	860652	1024327	1117392
Ireland	733	1182	1557	6840	9268	11566
USA	119802	135508	154402	889506	941191	1045894
	Share of BT Publication			**Index EU25=100**		
	94-96	**98-00**	**02-04**	**94-96**	**98-00**	**02-04**
EU25	11%	13%	13%	100	100	100
Ireland	11%	13%	13%	95	101	103
USA	13%	14%	15%	119	115	113

Source: BIOPOLIS research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.1. Citations to BT publications: absolute and indexed

	Citations to BT publications		Index EU25=100	
	94-98	**00-04**	**94-98**	**00-04**
EU25	6,14	7,28	100	100
Ireland	8.61	11.39	140	156
USA	6,39	8,54	104	117

Source: BIOPOLIS research
Ciatations data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.1. Graduates in life sciences pMC: absolute and indexed

	Graduates in Life Sciences		Population (million)	
	1998 / 1999	**2002**	**1998 / 1999**	**2002**
EU17	46,859**	81,316	552**	431
Ireland	1529	1772	4	4
USA	75,253*	70,950	276*	288
	Graduates pMC		**Index EU17=100**	
	1998 / 1999	**2002**	**1998 / 1999**	**2002**
EU17	85**	189	100	100
Ireland	414	454	487	241
USA	273*	246	321	131

Index EU17=100 for 1998 is EU-16, because for Portugal no data available
* data for 1998; ** data for 1999
Source: BioPolis Research
Graduates data OECD Education Database
Population source for US is the OECD

Raw data for Figure 3.2.1. Share of BT publications in subfields of total number of BT publications for the period 1994-1996

	1994-1996							
	Total	**Plant**	**Health**	**Animal**	**Food**	**Indus-trial**	**Environ-mental**	**Generic**
EU25	100%	8%	53%	5%	3%	1%	1%	30%
Ireland	100%	4%	43%	7%	6%	2%	1%	36%
USA	100%	6%	56%	5%	2%	0%	0%	30%

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.2.2. Share of BT publications in subfields of total number of BT publications for the period 2002-2004

	2002-2004							
	Total	**Plant**	**Health**	**Animal**	**Food**	**Indus-trial**	**Environ-mental**	**Generic**
EU25	100%	7%	58%	5%	4%	1%	1%	25%
Ireland	100%	3%	52%	8%	7%	1%	1%	26%
USA	100%	6%	59%	5%	3%	0%	1%	26%

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.3. BT publications in subfields for the period 1994-1996

	1994-1996							
	Total	**Plant**	**Health**	**Animal**	**Food**	**Indus-trial**	**Environ-mental**	**Generic**
EU25	97217	7629	51944	4375	2434	624	576	29635
Ireland	735	32	315	51	47	18	5	267
USA	111686	7118	62274	5580	2230	296	459	33729

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.3. BT publications in subfields for the period 2002-2004

	2002-2004							
	Total	**Plant**	**Health**	**Animal**	**Food**	**Indus-trial**	**Environ-mental**	**Generic**
EU25	140984	10494	81220	6821	5017	1162	1126	35144
Ireland	1474	51	764	123	107	19	21	389

USA	141680	7910	84234	6872	4070	436	724	37434

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.3. Growth rate of BT publications in subfields between the periods 1994/96 – 2002/04

	1994-1996/2002-2004						
	Plant	**Health**	**Animal**	**Food**	**Industrial**	**Environ-mental**	**Generic**
EU25	38%	56%	56%	106%	86%	95%	19%
Ireland	59%	143%	141%	128%	6%	320%	46%
USA	11%	35%	23%	83%	47%	58%	11%

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)

Raw data for Figure 3.4. BT Patents pMC: absolute and indexed

	BT Patents			**Population (million)**		
	94-96	**98-00**	**01-03**	**1996**	**2000**	**2003**
EU25	4924	8921	10119	447	451	455
Ireland	39	87	83	4	4	4
USA	8590	14396	12348	264	276	292*
	BT Patents/pMC			**Index**		
	94-96	**98-00**	**01-03**	**94-96**	**98-00**	**01-03**
EU25	11	20	22	100	100	100
Ireland	11	23	21	98	116	94
USA	33	52	42	295	264	190

Source: BioPolis Research
Publication data: Science Citation Index (through online database vendor STN International)
Patent data: EPPATENT, WOPATENT (online database vendor Questel Orbit).

Raw data for Figure 3.5. Number of BT pMC for years 2001 – 2004: absolute and indexed

	BT companies				**Population (x1,000)**			
	2001	**2002**	**2003**	**2004**	**2001**	**2002**	**2003**	**2004**
Europe	1879	1878	1861	1815	452016	452641	454580	456863
EU Available	1643	1650	1782	1605	319337	319484	408602	322210
Ireland	30	35	35	36	3833	3900	3964	4028
USA	1457	1472	1473	1444	285102	287941	290789	291685
	BT companies pMC				**Index**			
	2001	**2002**	**2003**	**2004**	**2001**	**2002**	**2003**	**2004**
Europe								
EU Available	5.14	5.16	4.36	4.98	100	100	100	100

Ireland	7.92	8.98	8.83	8.94	154	174	202	179
USA	5.11	5.11	5.06	4.95	99	99	116	99

Note: EU Available is the result of the sum of available EU member states
Source: BioPolis Research
Biotech companies data: Ernst and Young 2002-2004, EuropaBio

Raw data for Figure 3.5. BT start-ups pMC for period 2001-2003 and year 2003: absolute and indexed

	BT Start-ups		**Population (x1,000)**	
	2001-2003	**2003**	**2003**	
Europe (EU 15 - Cyprus - Greece + Norway + Switzerland)	523	132	367051	
Ireland	9	4	3964	
USA	355	83	290789	
	Biotec Start-up/pMC	**Index**	**Biotec Start-up/pMC**	**Index**
	2001-2003	**2001-2003**	**2003**	**2003**
Europe (EU 15 - Cyprus - Greece + Norway + Switzerland)	1.4	100	0.36	100
Ireland	1.01	281	2.3	159
USA	1.2	86	0.29	79

Source: BioPolis Research
Start-ups data: EuropaBio

Raw data for Figure 3.5. Number of BT IPO's pMC: absolute and indexed

	BT IPO	**Population T**				
	2002-2005	**2002**	**2003**	**2004**	**2005**	**2002-2005**
EU Available	29	452927	454869	457154	461593	456636
Ireland	1	3900	3964	4028	4109	4000
USA	52	287941	290789	291685		290138

	IPO /pMC	**Index**
	2002-2005	**2002-2005**
EU Available	0,00	100
Ireland	0.00	394
USA	0,00	282

Note: EU Available is the result of the sum of available EU member states
Source: BioPolis Research
IPO data: Ernst and Young 2002-2004, London Stock Exchange, Frankfurt Stock Exchange, Euronext, Nasdaq, Burril & Company

Raw data for Figure 3.5. Venture capital pC: absolute and indexed

	Venture Capital in Biotechnology companies M€			Population (x 1,000)		
	2002	**2002**	**2002**	**2002**	**2003**	**2004**
Europe	1100	920	2800			
EU Availiable	890	883	1111	315584	319663	325131
Ireland	n.a.	n.a.	3			4028
USA	2288	2498	2855	287941	290789	291685
	Venture Capital in €/pTC			**Index**		
	2002	**2003**	**2004**	**2002**	**2003**	**2004**
Europe						
EU Availiable	2.8	2.8	3.4	100	100	100
Ireland	n.a.	n.a.	2.8	n.a.	n.a.	81
USA	7.9	8.6	9.8	282	311	286

Source: BioPolis Research
VC data: E&Y Beyond Borders 2002, 2003, 2004

Raw data for Figure 3.6. Number of Biomedicines pMC

	Biomedicines	Population (Million)	Biomedicines / pMC	Index
	1995-2002	**2002**		**1995-2002**
EU15	39	378	0.10	100
Ireland	0	4	0.00	0
USA	115	289	0.40	387

Note: EU 15 is the result of the sum of the 15 old EU member states
Source: BioPolis Research
Number of medicines: Benchmarking of public biotechnology policy 2005

Raw data for Figure 3.6. Number of field trials pMC

	Field Trials	Population in M	Field Trials pMC	Index
	1996-2001	**2001**	**1996-2001**	**1996-2001**
EU15	1334	379	4	100
Ireland	4	4	1	30
USA	6745	278	24	688

Note: EU 15 is the result of the sum of the 15 old EU member states
Source: BioPolis Research
Field trials: Biotechnology Innovation Scoreboard 2002

Raw data for biotechnology acceptance.

BT Acceptance Index 2002		
	Index Average	**N (sample size)**
EU - 15*	100.29	16828
Ireland	100.28	931

*Weighted Average according to the weight "W13" of the Eurobarometer 58.2, which considers population differences among countries and corrects for inconsistencies in the national samples
Source: BioPolis Research
BT acceptance index: Benchmarking of public biotechnology policy 2005

References:

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Websites:

London Stock Exchange	http://www.londonstockexchange.com/
Frankfurt Stock Exchange	http://deutsche-boerse.com/
Euronext	http://www.euronext.com/
Nasdaq	http://www.nasdaq.com/
Burril & Company	http://www.burrillandco.com/
EuropaBio	http://www.europabio.org/
EUROSTAT	http://epp.eurostat.cec.eu.int/
OECD Education Database	http://www.oecd.org/
OECD Statistics	http://www.oecd.org/
STN International	http://www.stn-international.de/
Questel Orbit	http://www.questel.orbit.com/index.htm

Annex 6: Abbreviations

BRI ..... BioResearch Ireland
CAP ..... Common Agricultural Policy
CSET ..... Centres of Science Engineering and Technology
Coford ..... National Council for Forestry Research and Development
DETE ..... Department of Enterprise, Trade and Employment
EI ..... Enterprise Ireland
ELSA ..... Ethical Legal and Social Aspects
UREKA ..... Undergraduate Research Experience & Knowledge Award
GDP ..... Gross Domestic Product
GMO ..... Genetically Modified Organism
GNP ..... Gross National Product
GOVERD ..... Governmental Expenditure in R&D
HEA ..... Higher Education Authority
HRB ..... Health Research Board
ICS ..... Irish Cancer Society
IRCSET ..... Irish Research Council in Science, Engineering and Technology
IRCSSH ..... Irish Research Council in Social Sciences and Humanities
MRC ..... Medical Research Charities
NDP ..... National Development Plan
OECD ..... Organisation for Economic Cooperation and Development
OST ..... Office of Science and Technology
PAT ..... Programme of Advanced Technology
PRO ..... Public Research Organisation
R&D ..... Research and Development
PRTLI ..... Programme for Research in Third Level Institutions
SFI ..... Science Foundation Ireland
STAR ..... Secondary Teacher Assistant Researchers