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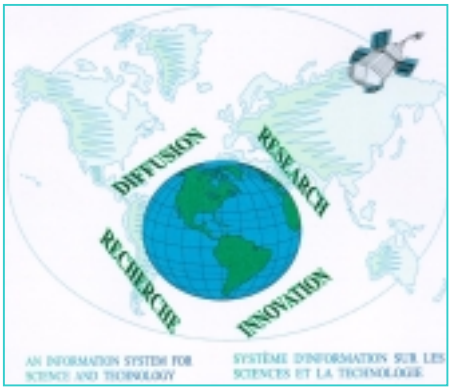
Biotechnology Use and Development - 1999



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BIOTECHNOLOGY USE AND DEVELOPMENT - 1999

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Science, Innovation and Electronic Information Division

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The Science and Innovation Information Program

The purpose of this program is to develop **useful indicators of science and technology activity** in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed in five key entities:

- **Actors**: are persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.
- **Activities**: include the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.
- **Linkages**: are the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, the source of ideas for innovation in industry.
- **Outcomes**: are the medium-term consequences of activities. An outcome of an innovation in a firm may be more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.
- **Impacts**: are the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and we are continuing with our efforts to understand the characteristics of innovative and non-innovative firms, especially in the service sector that dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology in which it invests over five billion dollars each year. In the past, it has been possible to say only *how much* the federal government spends and *where* it spends it. Our report **Federal Scientific Activities, 1998 (Cat. No. 88-204)** first published socio-economic objectives indicators to show *what* the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, all of this information has been used to provide a context for performance reports of individual departments and agencies.

As of April 1999, the Program has been established as a part of Statistics Canada's Science, Innovation and Electronic Information Division.

The final version of the framework that guides the future elaboration of indicators was published in December, 1998 (**Science and Technology Activities and Impacts: A Framework for a Statistical Information System,** Cat. No. 88-522). The framework

has given rise to **A Five-Year Strategic Plan for the Development of an Information System for Science and Technology** (Cat. No. 88-523).

It is now possible to report on the Canadian system on science and technology and show the role of the federal government in that system.

Our working papers and research papers are available at no cost on the Statistics Canada Internet site at http://www.statcan.ca/english/research/scilist.htm.

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Working Papers

The Working Papers publish research related to science and technology issues. All papers are subject to internal review. The views expressed in the articles are those of the authors and do not necessarily reflect the views of Statistics Canada.

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The survey also owes a debt of gratitude to the firms, that must remain anonymous, who gave their time and ideas in development and testing of the survey and as well as those firms that responded to the survey.

At Statistics Canada numerous people contributed to the survey, among those are Antoine Rose, Claire Racine-Lebel, Annie Gilbert and the methodology team of Yves Morin, Lyne Guertin, Richard Laroche and Nicolas Lavigne.

Introduction

Canada had 358 biotechnology firms[1] in 1999 that generated revenues of more than $1.9 billion from activities directly related to biotechnology, according to data from the Biotechnology Use and Development Survey -1999. The survey, administered by the Science, Innovation and Electronic Information Division of Statistics Canada, provides information on companies involved in developing new products and processes using biotechnologies and was conducted as part of a project to develop biotechnology statistics under the Canadian Biotechnology Strategy.

The survey was conducted as part of a project to develop biotechnology statistics and was funded under the Canadian Biotechnology Strategy. It addressed the questions: What are the characteristics and activities of firms that use or develop biotechnology as an important part of their firms' activities? This paper begins to answer those questions with a summary of the revenue, research and development, import and export, product pipeline and human resources characteristics of biotechnology firms.

Canadian biotechnology firms demonstrated growth in activities including revenues, research and development, and imports and exports. Revenues for 1999, a 25% increase over 1998 revenues, are expected to more than double to $5 billion by 2002. The $1.9 billion in revenues from biotechnology make up just 11% of the more than $18 billion in total revenues for firms engaged in biotechnology.

Biotechnology firms are active in exporting biotechnology, with the value of biotechnology firms' biotechnology exports exceeding $700 million in 1999, growing to almost $1.7 billion in 2002. Among those core firms, biotechnology exports exceed biotechnology imports by a greater margin each reporting year.

Firms were actively involved in the development of new biotechnology products or processes with about one-half of the over 17,000 products or processes currently in development at the research and development stage. Products range from environmental products or processes to human health to the human genome, and are being developed by large and small firms across Canada.

Background

The use of biotechnology in human activity is not new. Classical forms of biotechnologies such as fermentation have been a part of industrial processes for decades, if not centuries. But today, more recent developments in biotechnologies are diffusing throughout the economy. Industrial, health and environmental activities are being transformed and new ones are emerging. Traditional biological processes continue today

[1] Biotechnology firms are defined as those firms performing research and development in biotechnology and develop new biotechnology processes or products. This group completed the entire questionnaire with the exception of question 2.

but are enhanced by scientific processes intended to not only understand organisms but to decode and modify organisms and at times contributing to new products or processes. The Canadian Biotechnology Advisory Committee[2] (CBAC) described "biotechnology as a body of technical knowledge about living organisms or their constituent parts and applied biotechnology as those aspects of biotechnology that are used to make products and drive processes that serve social, scientific or economic purposes."

This survey is the latest in a series of initiatives intended to develop a biotechnology statistics program. Statistics Canada administered two previous surveys dedicated to biotechnologies. The first, the Biotechnology Use Survey – 1996[3] examined the use of biotechnologies in selected Canadian industries. The second, the Biotechnology Firm Survey - 1997 was aimed at those firms actively conducting research and development and considered to be the core biotechnology firms.

The Biotechnology Use and Development Survey – 1999 combines elements and the legacy of those surveys in order to provide a comprehensive set of statistics. It addresses questions such as who is using biotechnologies and why they are using biotechnologies, who develops biotechnologies and what is being developed. This survey in conjunction with studies examining the supply and demand of capital, as well the growth of biotechnology firms begins to contribute to the complete portrait of Canada's biotechnology sector.

Data were slightly revised after the initial Daily release of February 12, 2001. The data most affected by this revision are the total revenue from all sources. Other variables such as biotechnology revenues and biotechnology research and development spending were only marginally affected.

The purpose of the survey was to provide an accurate statistical portrait of biotechnology in Canada from three perspectives and these perspectives provide the outline for this paper and the two forth-coming papers. Three groups are discussed: core biotechnology firms, users of biotechnology and non-users of biotechnology.

This paper through the use of data tables and accompanying text gives an overview of the financial characteristics, human resources, product pipeline, and research and development spending of core biotechnology firms. These firms conduct an active research and development program in biotechnology and consider biotechnology central to their activities by using biotechnology to develop new knowledge, products and processes. The second paper will examine the business and strategic activities such as collaborations and intellectual property of biotechnology firms.

The final paper will discuss data on the firms that use biotechnology in their day-to-day operations, but do not develop new products or processes. They use biotechnology as they would use any other factor of production. Biotechnologies are simply an expedient way of conducting business. The paper will include information on the final group, non-

[2] See Canadian Biotechnology Advisory Committee Annual Report 1999-2000
[3] See Antoine Rose *Biotechnology Use by Canadian Industry – 1996*, Statistics Canada for complete details

users of biotechnologies. These firms provided information on why they did not use biotechnologies.


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Biotechnology Firm Characteristics and Activities

Distribution of Firms

Canada had 358 biotechnology firms[4] in 1999, which generated revenues of more than $1.9 billion from activities directly related to biotechnology. Just over 40% of firms are concentrated in the human health sector, followed by the agriculture sector with 25% of firms and the environment sector with 10% of firms. See Table 1 for distribution by firm size, province and sector.

Geographically, biotechnology firms are centred in Ontario (31%), Quebec (30%), and British Columbia (20%) with biotechnology firms found in all provinces through the rest of Canada.

Canada's biotechnology companies tend to be small firms (50 or less employees) which make up 75% of firms and 14% are medium sized firms (51-150 employees). Eleven percent are large firms (151 or more employees). They account for over 70% of biotechnology revenues and 60% of biotechnology research and development.

[4] These 358 firms are referred to throughout the paper as biotechnology firms or core biotechnology firms or core firms.

Table 1
Distribution of Biotechnology Firms by Size, Sector and Province

Number of Biotechnology Firms by Size	
	Number of Firms
Small (50 or less employees)	270
Medium (51-150 employees)	51
Large (151 or more employees)	37
TOTAL	**358**

Number of Biotechnology Firms by Sector	
	Number of Firms
Human Health	150
Agriculture	90
Natural Resources	18
Environment	35
Aquaculture	14
Bio-Informatics	18
Food Processing	29
Other	4*
TOTAL	**358**

Number of Biotechnology Firms by Province	
	Number of Firms
British Columbia	71
Alberta	28
Saskatchewan	16
Manitoba	6
Ontario	111
Quebec	107
Nova Scotia	7
Maritimes	19
Territories	-
Canada	**358**

Source: Statistics Canada

*: Please use with caution, unreliable due to high coefficient of variation

Maritimes includes NS, PEI, NB & Nfld.

Revised Figures

Revenues and Research & Development

Biotechnology revenues were more than $1.9 billion (see Tables 2-4 for detailed data) in 1999 and this 25% increase was almost $400 million more than 1998 revenues. Biotechnology firms expect revenues to exceed $5 billion in 2002. This increase can be attributed, at least in part, to firms reaching the market with new biotechnology products and processes following an often long and costly research and development (R&D) program.

> **Note To Readers**
> Financial totals and other totals referred to in this paper are for the 358 core biotechnology firms only. Total revenues are revenues for the 358 biotechnology firms from all sources. Biotechnology revenues reflect only the proportion of revenues derived from biotechnology. This concept applies to research & development and imports & exports. Data for 2002 revenues, research and development, and imports and exports are forecasts provided by respondents and are not forecasts created by Statistics Canada.

The increase in revenues that are anticipated in 2002 perhaps gives rise to optimism in the sector as firms begin to see the results of research and development programs on the revenue side of financial statements. In 1999, only about 65% of firms conducting biotechnology research had revenues from biotechnology sources. In other words almost 35% of biotechnology firms are conducting research in biotechnology areas that are not yet generating revenues. In 1999, 15% of firms had no revenues to offset biotechnology R&D expenditures. Spending on biotechnology research and development in 1999 amounted to $827 million, up 19% from 1998. Firms expect to spend almost $1.5 billion in 2002 on biotechnology research and development.

There were a similar number of firms in Ontario and Quebec in 1999, but differences can be found in biotechnology research and development expenditures, and are expected to continue into 2002. Quebec firms spent $337 million on biotechnology research and development, about 40% of the total. Ontario companies spent $223 million, about 27% of the total, and British Columbia firms $131 million, or about 16%. Firms in Quebec and British Columbia anticipate almost doubling their spending on biotechnology research and development in 2002. Spending in Ontario is expected to increase over 60% or $155 million. In all provinces for which data is available, biotechnology R&D expenditures are expected to increase.

Although small firms dominate the biotechnology landscape with 75% of the firms, followed by medium and large firms with 14% and 11% respectively, large firms contribute the most revenue with over 70% of total biotechnology revenues. Large firms also contribute 57% of biotechnology research and development. Among large firms biotechnology R&D spending is about one-half of biotechnology revenues. This compares to small firms where biotechnology R&D expenditures actually exceed

biotechnology revenues in 1999. This underscores the intensive research nature of small firms. Although revenues are expected to exceed R&D expenditures in 2002, small firms still expect to spend over $500 million on biotechnology R&D representing 75% of the over $750 million in anticipated biotechnology revenues.

Despite experiencing and anticipating large growth in revenues, firms are not resting on past R&D programs. There appears to be a long-term commitment to research and development. Evidence for this is found in R&D expenditures with anticipated growth to over $2 billion in 2002, a doubling between 1998 and 2002. Biotechnology research and development expenditures were $827 million in 1999 and are expected to reach $1.4 billion in 2002. As a percentage of biotechnology revenue, biotechnology R&D drops from almost 45% in 1998 to an estimated 30% in 2002, despite an anticipated doubling in dollar value of R&D spending. This reflects the large (157%) anticipated growth over 1999 biotechnology revenue in 2002, to over $5 billion.

Each biotechnology sector has its unique characteristics, which are reflected in the revenues and expenditure patterns of the sector. For example the human health sector dominates biotechnology with 41% of the firms, 55% of biotechnology revenues, 86% of biotechnology R&D and 74% of total R&D. In contrast the natural resources sector dominates total revenue with 38%, but accounts for less than 5% of both biotechnology revenues and research and development.

Comparison of the ratio of biotechnology revenue to biotechnology R&D by sector highlights interesting differences. For example in 1999 in the human health sector the ratio was 68% and for agriculture 13%. This suggests two observations. First products developed in the agriculture sector may have reached a more advanced stage of commercialization compared to human health leading to the second observation. In human health the current level of research and development effort may hint of important revenues yet to come.

In the aquaculture and bioinformatics sectors, more than 90% of R&D expenditures are made on biotechnology and in the human health and food processing sectors over 75% of R&D expenditures are on biotechnology. These figures underscore the importance of biotechnology to these sectors. Combined spending in the agriculture, natural resources, environment and food processing sectors is over $130 million for biotechnology R&D in 1999, but this expenditure represents less than 1.5% of total revenues for each of these.

Bioinformatics was unique in 1999. It was the only sector where biotechnology R&D expenditures exceeded biotechnology revenues, and nearly equalled total revenues. By 2002 bioinformatics firms expect to have made gains in their revenue profile with R&D expenditures dropping to 55% of biotechnology revenues. Revenues and research and development both grow, but revenue growth is much greater than R&D expenditures growth. Revenues are expected to come primarily from biotechnology sources in 2002. It is important to note that these figures reflect bioinformatics activities reported by core firms. It is possible for bioinformatics, and indeed, most of the biotechnologies to be found in sectors not considered as core biotechnology.

Biotechnology revenues in the large firm group are expected to more than double in 2002, but R&D spending is not expected to match that pace, but still grows to over $700 million. In 1999 biotechnology revenues made up a small proportion of the total revenues of large firms, just over 6%. However among those same firms biotechnology research and development makes up over 60% of total research and development expenditures. In contrast among small firms biotechnology revenues comprise over 40% of total revenues and biotechnology R&D represents over 85% of total R&D.

The revenue and research and development profile has changed between 1998 and 1999 with even greater change expected in 2002. The biotechnology sector will likely continue its evolution as the results of research and development begin to contribute to the bottom line.

Table 2

Total Revenues, Biotechnology Revenues, Total R&D and Biotechnology R&D[1] Expenditures by Core Biotechnology Firms By Province

1998

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
British Columbia	1,838	72	137	117
Alberta	385*	36	61	45*
Saskatchewan	..	344	36	24
Manitoba	100	47	25	15
Ontario	7,404	614	383	208
Quebec	3,600	437	354	281
Nova Scotia	..	2	5	5
Maritimes	29	3	7	6
Canada	**17,998**	**1,554**	**1,002**	**695**

1999

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
British Columbia	1,880	138	158	131
Alberta	392	90	102	81
Saskatchewan	..	433	43	28
Manitoba	123	69	31	20
Ontario	8,121	635	423	223
Quebec	3,960	554	448	337
Nova Scotia	..	2	4	4
Maritimes	86	28	6	6
Canada	**18,730**	**1,948**	**1,210**	**827**

2002 - Respondent Forecast

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
British Columbia	2,671	515	284	251
Alberta	663	181	170	133
Saskatchewan	..	958	53	36
Manitoba	183	121	46	30
Ontario	9,654	1,299	666	378
Quebec	5,698	1,883	787	641
Nova Scotia	..	12	7	7
Maritimes	146	51	12	11
Canada	**25,222**	**5,009**	**2,018**	**1,481**

Source: Statistics Canada

[1] Revised Figures

*: Please use with caution, unreliable due to a high coefficient of variation

Maritimes includes NS, PEI, NB & Nfld.

Note: Due to rounding, components may not add to totals

.. Figures not available

Table 3
Total Revenues, Biotechnology Revenues, Total R&D and Biotechnology R&D Expenditures by Core Biotechnology Firms By Sector[1]

1998

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Human Health	2,632	863	755	599
Agriculture	7,223	405	87	43
Natural Resources	7,366	66	127	31
Environment	219	17	11	2
Aquaculture	7	5	3	..
Bio-Informatics	13	10	11	11
Food Processing	531	183	8	6
Other	6*	6*	1*	..
TOTAL	**17,998**	**1,554**	**1,002**	**695**

1999

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Human Health	3,185	1,036	917	703
Agriculture	6,674	524	115	66
Natural Resources	8,050	113	130	24
Environment	287	45	13	..
Aquaculture	22	19	4	4
Bio-Informatics	25	20	21	20
Food Processing	479	185	9	7
Other	7*	7*	1*	..
TOTAL	**18,730**	**1,948**	**1,210**	**827**

2002 - Respondent Forecast

	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Human Health	5,228	3,136	1,627	1,289
Agriculture	9,733	1,187	156	95
Natural Resources	9,014	189	138	19
Environment	415	68	17	6
Aquaculture	38	33	6	..
Bio-Informatics	149	144	61	56
Food Processing	634	240	12	9
Other	11*	11*	1*	..
TOTAL	**25,222**	**5,009**	**2,018**	**1,481**

Source: Statistics Canada

[1] Revised Figures

*: Please use with caution, unreliable due to a high coefficient of variation

Note: Due to rounding, components may not add to totals

.. Figures not available

Table 4
Total Revenues, Biotechnology Revenues, Total R&D and Biotechnology R&D Expenditures by Core Biotechnology Firms By Size

1998				
	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Small (50 or less employees)	480	190	227	202
Medium (51-150 employees)	900	225	150	78
Large (151 or more employees)	16,618	1,139	625	415
TOTAL	**17,998**	**1,554**	**1,002**	**695**

1999				
	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Small (50 or less employees)	590	249	294	256
Medium (51-150 employees)	849	295	184	106
Large (151 or more employees)	17,291	1,404	733	465
TOTAL	**18,730**	**1,948**	**1,210**	**827**

2002 - Respondent Forecast				
	Total Revenue ($000,000)	Biotechnology Revenues ($000,000)	Total R&D Expenditures ($000,000)	Biotechnology R&D Expenditures ($000,000)
Small (50 or less employees)	1,323	754	653	566
Medium (51-150 employees)	1,305	562	277	184
Large (151 or more employees)	22,594	3,694	1,088	731
TOTAL	**25,222**	**5,009**	**2,018**	**1,481**

Source: Statistics Canada

Revised Figures

Note: Due to rounding, components may not add to totals

Biotechnology Firm Import & Export Activities

The Canadian Biotechnology Advisory Committee[5] recently reported that the world market for biotechnology-based products will increase from $20 billion in 1995 to $50 billion in 2005. This anticipated growth of biotechnology products suggests an increasingly significant opportunity in international trade. Biotechnologies are new products and processes and are the result of intensive research and development programs or the integration of other innovative processes or products in creating value-added products that could hold great significance for Canada's export market. Biotechnology exports by core biotechnology firms exceed biotechnology imports by a ratio of 2:1 in 1998, 3:1 in 1999 and expect to exceed a ratio of 5:1 in 2002

[5] Canadian Biotechnology Advisory Committee Annual Report 1999-2000

Note to Readers
Total exports and biotechnology exports refer to the export activities of firms in the estimate of 358 core biotechnology firms. These figures should not be construed as the total or total biotechnology exports for Canada, but only as the total exports and biotechnology exports of core biotechnology firms. Firms outside of the core may export biotechnology-related products and these may not be captured by this survey. The same principle is applied to imports.

Biotechnology exports play an increasingly important role in the revenues of biotechnology firms. Biotechnology exports are expected to dramatically increase from $372 million in 1998, approaching $1.7 billion in 2002, while becoming a growing proportion of total exports for biotechnology firms.

In 1999, 60% of all firms exported products and of those 54% exported biotechnology products. Export revenues for the 208-exporting firms were over $2.5 billion, of which biotechnology contributed less than 30% of the total. The 32 large exporting firms, represents 15% of exporting firms, but accounted for 89% of total exports and 82% of biotechnology exports. In contrast small firms comprised 75% of total exporters, but only 11% of biotechnology exports and 6% of total exports. Biotechnology accounted for 52% of exports for small firms. In contrast biotechnology exports accounted for 26% of total exports in large firms.

Biotechnology exports are expected to grow over 400% between 1999 and 2002 in the small firm sector and are expected to account for almost 75% of small firm total exports. In the medium sized firm group, growth is expected to almost triple the value of biotechnology exports from $51 million to $152 million. The proportion of exports from biotechnology is expected to grow from less than 30% in 1998 to over 50% in 2002. Export growth in the large firms is expected to be 23%, but the proportion of exports from biotechnology is expected to increase from 26% of total exports in 1999 to over 40% in 2002.

The medium sized firm group is unique, it is the only group to have total imports and biotechnology imports exceed total exports and biotechnology exports in 1998 and 1999. Firms expect to reverse this situation in 2002 with exports exceeding imports by more than $50 million. Biotechnology imports in medium firms increased 17% between 1998 and 1999, compared to an increase in exports of 48% during the same time frame.

In 1998, biotechnology firms in Saskatchewan led Canada in both total exports and biotechnology exports with 38% of biotechnology exports and 33% of total exports. The province increased its biotechnology exports in 1999 by 32% to over $200 million dollars, but placed second behind Quebec, where growth in biotechnology exports from biotechnology firms more than doubled to $227 million in 1999. All provinces experienced growth in exports between 1998 and 1999, and continue to expect substantial growth into 2002.

Ontario was the sole province where imports exceeded exports in both 1998 and 1999. This is expected to change in 2002 when provincial biotechnology exports will surpass imports by more than $125 million. Biotechnology exports contributed just under 25% of the biotechnology revenues of biotechnology firms in 1998. This contribution increased to 37% in 1999 and the anticipated $1.7 billion in biotechnology exports are expected to contribute 34% to biotechnology revenues in 2002.

The human health and agriculture sectors dominated the total exports and biotechnology exports in 1998 and 1999. The human health sector grew by $250 million between 1998 and 1999, surpassing the almost 50% increase in agriculture related biotechnology exports. Human health exports are expected to exceed $1.4 billion in 2002, of which biotechnology comprises over $1 billion dollars.

Table 5
Total Exports, Biotechnology Exports, Total Imports and Biotechnology Imports by Core Biotechnology Firms by Province

1998				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
British Columbia	261	38	22	18
Alberta	49	8	..	..
Saskatchewan	737	142	..	..
Manitoba	33	..	11	10
Ontario	547	103	154	144
Quebec	622	57	25	23
Nova Scotia	1	..	..	..
Maritimes	2	2	..	..
Canada	**2,251**	**372**	**213**	**195**

1999				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
British Columbia	290	60	33	26
Alberta	101	15	1	..
Saskatchewan	763	208	..	..
Manitoba	53	43	12	10
Ontario	709	164	183	172
Quebec	612	227	29	26
Nova Scotia	2	..	..	..
Maritimes	2	..	..	..
Canada	**2,530**	**718**	**258**	**234**

2002 - Respondent Forecast				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
British Columbia	595	343	44	41
Alberta	179	67	1	..
Saskatchewan	862	349	1	..
Manitoba	84	71	..	..
Ontario	816	357	272	231
Quebec	1,087	489	41	35
Nova Scotia	13	13	..	..
Maritimes	22	17	1	..
Canada	**3,645**	**1,694**	**368**	**317**

Source: Statistics Canada

*: Please use with caution, unreliable due to a high coefficient of variation

Maritimes includes NS, PEI, NB & Nfld.

Note: Due to rounding, components may not add to totals

Table 6
Total Exports, Biotechnology Exports, Total Imports and Biotechnology Imports by Core Biotechnology Firms by Sector

1998				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
Human Health	539	152	169	153
Agriculture	1,082	158	20	19
Natural Resources	498	..	1	..
Environment	14	2	1	..
Aquaculture	2	2	..	..
Bio Informatics	3	3	1	..
Food Processing	112	45	21	21
Other	..	..	..	..
TOTAL	**2,251**	**372**	**213**	**195**

1999				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
Human Health	578	410	205	185
Agriculture	1,157	233	27	25
Natural Resources	504	..	2	..
Environment	6	3	1	..
Aquaculture	..	2	1	..
Bio Informatics	6	5	..	..
Food Processing	276	51	23	23
Other	..	..	..	..
TOTAL	**2,530**	**718**	**258**	**234**

2002 - Respondent Forecast				
	Total Exports ($000,000)	**Biotechnology Exports ($000,000)**	**Total Imports ($000,000)**	**Biotechnology Imports ($000,000)**
Human Health	1,424	1,118	287	260
Agriculture	1,408	425	43	26
Natural Resources	571	26	..	..
Environment	41	13	1	1
Aquaculture	..	..	1	1
Bio Informatics	40	33	8	..
Food Processing	154	73	27	27
Other	..	..	..	..
TOTAL	**3,645**	**1,694**	**368**	**317**

Source: Statistics Canada

*: Please use with caution, unreliable due to a high coefficient of variation

Note: Due to rounding, components may not add to totals

.. Figures not available

Table 7
Total Exports, Biotechnology Exports, Total Imports and Biotechnology Imports by Core Biotechnology Firms by Size

1998

	Total Exports ($000,000)	Biotechnology Exports ($000,000)	Total Imports ($000,000)	Biotechnology Imports ($000,000)
Small (50 or less employees)	75	51	27	23
Medium (51-150 employees)	127	36	61	58
Large (151 or more employees)	2,048	286	125	114
TOTAL	**2,251**	**372**	**213**	**195**

1999

	Total Exports ($000,000)	Biotechnology Exports ($000,000)	Total Imports ($000,000)	Biotechnology Imports ($000,000)
Small (50 or less employees)	150	78	38	31
Medium (51-150 employees)	131	51	76	70
Large (151 or more employees)	2,249	589	145	133
TOTAL	**2,530**	**718**	**258**	**234**

2002 - Respondent Forecast

	Total Exports ($000,000)	Biotechnology Exports ($000,000)	Total Imports ($000,000)	Biotechnology Imports ($000,000)
Small (50 or less employees)	444	323	63	39
Medium (51-150 employees)	289	152	112*	97*
Large (151 or more employees)	2,911	1,219	193	181
TOTAL	**3,645**	**1,694**	**368**	**317**

Source: Statistics Canada

*: Please use with caution, unreliable due to a high coefficient of variation

Note: Due to rounding, components may not add to totals

Table 8

Number of Core Biotechnology Firms Reporting Exports, Biotechnology Exports, Imports and Biotechnology Imports in 1999 by Province, Sector, and Size

Province - 1999

	Total Exports	Biotechnology Exports	Total Imports	Biotechnology Imports
British Columbia	42	33	24	17
Alberta	24	14	6	..
Saskatchewan	13	8	5	..
Manitoba	5	4	..	4
Ontario	64	34	27	16
Quebec	49	30	19	17
Nova Scotia	4	..	..	..
Maritimes	11	..	7	5
Canada	**208**	**133**	**92**	**61**

Sector - 1999

	Total Exports	Biotechnology Exports	Total Imports	Biotechnology Imports
Human Health	81	59	41	34
Agriculture	60	33	20	10
Natural Resources	7	..	5	..
Environment	12	6	4	3
Aquaculture	..	14	8	8
Bio Informatics	8	7	..	..
Food Processing	25	12	10	5
Other	..	..	..	..
TOTAL	**208**	**133**	**92**	**61**

Size - 1999

	Total Exports	Biotechnology Exports	Total Imports	Biotechnology Imports
Small (50 or less employees)	153	99	60	38
Medium (51-150 employees)	24	13	16	11
Large (151 or more employees)	32	22	17	12
TOTAL	**208**	**133**	**92**	**61**

Source: Statistics Canada

Note: Due to rounding, components may not add to totals

.. Figures not available

Maritimes includes NS, PEI, NB & Nfld.

The Product Pipeline: Biotechnology Products/Processes Profile

The distribution of biotechnology is not limited to any single industry or process, but instead, biotechnology products range through a diverse set of industries and areas of interest from agricultural initiatives to increase crop yields, human genome research, drug discovery, innovative medical procedures, bioinformatics, to waste and environmental management. A significant measure of the biotechnology sector is the products pipeline i.e. the products in development for the marketplace.

Further the product pipeline is a significant indicator of the future growth of a sector. Biotechnology is characterised by significant time and cost factors as well as a high attrition rate in bringing a single product to market. Estimates in the United States have suggested that a single health related biotechnology product, from the research and development stage to market, requires 7-10 years and $US200-350 million[6]. A healthy pipeline is essential for the future of the biotechnology sector.

Biotechnology firms reported (see Tables 9 – 14 for detailed data) more than 17,000 biotechnology products and processes at all stages[7] of development and on market. Of these, almost half were in the research and development stage, and close to 40% were approved, in the market or in production. Poised to enter the market soon are over 1,600 products and processes in the regulatory phase/unconfined release assessment stage of development. It is not difficult to see the relationship between the product pipeline and the expected growth in biotechnology revenues in 2002. The anticipated revenue increase is in part dependent on these new products entering the market place.

At the research and development stage the bioinformatics sector leads with over 3,000 products. This sector includes genomics, genetic modelling and databases for organisms as well as gene therapy. Only 11 bioinformatics firms dominates the products at the 'on market' stage with over 54% of the total number of products on market. In contrast to the dominance at each end of the scale, the sector has fewer than 100 products in the pre-clinical trial or regulatory phase stages. Overall bioinformatics comprises 41% of all products at all stages of development despite comprising only 14% of the total number of biotechnology firms. The bioinformatics sector dominated by small firms (75%) is centred in Quebec with over 90% of the products and close to 40% of the firms. Ontario and British Columbia follow with 27% and 20% of bioinformatics firms.

The human health sector has the greatest number of firms (53%) and over 50% of biotechnology revenues despite having less than 10% of the on market products. Based on the number of products in human health, British Columbia leads the country with 63% of the products in the pipeline, but Ontario and Quebec have the most firms with 35% and 29% of human health sector firms. Despite comprising only 9% of human health

[6] U.S. Office of Technology Assessment.

[7] The questionnaire used the following classifications for stages of development 1) Research & Development 2) Pre-clinical trials/Confined field trials 3) Regulatory phase/Unconfined release assessment 4) Approved/On market/In production.

firms, medium firms have 54% of the products in human health, in this, a sector dominated by small firms (157).

The agriculture sector has close to 3,000 products at the research stage with over 1,000 products in the final stage before joining the 1,500 products currently on market. Included in the agriculture sector are plant biotechnologies, animal biotechnologies and non-food biotechnologies. Firms did not distinguish between domestic and foreign markets. Examples of what is included in the agriculture sector can be found in the questionnaire, question 9, page 7, Appendix 1. Agricultural products make up 63% of the products at this last stage of development before entering the market place. Medium sized firms have over 3,000 or 55% of all agriculture products, followed by small firms with 42% and large firms with only 3% of agriculture biotechnology products.

Table 9
Number of Biotechnology Products or Processes by Sector & Stage of Development

	1999				
	Research & Development	**Pre-Clinical Trials**	**Regulatory Phase**	**On Market**	**Total**
Human Health	2,382	408	103	542	3,435
Agriculture	2,892	88	1,051	1,527	5,557
Natural Resources	36	..	12	107*	162
Environment	46	12	..	174	233
Aquaculture	23	13	..	12	48
Bio-Informatics	3,153	59	..	3,568	7,249
Food Processing	130	39	19	596	785
Other	28	..	..	70*	103
TOTAL	**8,690**	**628**	**1,659**	**6,597**	**17,574**

Source: Statistics Canada

.. Figures not available

*: Please use with caution, unreliable due to a high coefficient of variation

Table 10
Number of Core Biotechnology Firms Developing Biotechnology Products or Processes by Sector & Stage of Development

	1999				
	Research & Development	**Pre-Clinical**	**Regulatory Phase**	**On Market**	**Unique Firms**
Human Health	142	76	51	71	188
Agriculture	104	36	18	61	117
Natural Resources	17	..	7	9	20
Environment	19	11	..	32	51
Aquaculture	14	5	..	11	21
Bio Informatics	51	5	..	11	51
Food Processing	38	20	7	29	53
Other	16	..	..	17	21
UNIQUE FIRMS	**273**	**132**	**75**	**191**	**358**

Source: Statistics Canada

Firms may be counted more than once. Total number of core biotechnology firms of firms is 358.

.. Figures not available

*: Please use with caution, unreliable due to a high coefficient of variation

Table 11
Number of Biotechnology Products or Processes at All Stages of Development by Sector & Province

	1999								
	Human Health	Agriculture	Natural Resources	Environment	Aquaculture	Bioinformatics	Food Processing	Other	TOTAL
British Columbia	2,167	3,192	119*	124*	33	571	169	6*	6,380
Alberta	55	67	..	5	..	..	21	..	164
Saskatchewan	..	76	..	3*	..	5	12	..	114
Manitoba	26	7	..	..	..	..	..	..	33
Ontario	678	2,031	18	47	..	49	53	..	2,880
Quebec	462	140	19	49	..	6,615	530	88	7,903
Nova Scotia	..	..	..	..	..	..	..	..	85
Maritimes	43	..	..	6*	6	..	..	..	100
Canada	**3,435**	**5,557**	**162**	**233**	**48**	**7,249**	**785**	**103**	**17,574**

Source: Statistics Canada

*: Please use with caution, unreliable due to a high coefficient of variation

.. Figures not available

Maritimes includes NS, PEI, NB & Nfld.

Table 12
Number of Core Biotechnology Firms Developing Products or Processes at All Stages of Development by Sector & Province

	1999								
	Human Health	Agriculture	Natural Resources	Environment	Aquaculture	Bioinformatics	Food Processing	Other	TOTAL
British Columbia	43	19	10	6	11	10	16	..	71
Alberta	14	16	..	4*	..	..	8	..	28
Saskatchewan	..	9	..	3*	..	4	3	..	16
Manitoba	..	..	..	..	..	..	..	..	6
Ontario	66	52	5	9	..	14	12	..	111
Quebec	54	16	4	24	..	20	14	15	107
Nova Scotia	5	..	..	..	..	..	..	..	7
Maritimes	6	..	..	6*	6	..	..	..	19
Canada	**188**	**117**	**20**	**51**	**21**	**51**	**53**	**21**	**358**

Source Statistics Canada

Firms may be counted more than once. Total number of core biotechnology firms of firms is 358.

.. Figures not available

Maritimes includes NS, PEI, NB & Nfld.

*: Please use with caution, unreliable due to a high coefficient of variation

Table 13
Number of Biotechnology Products or Processes at All Stages of Development by Sector and Firm Size

	1999								
	Human Health	Agriculture	Natural Resources	Environment	Aquaculture	Bioinformatics	Food Processing	Other	TOTAL
Small (50 or less employees)	1,466	2,338	141	176	48	6,659	279	85	11,192
Medium (51-150 employees)	1,840	3,078	..	42	0	579	139	18*	5,705
Large (151 or more employees)	130	141	..	14	0	11	367*	0	676
TOTAL	**3,435**	**5,557**	**162**	**233**	**48**	**7,249**	**785**	**103**	**17,574**

Source: Statistics Canada

.. Figures not available

*: Please use with caution, unreliable due to a high coefficient of variation

Table 14
Number of Core Biotechnology Firms Developing Products or Processes at All Stages of Development by Sector & Firm Size

	1999								
	Human Health	Agriculture	Natural Resources	Environment	Aquaculture	Bioinformatics	Food Processing	Other	TOTAL
Small (50 or less employees)	157	91	13	23	21	38	41	12	269
Medium (51-150 employees)	17	16	..	20	0	7	4	9*	51
Large (151 or more employees)	14	10	..	8	0	6	8	0	37
UNIQUE FIRMS	**188**	**117**	**20**	**51**	**21**	**51**	**53**	**21**	**358**

Source: Statistics Canada

Firms may be counted more than once. Total number of core biotechnology firms of firms is 358.

.. Figures not available

*: Please use with caution, unreliable due to a high coefficient of variation


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Human Resources in Biotechnology

In 1999 there were 7,695[8] employees working in biotechnology related jobs (see Table 15). This represents about 12% of the total workforce of 62,667 employees working in core biotechnology firms. Biotechnology employees are centred in human health with just over 70% of all biotechnology employees, followed by agriculture with 13% and food processing with 4%.

In 1999, a report published by BIOTECanada and showed total biotechnology employment as 9,823. Since the two surveys are different, including different methodologies, questions and estimation procedures it is premature to conclude a decrease in biotechnology employment. A comparison between the two surveys requires further study and will be the subject of a future paper.

Over 40% of total employees in the human health sector are biotechnology employees compared to next highest sector, agriculture where biotechnology employees make up 5% of the workforce of biotechnology companies. Several sectors exceed 10,000 employees but biotechnology makes up only a small proportion of the total workforce.

Ontario and Quebec are almost tied in the number of biotechnology employees with over 2,500 each and each province comprises about one third of the biotechnology workforce. British Columbia has about 15% of the biotechnology work force.

Biotechnology employees are mainly found in the large firm category with 45% of employees and small firms with 38% of the biotechnology employees. However, the ratio of biotechnology employees to total employees is very different. In the small firm category 60% of the employees have biotechnology responsibilities, while in the large category biotechnology employees make up 7% of the workforce.

Additional human resources data will be released in Spring, 2001.

[8] Please note these are preliminary figures subject to revision.

Table 15
Total Employees and Biotechnology Employees in Core Biotechnology Firms by Province

1999

	Total Employees	Biotechnology Employees
British Columbia	7,558	1,191
Alberta	3347*	574
Saskatchewan	..	289
Manitoba	635	357
Ontario	14,583	2,547
Quebec	31,092	2,557
Nova Scotia	..	75
Maritimes	681	181
Canada	**62,667**	**7,695**

Total Employees and Biotechnology Employees in Core Biotechnology Firms by Sector

1999

	Total Employees	Biotechnology Employees
Human Health	13,029	5,433
Agriculture	18,066	985
Natural Resources	12,710	149
Environment	4,187	323
Aquaculture	232	167
Bio Informatics	368	227
Food Processing	13,866	338
Other	208*	74
TOTAL	**62,667**	**7,695**

Total Employees and Biotechnology Employees in Core Biotechnology Firms by Province

1999

	Total Employees	Biotechnology Employees
Small (50 or less employees)	4,941	2,902
Medium (51-150 employees)	4,693	1,323
Large (151 or more employees)	53,033	3,470
TOTAL	**62,667**	**7,695**

Source: Statistics Canada

*: Please use with caution, unreliable due to a high coefficient of variation

Maritimes includes NS, PEI, NB & Nfld.

.. Figures not available

These are preliminary figures subject to revision

Methodology

The survey was mailed to 3377 firms in selected NAICS codes in May 2000. The sample drawn from the Business Register of Statistics Canada was supplemented by a list of firms prepared by industry experts. Biotechnology does not fit into a single NAICS code so the need to sample based on the possibility of biotechnology use is required. Selected NAICS codes, mainly in the manufacturing sector, were identified as sectors of the economy where there was the possibility of firms using biotechnologies. Firms were selected to provide a representative sample based on size, industry, and province. Overall response rate was 66%. Results from this survey were weighted to reflect the entire count of firms in the selected industry sectors.

Excluded from the sample and from the estimates are the very small biotechnology firms. These firms had less than 5 employees and less than $100,000 in research and development expenditures. The impact on the results was minimal, for example less than 1% of biotechnology research and development expenditures and new product and processes.

The questionnaire was compiled and written with the active input of a consultation group of biotechnology experts from a variety of areas of expertise and interest. Following its initial design, the questionnaire was field tested with potential respondents, whose comments on the design and content were then incorporated into the questionnaire.

A challenge facing the survey, and indeed all research into the nature of the biotechnology sector, is the fact that biotechnology is not single product or process nor a single group of products or processes. It is a broad spectrum of products and processes spanning human health, agriculture, environmental and other industries and classifications. The sampling techniques reflect this so that the sample reflects not a single well-defined industry but a developing sector with a multitude of characteristics, some known and some not known.

Definitions

Debate on what constitutes biotechnology continues and one of the threads of debate is the debate between old biotechnologies and new biotechnologies. Old biotechnologies include traditional fermentation and yogurt making. The new biotechnologies build on the advances in science in the 1970s' and 80s'. This survey does not attempt to reconcile that debate, but did actively seek out the use of the new biotechnologies, developed in the past several decades, as opposed to the more traditional biotechnologies.

As part of its ongoing initiatives, the Division is actively involved with the OECD in developing international definitions for biotechnology. This is an ongoing project. Several methods of defining biotechnology were attempted and a list-based definition emerged as the preferred method for test respondents. The list of biotechnologies used is question 1, page 2 of the questionnaire, found in Appendix 1.

Classifications

This report uses a series of classifications in data tables. These are firm size, sector and geography.

Geography is the standard geography classifications of Statistics Canada[9]

Size is based on the number of employees a firm reports:

- Small - 50 or fewer employees
- Medium - 51 to 150 employees
- Large - 151 or more employees

Sector consists of 8 groups including an 'other' category. These categories are human health, agriculture, natural resources, environment, aquaculture, bioinformatics, and food processing. Additional detail for each of these categories can be found on page 7, Question 9 of the questionnaire contained in Appendix 1.

Data Quality

This survey, as with all surveys using a sample, must reach a balance between time, cost and the quality of data. In cases where the quality of data is questionable based on a high coefficient of variation or for other reasons the data is either not published or indicated as being unreliable. Data users are reminded to use this data with caution. Data that could in any way be used to identify a firm was suppressed to ensure confidentiality.

Some figures used in this publication are revised figures of the originally published preliminary results. Other data is preliminary data and may be revised. Data are estimates based on weighted responses, and were subjected to an intensive follow-up, editing and imputation process. Users are also cautioned in making direct comparisons to the 1997 data. Some of the concepts and methods are different. Efforts are in progress to harmonise the two surveys.

Respondent Categories

The questionnaire was designed to alleviate respondent burden as much as possible. For example the first group of respondents, the non-users of biotechnology, were able to quickly exit the survey with minimal effort. The second group, biotechnology users answered a series of questions covering 3 additional pages, while core respondents completed the full survey. Respondent testing of the survey revealed that the full questionnaire could be completed in 1.5 hours. The frequency of the survey is planned for every second year.

The survey was designed to capture data from three distinct groups. The first group do not use biotechnology. This non-users group provided information on why they did not

[9] For a full discussion see Census Dictionary, Geography Division, Statistics Canada

use biotechnologies. This group responded to questions 1 and 2 in the survey. The second group is the firms that use biotechnologies as part of their day-to-day operations, as they would use any other factor of production. For this group biotechnologies are simply an expedient way of conducting business. This group responded to questions 1, 3, 4, 5, 6, 7, and 8 of the questionnaire. Characteristics of these two groups will be reported on in a forthcoming paper.

The final group is the core firms. These firms are conducting an active research and development program in biotechnology and consider biotechnology central to their activities. This group completed the entire survey with the exception of question 2. This group of 358 firms is the focus of this paper and a subsequent paper.

Appendix 1

Science, Innovation and Electronic Information Division

Biotechnology Use and Development Survey - 1999

Confidential when completed

Collected under the authority of the Statistics Act, Revised Statutes of Canada, 1985, c. S-19.
Completion of the questionnaire is a legal requirement under the Statistics Act.

Si vous préférez ce questionnaire en français, veuillez cocher ☐

Survey Purpose

Statistics Canada is undertaking this survey in support of the Canadian Biotechnology Strategy. The purpose is to produce information about firms engaged in biotechnology activities by addressing the following question. What are the characteristics and activities of firms that use or develop biotechnology as an important part of their firm's activity?

Biotechnology is a dynamic emerging sector of the Canadian economy and its impact has the potential to be felt through all parts of Canadian society. An accurate understanding of biotechnology requires comprehensive data. Information from this survey may be used by businesses for economic or market analysis, by trade associations to study industry performance, government departments and agencies to assist policy formation, and the academic community for research purposes. Statistics Canada will create a database combining survey responses with existing Statistics Canada data records. **An executive summary of the results will be sent to all respondents**.

Please report on Canadian biotechnology activities of your firm. Complete a separate questionnaire for each firm engaged in biotechnology activity in Canada.

Authority

Collected under the authority of the Statistics Act, Revised Statutes of Canada, Chapter S19. Completion of this questionnaire is a legal requirement under the Statistics Act.

Confidentiality

Statistics Canada is prohibited from publishing or releasing any statistics that would divulge information obtained from this survey that relates to any identifiable firm without the previous written consent of that firm. The data reported in this questionnaire will be treated in strict confidence, used for statistical purposes and released in aggregate form only. The confidentiality provisions of the Statistics Act are not affected by either the Access to Information Act or any other Legislation.

If you require assistance in the completion of the questionnaire or have any questions regarding the survey, please contact:

Claire Racine-Lebel
Science, Innovation and Electronic Information Division
Statistics Canada
Tunney's Pasture
Ottawa, Ontario
K1A 0T6
Phone: (613) 951-6309 (please call collect) - Fax: (613) 951-9920
e-mail: Claire.Racine-Lebel@statcan.ca

Please indicate the name of the person completing this form so we know who to contact should we have questions about this report.

Name	Title
Telephone Number ☐☐☐ - ☐☐☐ - ☐☐☐☐ Fax Number ☐☐☐ - ☐☐☐ - ☐☐☐☐	Email

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1 Biotechnologies

1. Please review the following list of biotechnologies and check the applicable circle or circles.

	Biotechnologies	Currently Used in Operations	If currently using, do you use them for: Product/Process Research & Development	Current Production	Environmental Purposes	Number of Years in Use	If No: Do you plan to use within 3 years
		0	1	2	3	4	5
	DNA Based						
1110	Gene Probes/DNA Markers	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1120	Bio-Informatics	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1130	Genomics/Pharmacogenetics	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1140	Genetic Engineering/DNA Sequencing/Synthesis/Amplification	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
	Biochemistry/Immunochemistry						
1150	Vaccines/Immune Stimulants	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1160	Drug Design & Delivery	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1170	Diagnostic Tests/Antibodies	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1180	Peptide/Protein Sequencing/ Synthesis	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1190	Cell Receptors/Signalling/ Pheromones/Structural Biology	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1200	Combinatorial Chemistry/ 3D Molecular Modelling	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1210	Biomaterials	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1220	Microbiology/Virology/Microbial Ecology	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
	Bioprocessing Based						
1230	Cell/Tissue/Embryo Culture Manipulation	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1240	Extraction/Purification/Separation	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1250	Fermentation/Bioprocessing/ Biotransformation/Natural Products Chemistry	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
	Environment						
1260	Bioleaching/Biopulping/Biobleaching/ Biodesulphurization	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1270	Bioremediation/Biofiltration/ Phytoremediation	○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
	Other *(please specify)*						
1280		○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No
1290		○ Yes → ○ ○ ○ ☐ ; ○ No →					○ Yes ○ No

→ **If you use at <u>least one</u> of the biotechnologies in Question 1 go to Question 3.**

→ **If you don't use any of the biotechnologies listed in Question 1 go to Question 2.**

2 Barriers to Using Biotechnologies

2. Rate the following factors' influence on your firm's decision **not** to use biotechnology. Use the following scale where 1 is low importance and 5 is high importance. Indicate if not applicable to your firm.

		Importance					
		Low				High	Not Applicable
		1	2	3	4	5	0
	Lack of Financial Justification						
2100	Small market size	◯	◯	◯	◯	◯	◯
2110	High cost of equipment	◯	◯	◯	◯	◯	◯
2120	High cost to implement/integrate biotechnology	◯	◯	◯	◯	◯	◯
2130	Cost of capital	◯	◯	◯	◯	◯	◯
	Human Resources						
2140	Shortage of skilled or trained staff	◯	◯	◯	◯	◯	◯
2150	Worker resistance	◯	◯	◯	◯	◯	◯
2160	Increased labour costs	◯	◯	◯	◯	◯	◯
	External						
2170	Government regulations	◯	◯	◯	◯	◯	◯
2180	Public acceptance/perception of biotechnology	◯	◯	◯	◯	◯	◯
	Technology						
2190	Biotechnology not sufficiently developed	◯	◯	◯	◯	◯	◯
2200	Lack of external technical expertise/support	◯	◯	◯	◯	◯	◯
	Other (*please specify*)						
2210		◯	◯	◯	◯	◯	◯

If you are <u>not</u> using any biotechnology, please stop here.

Please return the questionnaire in the return prepaid envelope.

Thank you for your co-operation

3 Information Sources on Biotechnology

3. Rate the importance of the following sources of information on biotechnology as used by your firm. Use the following scale where 1 is low importance and 5 is high importance. Indicate if not applicable to your firm.

	Sources of Information on Biotechnology	Importance Low 1	2	3	4	High 5	Not Applicable 0
3100	Internal resources/staff or parent/subsidiary firm	◯	◯	◯	◯	◯	◯
3110	Academic journals/trade publications	◯	◯	◯	◯	◯	◯
3120	Universities/colleges/private training institutes	◯	◯	◯	◯	◯	◯
3130	Federal government department/agency	◯	◯	◯	◯	◯	◯
3140	Personal contact with others (tacit knowledge)	◯	◯	◯	◯	◯	◯
3150	Other companies	◯	◯	◯	◯	◯	◯
3160	Provincial government department/agency	◯	◯	◯	◯	◯	◯
3170	Professional/industry associations	◯	◯	◯	◯	◯	◯
3180	Library/literature search	◯	◯	◯	◯	◯	◯
3190	Database retrieval services	◯	◯	◯	◯	◯	◯
3200	Conferences/workshops/trade shows	◯	◯	◯	◯	◯	◯
3210	Other (*please specify*)	◯	◯	◯	◯	◯	◯

4 Benefits from Using Biotechnology

4. a) Does your firm use biotechnology in its production or processing operations?

4100 ◯ No → Go to Question 5.

◯ Yes

b) Rate the benefits from using biotechnologies in your firm's production or processing operations. Use the following scale where 1 is low importance and 5 is high importance. Indicate if not applicable to your firm.

	Benefit of Using Biotechnology	Importance Low 1	2	3	4	High 5	Not Applicable 0
	Productivity Improvement						
4110	Lower labour costs	◯	◯	◯	◯	◯	◯
4120	Lower capital costs	◯	◯	◯	◯	◯	◯
4130	Lower energy costs	◯	◯	◯	◯	◯	◯
	Product Improvement						
4140	Develop new products or processes	◯	◯	◯	◯	◯	◯
4150	Extend product range	◯	◯	◯	◯	◯	◯
4160	Improvement in product quality	◯	◯	◯	◯	◯	◯
	Plant Organization						
4170	Increase production flexibility	◯	◯	◯	◯	◯	◯
4180	Lower maintenance expenses	◯	◯	◯	◯	◯	◯
4190	Cleaner production/pollution reduction	◯	◯	◯	◯	◯	◯
	Market Performance						
4200	Improve market position	◯	◯	◯	◯	◯	◯
4210	Increase sales	◯	◯	◯	◯	◯	◯
4220	Reduced time to market/Faster delivery time	◯	◯	◯	◯	◯	◯
	Other (*please specify*)						
4230		◯	◯	◯	◯	◯	◯

5 Human Resources

For the purposes of this survey Employees are defined as those workers for whom you completed a Revenue Canada T4-Statement of Remuneration Paid Form for the 1999 tax year. Include working owner(s). Do not include students.

5. a) How many employees does your firm currently employ? ☐ 5100

b) How many employees have biotechnology-related responsibilities? ☐ 5110

c) In the table below provide the number of biotechnology employees. Class the employee by their primary area of responsibility. For example, a person working 60% of their time on biotechnology research would be counted once as mainly working in scientific/research direction.

	Position	Number Currently Employed		
		Working full-time on biotechnology (more than 50% of time) 1	Working part time on biotechnology (less than 50% of time) 2	Estimated number to be employed in biotechnology in 2002 3
	Biotechnology R&D Activities			
5120	Scientific/Research Direction			
5130	Technicians/Engineering			
5140	Regulatory/Clinical Affairs			
	Biotechnology Administration & Production			
5150	Production			
5160	Finance/Marketing			
5170	Management/Licensing/Administration			

d) Does your firm currently have unfilled full time biotechnology-related positions?

5180 ◯ No → Go to Question 5 e)

◯ Yes

	Position	If Yes, was the reason due to			
		Number of Unfilled Full-Time Positions 1	Lack of qualified candidates 2	Compensation required by qualified candidated too high 3	Other 4
	Biotechnology R&D Activities				
5190	Scientific/Research Direction		◯	◯	◯
5200	Technicians/Engineering		◯	◯	◯
5210	Regulatory/Clinical Affairs		◯	◯	◯
	Biotechnology Administration & Production				
5220	Production		◯	◯	◯
5230	Finance/Marketing		◯	◯	◯
5240	Management/Licensing/Administration		◯	◯	◯

e) Does your firm employ (either paid or unpaid) post-secondary students in biotechnology-related activities? Include co-op placements, part-time, and full-time positions.

5250 ◯ No → Go to Question 5 f)

◯ Yes → What level of education? →
- 1 ◯ Technical/Trade/College
- 2 ◯ Undergraduate level
- 3 ◯ Graduate level

---

f) Does your firm contract out any of the following biotechnology-related activities?

	Biotechnology Activity	No 0	Yes	If yes, what is the value (in $000) of contracts in 1999? If more than one what is the total value? 1
5260	Research & Development	◯	◯ →	$,000
5270	Regulatory/Clinical Affairs	◯	◯ →	$,000
5280	Marketing/Distribution	◯	◯ →	$,000
5290	Management/Licensing/Administration	◯	◯ →	$,000

6 Recruiting Practices

6. Check any of the following methods used to fill biotechnology-related positions.

6000
- 1 ◯ Internet resources
- 2 ◯ University recruitment
- 3 ◯ Use under-qualified staff
- 4 ◯ Temporary/contract staff
- 5 ◯ Employment agencies
- 6 ◯ In-house training
- 7 ◯ Use over-qualified staff
- 8 ◯ Networking
- 9 ◯ Newspaper/journal ads
- 10 ◯ Professional associations
- 11 ◯ Other (*please specify*) _____

---

7. a) Did you attempt to hire biotechnology staff from outside Canada in 1999?

6100 ◯ No → Go to Question 7 c)

◯ Yes → From where? →
- 1 ◯ USA
- 2 ◯ Europe
- 3 ◯ Asia
- 4 ◯ Latin America
- 5 ◯ Other

---

b) Were you successful in hiring biotechnology staff from outside Canada?

6120 ◯ No

◯ Yes → How many biotechnology staff did you hire from outside Canada in 1999? 1 ☐

---

c) Did biotechnology personnel leave your firm in 1999?

6130 ◯ No

◯ Yes → How many? 1 ☐

7 Product/Process Development

8. a) Is your firm currently **developing** product that **requires** the use of biotechnologies?

7000 ◯ Yes

◯ No

8. b) Is your firm currently **developing** processes that **requires** the use of biotechnologies?

7110 ◯ Yes

◯ No

c) Does your firm consider biotechnology central to its activities?

7120 ◯ Yes

◯ No

Did you answer "Yes" to any part of Question 8?

7130 ◯ Yes → Go to Question 9

◯ No → Please stop here. Return the questionnaire in the prepaid return envelope. Thank you for your cooperation.

8 Biotechnology Products

9. Please provide the **number** of biotechnology products or processes your firm has at each stage of development.

	Biotechnology Sector	Number of biotechnology products/processes by development stage			
		Research & Development 0	Pre-clinical trials/ Confined field trials 1	Regulatory phase/ Unconfined release assessment 2	Approved/ On market/In production 3
	Human Health				
8110	**Diagnostics** (e.g. biosensors, immunodiagnostics, gene probes)				
8120	**Therapeutics** (e.g. vaccines, immune stimulants, biopharmaceuticals, rational drug design, drug delivery, combinatorial chemistry)				
	Agriculture Biotechnology				
8130	**Plant Biotechnology** (e.g. tissue culture, embryo-genesis, genetic markers, genetic engineering)				
8140	**Animal Biotechnology** (e.g. diagnostics, therapeutics, embryo transplantation, genetic markers, genetic engineering)				
8150	**Non-food Agriculture** (e.g. fuels, lubricants, commodity and fine chemical feedstocks, cosmetics)				
	Natural Resources				
8160	**Energy** (e.g. microbiologically enhanced petroleum recovery, industrial bioprocessing, biodesulphurization)				
8170	**Mining** (e.g. microbiologically enhanced mineral recovery, industrial bioprocessing, biodesulphurization)				
8180	**Forest Products** (e.g. biopulping, biobleaching, biopesticides, tree biotechnology, industrial bioprocessing)				
	Environment				
8190	**Air** (e.g. bioremediation, diagnostics, phytoremediation, biofiltration)				
8200	**Water** (e.g. biofiltration, diagnostics, bioremediation, phytoremediation)				
8210	**Soil** (e.g. biofiltration, diagnostics, bioremediation, phytoremediation)				

Biotechnology Products

	Biotechnology Sector	Number of biotechnology products/processes by development stage			
		Research & Development 0	Pre-clinical trials/ Confined field trials 1	Regulatory phase/ Unconfined release assessment 2	Approved/ On market/In production 3
	Aquaculture				
8220	Fish health, broodstock genetics, bioextraction				
	BioInformatics				
8230	**Genomics & molecular modelling** (e.g. DNA/RNA/ protein synthesising & databases for humans, plants, animals, and micro-organisms)				
8240	**Gene therapy** (e.g. gene identification, gene constructs, gene delivery)				
	Food Processing				
8250	**Bioprocessing** (e.g. using enzymes and bacteria culture)				
8260	**Functional Foods/Nutraceuticals** (e.g. probiotics, unsaturated fatty acids)				
	Other *(please specify)*				
8270					
8280					

9 Cooperative/Collaborative Arrangements

10. Was your firm involved in biotechnology-related **cooperative/collaborative arrangements** with other companies or organizations in 1999?
Cooperative and collaborative arrangements involve the active participation in projects by your company and other companies or organizations in order to develop and/or continue work on new or significantly improved biotechnology processes, products and/or services. Pure contracting-out is not regarded as collaboration.

9100 ◯ No → Go to question 13

◯ Yes → How many? → [ ] 1

11. Please indicate for which purposes. Check any that are applicable.

	Arrangement Purpose	
9110	To conduct research & development (R&D)/ Access to specialized inputs	◯
9120	Regulatory affairs	◯
9130	To access knowledge/skills/critical expertise	◯
9140	Prototype development/production/manufacturing	◯
9150	Access markets/distribution channels	◯
9160	Access to capital	◯
9170	Intellectual Property Protection	◯
9180	Other (*please specify*)	◯

12. Check collaboration/co-operation arrangements by each type and their geographic location.

	Partner Category	Canada 0	USA 1	Europe 2	Latin America 3	Asia 4
9190	A firm of smaller or equal size	◯	◯	◯	◯	◯
9200	A larger firm	◯	◯	◯	◯	◯
9210	Government department/agency	◯	◯	◯	◯	◯
9220	University/Hospital/Research network	◯	◯	◯	◯	◯
9230	Other (*please specify*)	◯	◯	◯	◯	◯

13. Would you describe your firm as a 'spin-off'?
A Spin-off is defined as a new firm created to transfer and commercialize inventions and technology developed in universities, firms or laboratories.

9240 ◯ No → Go to Question 14

◯ Yes → Was your firm a spin-off from; →
- 1 ◯ University/hospital
- 2 ◯ Another company
- 3 ◯ Government agency/lab
- 4 ◯ Other (*please specify*) _____

10 Obstacles to Biotechnology Commercialization

14. Rate the following **obstacles to advancement of biotechnology commercialization** activities in your firm.
Use the following scale where 1 is low importance and 5 is high importance. Indicate if not applicable to your firm.

		Importance Low 1	2	3	4	High 5	Not Applicable 0
	Inputs						
10100	Access to capital	◯	◯	◯	◯	◯	◯
10110	Access to technology/information	◯	◯	◯	◯	◯	◯
10120	Access to human resources	◯	◯	◯	◯	◯	◯
	Markets						
10130	Domestic market too small	◯	◯	◯	◯	◯	◯
10140	Lack of access to international markets	◯	◯	◯	◯	◯	◯
10150	Transportation regulations on biotechnology	◯	◯	◯	◯	◯	◯
10160	Lack of distribution & marketing channels	◯	◯	◯	◯	◯	◯
	Constraints						
10170	Public perception/acceptance	◯	◯	◯	◯	◯	◯
10180	Regulatory requirements	◯	◯	◯	◯	◯	◯
10190	Time/cost	◯	◯	◯	◯	◯	◯
10200	Patent rights held by others	◯	◯	◯	◯	◯	◯
10210	Lack of patent protection for plants	◯	◯	◯	◯	◯	◯
10220	Lack of patent protection for animals	◯	◯	◯	◯	◯	◯
10230	Lack of patent protection for human components (e.g., organs, tissues)	◯	◯	◯	◯	◯	◯
10240	**Other** (*please specify*)	◯	◯	◯	◯	◯	◯

11 Patents

15. a) How many patents and/or pending patents does your firm currently have in each region. (Indicate '0' if none).

		Geographic Location					
		None 5	Canada 0	USA 1	Europe 2	Latin America 3	Asia 4
11100	Existing patents						
11110	Pending patents						

b) Please indicate the number of **patent applications** your company submitted to the following Patent Offices. (Indicate '0' if none)

	Patent Office/Year	1998 0	1999 1
11130	Canadian Intellectual Property Office (CIPO)		
11140	United States Patent & Trademark Office (USPTO)		
11150	European Patent Office (EPO)		
11160	Other (*please specify*)		

c) Please indicate the number of applications for **plant breeders' rights** your company submitted. (Indicate '0' if none)

	Patent Office/Year	1998 0	1999 1
11170	Canadian Plant Breeders' Rights Office		
11180	Plant Variety Protection Office, USDA		
11190	Community Plant Variety Office, EU		
11120	Other (*please specify*)		

12 Intellectual Property

16. During the last two years, 1998-1999 did your firm **grant the right to use intellectual property** to another firm or did your firm **acquire the right to use intellectual property** from another firm?

12100 ◯ No → Go to Question 17

◯ Yes → Please indicate the type and direction of such intellectual property transfer.

	Intellectual Property	Granted Rights to Canadian Firms 0		Granted Rights to Foreign Firms 1		Acquired Rights from Canadian Firms 2		Acquired Rights from Foreign Firms 3	
		Yes	No	Yes	No	Yes	No	Yes	No
12110	Trade Secrets/Licensing Agreements	◯	◯	◯	◯	◯	◯	◯	◯
12120	Patents	◯	◯	◯	◯	◯	◯	◯	◯
12130	Plant breeders' rights	◯	◯	◯	◯	◯	◯	◯	◯

13 Revenues, Expenditures & Trade

17. Please provide financial details in the following table. Please report for fiscal years and in thousands of dollars ($,000's). Indicate "0" if none

		Please provide details in $,000's for the years		What is your forecast for 2002
		1998 (0)	1999 (1)	2002 (2)
13100	Total Firm Sales/Revenue	$,000	$,000	$,000
13110	% of Total Sales/Revenue From Biotechnology	%	%	%
13120	Total R&D Spending	$,000	$,000	$,000
13130	% of R&D Spending on Biotechnology R&D	%	%	%
13140	Total Exports (including licensing agreements)	$,000	$,000	$,000
13150	% of Exports from Biotechnology	%	%	%
13160	Total Imports	$,000	$,000	$,000
13170	% of Imports from Biotechnology	%	%	%

18. If your firm **exported** biotechnologies, what percentage (%) of biotechnology ***exports*** went to the following geographic locations in 1999? Include licensing agreements. What is your forecasted distribution for 2002?

	Year	Geographic Location				
		Canada (0)	USA (1)	Europe (2)	Latin America (3)	Asia (4)
13180	1999					
13190	Forecast for 2002					

19. If your firm **imported** biotechnologies, what percentage (%) of biotechnology ***imports*** came from the following geographic locations in 1999? Include licensing agreements. What is your forecasted distribution for 2002?

	Year	Geographic Location				
		Canada (0)	USA (1)	Europe (2)	Latin America (3)	Asia (4)
13200	1999					
13210	Forcast for 2002					

20. a) Did your firm attempt to raise capital for biotechnology in fiscal year 1999?

13220 ◯ No → Go to Question 20 c)

◯ Yes

b) Were you successful in raising capital?

13230 ◯ No → Go to Question 20 c)

◯ Yes → How much did you raise? (in thousands) → $,000

Indicate the sources of capital and the percentage (%) of total capital that source provided in 1999.

	Source	% of Total Capital
13240	Angel investors/family/friends	
13250	Government loans/grants/incentives	
13260	Venture Capital funds	
13270	Conventional sources (i.e. banks)	
13280	Initial Public Offering (IPO)	
13290	Collaborative alliance	
13300	Other *(please specify)*	
	TOTAL	**100%**

20. c) Does your firm plan to raise capital in 2002?

13310 ◯ No → Go to Question 21

◯ Yes → How much do you plan to raise in 2002? →
1 ◯ Less than $500,000
2 ◯ $500,000 to $5,000,000
3 ◯ More than $5,000,000

---

21. In the past 5 years did your firm apply for the tax benefit for biotechnology related activities under the R&D (SRED) tax program?

13320 ◯ No → Why? →
1 ◯ Complexity of application process
2 ◯ Uncertainty of eligibility
3 ◯ Did not meet eligibility requirements
4 ◯ Other (*please specify*) _____

◯ Yes

---

22. Does your firm use the Internet?

13330 ◯ No → Go to Question 23

◯ Yes → Indicate for what purposes your firm uses the Internet.
(Check any that are applicable.)

1 ◯ Sharing research & development
2 ◯ Marketing/selling
3 ◯ Purchasing goods and services
4 ◯ Accessing databases/information sources
5 ◯ E-commerce
6 ◯ Human resource search
7 ◯ Public relations
8 ◯ General communication
9 ◯ Other (*please specify*)

_____

---

23. Which of the following strategies did your firm use in 1999?
(Check any that are applicable)

13400

1 ◯ Refocused product development
2 ◯ Downsized
3 ◯ Increased size
4 ◯ Entered product trials
5 ◯ Launched new product
6 ◯ Acquired a company
7 ◯ Out-source production
8 ◯ Licensed in technology
9 ◯ Licensed out technology
10 ◯ Merged with other company
11 ◯ Formed a joint venture
12 ◯ Expanded into foreign markets
13 ◯ No change
14 ◯ Other (*please specify*)

Comments

14100

If you have any comments regarding this survey, please provide them in the space below.

_____

_____

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Thank you for your co-operation

Please return the questionnaire in the return prepaid envelope.

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