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Canadian Biotechnology Innovation Scoreboard 06

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Science-Metrix specializes in the measurement and evaluation of science, technology and innovation. Science-Metrix data collection and assessment methods include bibliometrics, scientometrics, technometrics, surveys and interviews, environmental scans, monitoring and intelligence gathering. The company performs program and policy evaluations, benchmarking and sector analyses, market studies and strategic planning.

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Executive Summary

The *Canadian Biotechnology Innovation Scoreboard 2006* aims to analyze and evaluate specific aspects of the biotechnology field by comparing Canada with other international leaders in biotechnology. Scoreboards are designed to inform and stimulate debate among policy makers and other stakeholders. This scoreboard presents comparable, relevant and timely data on biotechnology for Canadian policy makers. The dimensions addressed in the report are:

- Scientific and technological outputs of biotechnology research;
- Level of dissemination of biotechnology knowledge;
- Commercialization of biotechnology products;
- Economic, social, and environmental impacts of biotechnology activities.

The main difficulties encountered stem from a lack of standardization and, therefore, comparability of data presented in international reports. These difficulties were addressed by adherence to the guidelines provided in the OECD *Framework for Biotechnology Statistics,* published in June 2005. Problems of category and definition were resolved to the extent possible, while problems of comparability, coherence, reporting agent, and scope of the data were used as a basis for the inclusion or the exclusion of data in the scoreboard.

One limitation of this scoreboard is that the latest data available from Statistics Canada Biotechnology Use and Development Survey are for the 2003 survey; the results of the 2005 survey are not yet available. Thus, in many cases data for Canada are not as up to date as those for other countries. As this report used 2003 data for Canada, compared to more recent data for other countries (when available), the observations and conclusions presented here hold to the extent that Canada maintains performance in subsequent years.

The 2006 scoreboard demonstrates that Canada has the fastest growing biotechnology market in the world and that it has benefited from large amounts of Business Enterprise Sector (BES) research and development (R&D) investments in biotechnology, and high-value venture capital investments. The country possesses significant numbers of biotechnology firms, BES employees and R&D employees. Furthermore, Canadian biotechnology firms can count on significant revenues and Canada has an important intellectual property (IP) portfolio. In fact, when compared to the top three world leading biotechnology countries (the US, the UK, Germany), Canada leads in five indicators and there is sufficient evidence to suggest that Canada will perform better on at least 7 indicators (especially firms per gross domestic product (GDP), BES employees, BES R&D employees, venture capital (VC), and revenues) given a 2% to 4% increase of 2004 data relative to 2003.

However, Canada has some weaknesses. For instance, relative to other countries, Canada appears to be decreasing it R&D efforts in biotechnology. Canada is also lagging somewhat with respect to the number of citation of its scientific papers. Thus, Canada's present position as a world leader in biotechnology may worsen if the observed declining scores in scientometric indicators are resulting from a drop in the proportion of biotechnology R&D employees, something not measured in this report due to a lack of timely Canadian biotechnology statistical data on inputs.

Acronyms

ARC	Average of Relative Citations
BERD	Business Enterprise Expenditures on Research and Development
BES	Business Enterprise Sector
BUDS	Biotechnology Use and Development Survey
CAD	Canadian Dollars
DBF	Dedicated Biotechnology Firm
EC	European Commission
IBF	Innovative Biotechnology Firm
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditures on Research and Development
GOVERD	Federal Government Expenditures on Research and Development
HERD	Higher Education Expenditures on Research and Development
IP	Intellectual Property
ISI	Institute of Scientific Information
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
RAC	Relative Average Citation
R&D	Research and Development
SCI	Science Citation Index
SI	Specialization Index
STI	Science, Technology and Innovation
UN	United Nations
USD	United States Dollars
VC	Venture Capital
USPTO	United States Patent and Trademark Office

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Introduction

In a recently released report, the Canadian Biotechnology Advisory Committee confirmed the importance of Biotechnology in helping Canada achieve its environmental objectives and sustainable development goals while enhancing its overall economy (Hanson *et al.*, 2006: 7). Biotechnology was identified as a potential source of long-term economic, social, and environmental benefits, helping Canada to meet sustainable development objectives such as reducing greenhouse gases and pesticide use, while providing employment and income opportunities through new value chains in a variety of industries, savings through greater material-efficient manufacturing, and health benefits resulting from reduced environmental pollution.

Many governments have developed national biotechnology policies, but because development of biotechnology for sustainable development is neither fully predictable nor well structured, the use of adaptive planning and management practices that provide information for risk management but that also entail policy adjustments was introduced. It is in this context that the use of bibliometrics and other quantitative methods offering a wide range of indicators for extensive measurement has been gradually incorporated in scoreboards over the last 10 years to enable policy makers to determine strategic objectives and evaluate publicly funded research programmes (OECD, 2005). Also, amid growing concerns over accountability in relation to public spending on science, policy makers are relying increasingly on metrics and information to monitor progress and make informed, responsible choices (Archambault, Vignola-Gagné and Bouffard, 2005).

Biotechnology scoreboards have been recognized to be valuable tools both for the diffusion of reliable information as well as for evaluation and assessment of biotechnology in specific policy areas. They include numerous indicators that are updated on a regular basis, which allow multicriteria analyses to be conducted to assist policy makers in understanding and evaluating research and development (R&D) activities and their outputs. Scoreboards in the form of statistical yearbooks and compendia that use science, technology, and innovation (STI) indicators, as well as benchmarking studies and indexes, have existed for years.

Although many of these scoreboards are useful for evaluating national systems of biotechnology innovation, it is often not clear whether the information they provide is up-to-date or how frequently it is updated (Archambault *et al.*, 2005). Moreover, although many of these reports provide overviews of biotechnology developments in selected countries, a benchmarking of countries' achievements in biotechnology, and literature reviews, they often do not address the implications of the data for specific policy areas, or the known methodological problems related to biotechnology statistics, such as data scope, reporting agents, consistency of firm type categories, and definitions of biotechnology (OECD, 2005).

Science-Metrix' first edition of the Canadian biotechnology innovation scoreboard was published in early 2006 with the clear objective of providing valuable information to policy-makers about biotechnology developments in specific countries, with a focus on comparing Canadian biotechnology activities with those of other countries. This second edition of Science-Metrix'

Canadian biotechnology innovation scoreboard updates this information, based on the most recent biotechnology statistics available.

The Canadian biotechnology innovation scoreboard takes into account the value of each indicator for specific policy areas, and their specific meaning for the Canadian biotechnology field. The indicators fall into three categories and are described in the three sections of this report: Section I, Scientific publications in biotechnology; Section II, Intellectual property in biotechnology; and Section III, Firms, workforce, and financial flows. The data presented in the scoreboard originate from various sources ranging from publicly available reports and statistics to specialized databases. Syntheses of these data and data sources are presented in Appendices A and B. The scoreboard addresses some methodological problems commonly encountered with biotechnology statistics in order to provide more relevant, timely, significant, comparable, and accurate information on biotechnology.

Methods

There are substantial methodological impediments to the compilation of biotechnology statistics. As noted in the OECD's (2005) *Framework for Biotechnology Statistics*, there are problems pertaining to definitions, categories, consistency, accuracy, accessibility, timeliness, comparability, coherence, completeness, sampling errors, and exhaustiveness. The present report conforms to the guidelines provided by the OECD (2005) for addressing some of these common methodological problems and identifying biases and limitations in the data available. As is the case for all statistical compendia, this study relies on a clear definition of its subject, in this case biotechnology, and is based on two definitions provided by the OECD (2005).

The initial general definition is straightforward:

> The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services. (OECD, 2005: 9)

The more detailed definition is list-based:

> **DNA/RNA**: Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology.
>
> **Proteins and other molecules**: Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics, protein isolation and purification, signalling, identification of cell receptors.
>
> **Cell and tissue culture and engineering**: Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation.
>
> **Process biotechnology techniques**: Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation, biofiltration, and phytoremediation. Gene and RNA vectors: Gene therapy, viral vectors.
>
> **Bioinformatics:** Construction of databases on genomes, protein sequences; modelling complex biological processes, including systems biology.
>
> **Nanobiotechnology**: Applies the tools and processes of nano/microfabrication to build devices for studying biosystems and applications in drug delivery, diagnostics, etc. (OECD, 2005: 9)

The indicators presented in the current study rely in part on Science-Metrix' 2005 report *Towards a Canadian Biotechnology Innovation Scoreboard*, which proposed an initial set of 20 absolute indicators related to human resources, companies, finance, and science and technology (S&T) to measure the performance of the Canadian biotechnology sector. Following a review of the international sources, problems were identified related to availability, consistency, coherence, and timeliness of data for several of the proposed indicators, which would affect the comparability of data. For reasons of limited availability and the costs associated with gathering some of the data, only 10 of the 20 indicators initially proposed are used in this report. However, 12 other indicators for which reliable data were available were added, producing a total of 22 indicators.

Data on scientific and technological outputs were readily available for all countries. However, data on human resources, companies and finance were available for only a limited set of the countries selected for inclusion in the scoreboard. The availability of data for each indicator for these countries is presented in Table V in Appendix A. On close examination, the reliability of data for India appeared to be questionable and, consequently, this country was excluded from the scoreboard, leaving a total of 23 countries. Details on indicators used in each section of the scoreboard and an assessment of the report's limitations are presented in the following subsections.

Scientometric analysis

Dataset

The scientometric analysis (Section I) is based on the use of Thomson Scientific's Science Citation Index Expanded (SCI Expanded) database. A subset of biotechnology papers was retrieved from this database using keywords-in-title searches relating to the two biotechnology definitions mentioned above, for the 2001–2005 period. The dataset includes four document types considered to be original contributions to scientific knowledge: articles, notes, reviews, and conference proceedings. In this report we refer to these four document types collectively as "papers". The statistics were computed based on the resulting dataset.

Caveats

The use of keywords-in-title searches leads to an underestimation of scientific output, as some papers do not have titles that contain keywords specific to their fields. However, because keywords-in-title is more subject-specific than keywords-in-abstract or keywords-in-full text, this strategy reduces the occurrence of "false positives" (i.e., papers selected through a query, that do not belong to the field being investigated). Despite this tendency to underestimate scientific output, the keywords-in-title method is adequate given that the goal of this study is not to produce a census of papers in the field, but rather to provide an unbiased comparison of the scientific production of countries active in biotechnology.

The SCI Expanded provides the most extensive coverage of high-quality scientific research because it indexes approximately 6,000 of the world's leading scholarly science and technical journals in more than 150 disciplines. These journals are considered to be the most important peer-reviewed journals in their respective fields. They reflect significant scientific achievement and are the most widely cited journals in the world (over 80% of the world's citations). In addition, the SCI Expanded is the only database that compiles references made to and the citations received, by papers. This information is invaluable in the benchmarking of scientific research.

Indicators

The biotechnology papers dataset was used to produce detailed statistics based on the following indicators:

- **Papers:** Number of scientific papers written by authors located in a given geographical, sectoral, organizational, or individual entity (e.g., country, city, or institution).

- **Papers per billion GDP:** Ratio of the number of papers in a given period of time to Gross Domestic Product (GDP in USD Purchasing Power Parity—PPP) for the period.
- **Specialization index (SI):** An indicator of the intensity of research of a given geographic or organizational entity (e.g., a country) in a given research area (domain, field) relative to the intensity of research in a reference entity (e.g. the world) in the same research area. SI can be formulated as:

$$SI = \frac{(X_S/X_T)}{(N_S/N_T)}$$

where,

X_S = Papers from entity X in a given research area (e.g., Canada in biotechnology)

X_T = Papers from entity X in a reference set of papers (e.g., Canada in the whole SCI Expanded database)

N_S = Papers from the reference entity N in a given research area (e.g., world in biotechnology)

N_T = Papers from the reference entity N in a reference set of papers (e.g., world in the whole SCI Expanded database)

An index above 1 means that a given entity is specialized relative to the reference entity.

- **Average of relative citations (ARC):** This is an indicator of the scientific impact of papers produced by a given entity. In general, the number of citations received by each paper was counted for the year of publication and the two subsequent years, i.e. for papers published in 2001, citations received in 2001, 2002, and 2003 were counted. The exceptions are for 2004 publications, where the citation window is only two years (2004 and 2005), and 2005, where the citation window is only one year based on available data. For a paper in a given subfield (reference subfields are those defined by CHI Research Inc. for the National Science Foundation [NSF] and used in the Science and Engineering Indicators), the citation count was then divided by the average count of all papers in this subfield to obtain a relative citation count (RC). The ARC of a given entity is computed using the RC of each paper belonging to it.

Technometric analysis

Dataset

The technometric analysis is based on the use of the United States Patent and Trademark Office (USPTO) database. Delineation of the field of biotechnology was performed iteratively. First, keywords extracted from the *Biotechnology Use and Development Survey 2001* (McNiven *et al.*, 2003) were used to search patent titles and abstracts. Second, the classes from each of 20 patents selected by each keyword were extracted. From this list of US patent classes, the classes that were deemed relevant to the field of biotechnology were selected. Third, each selected class was analyzed to confirm its relevance to the field before being used to construct the basic dataset for this study.

The technometric analysis aimed at comparing countries' IP portfolios of active biotechnology patents for 2005. Because issued patents generally provide assignees exclusive rights to use, make, sell, or import an invention for a period of 20 years following the original filing of the patent, IP portfolios in 2005 include patents filed from 1986 and issued before December 31st 2005. Thus, the patent dataset includes patents issued before December 31st 2005, filed during the 1986–2005 period. Patents that expired during this period and were not reinstated through payment of a renewal fee, were removed from the dataset; thus, only active patents in any country's portfolio were retained.

Caveats

There are several well-known shortcomings to the use of statistics based on patents for describing technological innovation in specific fields:

- Incompleteness: Many inventions are not patented, since patenting is only one way of protecting an invention;
- Inconsistency in quality: The importance and value of patented inventions vary considerably;
- Inconsistency across industries and fields: Industries and fields vary considerably in their propensity to patent inventions;
- Inconsistency across countries: Propensity to patent varies among inventors from different countries, and patent laws vary across countries.

Despite these weaknesses, technometric indicators are widely used to compare the level of technological development of different geographic locations. Although the USPTO database presents an obvious bias towards the US, because it is one of the largest repositories of patented inventions in the world, it is generally used to measure invention. In addition, because the US is the largest market in the world, the most important inventions tend to be patented there. Thus, the USPTO database remains a potent tool for making country comparisons.

Indicators

The patent dataset was used to produce detailed statistics on the 2005 IP portfolios of active biotechnology patents based on the following indicators:

- **IP:** Patents include two fields that contain bibliographic information that helps to determine where a patent originates: the inventor field and the assignee field. The inventor is necessarily a person, whereas the assignee can be a person and/or an organization. These fields are used to compute statistics on two indicators, namely invention and intellectual property (IP). This report presents data on IP that provides rights on inventions.
- **IP per billion GDP:** Ratio of IP in the 2004 portfolio of a given geographic or organizational entity (e.g., a country) to Gross Domestic Product (GDP) of the same entity in 2004.
- **SI:** An indicator of the intensity of patenting of a given geographic or organizational entity (e.g., a country) in a given area (domain, field) relative to the intensity of patenting in a reference entity (e.g., the world) in the same area. The SI can be formulated as:

$$SI = \frac{(X_S / X_T)}{(N_S / N_T)}$$

where,

X_S = IP from entity X in a given portfolio (e.g., Canada's 2005 IP portfolio in biotechnology)

X_T = IP from entity X in a reference portfolio (e.g., Canada's 2005 IP portfolio in the whole USPTO database)

N_S = IP from the reference entity N in a given portfolio (e.g., the world's 2005 IP portfolio in biotechnology)

N_T = IP from the reference entity N in a reference portfolio (e.g., the world's 2005 IP portfolio in the whole USPTO database).

An index above 1 means that a given entity is specialized relative to the reference entity.

- **Relative Average Citation (RAC):** An indicator of the number of times patents owned by a given geographic or organizational entity (e.g., a country) are cited relative to those of a reference entity (e.g., the world). The average number of citations received per patent in the IP portfolio of a given entity as of 2005 is divided by the average number of citations received per patent in the IP portfolio of the reference entity as of 2005. A RAC above 1 means that patents owned by a given entity are more cited, on average, than patents owned by the reference entity.

Firms, workforce, and financial flows analysis

Dataset

Biotechnology firms, workforce, and financial flows are essential components of the *Canadian Biotechnology Innovation Scoreboard*. They provide valuable information on different aspects of the Canadian biotechnology innovation system and enable international comparisons. As the ultimate objective of the scoreboard is to present an extensive table of the indicators that provide information on the strengths and weaknesses of Canada and competing countries in biotechnology, these indicators are essential, even though they have some methodological limitations. Methodological tools were needed to address availability and consistency issues. The method used in this study is based on the work of the OECD (2005) and EC (2002) and builds on the indicators identified in Science-Metrix' (2004) report *Towards a Biotechnology Innovation Scoreboard*.

The method used consisted of scanning publicly available reports and other sources of structured information on biotechnology, gathering available data on different indicators, standardizing the categories, and creating an extensive database of indicators on biotechnology. Data sources are presented in Appendix B.

Caveats

The present study conforms to the quality dimensions provided in OECD (2005) for conducting a literature review and takes account of the following aspects:

- **Relevance:** Link between the indicators and their relevance for the main policy areas, which is provided prior to presentation of the data;
- **Timeliness:** Within the limits of data comparability, the scoreboard presents the most recent data on biotechnology available from public sources;
- **Accuracy:** The scoreboard privileges data from national surveys, which are estimated such that the deviation between the target value determined by a perfect process (true parameter) and the value determined by the imperfect process (estimate) is minimized. The methods underlying the estimation of the data presented in the scoreboard are presented in Appendix A;
- **Accessibility:** The scoreboard adopts a transparent approach to the presentation of data, methods and calculations;

- **Comparability:** The scoreboard, for the most part, compares data within the same time span; when data from different time spans are included in a comparison, this is clearly indicated. Details of the number of years available for each indicator and each country are provided in Appendix A;
- **Coherence:** The concepts and definitions used in international reports to describe and measure biotechnology activities were reviewed in order to identify discrepancies. An assessment of the coherence of biotechnology definitions and biotechnology firm type definitions underlying the data presented in the current report is provided in Appendix A;
- **Completeness:** The preliminary report 'Towards a Canadian Biotechnology Innovation Scoreboard' provides theoretical considerations of the utility of the indicators presented in the scoreboard to specific policy areas. These considerations show the completeness of the indicators for the specific user needs and priorities;
- **Scope and coverage:** Assessment of the scope and coverage of data presented in the current report is provided in Appendix A;
- **Reporting unit:** The scoreboard privileges data from official sources such as governments and recognized statistical organizations. Data sources exploited for the current report are indicated in Appendix A.

Throughout this report, the term "*Business Sector*" rather than "*Biotechnology Industry*" is used to define the biotechnology economic sector. As noted in 2005 by Antoine Rose, senior analyst at Statistics Canada, it is a common mistake to associate the concept of industry with the more general concept of an economic sector. Use of the expression biotechnology *"business sector"* has the advantage that it defines the economic sector of biotechnology while not falsely imputing to biotechnology the attribute of being a homogeneous industry. As a United Nations (UN) methodology guide states:

> An industry consists of a group of establishments engaged on the same or similar kinds of production activity (UN, 1993, par. 5.5 and 5.40).

Because it is used in a wide variety of circumstances, there is no harmonized definition of the term "industry" in business statistics (OECD, 2001); thus use of the term "*Biotechnology Industry*" raised the possibility of its not being consistent with the OECD's list-based definition of biotechnology. Also, in this report, the generic term "*biotechnology firms*" encompasses all definitions of biotechnology firms encountered in international reports, as no single definition was used by the countries included in the scoreboard. The definitions in the literature include:

- **Biotechnology Active Firm (BAF):** "Firm engaged in key biotechnology activities such as the application of at least one biotechnology technique to produce goods or services and/or the performance of biotechnology R&D" (OECD, 2005: 10).
- **Innovative Biotechnology Firm (IBF):** "Biotechnology active firm that applies biotechnology techniques for the purpose of implementing new or significantly improved products or processes (per the Oslo Manual [OECD, 1997] for the measurement of innovation). It excludes end users who innovate simply by using biotechnology products as intermediate inputs (for instance, detergent manufacturers that change their formulation to include enzymes produced by other firms via biotechnology techniques)" (OECD, 2005: 10).
- **Dedicated Biotechnology Firm (DBF):** "Biotechnology active firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D" (OECD, 2005: 10).

- **Core Biotechnology Company:** "Firm that is active in R&D in biotechnology and for which biotech constitutes the firm's central activity" (Bloch, 2004).
- **Bioventure:** "Commercial enterprise that meets all four of the following conditions: 1) the company utilizes, or develops for, biotechnology, 2) the number of employees complies with the definition stipulated by Japan's 'Small and Medium Enterprise Basic Law' (i.e. manufacturing SMEs=300 employees or less; wholesale/service industry SMEs=100 employees or less; retail SMEs=50 employees or less), 3) the company is less than 20 years old, and 4) the company's primary operations involve research & development, funded research, manufacturing, or advanced scientific consulting" (JBA, 2005).

Because these definitions do not cover the same range of firm types, some (e.g., bioventure) being more restrictive than others (e.g., IBF), and because it is necessary to include data in the scoreboard that relate to different definitions, a degree of caution in making international comparisons is advised, as data could be over or underestimated for one country relative to the others.

Statistics on the biotechnology workforce introduced another data availability problem. For example, statistics on the government R&D workforce are only available for Canada. Moreover, for most countries, the total number of biotechnology employees for all sectors was not available. In fact, except for Canada, where workforce data and trends are included, only business sector data are available for international comparison.

Systematic collection, at reasonable cost, of many of the financial indicators initially proposed proved difficult. There was a particular problem in relation to defining an indicator for the value of publicly traded biotechnology companies, as this required an inventory of international companies to collect stock market data. Exhaustive listings of biotechnology companies are only available from national agencies, which are seldom allowed to disclose their survey information. Other listings, such as the online Nature Biotechnology Directory, which contains more than 8,000 references, were an option. However, such information is potentially biased, due to the data collection method used, namely voluntary questionnaires. The indicator could have been defined based on international meta-data from the NASDAQ, AMEX, Toronto, or Yahoo Biotechnology Indexes. These indexes offer an advantage in that they display international and historical trends in the biotechnology sector for the stock market as a whole, but not every country has such an index, and using existing indices would have created a bias in favour of the US. Consequently, because exhaustive and consistent international comparisons based on this indicator were impossible, it was discarded.

An updated set of the 2003 data presented in the 2005 edition of the Canadian biotechnology innovation scoreboard is provided in the third section of this report along with2004 data, thus ensuring timeliness for each indicator and allowing for optimal comparability between successive annual scoreboard indicator values.

Indicators

The dataset, which was based on the literature review, was created to provide detailed statistics on the following indicators:

- **Biotechnology firms:** Within the context of the scoreboard, the generic term "*biotechnology firms*" is used to encompass data obtained using the following definitions of biotechnology firms: innovative biotechnology firms, dedicated biotechnology firms, core biotechnology companies, and bioventures.

- **Biotechnology firms per billion GDP:** Ratio of the number of biotechnology firms in a country in year X to the country's GDP in year X.
- **Biotechnology business sector employees:** Number of biotechnology employees in the business sector.
- **Biotechnology business sector employees per thousand labour force:** Ratio of biotechnology business sector employees in a country in year X over the country's labour force in year X.
- **Biotechnology business sector R&D employees:** Number of biotechnology R&D employees in the business sector.
- **Proportion of biotechnology business sector R&D employees among biotechnology business sector employees:** Ratio of the number of biotechnology R&D employees in the business sector in a country in year X to the country's total number of biotechnology employees in the business sector in year X.
- **Federal government expenditures on biotechnology R&D:** Only for Canada.
- **Federal government expenditures on biotechnology R&D as a percentage of total federal government expenditure on R&D:** Only for Canada.
- **Biotechnology business sector R&D expenditures**
- **Biotechnology business sector R&D expenditures as a percentage of business enterprise R&D (BERD):** Ratio of biotechnology business sector R&D expenditure in a country in year X over that country's total Business Enterprise R&D (BERD) expenditure in year X.
- **Biotechnology VC:** Venture capital raised by biotechnology firms in a given year.
- **Biotechnology VC per billion GDP:** Ratio of VC raised by biotechnology firms to country's GDP.
- **Biotechnology market size:** Estimated size of demand for biotechnology goods and services in a country.
- **Average Annual Growth Rates of Biotechnology Markets:** The average yearly growth of biotechnology markets in a given period

$$\frac{\left[\sum_{i=2}^{N}(X_i - X_{i-1})/X_{i-1}\right]}{N-1}$$

where,

X_i = Market size in year i

N = Total number of years included in the dataset;

- **Biotechnology company revenues:** Revenues of biotechnology firms by year.
- **Biotechnology company revenues per billion GDP:** Ratio of biotechnology firm's revenues in a country in year X to the country's GDP in year X.

SECTION I SCIENTIFIC PUBLICATIONS IN BIOTECHNOLOGY

1 Scientific output at international level

It has been suggested that in a knowledge-driven economy focused on innovation, basic research has a direct economic impact at many levels, including: (1) increasing the stock of useful knowledge; (2) training skilled graduates; (3) creating new scientific instrumentation and methodologies; (4) forming networks and stimulating social interaction; (5) increasing the capacity for scientific and technological problem-solving; and (6) creating new firms (Salter and Martin, 2001). Moreover, a study commissioned by the OECD estimated that for each extra percentage point invested in public R&D, there is an extra 0.17% growth in productivity (Guellec and van Pottelsberghe de la Potterie, 2001). The number of papers that a country publishes in top-ranking peer-reviewed journals and their scientific impact constitute reliable proxies for scientific activities. In addition, these indicators enable evaluation of the extent to which the knowledge produced by a country is disseminated.

This section provides an overview of the global rate of growth of scientific papers in the field of biotechnology at world level (Section 1.1), and benchmarks countries based on their scientific output (Section 1.2). The benchmarking analysis is based on the 2001–2005 period and provides up to date trends in knowledge creation in biotechnology.

1.1 Global trends in publishing biotechnology

The number of scientific papers published in biotechnology grew more rapidly between 1990 and 1995 than subsequently (Figure 1), although there was a noticeable increase in 2005 (22,330 papers) compared to the preceding two years (19,915 and 19,213, in 2003 and 2004 respectively). Starting from about 11,000 papers in 1990, the number of scientific papers in biotechnology at world level has grown by about 5% per year on average over the 15-year period studied. Although the volume of scientific output in biotechnology has doubled over the past 15 years, growth slowed over the last 10 years, with an average annual growth rate of 2.7%.

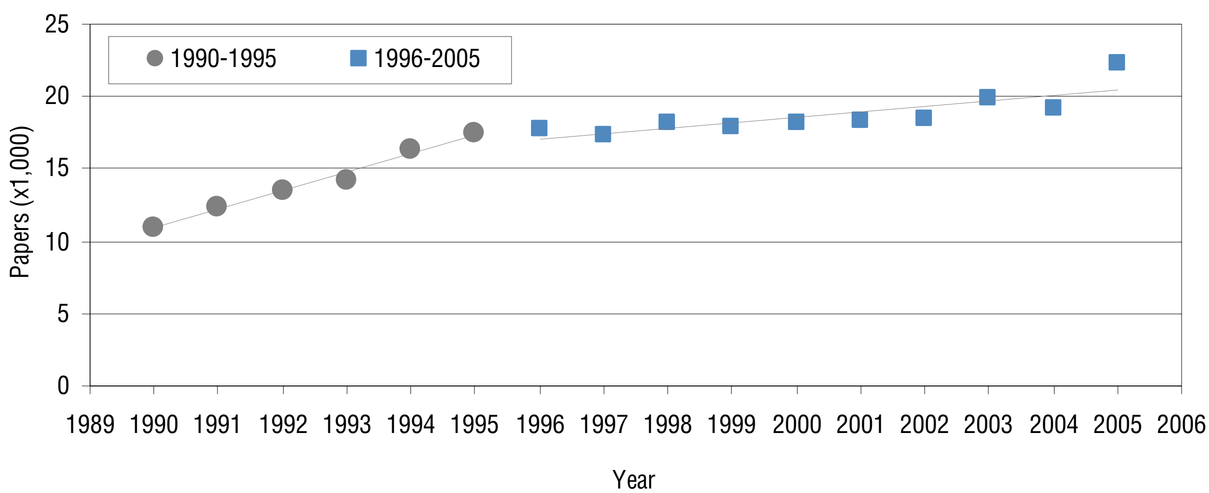


Figure 1 Biotechnology papers in SCI Expanded, 1990–2005

Source: Compiled by Science-Metrix from SCI Expanded (Thomson Scientific)

1.2 Benchmarking selected countries based on their scientific output

Table I presents the ranking of selected leading countries. This is not an exhaustive list and some countries that should be included based on their leadership in the field, had to be excluded because of poor data availability and quality. The US dominates in terms of scientific output with about 32,700 papers published during the 2001-2005 period, which is nearly three times as many as its closest rival, Japan, which published around 11,000 papers. Germany, the UK, and France follow, their numbers of biotechnology papers ranging from around 9,000 to 5,800. China, in 6th place, has almost as many papers as France, followed by Canada in 7th place, with nearly 4,400 papers.

Table I Multicriteria ranking of selected countries based on the number of papers, the number of papers per billion GDP, the SI, and the ARC, 2001–2005

	Papers		Papers per billion GDP (USD PPP)		SI		ARC		Multicriteria Ranking
Country	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	
Denmark	1,293	16	1.52	3	1.29	2	1.35	2	1
Switzerland	2,009	14	1.62	2	1.11	7	1.37	1	2
Netherlands	2,762	11	1.06	5	1.09	9	1.29	4	3
Sweden	2,192	13	1.64	1	1.14	6	1.11	10	4
Germany	8,939	3	0.78	12	1.07	10	1.17	9	5
Austria	1,147	17	0.90	8	1.18	5	1.22	6	6
Belgium	1,522	15	0.97	7	1.10	8	1.20	7	7
United States	32,662	1	0.59	19	0.99	15	1.35	3	8
United Kingdom	7,801	4	0.88	11	0.89	20	1.23	5	9
Japan	11,332	2	0.63	16	1.28	3	0.84	20	10
Canada	**4,365**	**7**	**0.88**	**10**	**0.97**	**17**	**1.19**	**8**	**11**
Republic of Korea	3,161	9	0.68	13	1.41	1	0.69	22	12
Australia	2,678	12	0.89	9	0.94	19	1.10	11	13
Finland	924	18	1.21	4	0.98	16	1.03	13	13
France	5,765	5	0.65	14	0.96	18	1.02	14	13
Spain	3,083	10	0.59	18	1.00	13	0.98	15	16
Portugal	640	19	0.64	15	1.27	4	0.91	19	17
Italy	4,221	8	0.53	21	0.99	14	0.97	16	18
China	5,439	6	0.16	23	1.06	11	0.61	23	19
New Zealand	482	21	1.03	6	0.84	22	0.96	18	20
Ireland	398	23	0.58	20	1.01	12	0.96	17	21
Norway	546	20	0.61	17	0.81	23	1.03	12	21
South Africa	443	22	0.18	22	0.88	21	0.79	21	23
World	**98,265**		**0.37**		**1.00**		**1.00**		

Note: The rankings reflect the positioning of countries among selected countries rather than within the world
Source: Compiled by Science-Metrix from SCI Expanded (Thomson Scientific) and WorldData Annual Time Series (The Economist Intelligence Unit)

While for most countries in the top 10 (based on absolute output), scientific output in biotechnology has levelled off since 1995, for China (6th place) and the Republic of Korea (9th place) it has increased (annual average growth of 28.5% and 16.1% respectively). In fact, China overtook Canada in 2003, and France in 2004. In addition, as was forecast in the last edition of this scoreboard, China's scientific output overtook the UK's annual production in 2005, and could well surpass that of Germany in the near future. Based on spectacular growth, the Republic of Korea outperformed Spain in 2004 and could very well overtake Canada in 2006.

The number of biotechnology papers per billion GDP is an indicator of the importance attributed to biotechnology science in a country's economy (i.e., it allows for comparison among different countries' scientific output taking account of the potential bias resulting from differences in the scale of those countries' economies). When considering GDP, larger countries with high absolute scientific publication production (e.g., the US, Japan, Germany, the UK, France, and China) are being overtaken by countries where science occupies a position of greater importance in the economy although their absolute scientific output is smaller (Table I).

Sweden, Switzerland, Denmark, Finland, the Netherlands, New Zealand, Belgium, Austria, and Australia, ranked 1st to9th, respectively for output per GDP, are ranked 13th, 14th, 16th, 18th, 11th, 21nd, 15th, 17th, and 12th for absolute output. Among the top 10 countries for absolute output, Canada is the best in terms of relative scientific output, ranking 10th, followed by the UK, Germany, the Republic of Korea, France, Japan, Spain, the US, Italy, and China, in 11th, 12th, 13th, 14th, 16th, 18th, 19th, 21st, and 23rd places, respectively. Note that in the top nine countries for output per GDP, average annual GDP did not exceed US $600 billion (at PPP) and averaged US $292 billion over the period, whereas Canada's average annual GDP for the 2001-2005 period was more than 1.5 times the highest value observed for those top 9 countries (i.e., around US $990 billion) Thus, Canada is performing quite well, ranking 6th when relative and absolute scientific output in biotechnology are jointly considered. In the top ten countries in terms of absolute output, Canada comes behind Germany and the UK, but is performing better than France, Japan, and the US when Relative and absolute scientific output combined.

The SI provides an assessment of the intensity of research in a specific field in a country relative to the intensity of research in the same field at world level; a score above 1 means that a country is specialized in the research area relative to the world. Over the five-year period, the Republic of Korea was the most specialized, with 41% more of its papers in the field of biotechnology than the world average (Table I). Denmark, Japan, and Portugal follow in 2nd, 3rd, and 4th places, with around 30% more of their papers in the field of biotechnology than the world average. Austria ranks 5th, with a SI of 1.18, followed by Sweden (SI = 1.14), Switzerland (SI = 1.11), and Belgium (SI = 1.10). Canada is not specialized in biotechnology, with 3% fewer papers in the field than the proportion at world level (SI = 0.97). Relative to the 2004 scoreboard, Canada has slipped from 13th to 17th position in terms of specialization in the field compared to other leading countries. Nevertheless, Canada is not far behind the US (SI = 0.99) and is performing better than France (SI = 0.96) and the UK (0.89), which are also in the top 10 in terms of absolute output.

The ARC is an indicator of the scientific impact of a country's papers on biotechnology. The leading countries in terms of scientific impact are Switzerland, Denmark, the US, and the Netherlands, with ARC scores ranging from 1.37 to 1.29 (Table I). The UK, Austria, Belgium, Canada, and Germany follow, with ARC scores ranging from 1.23 to 1.17. It should be noted that the more papers a country produces, the harder it is for the country to maintain a high ARC, and Canada, the US, Germany, and the UK are the only countries in the top 10 in absolute output that also rank in the top 10 for scientific impact. Although the Republic of Korea and China are performing very well in absolute production of biotechnology papers and exhibited strong growth over the 2001–2005 period, they rank nearly last (just in front of India) for impact.

The multicriteria ranking provides an overall assessment of the leading countries in biotechnology scientific output. The indicators considered in the multicriteria ranking are number of papers, number of papers per GDP, SI, and ARC. In this multicriteria benchmarking, Canada performs moderately well, ranking 11th behind Japan (compared to 8th in the 2004 scoreboard), and performs better than other countries that are included in the top ten in absolute output, namely the Republic of Korea (12th), France (13th), Italy (18th), and China (19th). Denmark is in 1st place, followed by Switzerland the Netherlands, Sweden and Germany in 2nd, 3rd, 4th and 5th places.

Figure 2 positions countries in a two-dimensional space based on their SI and ARC. The SI and the ARC are log transformed such that the origin (0, 0) represents the world level. For both these indicators, a value above zero means that the score is higher than the world, and vice versa. Consequently, the leaders are in the top right quadrant (high level of specialization, high level of impact) and the laggards are in the lower left quadrant. In interpreting country positions, the number of papers published over the period examined should also be considered. For example, a country may be positioned in the top right quadrant, but may have made a very modest scientific contribution to the field. In this positional analysis, the size of bubble is proportional to the number of biotechnology papers published.

Figure 2 shows that Denmark and Switzerland, in the top right quadrant, are top biotechnology performers, with scientific production in the field of biotechnology 29% and 11% respectively, greater than the world average, and with 35% and 37% respectively, more citations than world papers on average. Other countries in the top right quadrant include the Netherlands, Austria, Belgium, Sweden, and Germany. Countries such as South Africa, in the lower left quadrant, are lagging; they are not specialized in biotechnology and their papers have less scientific impact than world papers on average. Although the US, the UK, and Canada are not specialized in biotechnology, in terms of absolute number of publications and high impact, they can be considered key players.

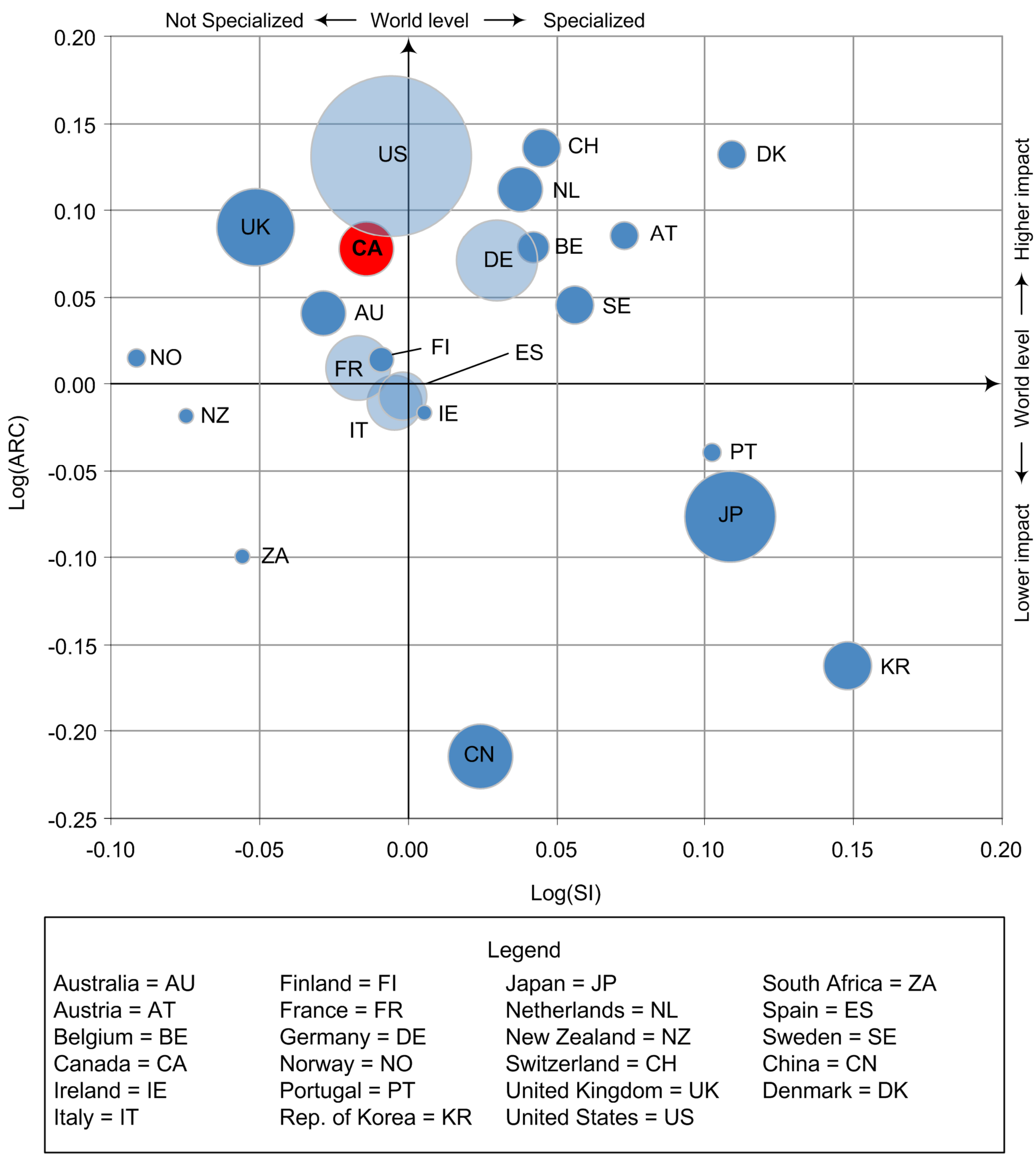


Figure 2 Positioning of Canada among leading countries for its scientific output in biotechnology, 2001-2005.

Source: Compiled by Science-Metrix from SCI Expanded (Thomson Scientific) and WorldData Annual Time Series (The Economist Intelligence Unit)

SECTION II INTELLECTUAL PROPERTY IN BIOTECHNOLOGY

2 Technological output at the international level

Table II presents the ranking of selected leading countries relative to the strength of their IP portfolio in the US. IP indicators based on active biotechnology patents are useful for assessing a country's potential to commercialize biotechnology inventions and the level of dissemination and impact of its inventions. This section benchmarks countries based on their 2005 IP portfolio of active biotechnology patents to provide an up-to-date view of their respective capacities to achieve economic gains from biotechnology R&D.

Table II Multicriteria ranking of selected countries' 2005 intellectual property portfolios in biotechnology using the following indicators: IP, IP per billion GDP, SI, and RAC

	IP		IP per billion GDP (USD PPP)		SI		RAC		Multicriteria Ranking
Country	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	
Denmark	902	8	4.83	1	5.61	1	0.90	4	1
United States	47,711	1	3.83	2	1.26	15	1.13	1	2
United Kingdom	2,112	4	1.08	11	1.94	5	0.88	6	3
Netherlands	1,050	7	1.87	5	1.92	6	0.85	9	4
Canada	**2,049**	**5**	**1.86**	**6**	**1.62**	**8**	**0.84**	**10**	**5**
Sweden	618	11	2.09	4	0.99	17	0.91	3	6
Switzerland	866	9	3.20	3	1.28	14	0.80	11	7
Australia	673	10	1.00	13	2.36	4	0.57	15	8
Belgium	439	13	1.29	9	2.36	3	0.52	19	9
France	1,943	6	1.03	12	1.29	13	0.63	14	10
Germany	2,930	3	1.19	10	0.74	20	0.68	12	10
Japan	5,390	2	1.38	8	0.34	22	0.67	13	10
Norway	127	17	0.64	16	1.44	10	1.02	2	10
Finland	275	15	1.67	7	0.79	18	0.87	7	14
Austria	186	16	0.67	15	1.26	16	0.90	5	15
New Zealand	93	19	0.89	14	2.42	2	0.47	22	16
Ireland	71	21	0.44	17	1.70	7	0.53	18	17
Spain	106	18	0.09	20	1.44	9	0.56	16	17
South Africa	28	22	0.05	21	0.79	19	0.85	8	19
China	86	20	0.01	23	1.39	11	0.55	17	20
Italy	445	12	0.27	19	0.73	21	0.51	20	21
Republic of Korea	372	14	0.35	18	0.26	23	0.49	21	22
Portugal	4	23	0.02	22	1.35	12	0.00	23	23
World	**69,073**		**1.15**		**1.00**		**1.00**		

Note: The rankings reflect the positioning of countries among selected countries rather than within the world
Source: Compiled by Science-Metrix from USPTO database and WorldData Annual Time Series (The Economist Intelligence Unit)

In terms of IP, the US owns close to 70% of the world's active biotechnology patents in the USPTO in 2005 (about 48,000 patents, Table II). It must be remembered, however, as referred to in the methods section, that the use of the USPTO database creates a bias towards the US. Therefore, the data in this section are better suited for comparing amongst the other countries.

Japan and Germany rank 2nd and 3rd, with approximately 5,400 and 3,000 patents, respectively. Canada ranks 5th with about 2,000 patents, close behind the UK in 4th place. Canada is followed by France (6th place), the Netherlands (7th place), Denmark (8th place), Switzerland (9th place), and Australia (10th place). Relative to their 2004 IP portfolios, the 2005 IP portfolios of the top 10 in absolute IP have increased from 0.5% (Japan) to 4.5% (Switzerland). In terms of growth, the most noticeable changes relate to China (19.4%), the Republic of Korea (9.4%), and Ireland (9.2%).

The number of active biotechnology patents per billion GDP avoids bias due to differences in the scale of the countries' economies. As in the case of scientific output, when GDP is taken into account, the larger countries with high absolute IP (e.g., Japan, Germany, and the UK) are being overtaken by countries with low absolute IP scores (e.g., Denmark, Switzerland, and Sweden) (Table II). The only exception is the US, which ranks 1st and 2nd in both absolute and relative IP, but again, the use of the USPTO database creates a bias in its favour. Canada ranks 5th and 6th in absolute and relative IP.

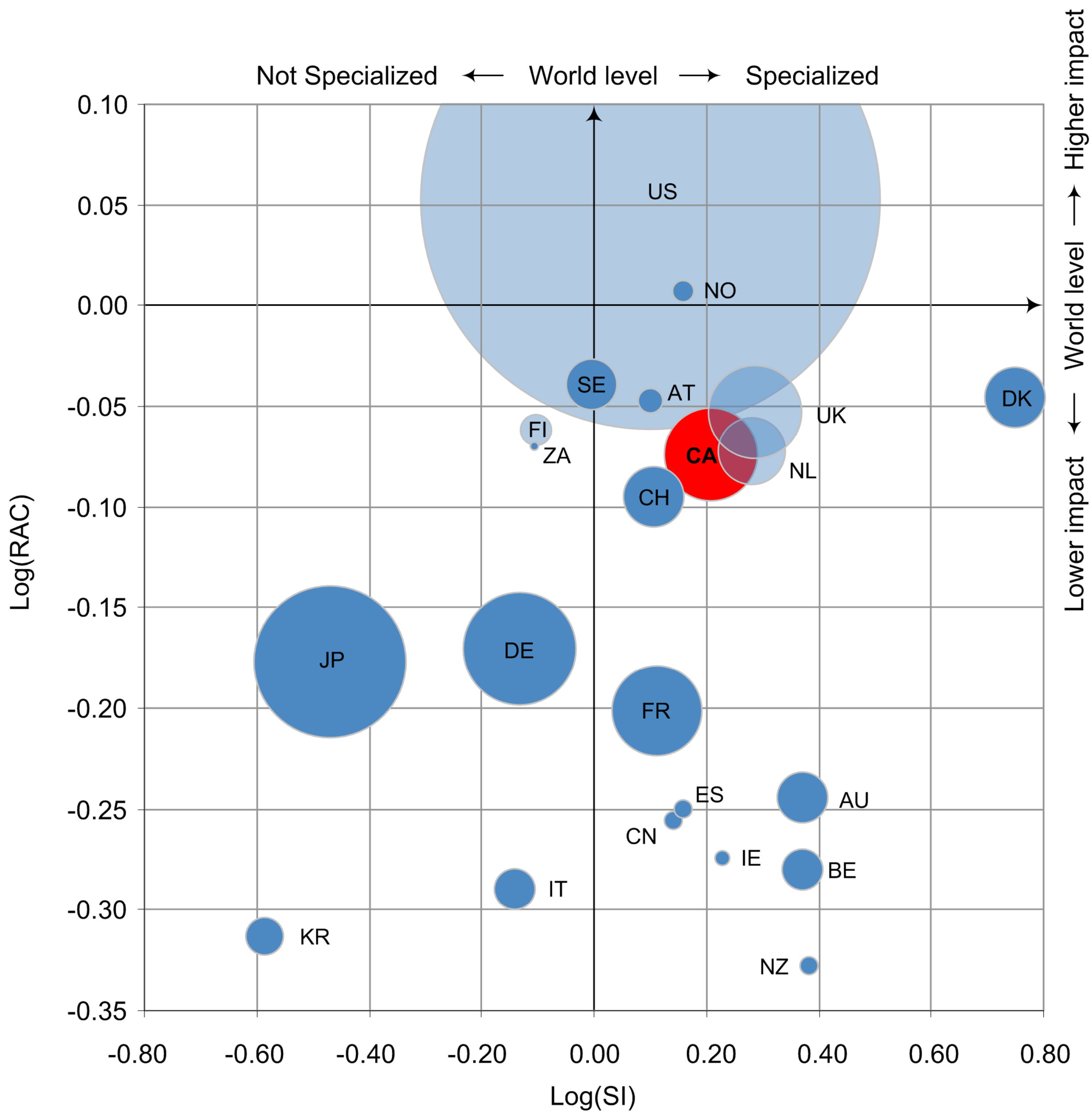
The SI is an indicator of the intensity of patenting in a specific field in a country relative to intensity of patenting in the same field in the world; a score above 1 means that a country is specialized in the field, in this case biotechnology, relative to the world. Highly specialized countries based on patenting in biotechnology, with a proportion of their IP in the field of biotechnology more than twice that of the world average, include Denmark in 1st place, New Zealand in 2nd place, Belgium in 3rd place, and Australia in 4th place (Table II). The UK , the Netherlands, Ireland , and Canada follow in 6th 7th and 8th places, with at least 50% more of their IP in the field of biotechnology than the world average (which must be understood as being highly determined by the US). Other countries specialized in biotechnology include Spain, Norway, China, Portugal, France, Switzerland, the US, and Austria.

The ARC is an indicator of the number of times a country's patents are cited relative to the world average, and can be used as a proxy for the technological impact of a country's biotechnology patents. A score above 1 indicates that a country's biotechnology patents are cited more often than biotechnology patents on average. Only two of the selected countries have a technological impact above the world average, the US in 1st place and Norway in 2nd place (Table II). This result (that the average citation of patents owned by the US is greater than that of patents owned by other countries in the selection) is based on the fact that the US owns close to 70% of the world's active USPTO biotechnology patents in 2005. Thus, the US level moves the world average citation level towards its own average citation level. Canada ranks 10th for this indicator.

Canada is clearly among the world leaders with respect to its 2005 IP portfolio of active biotechnology patents. Similar to 2004, Canada, Denmark and the Netherlands are in the top 10 for all four indicators; Canada ranks 5th (down from 4th position ex-æquo with the UK in the 2004 scoreboard) after the Netherlands, in the multicriteria benchmarking (Table II), which provides an overall assessment of the performance of selected countries in terms of technological output in biotechnology. In 1st place is Denmark, followed by the US, and the UK. Sweden and Switzerland follow the Netherlands and Canada in 6th and 7th places, respectively.

Figure 3 positions countries in a two-dimensional space based on their SI and RAC and should be interpreted similarly to Figure 2. As noted previously, the US owns 70% of the patents granted by the USPTO and consequently to a great extent the country's IP portfolio determines the world average. This is the reason why, in this specific case, some of the leaders are in the lower right quadrant (i.e., those countries near the world level).

Although the US clearly stands out in Figure 3, the use of the USPTO database creates a bias in its favour, a so-called home advantage. Thus, if we ignore the US, the main leaders are Denmark, the UK, the Netherlands, Canada, Sweden, and Switzerland. Norway is specialized and has a good impact, but has a fairly modest IP portfolio. Although Japan and Germany are not specialized and have less impact than the above mentioned countries, they are important players in terms of their potential to commercialize biotechnology inventions given that they have the largest IP portfolios in 2005 after the US. Also, the larger its portfolio, the harder it is for a country to maintain a high ARC. Countries such as the Republic of Korea and Italy, in the lower left quadrant, are lagging in terms of not being specialized in biotechnology, having less impact than most countries, and having small portfolios of active biotechnology patents. Portugal does not appear on Figure 3; it received no citations and has a low absolute IP value.



Legend

Australia = AU	Finland = FI	Italy = IT	South Africa = ZA
Austria = AT	France = FR	Japan = JP	Spain = ES
Belgium = BE	Germany = DE	Netherlands = NL	Sweden = SE
Canada = CA	New Zealand = NZ	Switzerland = CH	China = CN
Norway = NO	United Kingdom = UK	Denmark = DK	Ireland = IE
Rep. of Korea = KR	United States = US		

Figure 3 Positioning of Canada among leading countries for its scientific output in biotechnology, 2001-2005.

Source: Compiled by Science-Metrix from SCI Expanded (Thomson Scientific) and WorldData Annual Time Series (The Economist Intelligence Unit)

SECTION III FIRMS, WORKFORCE AND FINANCIAL FLOWS

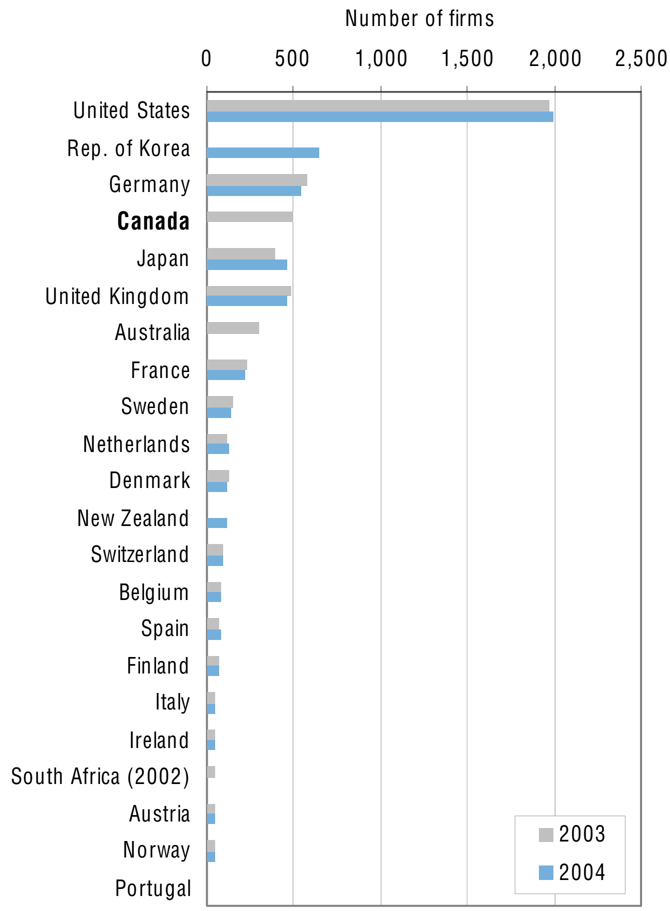
3 Biotechnology firms

The number of a country's biotechnology firms indicates the extent to which biotechnology-related knowledge is diffused within the industrial fabric of that country (OECD, 2005). It has been found that biotechnology firms cannot function in autarky and are highly dependent on external institutions and other firms (Mangematin *et al*., 2003). Strong and sustained economic growth has often been seen to result from high levels of research, and clusters of firms that interact (Colgan *et al*., 2000). Moreover, since biotechnology firms are often spin-offs or start-ups from research institutions (Niosi and Bas, 2003), they tend to create links with universities, government research institutes, and industries.

Because the development of biotechnology firms is one of the main goals of most biotechnology innovation policies, and because biotechnology firms are known to create links with the private sector and universities, which are likely to stimulate research and the development of new products (Mangematin *et al.*, 2003), these firms are an important indicator of a country's research activity and commercialization of research.

With 28.8% (1,991 firms) of the world's biotechnology firms in 2004, the US leads in terms of commercialization of biotechnology research, the countries for which data on biotechnology firms were available (Figure 4). Based on number of biotechnology firms (490) in 2003, Canada ranked 4^{th}-5^{th} in 2004 behind the US, the Republic of Korea and Germany, and perhaps Japan, whereas it ranked approximately 4^{th} in 2003 (behind the US, the Republic of Korea and Germany). This ranking is approximate first because no data for 2004 were available for Canada, and second because the number of biotechnology firms for the Republic of Korea and New Zealand may be overestimated, as the definition used by those countries includes dedicated, innovative, and active biotechnology firms.

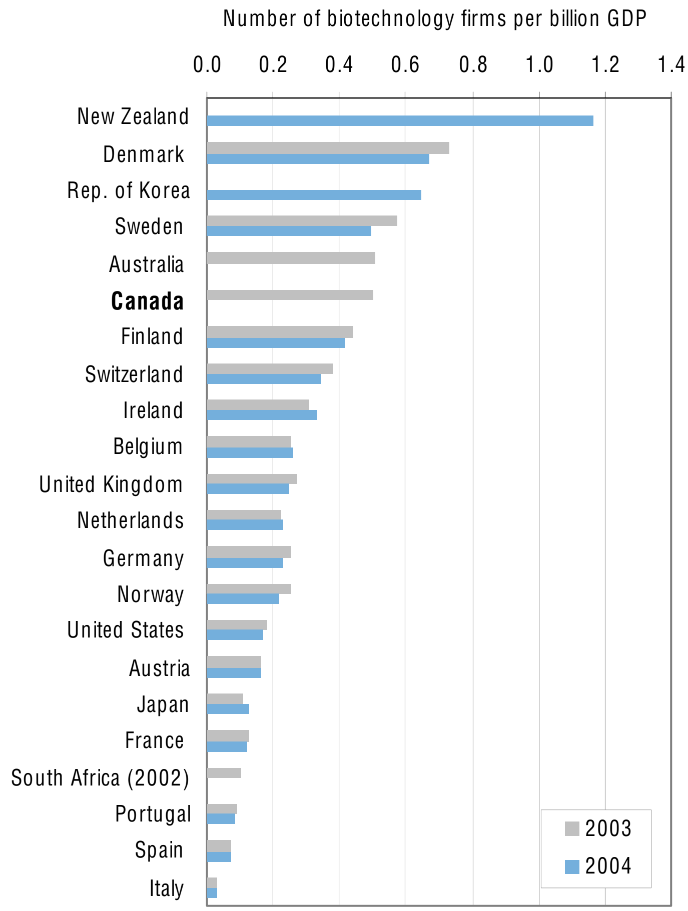
In addition, Canada and Iceland count the number of "Innovative biotechnology firms", which is more restrictive than the "Core biotechnology firms" definition used by the other 23 countries. Thus, Canada can certainly be considered to be strong in terms of commercialization of biotechnology research. Japan and the UK follow Canada with 464 and 457 biotechnology firms. It should be noted that, because of the different definitions of biotechnology firms, this comparison (and the following, where the biotechnology firms definition is used) aims at an approximate positioning of countries internationally (see Methods). The countries of Europe taken together have about 2,100 biotechnology firms, constituting about 34% of the world's biotechnology firms.



Country	2003	2004
United States	1,975	1,991
Rep. of Korea	N/A	640
Germany	575	538
Canada	**490**	**N/A**
Japan	387	464
United Kingdom	484	457
Australia	304	N/A
France	225	223
Sweden	151	138
Netherlands	116	124
Denmark	121	117
New Zealand	N/A	116
Switzerland	93	90
Belgium	79	84
Spain	74	81
Finland	66	66
Italy	43	51
Ireland	42	49
South Africa (2002)	47	N/A
Austria	41	44
Norway	43	41
Portugal	17	17

Figure 4 Number of biotechnology firms in selected countries for 2003 and 2004
Source: Data from international reports (see Appendix B for data sources).

Figure 5 presents the number of biotechnology firms in each country relative to its GDP. For this indicator, it is difficult to determine Canada's precise ranking since for several countries data were missing for 2003 or 2004. Based on the trends in the Figure 5 (number of firms per GDP for most countries fell between 2003 and 2004), it could be argued that Canada ranked 6th in 2004 behind New Zealand, Denmark, Korea, Sweden and Australia. Ranking 12th in absolute number of biotechnology firms, New Zealand leads in relative number of biotechnology firms, with more than one biotechnology firm per billion GDP in 2004. Among selected countries, New Zealand has the lowest 2004 GDP (100 billion USD PPP), which is about 57% of the GDP level of its closest rival, Denmark, but about 10% that of Canada. Among the top 10 countries in terms of GDP, Canada ranks 2nd behind the Republic of Korea for relative number of firms



Country	2003	2004
New Zealand	N/A	1.16
Denmark	0.73	0.67
Rep. of Korea	N/A	0.64
Sweden	0.57	0.49
Australia	0.51	N/A
Canada	**0.50**	**N/A**
Finland	0.44	0.42
Switzerland	0.38	0.35
Ireland	0.31	0.33
Belgium	0.25	0.26
United Kingdom	0.27	0.25
Netherlands	0.22	0.23
Germany	0.25	0.23
Norway	0.25	0.22
United States	0.18	0.17
Austria	0.16	0.17
Japan	0.11	0.13
France	0.13	0.12
South Africa (2002)	0.10	N/A
Portugal	0.09	0.08
Spain	0.07	0.07
Italy	0.03	0.03

Figure 5 Number of biotechnology firms per billion GDP (USD at PPP) in selected countries, 2003 and 2004

Source: Data from international reports (see Appendix B for data sources) and SourceOECD

The smaller countries with low levels of GDP, Finland, Switzerland and Ireland, are ranked 7th, 8th, and 9th, respectively. Countries with high GDP, such as the UK, Germany, the US, Japan, and France, have not performed well in relative terms, ranking 11th, 13th, 15th, 17th, and 18th, respectively. Ranking 4th and 6th with respect to absolute and relative number of biotechnology firms in 2004, based on 2003 data (Figure 4 and Figure 5), Canada is shown to have an environment favourable to the commercialization of biotechnology research, which is clearly a key aspect of its national biotechnology innovation system. Furthermore, Canada has many innovative biotechnology firms that are likely to be members of networks involving academia and governments research institutes, and which provide access to and enable the dissemination of the new biotechnology knowledge that will promote innovation.

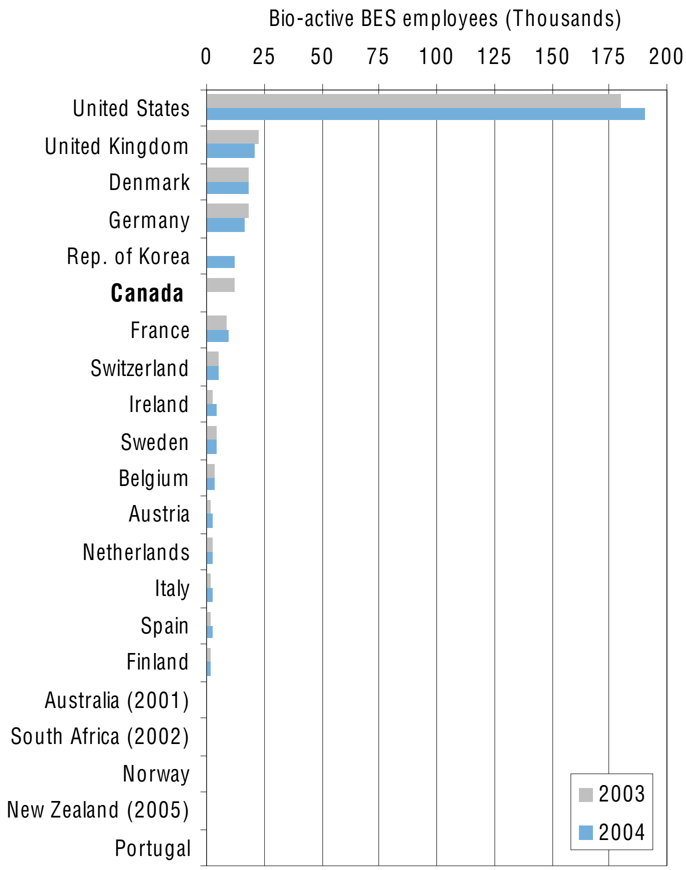
4 Biotechnology workforce

The number of biotechnology employees in a country's business sector is an indicator of the potential for commercialization of research (OECD, 2005). The number of biotechnology employees in the business sector relative to a country's total labour force, indicates the importance of biotechnology in the business sector. R&D workforce is another factor that is likely to impact on the development of biotechnology; research staff are often more specialized than production staff, making this a good indicator of the workforce specialization in the field (Lee *et al.*, 2005). Moreover, employees have been described as the main vehicle for technology transfer (Hsu *et al.*, 2005). Thus, they play an important role in the production and dissemination of biotechnology knowledge. The biotechnology workforce is described in Sections 4.1 and 4.2 . It should be noted that for Denmark, the data probably overestimate biotechnology employment since for one or more large pharmaceutical firms all employees were categorized as biotechnology workforce. The situation is similar for biotechnology business enterprise sector (BES_ R&D employment and to revenues generated from the sale of biotechnology products (see Beuzekom and Arundel, 2006: 9).

4.1 Total biotechnology workforce

Based on the size of its BES biotechnology workforce in 2003 (about 12,000 employees), Canada ranks 6th among the selected countries, with a share of about 4% of the reported 313,000 biotechnology BES employees for these countries in 2004 (Figure 6).

As is the case for the number of biotechnology firms, the US leads, with a share of some just over 60% (190,000 employees) of reported biotechnology employees in the BES in 2004. The UK is in 2nd place, with about 21,000 employees, or 6.7% of reported biotechnology BES employees. Denmark (3rd place), Germany (4th place) and the Republic of Korea (5th place) have about 18,500 (5.9%), 16,000 (5.1%) and 12,000 (3.9%) biotechnology BES employees, respectively. France follows Canada with about 9,000 employees (2.9%). Switzerland, Ireland, and Sweden follow with 1.6%, 1.4% and 1.3% of the selected countries' biotechnology BES employees, respectively. Assuming that Canada's number of biotechnology employees did not drop significantly in 2004, Canada has a relatively high capacity for producing and commercializing biotechnology research compared to other leading countries. This is consistent with its high number of biotechnology firms, which is comparable to the number of firms in other leading countries, e.g. Germany, the UK, and the Republic of Korea.



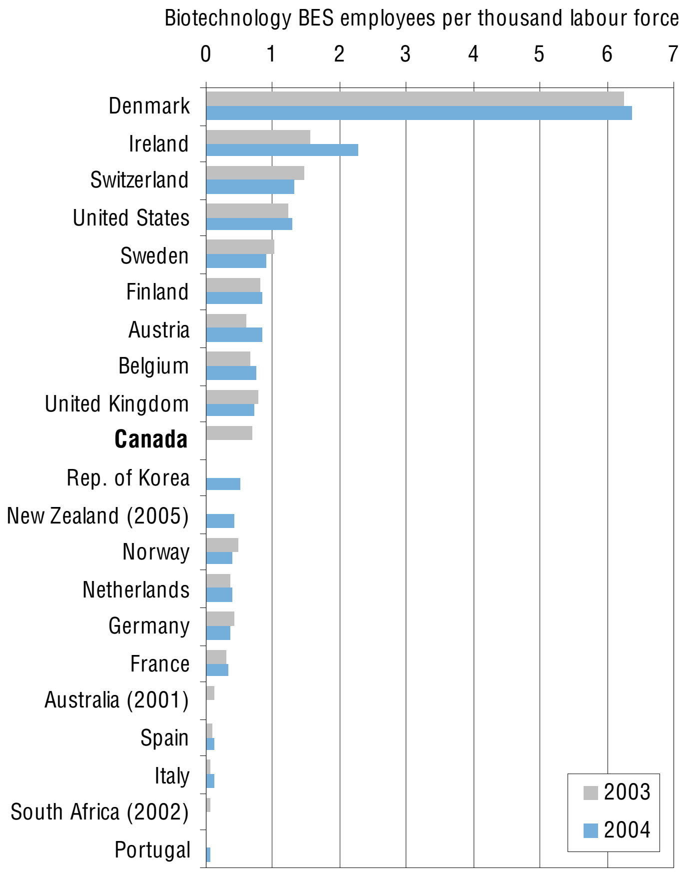
Country	2003	2004
United States	179,657	190,462
United Kingdom	22,834	21,134
Denmark	17,902	18,461
Germany	18,410	16,094
Rep. of Korea	N/A	12,138
Canada	**11,863**	**N/A**
France	8,373	9,142
Switzerland	5,503	4,990
Ireland	2,941	4,436
Sweden	4,542	3,942
Belgium	3,070	3,654
Austria	2,099	2,842
Netherlands	2,761	2,837
Italy	1,648	2,654
Spain	1,961	2,201
Finland	2,110	2,160
Australia (2001)	1,191	N/A
South Africa (2002)	1,020	N/A
Norway	1,161	931
New Zealand (2005)	N/A	918
Portugal	201	256

Figure 6 BES biotechnology employees among biotechnology firms in selected countries, for 2003 and 2004 if not otherwise indicated.

Note: Data for Denmark probably overestimate biotechnology employment (see Section 4, p. 26).
Source: Data from international reports (see Appendix B for data sources).

Canada does not seem to perform as well in terms of biotechnology employees per thousand labour force, ranking 10th among the 21 countries for which data were available (Figure 7). Again, it should be noted that Canada's ranking is based on its BES biotechnology workforce in 2003 since data were not available for 2004.

Canada has 0.7 biotechnology employees in the BES per thousand labour force, compared with 6.37 biotechnology BES employees per thousand labourers in Denmark, 2.27 in Ireland, 1.32 in Switzerland, 1.29 in the US, 0.88 in Sweden, 0.83 in Finland and Austria, 0.76 in Belgium, and 0.71 in the UK. Thus, the importance of biotechnology in the BES in Canada is lower than in some smaller countries, such as Denmark, Ireland, and Switzerland, but is comparable or higher to some of the leading countries (e.g., the UK, the Republic of Korea, Germany, and France) in terms of number of biotechnology firms and absolute size of the biotechnology workforce.



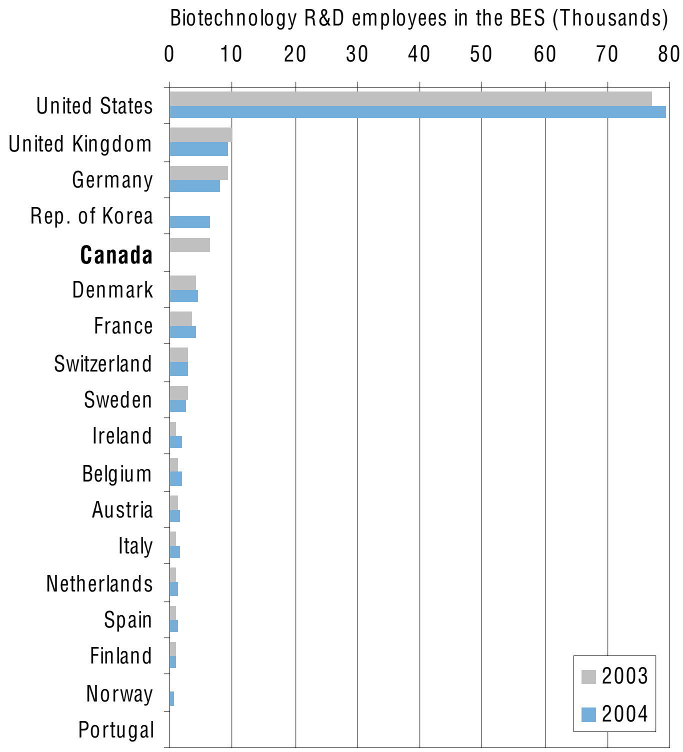
Country	2003	2004
Denmark	6.25	6.37
Ireland	1.55	2.27
Switzerland	1.46	1.32
United States	1.23	1.29
Sweden	1.02	0.88
Finland	0.81	0.83
Austria	0.61	0.83
Belgium	0.65	0.76
United Kingdom	0.77	0.71
Canada	**0.70**	**N/A**
Rep. of Korea	N/A	0.52
New Zealand (2005)	N/A	0.43
Norway	0.49	0.39
Netherlands	0.37	0.38
Germany	0.43	0.37
France	0.30	0.33
Australia (2001)	0.12	N/A
Spain	0.10	0.11
Italy	0.07	0.11
South Africa (2002)	0.06	N/A
Portugal	0.04	0.05

Figure 7 BES biotechnology employees per thousand labour force in selected countries, for 2003 and 2004 if not otherwise indicated.

Note: Data for Denmark probably overestimate biotechnology employment (see section 4, p. 26).
Source: Data from international reports (see Appendix B for data sources) and WorldData Annual Time Series (The Economist Intelligence Unit).

4.2 Biotechnology R&D workforce

The total number of BES biotechnology R&D employees indicates research and commercialization capacity in biotechnology, and the impact of its workforce on future developments in the field, while the proportion of BES biotechnology R&D employees among total biotechnology BES employees indicates the specialization of its workforce. As in 2003, the US leads with nearly 59% of the reported biotechnology R&D employees in 2004 (Figure 8), although it ranks only 16th out of 18 countries in terms of specialization, with 42% of its biotechnology workforce being allocated R&D responsibilities (Figure 9).



Country	2003	2004
United States	77,119	79,344
United Kingdom	9,896	9,384
Germany	9,226	8,138
Rep. of Korea	N/A	6,554
Canada	**6,441**	**N/A**
Denmark	4,265	4,459
France	3,651	4,246
Switzerland	2,778	2,796
Sweden	2,779	2,579
Ireland	1,080	1,839
Belgium	1,392	1,767
Austria	1,134	1,498
Italy	814	1,452
Netherlands	938	1,282
Spain	980	1,170
Finland	993	907
Norway	452	519
Portugal	89	129

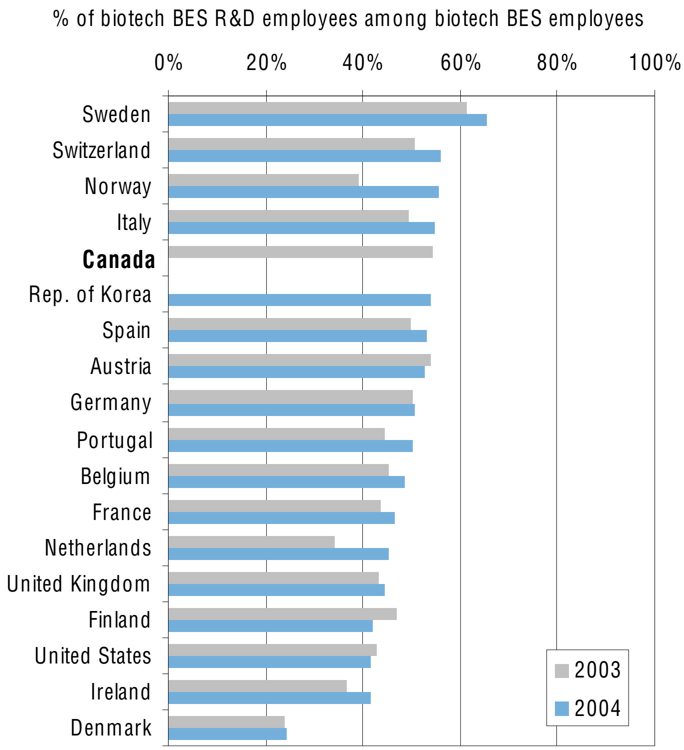
Figure 8 BES biotechnology R&D employees in selected countries, for 2003 and 2004.

Note: Data for Denmark probably overestimate biotechnology employment (see section 4, p. 26).

Source: Data from international reports (see Appendix B for data sources).

The UK ranks 2nd for number of biotechnology BES R&D employees (Figure 8), but, like the US, it does not perform as well in terms of proportion of biotechnology BES R&D employees among total biotechnology BES employees, ranking 14th (Figure 9). Germany, the Republic of Korea, and Canada perform well with respect to both indicators ranking 3rd, 4th, and 5th, respectively for number of biotechnology BES R&D employees, and 9th, 6th and 5th (Canada's positioning in 2004 is based on 2003 data; Canada was likely 4th depending on growth in 2004) respectively for proportion of R&D employees in the BES in biotechnology (Figure 8 and Figure 9). In fact, among the countries with more than 9,000 biotechnology employees in the BES, Germany, the Republic of Korea, and Canada are the only ones with at least 50% of their biotechnology workforce allocated to R&D.

The smaller countries in the group lead with respect to biotechnology workforce allocated to R&D in the BES, and therefore have highly specialized biotechnology workforces. Sweden leads with 65% of R&D employees in the BES in biotechnology, followed by Switzerland (56%), and Norway (56%). However, they do not perform as well in absolute numbers of biotechnology BES R&D employees. For example, Switzerland and Sweden rank 8th and 9th, respectively, with around 40% of Canada's number of R&D employees in the BES in biotechnology.



Country	2003	2004
Sweden	61.2%	65.4%
Switzerland	50.5%	56.0%
Norway	38.9%	55.7%
Italy	49.4%	54.7%
Canada	**54.3%**	**N/A**
Rep. of Korea	N/A	54.0%
Spain	50.0%	53.2%
Austria	54.0%	52.7%
Germany	50.1%	50.6%
Portugal	44.3%	50.4%
Belgium	45.3%	48.4%
France	43.6%	46.4%
Netherlands	34.0%	45.2%
United Kingdom	43.3%	44.4%
Finland	47.1%	42.0%
United States	42.9%	41.7%
Ireland	36.7%	41.5%
Denmark	23.8%	24.2%

Figure 9 Proportion of BES biotechnology R&D employees among biotechnology employees in biotechnology firms in selected countries, for 2003 and 2004.

Source: Data from international reports (see Appendix B for data sources).

When the overall biotechnology workforce in the countries for which data were available for all four indicators is analyzed, the US still dominates, followed by the UK, Switzerland, the Republic of Korea, Canada, Germany, and Sweden. Thus, the US is clearly the country in the sample with the strongest innovation and production capacities and, therefore, is the country most likely to lead future developments in the field of biotechnology. Canada has a strong capacity for disseminating biotechnology knowledge, ranking among the leaders for biotechnology workforce. Its high number of specialized workers likely has a positive impact on its capacity to stimulate economic, social, and environmental developments (OECD, 2005). The Republic of Korea compares to Canada in terms of both total R&D workforce and biotechnology R&D workforce in its BES.

5 Biotechnology financial inputs

The main sources of finance for biotechnology at national level are R&D expenditures and venture capital (VC). Because R&D expenditures play an essential role in advancing basic knowledge, and VC is critical for supporting commercialization of research, both are included in the scoreboard (Section 5.1 and 5.2).

5.1 R&D expenditures

R&D expenditure for biotechnology provides basic information on a country's overall biotechnology research capacity (OECD, 2005). This expenditure indicates the extent to which a country can develop and maintain its biotechnology sector, and the impact on its national system of biotechnology innovation. R&D expenditure is seen as stimulating the creation of national wealth in three domains: economic growth, social development, and environmental development (Furman *et al.*, 2002).

5.1.1 Trends in Canadian biotechnology R&D expenditure in the business enterprise and federal government sectors

BES biotechnology R&D expenditures for Canada for 2004 are not yet available, but were estimated at CDN $1,487 million in 2003 based on a compound annual growth rate (CAGR) for BES biotechnology R&D expenditure of 20.2% between 1997 and 2003. This rapid increase has translated into a considerable growth in the share of biotechnology BES R&D expenditure in total business enterprise expenditure on R&D (BERD) with a CAGR of 13.4% (Figure 10).

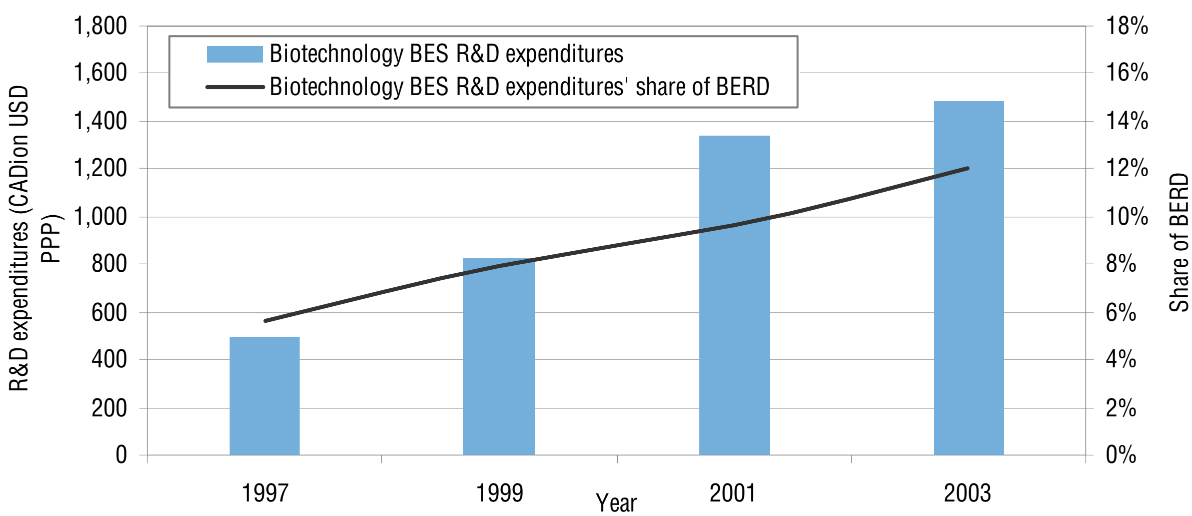


Figure 10 Canada's biotechnology BES R&D expenditure in CDN $ million and as a percentage of Canada's BERD , 1997–2003.

Source: Statistics Canada and SourceOECD.

The Canadian federal government spent over CDN $760 million on biotechnology R&D in 2004. Since 1997, biotechnology R&D expenditure in the government sector has increased markedly, at a CAGR of about 17% (Figure 11). As a result, the biotechnology R&D expenditure of federal government in total federal government expenditures on R&D (GOVERD) has increased at a CAGR of 7.2%.

From 1997 to 2003, the portion of BERD allocated to biotechnology increased from 6% to 12%, while the portion of GOVERD allocated to biotechnology increased from 8% in 1997 to 13% in 2004 (Figure 10 and Figure 11). Thus, the importance of biotechnology in the Canadian economy has increased significantly over the years and appears to be a key component of the Canadian innovation system.

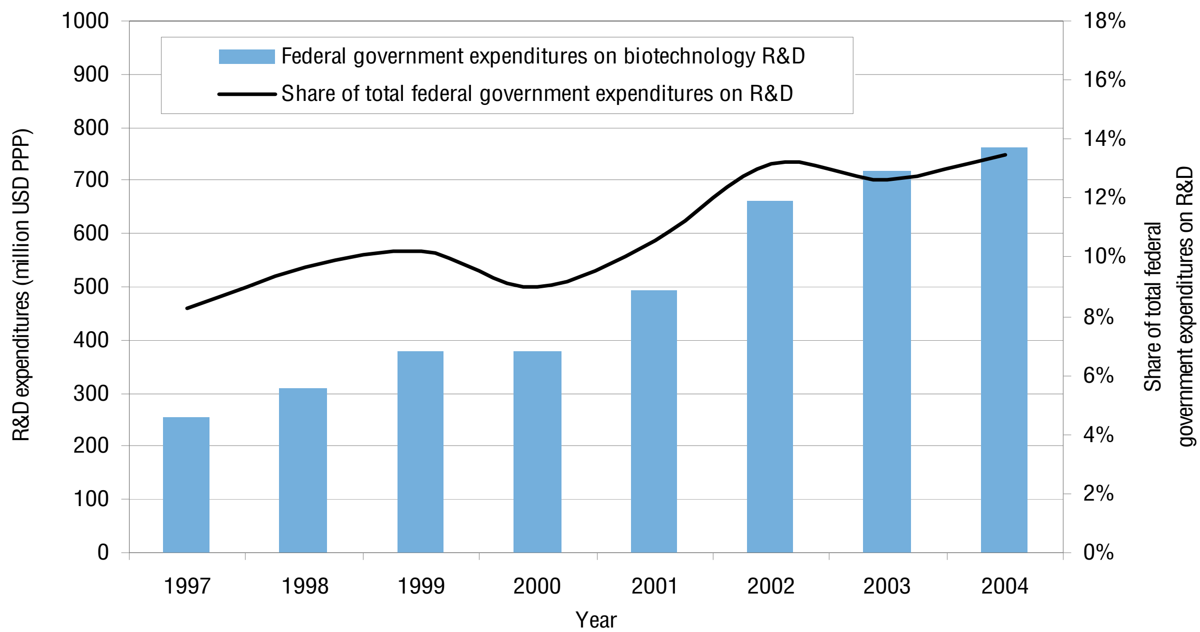
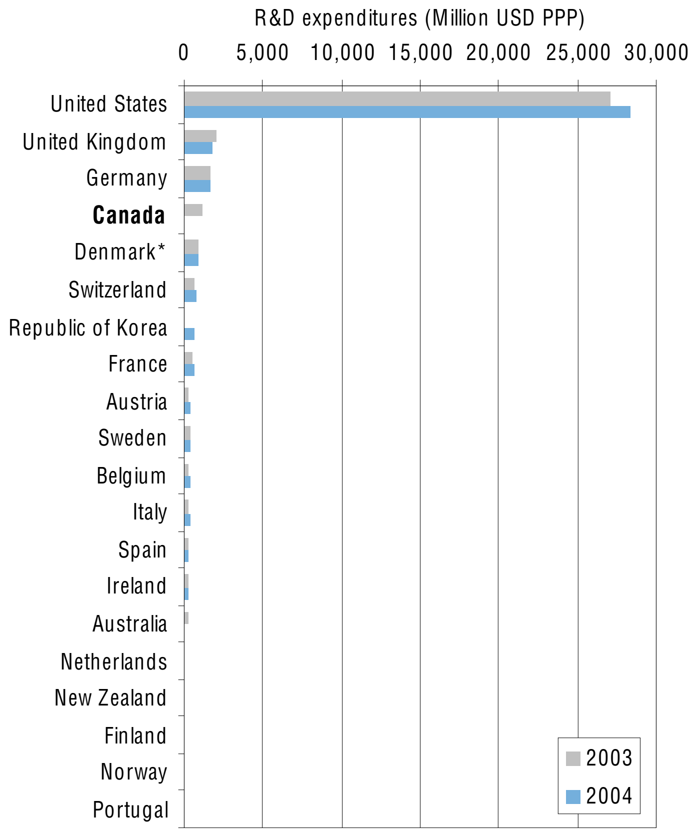


Figure 11 Federal government expenditure on biotechnology R&D in CDN $ million and as a percentage of total federal GOVERD in Canada, 1997–2004

Source: Statistics Canada and SourceOECD.

5.1.2 International comparison of BES spending in biotechnology R&D

Biotechnology R&D expenditure in the BES is a major part of a country's total biotechnology R&D expenditures. Figure 12 presents BES R&D expenditures for biotechnology in 2004 in the countries for which data were available. The US outperforms all countries, with spending on biotechnology R&D in the BES in 2004 more than 16 times that of its nearest competitor (i.e. over US $28 billion). The UK and Germany are in 2nd and 3rd place, with R&D expenditures of about US $1.7 billion at PPP and US $1.6 billion at PPP, respectively. R&D expenditures in the BES were slightly over US $1 billion at PPP in Canada. Thus, Canada is a world leader for BES R&D expenditures on biotechnology, ranking 4th among the countries for which data were available in 2004 and based on 2003 data for Canada.



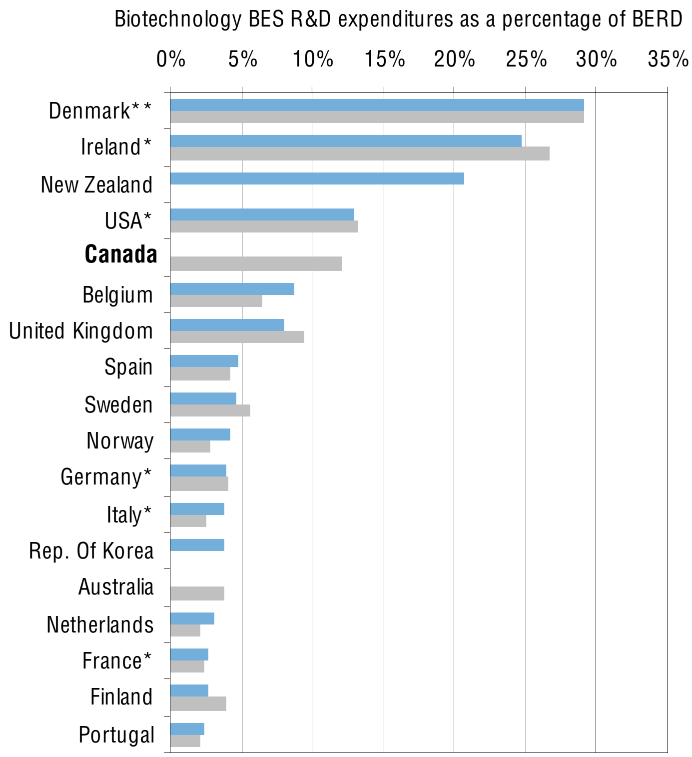
Country	2003	2004
United States	27,089	28,364
United Kingdom	2,059	1,742
Germany	1,652	1,617
Canada	**1,195**	**N/A**
Denmark*	879	879
Switzerland	644	716
Republic of Korea	N/A	699
France	571	644
Austria	294	387
Sweden	434	361
Belgium	264	358
Italy	213	334
Spain	252	282
Ireland	282	282
Australia	201	N/A
Netherlands	107	162
New Zealand	N/A	96
Finland	145	95
Norway	48	72
Portugal	10	11

Figure 12 BES R&D expenditures on biotechnology in million USD at PPP in selected countries, for 2003 and 2004.

Note: *Results for Denmark likely overestimate biotechnology R&D
Source: Data from international reports (see Appendix B for data sources).

Taking account of countries' BERD, Denmark, ranked 5th for BES R&D expenditures on biotechnology, leads with 29% of its BERD allocated to biotechnology (Figure 13). However, Denmark could be overestimated because a some of its health biotechnology firms assigned all R&D to biotechnology (OECD, 2006: 17). It should be noted that in Figure 13, Switzerland, and Austria do not appear because no recent value of BERD was available for these countries. It should also be noted that, for reasons of data availability, in most cases 2003 BERD levels were used. BERD for countries for which data were available for 2003 and 2004 shows an increase of 2% to 7.4%. Therefore, the BES R&D expenditures on biotechnology in 2004 as a percentage of 2003 BERD is likely overestimated, relative to countries for which the 2004 BERD figures were available.

Although Ireland and New Zealand are not performing particularly well with regard to BES R&D expenditure on biotechnology, ranking 14th and 17th respectively out of 20 countries for which data were available, they follow Denmark in 2nd and 3rd place, with 24.7% and 20.7%, respectively, of their BERD being allocated to biotechnology. The US and Canada (based on 2003 data) rank 4th and 5th, with 12.9% and 12.0% of their BERD allocated to biotechnology. Belgium and the UK follow in 6th and 7th places with 8.7, and 8.0%, respectively, of their BERD being allocated to biotechnology. Germany, the Republic of Korea, and France, all with BES R&D expenditures on biotechnology greater than US $600 million at PPP, rank 11th, 13th, and 16th, respectively, with less than 4% of their BERD being allocated to biotechnology. Figure 12 and Figure 13 clearly illustrate Canada's strength as a biotechnology research leader at the international level.



Country	2003	2004
Denmark**	29.1%	29.1%
Ireland*	26.8%	24.7%
New Zealand	N/A	20.7%
USA*	13.3%	12.9%
Canada	**12.0%**	**N/A**
Belgium	6.4%	8.7%
United Kingdom	9.4%	8.0%
Spain	4.3%	4.8%
Sweden	5.6%	4.7%
Norway	2.8%	4.2%
Germany*	4.1%	3.9%
Italy*	2.5%	3.8%
Rep. Of Korea	N/A	3.8%
Australia	3.7%	N/A
Netherlands	2.1%	3.1%
France*	2.4%	2.6%
Finland	4.0%	2.6%
Portugal	2.1%	2.4%

Figure 13 BES R&D expenditures on biotechnology as a percentage of 2003 BERD in selected countries, for 2003 and 2004.

Notes: * BES R&D expenditure and corresponding BERD were available for both 2003 and 2004; ** Results for Denmark likely overestimate biotechnology R&D.

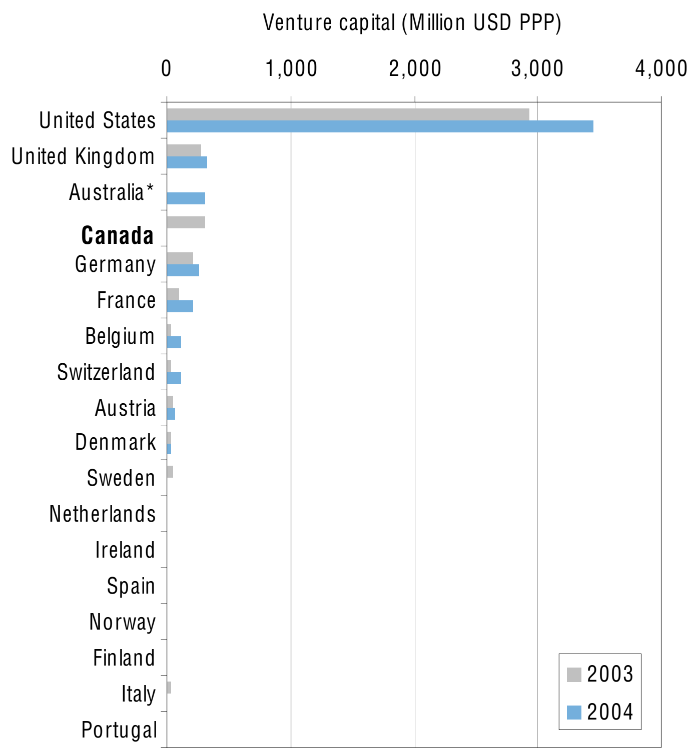
Source: Data from international reports (see Appendix B for data sources) and from SourceOECD

5.2 Venture capital

The level of VC in biotechnology is an indicator of research opportunities and the capacity to commercialize research (OECD, 2005). It has been shown that access to VC is positively correlated with fast development and success in the biotechnology research sector (Niosi, 2003; Bas, 2004). Thus, VC is an indicator of the extent to which a country actually excels at producing research in order to attract VC investment and the amount of VC available to a country to back the future development of its biotechnology field.

The US leads in terms of the amount of VC raised for biotechnology in 2004, with slightly more than US $3.4 billion, more than ten times more than its closest rival, the UK (US $329 million at PPP in 2003) (Figure 14). Australia and Canada follow with US $309 million and US $301 million, respectively. Thus, Canada is also among the leaders in levels of VC (for availability reasons, data for

Canada are for 2003 rather than 2004), ranking 4th, close behind Australia. Germany and France follow in 5th and 6th place, with US $262 million and US $212 million, respectively. Other countries show much lower levels with the exception of Belgium and Switzerland, which have seen their VC capital increase by 284% and 202%, respectively in 2004.

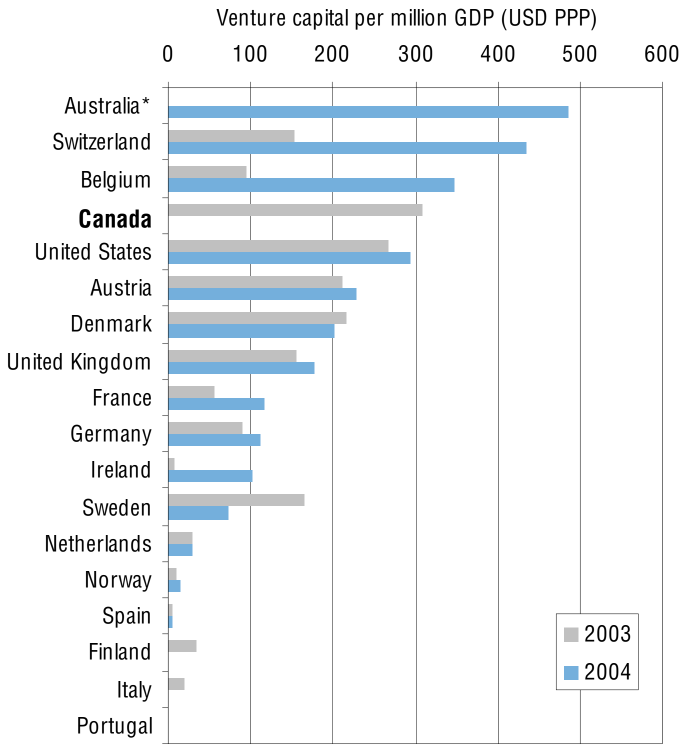


Country	2003	2004
United States	2,938	3,451
United Kingdom	276	329
Australia*	N/A	309
Canada	**301**	**N/A**
Germany	203	262
France	100	212
Belgium	30	114
Switzerland	38	113
Austria	53	61
Denmark	36	35
Sweden	44	21
Netherlands	15	15
Ireland	1	15
Spain	5	5
Norway	2	3
Finland	5	0
Italy	32	0
Portugal	0	0

Figure 14 Biotechnology venture capital in million USD at PPP in selected countries, for 2003 and 2004.

Note: * Australian VC could be overestimated, due to the inclusion of pharmaceuticals and health firms.
Source: Data from international reports (see Appendix B for data sources).

Figure 15 shows biotechnology VC per million GDP in selected countries for 2004. The relative indicator allows for comparison of the extent to which a country is able to attract VC in biotechnology, taking account of the size of each country's economy, both of which indicators are likely to be correlated. As in the case of absolute VC, Australia performs well in terms of relative VC, ranking 1st, with about US $486 at PPP in biotechnology VC per million GDP. Switzerland and Belgium are in 2nd and 3rd positions, respectively, attracting large amounts of VC for biotechnology, relative to their country's GDP. Canada is 4th (2003 data). With respect to the amount of relative VC raised, Austria's and Denmark's rankings are lower than in 2004 at 6th and 7th respectively. The larger countries, such as the US, the UK, France, and Germany, have performed less well in relative VC, ranking, respectively, 5th, 8th, 9th, and 10th. Sweden has seen a sharp drop in relative VC in 2004, going from the 7th position in 2003 to the 12th position in 2004. Sweden's VC has decreased by more than half from US $44 million at PPP in 2003 to US $21 million at PPP in 2004.



Country	2003	2004
Australia	N/A	486
Switzerland	153	435
Belgium	95	348
Canada	**308**	**N/A**
United States	268	295
Austria	212	228
Denmark	216	203
United Kingdom	156	176
France	56	117
Germany	89	111
Ireland	7	102
Sweden	165	74
Netherlands	29	29
Norway	10	14
Spain	5	5
Finland	34	0
Italy	20	0
Portugal	0	0

Figure 15 Biotechnology venture capital per million GDP (USD at PPP) in selected countries, for 2003 and 2004.

Note: * Australian VC could be overestimated, due to the inclusion of pharmaceuticals and health firms.
Source: Data from international reports (see Appendix B for data sources) and WorldData Annual Time Series (The Economist Intelligence Unit)

In terms of these two indicators, Canada is among the leaders in biotechnology with respect to VC investment, indicating Canadian excellence in biotechnology research. Moreover, the fact that Canada is attracting investors, to a certain extent guarantees its future development in biotechnology. Thus, these data suggest that the conditions for success are present in Canada.

6 Biotechnology financial outputs

This section refers to the biotechnology market (Section 6.1) and the revenues of biotechnology firms (Section 6.2). These two aspects can be seen as indicators of "success", showing how well countries are performing in terms of building an internal market and creating wealth in biotechnology firms.

6.1 Size of the local biotechnology market

The size of the local biotechnology market in different countries provides information on the economic demand for biotechnology products. Since investment usually occurs where demand is greatest, the size of the biotechnology market provides an insight into where future investments in biotechnology are most likely to occur.

The countries in Table III together account for approximately 92% of the world's biotechnology market, which was estimated at some US $126 billion in 2005 (Datamonitor, 2006). The US ranks 1st, with a biotechnology market worth US $69 billion in 2005, 54.3% of the world's biotechnology market in that year. Japan is 2nd follows with a market value of US $16.1 billion, accounting for 12.7% of the world biotechnology market. The UK and China are in 3rd and 4th positions, with biotechnology markets worth some US $7.7 billion and US $6.2 billion, respectively, and world market shares of approximately 6.1% and 4.9%, respectively. Canada, with a market of US $3.2 billion (a 2.5% share of the world market), ranks 7th. The European countries together account for nearly 16.1% of the world biotechnology market in 2005.

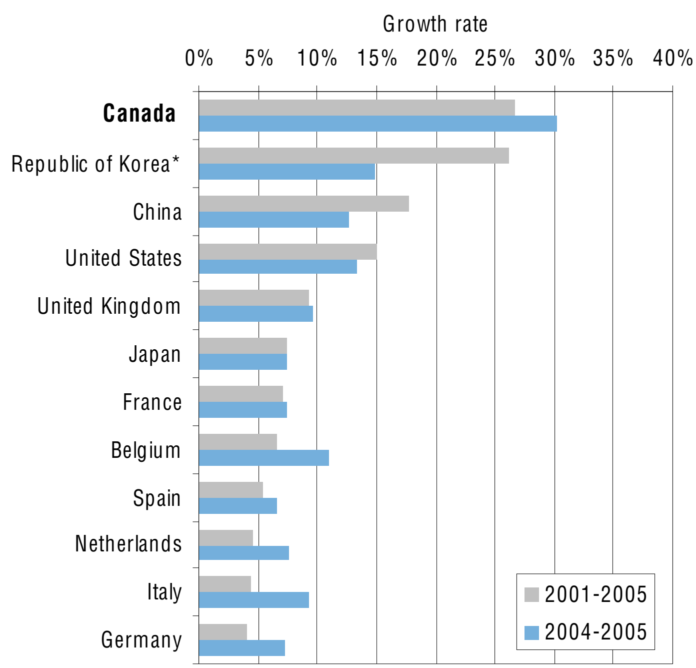
Table III Size of the biotechnology market in selected countries (million USD)

Country	2003	2004	2005
United States	53,700	60,500	68,600
Japan	13,900	15,000	16,100
United Kingdom	6,500	7,100	7,700
China	4,800	5,500	6,200
Germany	3,800	4,000	4,300
Belgium	2,700	3,000	3,300
Canada	**2,000**	**2,500**	**3,200**
France	2,415	2,580	2,771
Republic of Korea*	1,480	1,700	N/A
Italy	1,120	1,198	1,309
Spain	680	719	765
Netherlands	211	226	243
World	**101,000**	**112,600**	**126,300**

Note: * From Ahn 2004 (data for 2004 is a projected value).
Source: Data from Datamonitor biotechnology reports 2004–2006

It should be noted that data from sources other than those indicated in Table III show India to be a significant contributor to the world biotechnology market; based on these sources, India's biotechnology market would rank 2nd or 3rd among the selected countries (moving Canada to 8th place), with a value in 2001 estimated to be in the range of US $10.9 to US $18.7 billion (IMST, 2005; Chaturvedi, 2005). However, these data should be interpreted with caution as India's definition of biotechnology is broader than the definition proposed in the OECD's *2005 Framework for Biotechnology Statistics* (Chaturvedi, 2005). As the data for India are inconsistent with the results presented here, India was excluded from the present international comparison.

The compound annual growth of local biotechnology markets in recent years (2001–2005) shows where future demand for biotechnology products is most likely to arise and, therefore, where new investments are most likely (Figure 16). According to Datamonitor (2005, 2006), the world biotechnology market experienced a CAGR of 12.8% between 2001 and 2005.



Country	2001-2005	2004-2005
Canada	**26.7%**	**30.2%**
Republic of Korea*	26.2%	14.9%
China	17.7%	12.6%
United States	15.1%	13.3%
United Kingdom	9.3%	9.6%
Japan	7.4%	7.5%
France	7.1%	7.4%
Belgium	6.5%	10.9%
Spain	5.4%	6.5%
Netherlands	4.5%	7.6%
Italy	4.4%	9.3%
Germany	4.0%	7.3%

Figure 16 CAGR for 2001-2005 and 2004-2005 annual growth rate of selected countries, in the biotechnology markets.

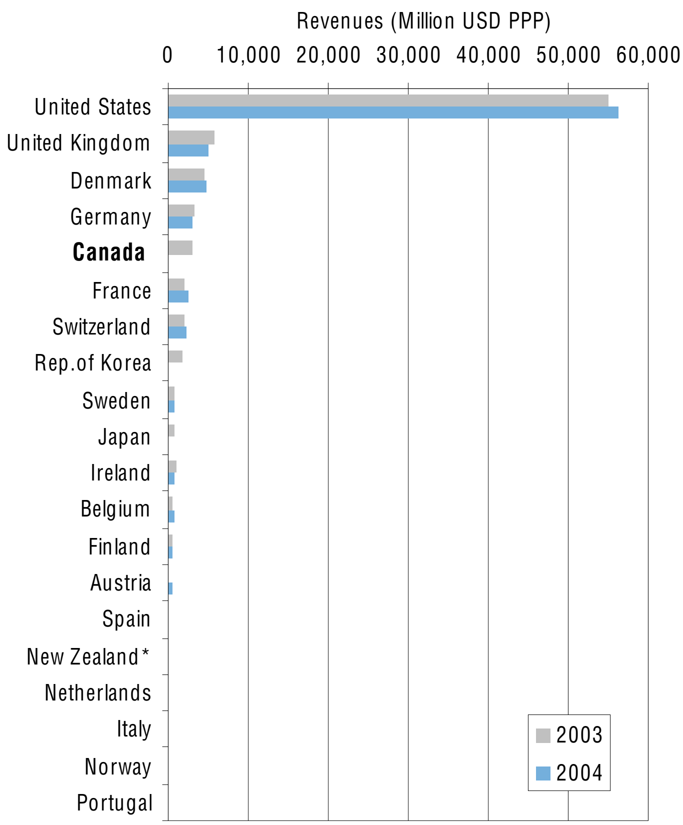
Note: * Data for 2000–2004 period (■), and for the 2003-2004 period (■).
Source: Growth rates are taken from Datamonitor biotechnology reports.

Among the selected countries, only four did better than the world average over the four year period—namely Canada (in 1st place), the Republic of Korea (in 2nd place), China (in 3rd place), and the US (in 4th place). Canada's biotechnology market continued to experience strong growth (30%) in 2004-2005, more than twice the world average (12%). Canada's biotechnology market, the 7th most important worldwide, grew by more than 4.5 times between 2001 and 2005, increasing from US $0.7 to US $3.2 billion. The US showed a CAGR of 15% and following it, in average annual growth rate for the 2004-2005 period, there are most noticeably China, Belgium, the UK, and Italy.

6.2 Company revenues

Company biotechnology revenues indicate the level of commercialization of biotechnology research, application or use of research results, and impact of research (OECD, 2005). Thus, company biotechnology revenues provide information about the impact of biotechnology R&D on a country's economy.

Again, the US outperforms other countries, with biotechnology revenues of about US $56 billion, more than ten times higher than its nearest competitor, the UK, with biotechnology revenues of about US $5 billion at PPP (Figure 17). Denmark, Germany and Canada are important in terms of financial outputs, ranking 3rd, 4th, and 5th, with revenues of US $4.77, US $3.1, and of about US $3 billion at PPP. France, Switzerland, and the Republic of Korea follow closely, ranking 6th, 7th and 8th, with revenues of US $2.4, US $2.1, and US $1.8 billion at PPP, respectively.

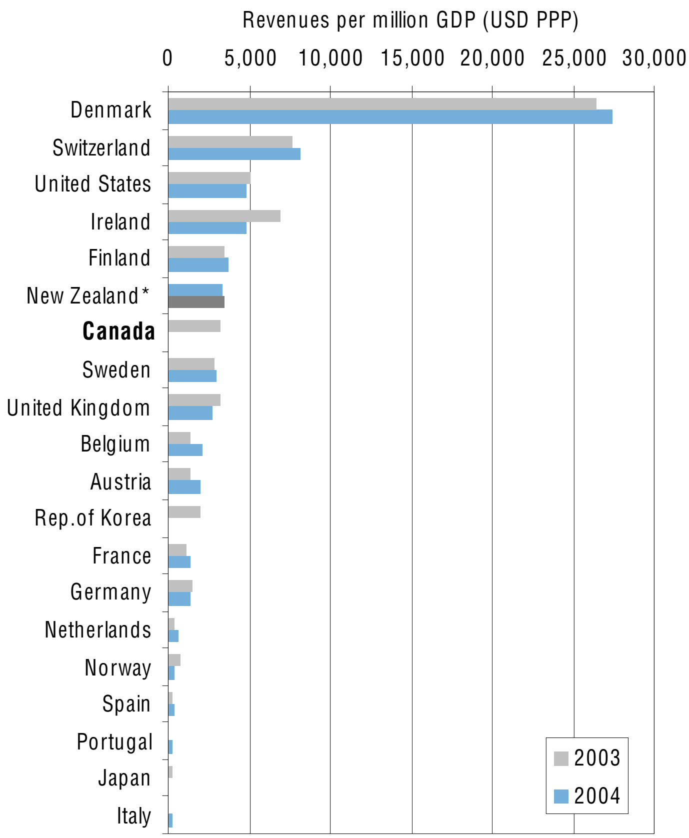


Country	2003	2004
United States	54,960	56,184
United Kingdom	5,714	5,059
Denmark	4,396	4,773
Germany	3,267	3,122
Canada	**3,088**	**N/A**
France	2,038	2,403
Switzerland	1,887	2,131
Rep.of Korea	1,800	N/A
Sweden	744	839
Japan	756	N/A
Ireland	942	702
Belgium	406	688
Finland	517	591
Austria	346	539
Spain	307	343
New Zealand*	343	349
Netherlands	189	338
Italy	235	336
Norway	128	73
Portugal	28	51

Figure 17 Biotechnology company revenues in selected countries in million USD at PPP, for 2003 and 2004.

Note: * New New Zealand has 2004 and 2005 data in place of 2003 and 2004, respectively.
Source: Data from international reports (see Appendix B for data sources).

When company biotechnology revenues are presented relative to GDP, it is easier to identify the contribution of biotechnology to a country's economy. Denmark leads, with revenues per million GDP of about US $27,000 at PPP (Figure 18). Switzerland also generates large biotechnology revenues relative to its GDP, with about US $8,000 per million GDP. The US and Ireland follow in 3rd and 4th places, respectively, each with about US $4,800 at PPP per million GDP. The remaining countries have biotechnology revenues per million GDP of US $3,000-US $4,000: Finland and New Zealand in 5th and 6th place, Canada in 7th place, Sweden in 8th, and the UK in 9th place. Canada is therefore consistently among the leaders for all aspects of financial outputs in biotechnology.



Countries	2003	2004
Denmark	26,449	27,354
Switzerland	7,674	8,180
United States	5,014	4,797
Ireland	6,917	4,791
Finland	3,447	3,738
New Zealand*	3,438	3,333
Canada	**3,166**	**N/A**
Sweden	2,812	2,996
United Kingdom	3,227	2,713
Belgium	1,300	2,108
Austria	1,386	2,031
Rep.of Korea	1,947	N/A
France	1,154	1,326
Germany	1,434	1,318
Netherlands	367	629
Norway	752	388
Spain	295	311
Portugal	146	252
Japan	214	N/A
Italy	148	206

Figure 18 Biotechnology company revenues per million GDP (USD at PPP) in selected countries, for 2003 and 2004.

Note: * New Zealand has 2004 and 2005 data in place of 2003 and 2004, respectively.
Source: Data from international reports (see Appendix B for data sources).

SECTION IV MAIN FINDINGS

7 Canada's ranking in biotechnology

On the one hand, based on the 22 indicators for which data were gathered, it can be stated that Canada is among the world leaders in biotechnology. But, on the other hand, as Canadian 2003 data were used for several indicators, in comparison with more recent data for other countries (when available), the present observations and conclusions will hold in cases where the Canadian 2004 data will not differ significantly from the 2003 data, or will follow their historical trend. Canada ranks in the top five among the selected 23 countries for which data were available, for 10 out of the 22 indicators, and ranks in the top 7 for 16 of these 22 indicators (Table IV). Canada stands out in terms of its biotechnology market CAGR, ranking 1^{st} among selected countries. Canada's biotechnology market is important and Canadian biotechnology firms rank 5^{th} in their capacity to generate revenues. Canada's business sector is ranked 4^{th} in terms of its R&D expenditure and 5^{th} in terms of its R&D expenditures in total R&D investments, among 18 countries. Canada ranks 4^{th} among 22 countries in terms of absolute number of biotechnology firms (6^{th} in terms of biotechnology firms per billion GDP) and 4^{th} among 18 countries in terms of absolute and relative amount of biotechnology venture capital. Canada ranks 5^{th} among 18 countries in terms of the number of biotechnology BES R&D employees and in percentage of BES biotechnology employees allocated to R&D. Canada ranks 5^{th} and 6^{th} among 23 countries in terms of the absolute and relative (i.e., over GDP) size of its IP portfolio. Other leaders in the field include the US, Denmark, the UK, Switzerland, Sweden, and Germany. Countries that are likely to become major biotechnology players in the near future include the Netherlands and the Republic of Korea.

Canada can be considered a world leader in biotechnology, although its ranking in 2004 relative to 2003 obviously suffers from lack of more timely data for a number of indicators. For example, Canada's position for at least 7 indicators (and especially firms per GDP, BES employees, BES R&D employees, VC, and revenues) would improve if data for 2004 had increased over 2003 by 2%-4%.

Nevertheless, there are some weaknesses, as denoted by Canada's 17^{th} position for specialization of its scientific output in biotechnology (Table IV). Canada has gone down four places for that indicator in 2001–2005 relative to 2000–2004, although its score for technological SI was as good in 2005. Thus, Canada's publishing of biotechnology research seems to be decreasing relative to the world average. Canada is also lagging with respect to ARC of its scientific papers (8^{th} in 2001–2005, down from 6^{th} place in 2000–2004). Furthermore, declining scores for some more recent scientometric indicators may reflect a recent drop in the proportion of biotechnology employees, R&D employees and expenditures over labour forces and overall business sector R&D expenditures, not measured in this report due to a lack of timely Canadian biotechnology statistical data.

Table IV Canada's ranking by biotechnology indicator among selected countries for which data were available

Indicator*/Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Scientific publications in biotechnology																							
Number of papers	US	JP	DE	UK	FR	CN	**CA**	IT	KR	ES	NL	AU	SE	CH	BE	DK	AT	FI	PT	NO	NZ	ZA	IE
Number of papers per billion GDP	SE	CH	DK	FI	NL	NZ	BE	AT	AU	**CA**	UK	DE	KR	FR	PT	JP	NO	ES	US	IE	IT	ZA	CN
Specialization index	KR	DK	JP	PT	AT	SE	CH	BE	NL	DE	CN	IE	ES	IT	US	FI	**CA**	FR	AU	UK	ZA	NZ	NO
Average of relative citations	CH	DK	US	NL	UK	AT	BE	**CA**	DE	SE	AU	NO	FI	FR	ES	IT	IE	NZ	PT	JP	ZA	KR	CN
Intellectual property in biotechnology																							
Intellectual property	US	JP	DE	UK	**CA**	FR	NL	DK	CH	AU	SE	IT	BE	KR	FI	AT	NO	ES	NZ	CN	IE	ZA	PT
Intellectual property per billion GDP	DK	US	CH	SE	NL	**CA**	FI	JP	BE	DE	UK	FR	AU	NZ	AT	NO	IE	KR	IT	ES	ZA	PT	CN
Specialization index	DK	NZ	BE	AU	UK	NL	IE	**CA**	ES	NO	CN	PT	FR	CH	US	AT	SE	FI	ZA	DE	IT	JP	KR
Relative average citation	US	NO	SE	DK	AT	UK	FI	ZA	NL	**CA**	CH	DE	JP	FR	AU	ES	CN	IE	BE	IT	KR	NZ	PT
Firms, workforce and financial flows																							
Biotechnology firms	US	KR	DE	**CA**	JP	UK	AU	FR	SE	NL	DK	NZ	CH	BE	ES	FI	IT	IE	ZA	AT	NO	PT	
Biotechnology firms per billion GDP	NZ	DK	KR	SE	AU	**CA**	FI	CH	IE	BE	UK	NL	DE	NO	US	AT	JP	FR	ZA	PT	ES	IT	
Biotechnology BES employees	US	UK	DK	DE	KR	**CA**	FR	CH	IE	SE	BE	AT	NL	IT	ES	FI	AU	ZA	NO	NZ	PT		
Biotechnology BES employees per thousand labour forces	DK	IE	CH	US	SE	FI	AT	BE	UK	**CA**	KR	NZ	NO	NL	DE	FR	AU	ES	IT	ZA	PT		
Biotechnology BES R&D employees	US	UK	DE	KR	**CA**	DK	FR	CH	SE	IE	BE	AT	IT	NL	ES	FI	NO	PT					
BES R&D employees over BES employees in biotechnology	SE	CH	NO	IT	**CA**	KR	ES	AT	DE	PT	BE	FR	NL	UK	FI	US	IE	DK					
Biotechnology BES R&D expenditures	US	UK	DE	**CA**	DK	CH	KR	FR	AT	SE	BE	IT	ES	IE	AU	NL	NZ	FI	NO	PT			
Biotechnology BES R&D expenditures over BERD	DK	IE	NZ	US	**CA**	BE	UK	ES	SE	NO	DE	IT	KR	AU	NL	FR	FI	PT					
Biotechnology venture capital	US	UK	AU	**CA**	DE	FR	BE	CH	AT	DK	SE	NL	IE	ES	NO	FI	IT	PT					
Biotechnology venture capital per million GDP	AU	CH	BE	**CA**	US	AT	DK	UK	FR	DE	IE	SE	NL	NO	ES	FI	IT	PT					
Size of the biotechnology market	US	JP	UK	CN	DE	BE	**CA**	FR	KR	IT	ES	NL											
Compound annual growth rate of the biotechnology market	**CA**	KR	CN	US	UK	JP	FR	BE	ES	NL	IT	DE											
Company biotechnology revenues	US	UK	DK	DE	**CA**	FR	CH	KR	SE	JP	IE	BE	FI	AT	ES	NZ	NL	IT	NO	PT			
Company biotechnology revenues per million GDP	DK	CH	US	IE	FI	NZ	**CA**	SE	UK	BE	AT	KR	FR	DE	NL	NO	ES	PT	JP	IT			

Note: The positions highlighted in grey indicate Canada's ranking in 2003 while the positions highlighted in blue indicate Canada's ranking in 2004. Canada's ranking in 2004 relative to 2003 suffers the lack of update of data for 2004 with respect to some indicators. * Data were not available for all countries for all indicators; thus the rankings provided in the present scoreboard not reflect their positioning in the world, but within the group of countries for which data are presented. The coding of countries' names is based on the ISO 3166 codes.

Conclusion

Analysts, academics, and policy makers generally agree that biotechnology will be a major contributor to future economic and social development, and thus the measurement and evaluation of biotechnology activities have become increasingly important to governments, academics and business enterprise organizations alike. Efforts have been undertaken in a number of countries to measure biotechnology activities and compare performance with that of other countries. For instance, most OECD and many non-OECD countries are now performing biotechnology surveys. It has become apparent that policy-makers have been faced with a lack of "systematic (internationally comparable) data on many aspects of biotechnology and its effects on the economy and society" (EC, 2002: 6), as well as problems related to timeliness, accuracy, coherence, and completeness of biotechnology statistics (OECD, 2005).

Although several of the challenges involved in building a coherent scoreboard have been successfully addressed, the present exercise nevertheless has some limitations. The *Canadian Biotechnology Innovation Scoreboard 2006* reveals the particular difficulties associated with the lack of publicly available up to date data, which makes it difficult to identify trends at the international level. International data on government and university investments in biotechnology R&D are also not included in publicly available sources. In addition, very little information was available on collaboration between governments, universities, and the BES, which rendered assessment of this fundamental aspect of the biotechnology innovation process unfeasible. Finally, the lack of publicly available biotechnology firm databases made it impossible to compare the value of publicly traded biotechnology companies.

This 2006 scoreboard reconfirms Canada's position as a world leader in biotechnology. In particular, it suggests that Canada has the fastest growing biotechnology market in the world and that Canada has benefited from large amounts of BES R&D investment in biotechnology, as well as major venture capital investments. The country has significant numbers of biotechnology firms, BES employees, and R&D employees. Furthermore, Canadian firms have significant biotechnology revenues and Canada has an important IP portfolio. With respect to five indicators (papers per GDP, firms per GDP, BES R&D employees over BES employees, VC per GDP, and CAGR of the biotechnology market), Canada is outperforming the three world-leading biotechnology countries (the US, the UK, and Germany).

It must be stressed that the preceding analysis is largely based on 2003 Canadian biotechnology data. It thus would be unwise to qualify Canada as a definite world leader, knowing that the score shown in some more recent scientometric indicators are falling. Indeed, even though Canada's biotechnology firms face a significant and growing market, according to available data, Canada's recent decrease in scientific output may reflect a decline that could not be measured in this report, of corresponding inputs in scientific expertise and R&D investments. If this ends up being the case when updated Statistics Canada biotechnology data become available, there may very well be sufficient reasons to fear for Canada's present leadership position in this vital new industry. A recent 2006 report (Delucchi, 2006) conducted by PricewaterhouseCoopers and BIOTECanada revealed that almost half of the firms based in Canada were planning to move all or part of their businesses out of the country at some point in the next couple of years. This, and the results shown in this report converge in pointing to the need for policies towards the sustainable development of Canadian biotechnology.

References

A. van der Giessen, S. Kern, and Enzing C., 2003. Effectiveness of Innovation Policies: Biotechnology in Belgium (1994-2001). European Commission DG Research. TNO Report. *TNO Strategy, Technology and Policy*. 43p.

Archambault É., Vignola-Gagné É. and Bouffard D. 2005. *Towards a Canadian Biotechnology Innovation Scoreboard*. Prepared for Industry Canada (IC) Life Science Branch (LSB). Montreal: Science-Metrix, 55p. http://www.science-metrix.com/pdf/SM_2005_012_IC_Canadian_Biotech_Innovation_Scoreboard.pdf

Archambault É., Campbell D., and Côté G. 2004. *Benchmarking of Canadian Biotechnology Patents at the National and International Level, 1991-2003*. Update Prepared for the Canadian Biotechnology Secretariat (CBS). Montreal: Science-Metrix, 23p. http://www.science-metrix.com/pdf/SM_2004_004_CBS_Canadian_Biotechnology_Patents.pdf

Ahn, C. 2004. *Biotechnology Industry in Korea: Industry Sector Analysis*. U.S. & Foreign Commercial Service and U.S. Department of State. http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/fr/gr117524f.html (accessed July 11th, 2006)

Allansdottir, A., Bonaccorsi, A., Gambardella, A. *et al*. 2002. *Innovation and competitiveness in European biotechnology. Enterprise Papers No.7*. Enterprise Directorate. General European Commission. Brussels. http://europe.eu.int/comm/enterprise/library/enterprise-papers/pdf/enterprise_paper_07_2002.pdf (accessed July 11th, 2006)

Axiss Australia. 2005. *Venture Capital and Private Equity in Australia*. Invest Australia. Citing Australian Bureau of Statistics Catalogue No. 5678.0. http://www.investaustralia.gov.au/media/IS_FS_VentureCapital.pdf (accessed July 11th, 2006)

Bas T.G. 2004. *Les facteurs favorisant la croissance différentielle des entreprises de biotechnologie chez les leaders mondiaux: États-unis, Royaume-Uni et Canada*. Doctoral thesis, Université du Québec à Montréal.

Beuzekom B. and Arundel, A. 2006. OECD *Biotechnology Statistics-2006*. Paris: Organization for Economic Co-Operation and Development. http://www.oecd.org/dataoecd/51/59/36760212.pdf (accessed July 11th, 2006)

Bloch C. 2004. *Biotechnology in Denmark: A Preliminary Report*. Aarhus: The Danish Centre for Studies in Research and Research Policy. http://www.cfa.au.dk/Publikationer/Working_papers/WP2004_1.pdf (accessed July 11th, 2006)

Brunelle C., Campbell D., Côté G. and Archambault E. 2005. *Canadian Biotechnology Innovation Scoreboard*. Prepared for Industry Canada (IC) Life Science Branch (LSB). Montreal: Science-Metrix. 50p. http://www.science-metrix.com/pdf/SM_2005_012_IC_Canadian_Biotech_Innovation_Scoreboard.pdf (accessed August 23d, 2006)

Campbell D., Côté G., Bergeron S. and Archambault E. 2005. *Scan of Canadian Strengths in Biotechnology*. Prepared for the National Research Council (NRC) of Canada. Montreal: Science-Metrix, 53p. http://www.science-metrix.com/pdf/SM_2004_013_NRC_Biotechnology_Canadian_Strengths.pdf#search=%22scan%20biotechnology%20strengths%22 (accessed August 23d, 2006)

Canadian Trade Commissioner Service. 2003. *The Biotechnology Market in the Netherlands*. Department of Foreign Affairs and International Trade, 32 pages.

Chaturvedi, S. 2005. *Dynamics of Biotechnogy Research and Industry in India: Statistics, Perspectives and Key Issues*. Paris: OECD. STI Working paper. 62p.

Colgan C. and Baker C. 2000. *Prospects for Marine Biotechnology in Maine*. 54p. http://usm.maine.edu/~csc/homepage/Maine Biotech Report.pdf (accessed October 23rd 2006)

Commonwealth of Australia, Ernst and Young and Freehills. 2001. *Australian Biotechnology Report*. 79p

Critical I and EuropaBio. 2006. *Biotechnology in Europe: 2006 Comparative Study*. Critical I Comparative Study for EuropaBio. http://www.europabio.org/CriticalI2006/Critical2006.pdf (accessed July 11th, 2006)

Datamonitor. 2006. *Global Biotechnology Industry Profile*. Reference Code: 0199-0695
Datamonitor. 2006. *Biotechnology in Asia-Pacific: Industry Profile*. Reference Code: 0200-0695. 18p.
Datamonitor. 2006. *Biotechnology in Belgium: Industry Profile*. Reference Code: 0160-0695. 18p.
Datamonitor. 2006. *Biotechnology in Canada: Industry Profile*. Reference Code: 0070-0695. 18p.
Datamonitor. 2006. *Biotechnology in China: Industry Profile*. Reference Code: 0099-0695. 18p.
Datamonitor. 2006. *Biotechnology in France: Industry Profile*. Reference Code: 0164-0695. 18p.
Datamonitor. 2006. *Biotechnology in Germany: Industry Profile*. Reference Code: 0165-0695. 18p.
Datamonitor. 2006. *Biotechnology in Italy: Industry Profile*. Reference Code: 0171-0695. 18p.
Datamonitor. 2006. *Biotechnology in Japan: Industry Profile*. Reference Code: 0104-0695. 18p.
Datamonitor. 2006. *Biotechnology in Spain: Industry Profile*. Reference Code: 0180-0695. 18p.
Datamonitor. 2006. *Biotechnology in the Netherlands: Industry Profile*. Reference Code: 0176-0695. 18p.
Datamonitor. 2006. *Biotechnology in the UK: Industry Profile*. Reference Code: 0183-0695. 18p.
Datamonitor. 2006. *Biotechnology in the US: Industry Profile*. Reference Code: 0072-0695. 18p.

Delucchi J. and Brenders P., 2006. *Canadian Life Sciences Industry Forecast 2006, A vision of the future.* BIOTECanada and PricewaterhouseCoopers LLP. 16p. http://www.biotech.ca/PDFs/LifeScienceForecast2006.pdf

Devlin, A. 2003. *An overview of biotechnology statistics in selected countries (STI Workiing Paper 2003/13)*. Paris: OECD. http://www.olis.oecd.org/olis/2003doc.nsf/43bb6130e5e86e5fc12569fa005d004c/7524fee7966a86c2c1256de50049f989/$FILE/JT00154671.PDF (accessed July 11th, 2006)

Federal Statistical Office Germany. 2003. *Consolidation of the biotechnology branch: Press Release*. Federal Statistical Office of Germany. http://www.destatis.de/presse/deutsch/pk/2003/biotechnologie_2002i.pdf (accessed July 11th, 2006)

Forfas. 2005. *Business Expenditure on Research and Development (BERD) Ireland 2003/4*. Science and Technology Indicators Unit. 70p. http://www.forfas.ie/publications/0304_publicresearchsys/BaselineAsses.pdf (accessed July 11th, 2006)

Furman J. L., Porter M. E. and Stern S. 2002. The determinants of national innovative capacity. *Research Policy*. 31: 899-933.

Guellec, D. and van Pottelsberghe de la Potterie, B. 2001. R&D and Productivity Growth: Panel Data Anlysis of 16 OECD Countries. Paris: Organisation for Economic Co-operation and Development. STI WORKING PAPERS 2001/3.

Government of Japan. 2001. *The Science and Technology Basic Plan* (2001-2005), 48p. http://www8.cao.go.jp/cstp/english/basic/3rd-BasicPlan_06-10.pdf (accessed August 28th, 2006)

Haila, K. and Karjalainen, J. 2002. *Biotechnology in Finland: Impact of Research Funding and Strategies for the Future*. Evaluation Report. Helsinki: Academy of Finland, 110p. http://www.aka.fi/index.asp?id=E12080C439CB48A191E80295F382194F&data=1,URL,http://www.aka.fi/modules/page/show_page.asp?id=A120FE8E911A4CA0841893F46643A8CB&itemtype=00308B787886459385F296A5AFD4FA74 (accessed July 11th, 2006)

Hanson, A. J., Brown, P.G., Dale, A. *et al*. 2006. *BioPromise? Biotechnology, Sustainable Development and Canada's Future Economy. Technical Report to the Canadian Biotechnology Advisory Committee (CBAC) from the BSDE Expert Working Party, September 2006*. Ottawa. http://cbac-cccb.ca/epic/internet/incbac-cccb.nsf/vwapj/BSDE Technical Report-ENGLISH.pdf/$file/BSDE Technical Report-ENGLISH.pdf (accessed October 23rd, 2006)

Hsu Y.-G., Shyu J. Z. and Tzeng G.-H. 2005. Policy tools on the formation of new biotechnology firms in Taiwan. *Technovation*. 25: 281-292.

JBA. 2005. Bioventures Statistics Results. *Japan Bioindustries Letters*, 21(3-1), Available online at: http://www.jba.or.jp/eng/letters/Vol-21/3-1.htm. (accessed July 11th, 2006)

Kopp, P. 2004. *Panorama des biotechnologies en France*. France Biotech. http://www.cdcpme.fr/images/PDF/etude_france_biotech_1203.pdf (accessed July 11th, 2006)

Lee S.-H., Wong P.-K. and Chong C.-L. 2005. Human and Social Capital Explanations for R&D Outcomes. *IEEE Transactions on Engineering Management*. 52(1): 59-68.

Lim D. and Choi Y. H. 2004. The Economic Impact of Biotechnology and Bioindustry: methodologies and implications for the Bio-industry in Korea. *Industrial Economic Review*. Vol. 9 no.3. 42p.

Brännback M., Söderlund R. and Petrov M, 2004. *Case Study on Innovation: The Finnish Biotechnology Innovation System*. Organization for Economic Cooperation and Development. Turku. 100p.

Mangematin V., Lemarié S., Boissin J.-P. *et al*. 2003. Development of SMEs and heterogeneity of trajectories: the case of biotechnology in France. *Research Policy*. 32: 621-638.

Ministère de la Jeunesse, de l'Éducation et de la Recherche. 2001. *Les entreprises de biotechnologie en France. Note de recherche*. http://biotech.education.fr/download/DEP_sept_2003.pdf (accessed July 11th, 2006)

McNiven C., Raoub L. and Traoré N. 2003. *Features of Canadian Biotechnology Innovative Firms: Results from the Biotechnology Use and Development Survey 2001*. Statistics Canada Catalogue no. 88F0006XIE2003005. Science, Innovation and Electronic Information Division. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2003005.pdf (accessed July 7th, 2006)

Mulder, M. and Henschel, T. 2003. *National Biotech Survey. Idea to Industry*. Ecoli Bio. http://www.egolibio.co.za/pages/biotech_survey.pdf (accessed July 11th, 2006)

Niosi J. 2003. Alliances are not enough explaining rapid growth in biotechnology firms. *Research Policy*. 32: 737-750.

Niosi J. and Bas T.G. 2003. Biotechnology Megacentres: Montreal and Toronto Regional Systems of Innovation. *European Planning Studies*. 11(7): 789-804.

OECD. 2005. *A Framework For Biotechnology Statistics*. Organisation for Economic Co-Operation and Development. 51p. http://www.oecd.org/dataoecd/5/48/34935605.pdf (accessed July 11th, 2006)

OECD. 2003. OECD *Science, Technology and Industry Scoreboard*. Organisation for Economic Co-Operation and Development.

OECD. 2001. *Glossary of Statistical Terms*. 'Industry – SNA'. Available online at: http://stats.oecd.org/glossary/. (accessed July 11th, 2006)

Raoub L., Salonius A. and McNiven C. 2005. *Overview of the Biotechnology Use and Development Survey - 2003*. Statistics Canada Catalogue no. 88F0006XIE-009. Science, Innovation and Electronic Information Division. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2005009.pdf (accessed July 11th, 2006)

Raoub, L. 2004. *Evolution of Biotechnology in Canada- 1997-2001*. Statistics Canada Catalogue no. 88F0006XIF-017. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2004017.pdf (accessed July 11th, 2006)

Salter A. J. and Martin B. R. 2001. The economic benefits of publicly funded basic research: a critical review. *Research Policy*. 30: 509-532.

Science Foundation Ireland. 2002. *Baseline Assessment of the Public Research System in Ireland in the areas of Biotechnology and Information and Communication Technologies*. 118p.

SourceOECD Science and Technology Statistics. 2004. Research & Development Statistics - Total Business Expenditure on Research and Development (BERD) by Industry (Table 13) *ISIC Rev.2* Vol 2004 release 02 - Statistiques de la Recherche - Développement - Total DIRDE par industrie (Tableau 13) *CITI Rev. 2* Vol 2004 édition 02

Statistics Canada. 2006. *Biotechnology scientific activities in federal government departments and agencies, 2004-2005*. Service bulletin: Science statistics. Science, Innovation and Electronic Information Division. Vol. 30, No. 2. Statistics Canada Catalogue no. 88-001-XIF. Ottawa. http://www.statcan.ca/english/freepub/88-001-XIE/88-001-XIE2006002.pdf (accessed July 11th, 2006)

Statistics New Zealand. 2001. *Modern biotechnology activities in New Zealand*. http://www.stats.govt.nz/NR/rdonlyres/2BF13E3C-CF44-4DFB-9851-DE5CAD8DF2D6/0/BiotechnologyReport.pdf (accessed July 11th, 2006)

Statistics New Zealand. 2005. *Biotechnology in New Zealand 2004*. http://www.stats.govt.nz/NR/rdonlyres/FDD38C83-2F57-42C1-AE2D-84CCD7D4D143/0/BiotechNZ2004.pdf (accessed July 11th, 2006)

The Swedish Agency for Innovation Systems. 2001. *The Swedish Biotechnology Innovation System*. http://www.vinnova.se/upload/EPiStorePDF/vf-01-02.pdf (accessed July 11th, 2006)

Thumm, N. 2003. *Research and Patenting in Biotechnology: A Survey in Switzerland*. Swiss Federal Institute of Intellectual Property, 97p. http://www.ige.ch/E/jurinfo/documents/j10005e.pdf#search=%22Research%20and%20Patenting%20in%20Biotechnology%3A%20A%20Survey%20in%20Switzerland%22 (accessed July 11th, 2006)

United Nations. 1993. *System of National Account* (SNA). http://unstats.un.org/unsd/sna1993/toctop.asp (accessed August 28th, 2006)

USDC. 2003. *A Survey of the Use of Biotechnology in U.S. Industry*. U.S. Department of Commerce Technology Administration Bureau of Industry and Security. http://www.nist.gov/cgi-bin/exit_nist.cgi?url=http://www.technology.gov/reports/Biotechnology/CD120a_0310.pdf (accessed July 11th, 2006)

The World Bank. 2005. *World Development Indicators*. Available at: http://devdata.worldbank.org/data-query/ (accessed July 11th, 2006)

Appendix A Characterization of available statistics

Table V presents data availability by country and by indicator based on the data sources listed in Appendix B. The table shows that data for most indicators can be retrieved fairly easily for a single year, but they are not usually available for time-series analyses. The following tables characterize these data in greater details. Table VI examines company and product-level indicators, Table VII financial-level indicators, and Table VIII examines workforce-type indicators. Each of these tables highlights the following characteristics of the data based on data quality aspects of biotechnology surveys as prescribed by the OECD's *Framework for Biotechnology Statistics* (2005):

- **Source:** indicates the source of the data, and complete references are presented in Appendix B;
- **Data Scope:** indicates whether the data presented are from national or international surveys or from limited data;
- **Reporting unit:** indicates whether the data were produced by a government agency or if they originated from another institutional source;
- **Firm type:** indicates the firm definition that was used to estimate the number of biotechnology firms;
- **Consistency with OECD's definition of biotechnology:** indicates whether the data are consistent with the OECD's definition of biotechnology or if the definition of biotechnology used is not specified.

This characterization is not exhaustive but concentrates on aspects that are critical to an understanding of the limits of the *Canadian biotechnology innovation scoreboard*.

Legend (for Table V to Table VIII)

Consistency with OECD's definition of biotechnology

Mixed	Includes second-generation biotechnologies
Modern	Consist of third-generation biotechnologies that are similar to the OECD list-based definition in practice
None given	No biotechnology definition is provided in the report
OECD	Consistent with the definition of biotechnology prescribed by the OECD in the report: *A Framework for Biotechnology Statistics*

Firm type

AFB	Original firm type category is 'Active firms in biotechnology'
ALL	Includes DBF, IBF and AFB
BIO	Original firm type category is 'Bioventures'
CORE	Original firm type category is 'Core Biotechnology Companies'
DBF	Original firm type category is 'Dedicated Biotechnology Firm'
IBF	Original firm type category is 'Innovative Biotechnology Firms'
PBC	Publicly traded biotechnology companies
R&D	Limited to firms that haved performed biotechnology-related R&D

Reporting unit

AC	Academic Reporting Unit
GOV	Governmental Reporting Unit
NP-GOV	Conducted by a non-profit organisation at the request of a Government agency
PR	Private Reporting Unit

Table V   Data availability per country and by indicator, 1998-2006

Firms, workforce, financial and trade indicators	Australia	Austria	Belgium	Canada	China	China (Shanghai)	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Poland	Portugal	Rep.of Korea	South Africa	Spain	Sweden	Switzerland	United Kingdom	USA	Number of countries for which these data are available
	Number of years for which these data are available for each country																																
Biotechnology dedicated R&D expenditures by biotechnology firms				4																													4
Business Sector Biotechnology-Dedicated R&D Employees	1	2	3	2		1	5	2	5	5	5	2	2	1		4	1	2		1	2		4		3			4	3	3	4	5	72
Business Sector R&D Expenditures	2	2	2	4		1	8	2	5	4	4	2	2	1	2	3	1	3		1	2	2	5		2	1		8	4	4	3	4	84
Business Sector Total Bio-Active Employees Among Biotechnology Firms		3	4	4			4	2	5	6	5	2	2	1		4	1	4		1	3	1	4		4			2	3	3	4	4	76
Companies formed before 1988										1																							1
Companies formed in 2003		1	1	1			1		1	1	1					1		1			1				1				1	1	1	1	15
Debt		2	2				3	2	3	3	3	2	2			3		2			3		3		2			2	3	3	3	3	49
Exports				4																						1							5
Financing: united capitals				3																													3
Government R&D Expenditures	3			7			4		4	1	3				4						1	2	1				1		1				32
Government Total R&D Employees	1			6																													7
Higher Education R&D Expenditures	3								1													1							1				6
Imports				3																													3
Innovative Companies		1	1				1		1	1	1					1		1			1		1		1				1	1	1	1	15
Market Value			5	5	5					5	5							5	5		5							5			5	5	55
Market Value Growth			4	4	4					4	4							4	4		4							4			4	4	44
Number of Companies Founded		5	5				5		5	4	5					5		5			5		5		4				5	5	5	5	73
Number of firms	5	2	5	4		1	13	2	6	8	7	2	2	1	2	6	1	4	3	1	3	4	6	1	3	1	3	9	7	5	6	7	130
Private placements		2	2				2	2	3	3	3	2	2			3		2			2		2		2			1	3	2	3	3	44
Products in Phase I				4			1		1	1	1					1							1						1	1	1		13
Products in Phase II				4			1		1	1	1					1							1						1	1	1		13
Products in Phase III				4			1		1	1	1					1							1							1	1		12
Products in Phase IV				4																													4
Public Equity Offering		2	3				3	2	2	3	3	2	2			3		2			2		2		2			1	3	2	3	3	45
Revenues	2	2	2	4			3	2	4	3	3	2	2		2	3		2	1		2	2	3		2	1		2	4	3	3	5	64
Sales of biotechnology firms				1		1			1	1	1						1		1			2					1	1				1	12
Size of the Local Market	5		5	5	5					5	5				3				5		1					4					5	5	53
Total Equity (of which)		3	3				3	2	3	3	3	2	2			3		3			3		3		2			1	3	2	3	3	50
Total Number of Employees in Biotechnology Firms				4			1		1	1	1								1		1	4				1		5	2			4	26
Total R&D Employees	1			1			1			2	2				2				1							1							11
Total R&D Expenditures	1		1				4		3	2	2					2			1			1	2				1		1	2	2	1	26
Universities Total R&D Employees	1																																1
Value of PBC																																2	2
Venture Capital	1	3	4	3			4	2	4	6	3	2	2			3		3			3		3		2	1	1	7	4	2	3	12	78
Young Innovative Companies		1	1				1		1	1	1					1		1			1		1		1				1	1	1	1	15
Number of distinct indicators available	**12**	**14**	**18**	**23**	**3**	**4**	**21**	**10**	**22**	**26**	**25**	**10**	**10**	**4**	**6**	**18**	**5**	**16**	**9**	**4**	**19**	**9**	**18**	**1**	**14**	**8**	**5**	**14**	**20**	**18**	**21**	**21**	

Source: Sources are presented in Table V, VI, VII, VIII, and in Appendix B

Table VI Publicly available data on biotechnology firms and products in selected countries, 1998–2006

Indicators	Source	Biotech Definition	Firm type	Reporting Unit	RR	Extra-polation	Australia	Austria	Belgium	Canada	China (Shanghai)	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Poland	Portugal	Rep.of Korea	South Africa	Spain	Sweden	Switzerland	United Kingdom	USA
Biotechnology firms and products																																					
Companies formed before 1988	CI	Modern	Core	Critical I	...	Partial [1]									X																						
Companies formed in 2003	CI	Modern	Core	Critical I	...	Partial [1]		X	X	X		X		X	X	X					X		X			X				X				X	X	X	X
Innovative Companies	CI	Modern	Core	Critical I	...	Partial [1]		X	X			X		X	X	X					X		X			X		X		X				X	X	X	X
Number of Companies Founded	CI	Modern	Core	Critical I	...	Partial [1]		X	X			X		X	X	X					X		X			X		X		X				X	X	X	X
Number of firms	AU	OECD	AFB	GOV	..	Yes	X																														
	AU	OECD	All	GOV	..	Yes	X																														
	AU	OECD	Core	GOV	..	Yes	X																														
	BAK	Modern [2]	Core	BAK	..	..																									X						
	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]		X	X			X		X	X	X					X		X			X		X		X				X	X	X	X
	CI-2006	Modern	Core	Critical I	...	Partial [1]		X	X			X	X	X	X	X	X	X			X		X			X		X		X			X	X	X	X	X
	DNK	None given	Core	GOV	63%	Yes						X																									
	EC	Modern	DBF	EC	...	…			X					X		X					X							X						X	X	X	
	EY	None given	All	E&Y	...	Yes																														X	
	EY-1	None given	All	E&Y	...	Yes																															X
	FIN	Modern	Core	NP-GOV	..	Yes								X																							
	FR	OECD	All	GOV	...	Yes									X																						
	FR	OECD	Core	GOV	...	Yes									X																						
	FR-2	OECD	IBF	France	...	Yes									X																						
	GE	OECD	Core	Genoma	..	..																											X				
	GE	OECD	Core	Genoma	..	Yes																											X				
	GER	OECD	Core	GOV	65%	..										X																					
	IND	..	All	OECD	...	Yes														X																	
	ISL	OECD	All	GOV	96%	Yes																X															
	JAP	Modern [2]	BIO	GOV	...	Yes																		X													
	JBA	Mixed [3]	BIO	JBA	76%	No																		X													
	NOR-1	OECD	R&D	GOV	95%	Yes																						X									
	NZ	OECD	All	GOV	90%	No																					X										
	NZ	OECD	All	GOV	93%	No																					X										
	NZ-2	OECD	All	GOV	93%	No																					X										
	NZ-3	OECD	All	GOV	98,3	No																					X										
	OECD	None given	DBF	OECD	...	Mixed																												X			
	OCDE-06	Mixed	All [4]	NP-GOV	...	…																		X													
	OCDE-06	Modern	All	NP-GOV	...	…					X			X																							
	OCDE-06	Modern [2]	All	NP-GOV	…	…																			X												
	OCDE-06	None given	Core	NP-GOV	...	…																												X			
	OCDE-06	None given	R&D	NP-GOV	...	…						X																									
	OCDE-06	OECD	All	NP-GOV	...	…										X																					
	OCDE-06	OECD	Core	NP-GOV	...	…	X		X																												
	OCDE-06	OECD	IBF	NP-GOV	...	…									X				X																		
	OCDE-06	OECD	R&D	NP-GOV	...	…																	X														
	OCDE-06	OECD	..	NP-GOV	...	…																							X								
	SA	Mixed [3]	All	EgoliBio	72%	No																										X					
	SP	OECD	R&D	GOV	86%	Yes																											X				
	SP	OECD	R&D	GOV	86%	Yes																											X				
	SW	None given	Core	NP-GOV	..	..																												X			
	USA	None given	R&D	GOV	81%	No																															X
Products in Phase I	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
	Critical I	Modern	Core	Critical I	...	Partial [1]						X		X	X	X					X							X						X	X	X	
Products in Phase II	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]						X		X	X	X					X							X						X	X	X	
Products in Phase III	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]						X		X	X	X					X							X							X	X	
Products in Phase IV	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
Young Innovative Companies	CI	Modern	Core	Critical I	...	Partial [1]		X	X			X		X	X	X					X		X			X		X		X				X	X	X	X

Source: Refers to the formerly presented Legend and Source presented in Appendix B

Note:
1 Imputed or extrapolated results limited to selected firms or indicators, or to missing survey questions for respondents only
2 – May include some second generation biotechnologies
3 – May include some traditional and second generation biotechnologies
4 – May overestimate the number of firms (include traditional biotechnology and non-innovative firms)
.. Information not available
… Not relevant / Does not apply

Table VII Publicly available data on biotechnology workforce in selected countries, 1998–2006

Indicators	Source	Biotechnology Definition	Firm type	Reporting Unit	RR	Extra-polation	Australia	Austria	Belgium	Canada	China (Shanghai)	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Portugal	Rep. of Korea	Spain	Sweden	Switzerland	United Kingdom	USA
Workforce																																			
Business Sector Biotechnology-Dedicated R&D Employees	CAN	OECD	IBF	GOV	80%	Yes				X																									
	CI 3	Modern	Core	Critical I	...	Partial						X		X	X	X					X							X	X			X	X	X	X
	CI-06 3	Modern	Core	Critical I	...	Partial		X	X			X	X	X	X	X	X	X			X		X			X		X	X		X	X	X	X	X
	DNK [1]	None given	All	GOV	63%	Yes						X																							
	ISL	OECD	All	GOV	96%	Yes																X													
	OECD	OECD	All	OECD	...	Mixed	X																												
	OECD-06	Modern	All	NP-GOV	...	…					X			X	X																				
	OECD-06 [2]	Modern	All	NP-GOV	...	…																			X										
	OECD-06	OECD	All	NP-GOV	...	…										X																			
	OECD-06	OECD	Core	NP-GOV	...	…			X																										
	OECD-06	OECD	IBF	NP-GOV	...	…													X																
	SP [1]	OECD	R&D	GOV	86%	Yes																									X				
	USA	None given	R&D	GOV	81%	No																													X
Business Sector Total Bio-Active Employees Among Biotechnology Firms	CAN	OECD	IBF	GOV	80%	Yes				X																									
	CAN-2	OECD	IBF	GOV	...	Yes				X																									
	CI 3	Modern	Core	Critical I	...	Partial		X	X			X		X	X	X					X		X			X		X	X			X	X	X	X
	CI-06 [3]	Modern	Core	Critical I	...	Partial		X	X			X	X	X	X	X	X	X			X		X			X		X	X		X	X	X	X	X
	FR	OECD	IBF	GOV	...	Yes									X																				
	ISL	OECD	All	GOV	96%	Yes																X													
	OECD-06 [2]	Modern	All	NP-GOV	...	…								X											X										
	OECD-06	OECD	All	NP-GOV	...	…										X											X								
	OECD-06	OECD	Core	NP-GOV	...	…			X																										
	OECD-06	OECD	IBF	NP-GOV	...	…									X				X																
	OECD-06	OECD	R&D	NP-GOV	...	…																	X												
Government Total R&D Employees	CAN-3	OECD	IBF	GOV	...	No				X																									
	OECD	OECD	All	OECD	...	Mixed	X																												
Total Number of Employees in Biotechnology Firms	CAN	OECD	IBF	GOV	80%	Yes				X																									
	CAN-2	OECD	IBF	GOV	...	Yes				X																									
	DNK	None given	Core	GOV	63%	Yes						X																							
	EY-1	None given	All	Ernst & Young	...	Yes																													X
	FIN	Modern	Core	NP-GOV	..	Yes								X																					
	FR	OECD	IBF	GOV	...	Yes									X																				
	GE	OECD	Core	Genoma Espana	..	..																									X				
	GE	OECD	Core	Genoma Espana	..	Yes																									X				
	JAP [2]	Mixed	BIO	GOV	...	Yes																		X											
	KOR	Modern	Core	Academic	..	Yes																								X					
	NET	None given	Core	GOV	...	Yes																				X									
	NZ	OECD	All	GOV	90%	No																					X								
	NZ-2	OECD	All	GOV	93%	No																					X								
	NZ-3	OECD	All	GOV	98,3%	No																					X								
	OECD	..	All	OECD	...	Mixed										X																			
	OECD	OECD	All	OECD	...	Mixed																													X
	SW	None given	All	NP-GOV	..	..																										X			
	SW-1	None given	All	NP-GOV	..	..																										X			
	USA	None given	R&D	GOV	81%	No																													X
Total R&D Employees	CAN-1	OECD	IBF	GOV	...	Yes				X																									
	DNK	None given	Core	GOV	63%	Yes						X																							
	FR	OECD	All	GOV	...	Yes									X																				
	FR-2	OECD	IBF	France Biotech	...	Yes									X																				
	GER	OECD	Core	GOV	65%	Yes										X																			
	IND	..	All	OECD	...	Yes														X															
	JAP [2]	Mixed	BIO	GOV	...	Yes																		X											
	KOR	Modern	Core	Academic	..	Yes																								X					
	OECD	OECD	All	OECD	...	Mixed	X																												
Universities Total R&D Employees	OECD	OECD	All	OECD	...	Mixed	X																												

Source: Refers to the formerly presented Legend and Source presented in Appendix B

Note:
1 Time equivalents
2 May include some second generation biotechnologies
3 Imputed or extrapolated results limited to selected firms or indicators, or to missing survey questins for respondents only.
.. Information not available
… Not relevant / Does not apply

Table VIII Publicly available data on biotechnology financial indicators in selected countries, 1998–2006

Indicators	Source Code	Biotechnology Definition	Firm type	Reporting Unit	RR	Extra-polation	Australia	Austria	Belgium	Canada	China	China (Shanghai)	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Portugal	Rep.of Korea	South Africa	Spain	Sweden	Switzerland	United Kingdom	USA
Financial and trade information																																					
Biotechnology dedicated R&D expenditures by biotechnology firms	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
Business Sector R&D Expenditures	AU	OECD	DBF	GOV	..	Yes	X																														
	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-1	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]							X		X	X	X					X							X					X	X	X	X
	DNK	None given	All	GOV	63%	Yes							X																								
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	GE	OECD	Core	Genoma Espana	..	..																											X				
	IND	..	All	OECD	...	Yes															X																
	ISL	OECD	All	GOV	96%	Yes																	X														
	KOR	Modern	Core	Academic	..	Yes																									X						
	NOR-1	OECD	R&D	GOV	95%	Yes																							X								
	NZ-2	OECD	All	GOV	98,3%	No																						X									
	NZ-3	OECD	All	GOV	...	No																						X									
	OECD	OECD	Core	OECD	...	Mixed	X																						X								
	OECD-06	Modern	All	NP-GOV	...	…						X			X											X											
	OECD-06	Modern [2]	All	NP-GOV	...	…																				X											
	OECD-06	None given	R&D	NP-GOV	...	…							X																								
	OECD-06	OECD	All	NP-GOV	...	…											X																				
	OECD-06	OECD	IBF	NP-GOV	...	…										X				X																	
	OECD-06	OECD	R&D	NP-GOV	...	…																		X													
	SP	OECD	R&D	GOV	86%	Yes																											X				
	SW	None given	All	NP-GOV	..	..																												X			
	USA	None given	R&D	GOV	81%	No																															X
	CI-06	Modern	Core	Critical I	...	Partial [1]		X	X				X	X	X	X	X	X	X			X		X			X		X	X			X	X	X	X	X
Debt	CI	Modern	Core	Critical I	...	Partial [1]							X		X	X	X					X					X		X					X	X	X	X
	CI-06	Modern	Core	Critical I		Partial [1]		X	X				X	X	X	X	X	X	X			X		X			X		X	X			X	X	X	X	X
Exports	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
	KOR-2	Modern	IBF	GOV	...	Yes																									X						
Financing: united capitals	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	All	GOV	...	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
Government R&D Expenditures	AU	OECD	Core	GOV	..	Yes	X																														
	CAN-3	OECD	IBF	GOV	...	No				X																											
	DNK	None given	All	GOV	63%	Yes							X																								
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	FIN-2	OECD	IBF	Academic	...	Yes									X																						
	FR-2	OECD	IBF	France Biotech	...	Yes										X																					
	IND	..	All	OECD	...	Yes															X																
	NET	None given	Core	GOV	...	Yes																					X										
	NZ-2	OECD	All	GOV	98,3%	No																						X									
	NZ-3	OECD	All	GOV	...	No																						X									
	OECD	OECD	All	OECD	...	Mixed											X																				
	OECD	OECD	Core	OECD	...	Mixed																							X								
	OECD-06	Modern	All	NP-GOV	...	…									X																						
	SA	Mixed [3]	All	EgoliBio	72%	No																										X					
	SW	None given	All	NP-GOV	..	..																												X			
Higher Education R&D Expenditures	AU	OECD	DBF	GOV	..	Yes	X																														
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	NZ-3	OECD	All	GOV	...	No																						X									
	OECD	OECD	DBF	OECD	...	Mixed	X																														
	SW	None given	All	NP-GOV	..	..																												X			
Imports	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
Market Value	DM	None given	All [2]	Data Monitor	...	Yes			X	X	X					X	X							X	X		X						X			X	X
Market Value Growth	DM	None given	All 2	Data Monitor	...	Yes			X	X	X					X	X							X	X		X						X			X	X
Private placements	CI	Modern	Core	Critical I	...	Partial [1]									X	X	X					X												X		X	X
	CI-06	Modern	Core	Critical I	...	Partial [1]								X																							
						Partial [1]		X	X				X		X	X	X	X	X			X		X			X		X	X			X	X	X	X	X
Public Equity Offering	CI	Modern	Core	Critical I	...	Partial [1]			X				X			X	X					X												X		X	X
	CI-06	Modern	Core	Critical I	...	Partial [1]								X																							
						Partial [1]		X	X				X		X	X	X	X	X			X		X			X		X	X			X	X	X	X	X

Source: Refers to the formerly presented Legend and Source presented in Appendix B

Note:
1 Imputed or extrapolated results limited to selected firms or indicators, or to missing survey questions for respondents only
2 May include some second generation biotechnologies
3 Large firms in traditional biotechnology (fermented food products) were excluded, but some second generation biotechnology firms are in the sample
.. Information not available
… Not relevant / Does not apply

Table IX Publicly available data on biotechnology financial indicators in selected countries, 1998–2006

Indicators	Source Code	Biotechnology Definition	Firm type	Reporting Unit	RR	Extra-polation	Australia	Austria	Belgium	Canada	China	China (Shanghai)	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea	Netherlands	New Zealand	Norway	Portugal	Rep.of Korea	South Africa	Spain	Sweden	Switzerland	UK	USA
Financial and trade information																																					
Revenues	AU	OECD	DBF	GOV	..	Yes	X																														
	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]							X		X	X	X					X							X					X	X	X	X
	EY-1	None given	All	Ernst & Young	...	Yes																															X
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	IND	..	All	OECD	...	Yes															X																
	JAP	Mixed [2]	BIO	GOV	...	Yes																			X												
	KOR-2	Modern	IBF	GOV	...	Yes																									X						
	NZ-2	OECD	All	GOV	93%	No																						X									
	SW	None given	All	NP-GOV	..	..																												X			
	CI-06	Modern	Core	Critical I	...	Partial [1]		X	X				X	X	X	X	X	X	X			X		X			X		X	X			X	X	X	X	X
Sales of biotechnology firms	CAN	OECD	IBF	GOV	80%	Yes				X																											
	ISL	OECD	All	GOV	96%	Yes																	X														
	OECD-06	Mixed	All	NP-GOV	...	…																			X							X					
	OECD-06	Modern	All	NP-GOV	...	…						X			X																						
	OECD-06	OECD	All	NP-GOV	...	…											X											X					X				
	OECD-06	OECD	IBF	NP-GOV	...	…										X																					
	USA	None given	R&D	GOV	81%	No																															X
Size of the Local Market	BAK	Modern	Core [2]	BAK	..	..																									X						
	DM	None given	All [2]	Data Monitor	..	Yes	X		X	X	X					X	X								X											X	X
	KOR-2	Modern	IBF	GOV	...	Yes																									X						
	NET	None given	Core	GOV	...	Yes																					X										
Total Equity (of which)	CI	Modern	Core	Critical I	...	Partial [1]		X	X				X		X	X	X					X		X			X		X					X		X	X
	CI-06	Modern	Core	Critical I		Partial [1]		X	X				X	X	X	X	X	X	X			X		X			X		X	X			X	X	X	X	X
Total R&D Expenditures	AU	OECD	DBF	GOV	..	Yes	X																														
	DNK	None given	All	GOV	63%	Yes							X																								
	EC	Modern	All	EC	...	…			X						X	X	X					X													X	X	
	EC	Modern	DBF	EC	...	…																							X								
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	FR-2	OECD	IBF	France Biotech	...	Yes										X																					
	JAP	Mixed [2]	BIO	GOV	...	Yes																			X												
	NZ	OECD	All	GOV	90%	No																						X									
	OECD	None given	All	OECD	...	Mixed																							X								
	OECD	OECD	All	OECD	...	Mixed																X													X	X	X
	OECD	OECD	DBF	OECD	...	Mixed											X																				
	SA	Mixed	All [3]	EgoliBio	72%	No																										X					
	SW	None given	All	NP-GOV	..	..																												X			
Venture Capital	AU-1	None given	All	NP-GOV	..	Yes	X																														
	BEL	..	All	Academic	..	..			X																												
	CAN	OECD	IBF	GOV	80%	Yes				X																											
	CAN-2	OECD	All	GOV	...	Yes				X																											
	CAN-2	OECD	IBF	GOV	...	Yes				X																											
	CI	Modern	Core	Critical I	...	Partial [1]		X	X				X		X	X	X					X		X			X		X					X		X	X
	DNK	None given	All	GOV	63%	Yes							X																								
	EY-1	None given	All	Ernst & Young	...	Yes																															X
	FIN	Modern	Core	NP-GOV	..	Yes									X																						
	FR-2	OECD	IBF	France Biotech	...	Yes										X																					
	GE	OECD	Core	Genoma Espana	..	..																											X				
	KOR	None given	Core	Academic	..	Yes																									X						
	OECD	None given	All	OECD	...	Mixed																															X
	SA	Mixed	All [3]	EgoliBio	72%	No																										X					
	SW-1	None given	All	NP-GOV	..	..																												X			
	USA	None given	R&D	GOV	81%	No																															X
	CI-06	Modern	Core	Critical I	...	Partial [1]		X	X				X	X	X	X	X	X	X			X		X			X		X	X			X	X	X	X	X

Source: Refers to the formerly presented Legend and Source presented in Appendix B

Note:
1 Imputed or extrapolated results limited to selected firms or indicators, or to missing survey questions for respondents only
2 May include some second generation biotechnologies
3 Large firms in traditional biotechnology (fermented food products) were excluded, but some second generation biotechnology firms are in the sample
.. Information not available
… Not relevant / Does not apply

Appendix B Data sources

AU Commonwealth of Australia, Ernst and Young and Freehills. 2001. *Australian Biotechnology Report*. http://www.biotechnology.gov.au/assets/documents/bainternet/AustralianBiotechnologyReport200120050404142808%2Epdf (accessed July 11th, 2006)

AU-1 Axiss Autralia. 2005. *Venture Capital and Private Equity in Australia*. Invest Australia. Citing Australian Bureau of Statistics Catalogue No. 5678.0. http://www.investaustralia.gov.au/media/IS_FS_VentureCapital.pdf (accessed July 11th, 2006)

BAK Biotechnology Association of Korea. Data Available at: http://www.bak.or.kr/english/about/about_outline.html (accessed July 11th, 2006)

BEL A. van der Giessen, S. Kern, C. Enzing. 2003. *Effectiveness of innovation policies: biotechnology in Belgium (1994-2001)*. European Commission DG Research. TNO Report. TNO Strategy, Tecnology and Policy. 43p.

CAN Raoub L.; Salonius A.; McNiven C. 2005. *Overview of the Biotechnology Use and Development Survey - 2003*. Statistics Canada Catalogue no. 88F0006XIE-009. Science, Innovation and Electronic Information Division. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2005009.pdf (accessed July 7th, 2006).

CAN-1 McNiven C.; Raoub L.; Traoré N.. 2003. *Features of Canadian Biotechnology Innovative Firms: Results from the Biotechnology Use and Development Survey 2001*. Statistics Canada Catalogue no. 88F0006XIE2003005. Science, Innovation and Electronic Information Division. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2003005.pdf (accessed July 7th, 2006)

CAN-2 Raoub, L. 2004. *Evolution of Biotechnology in Canada- 1997-2001*. Statistics Canada Catalogue no. 88F0006XIF-017. Ottawa. http://www.statcan.ca/english/research/88F0006XIE/88F0006XIE2004017.pdf (accessed July 7th, 2006)

CAN-3 Statistics Canada. 2006. *Biotechnology scientific activities in federal government departments and agencies, 2004-2005*. Service bulletin: Science statistics. Science, Innovation and Electronic Information Division. Vol. 30, No. 2. Statistics Canada Catalogue no. 88-001-XIF. Ottawa. http://www.statcan.ca/english/freepub/88-001-XIE/88-001-XIE2006002.pdf (accessed July 7th, 2006)

CI-2006 Critical I and EuropaBio. 2006. *Biotechnology in Europe: 2006 Comparative Study*. Critical I Comparative Study for EuropaBio. http://www.europabio.org/CriticalI2006/Critical2006.pdf (accessed July 11th, 2006)

DM Data Monitor. 2004-2006. *Biotechnology in Asia-Pacific: Industry Profile*. RC-0200-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Belgium: Industry Profile*. RC-0160-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Canada: Industry Profile*. RC-0070-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in China: Industry Profile*. RC-0099-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in France: Industry Profile*. RC-0164-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Germany: Industry Profile*. RC-0165-0695. 18p.

DM Data Monitor. 2004-2006. *Global Biotechnology: Industry Profile*. RC-0199-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Italy: Industry Profile*. RC-0171-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Japan: Industry Profile*. RC-0104-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in Spain: Industry Profile*. RC-0180-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in the Netherlands: Industry Profile*. RC-0176-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in the United Kingdom: Industry Profile*. RC-0183-0695. 18p.

DM Data Monitor. 2004-2006. *Biotechnology in the United States: Industry Profile*. RC-0072-0695. 18p.

DNK Bloch, C. 2004. *Biotechnology in Denmark: A Preliminary Report*. The Danish Centre for Studies in Research and Research Policy. Aarhus. http://www.cfa.au.dk/Publikationer/Working_papers/WP2004_1.pdf (accessed on July 7th, 2006)

EC Allansdottir A., Bonaccorsi A., Gambardella A. and al. 2002. *Innovation and competitiveness in European biotechnology. Enterprise Papers No.7*. Enterprise Directorate. General European Commission. Brussels. http://europe.eu.int/comm/enterprise/library/enterprise-papers/pdf/enterprise_paper_07_2002.pdf (accessed July 11th, 2006)

FIN Academy of Finland. 2002. *Biotechnology in Finland: Impact of Research Funding and Strategies for the Future. Evaluation Report*. http://www.aka.fi/index.asp?id=E12080C439CB48A191E80295F382194F&data=1,URL,http://www.aka.fi/modules/page/show_page.asp?id=A120FE8E911A4CA0841893F46643A8CB&itemtype=00308B787886459385F296A5AFD4FA74 (accessed July 11th, 2006)

FIN-2 Brännback M., Söderlund R., Petrov M., 2004. *OECD Case Study on Innovation: The Finnish Biotechnology Innovation System*. INNOMARKET. Turku. http://www.oecd.org/dataoecd/23/6/31669860.pdf (accessed July 11th, 2006)

FR Ministère de la Jeunesse, de l'Éducation et de la Recherche. 2001. *Les entreprises de biotechnologie en France. Note de recherche*. http://biotech.education.fr/download/DEP_sept_2003.pdf (accessed July 11th, 2006)

FR-2 Kopp, P. 2004. *Panorama des biotechnologies en France*. France Biotech. http://www.cdcpme.fr/images/PDF/etude_france_biotech_1203.pdf (accessed July 11th, 2006)

GE Genoma Espana. 2005. *Spanish biotechnology: economic impact, trend and perspectives*. http://www.gen-es.org/02_cono/docs/SPA_BIOTECH.pdf (accessed July 11th, 2006)

GER Federal Statistical Office Germany. 2003. *Consolidation of the biotechnology branch: Press Release*. Federal Statistical Office of Germany. http://www.destatis.de/presse/deutsch/pk/2003/biotechnologie_2002i.pdf (accessed July 11th, 2006)

IND Chaturvedi, S. 2005. *Dynamics of biotechnogy research and industry in India: statistics, perspectives and key issues*. Organisation for Economic Co-operation and Development STI Working paper. 62p.

IND-2 Government of India. 2003. *Biotechnology Annual Report 2002-2003*. Ministry of Science and Technology - Department of Biotechnology. http://dbtindia.nic.in/publication/publicmain.html (accessed on July 20, 2006)

ISL Israel Central Bureau of Statistics. 2005. *Survey of Biotechnology Companies in Israel 2002*. http://www.cbs.gov.il/publications/biotech02/pdf/e_print.pdf (accessed July 11th, 2006)

JAP Government of Japan. 2001. *The Science and Technology Basic Plan (2001-2005)* http://www8.cao.go.jp/cstp/english/basic/3rd-BasicPlan_06-10.pdf (accessed July 11th, 2006)

JBA Japanese Biotechnology Association (JBA). 2005. *2005 bio venture statistical report (summary edition)*. Japanese Bioindustry Association. Ministry of Economy, Trade and Industry (METI). http://www.jba.or.jp/bv/2005-bv-summary.pdf (accessed July 11th, 2006)

KOR Lim D.; Choi Y.H. 2004. *The Economic Impact of Biotechnology and Bioindustry: methodologies and implications for the Bio-industry in Korea*. Industrial Economic Review. Vol. 9 no.3. 42p.

KOR-2 Ahn, C. 2004. *Biotechnology Industry in Korea: Industry Sector Analysis*. U.S. & Foreign Commercial Service and U.S. Department of State. http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/fr/gr117524f.html (accessed July 11th, 2006)

NET Canadian Trade Commissioner Service. 2003. *The Biotechnology Market in the Netherlands*. Department of Foreign Affairs and International Trade, 32 pages.

NOR-1 NIFU. 2005. *Bioteknologisk FoU 2003: Ressursinnsat I Universitets- og Hogskolesektoren og Instituttsektoren*

NZ Statistics New Zealand. 2005. *Biotechnology in New Zealand 2004*. http://www.stats.govt.nz/NR/rdonlyres/FDD38C83-2F57-42C1-AE2D-84CCD7D4D143/0/BiotechNZ2004.pdf (accessed July 11th, 2006)

NZ-2 Statistics New Zealand. 2001. *Modern biotechnology activities in New Zealand*. http://www.stats.govt.nz/NR/rdonlyres/2BF13E3C-CF44-4DFB-9851-DE5CAD8DF2D6/0/BiotechnologyReport.pdf (accessed July 11th, 2006)

NZ-3 Statistics New Zealand. 2005. *Research and Development in New Zealand 2004*. http://www.stats.govt.nz/NR/rdonlyres/4A0F6E02-7C5C-4A31-BDC6-3437C5AB0D34/0/RandD2004web.pdf (accessed July 11th, 2006)

OECD Devlin, A. 2003. *An overview of biotechnology statistics in selected countries (STI Workiing Paper 2003/13)*. OECD. Paris. http://www.olis.oecd.org/olis/2003doc.nsf/43bb6130e5e86e5fc12569fa005d004c/7524fee7966a86c2c1256de50049f989/$FILE/JT00154671.PDF (accessed July 11th, 2006)

OECD-06 Beuzekom, B. and Arundel, A.. 2006. OECD *Biotechnology Statistics-2006*. Organization for Economic Co-Operation and Development. Paris. http://www.oecd.org/dataoecd/51/59/36760212.pdf (accessed July 11th, 2006)

SA Mulder, M.; Henschel, T. 2003. *National Biotech Survey. Idea to Industry*. Ecoli Bio. http://www.egolibio.co.za/pages/biotech_survey.pdf (accessed July 11th, 2006)

SP Instituto Nacional de Estadìstica (INE). 2006. *Statistics on the use of Biotechnology 2004*. http://www.ine.es/inebase/cgi/axi?COMANDO=SELECCION&CGI_DEFAULT=/inebase/temas/english.opt&CGI_URL=/inebase/cgi/&AXIS_PATH=/inebase/temas/t14/p057/bio/2004/l1/&FILE_AXIS=01001.px##PX## (accessed July 11th, 2006).

SW The Swetish Agency for Innovation Systems. 2001. *The Swedish Biotechnology Innovation System*. http://www.vinnova.se/upload/EPiStorePDF/vf-01-02.pdf (accessed July 11th, 2006)

SW-1 The Swetish Agency for Innovation Systems. 2003. *Swedish Biotechnology: scientific publications, patenting and industrial development*. http://www.vinnova.se/SiteSeeker/HitCounter.aspx?url=http%3a%2f%2fwww.vinnova.se%2fupload%2fEPiStorePDF%2fva-03-02.pdf&pageid=570.1&word=swedish+biotechnology (accessed July 11th, 2006)

USA USDC. 2003. *A Survey of the Use of Biotechnology in U.S. Industry*. U.S. Department of Commerce Technology Administration Bureau of Industry and Security. http://www.nist.gov/cgi-bin/exit_nist.cgi?url=http://www.technology.gov/reports/Biotechnology/CD120a_0310.pdf (accessed July 11th, 2006)