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Use of Biotechnologies in The Canadian Industrial Sector: Results from the Biotechnology Use and Development Survey - 1999

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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.

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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Acknowledgements

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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 success of the survey and are owed thanks including Claire Racine-Lebel, Craig Byrd and Annie Gilbert, but especially to Antoine Rose, Special Advisor for his leadership. And finally thanks to the methodology team of Lyne Guertin, Richard Laroche, Nicolas Lavigne and Yves Morin.

Introduction

The *Biotechnology Use & Development Survey – 1999* administered by the Science, Innovation and Electronic Information Division of Statistics Canada, provides information on three groups of firms;

1) firms involved in developing new products and processes using biotechnologies
2) firms that use biotechnologies in their day to day activities
3) firms that do not use biotechnology

This paper focuses on the later two groups of firms.

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? Two papers (see McNiven, 2001a & 2001b) begin to address those questions by reporting on the revenue, research and development, import and export, product pipeline, human resources characteristics and business practices of core biotechnology firms. Table 1 summarizes selected characteristics of core biotechnology firms from the 1997 (see Traoré, 2001) and 1999 surveys. Table 2 gives a sector perspective from the 1999 survey.

Table 1 Core Biotechnology Firm Characteristics 1997-2002

Year	1997	1998	1999	2002[3]
Number of Biotechnology Firms	282	…	358	…
Biotechnology Revenues ($000,000)	813	1,554	1,948	5,009
Biotechnology R&D Spending ($000,000)	494	695	827	1,481
Biotechnology Exports ($000,000)	311	372	718	1,694
Biotechnology Employees	9,019	…	7,748	…
Number of Biotechnology Products Pre-market	7,166	…	10,977	…
Number of Biotechnology Products On Market	1,758	…	6,597	…

1) Source: Statistics Canada 2) … data not collected 3) 2002 forecast provided by respondents

Table 2 Selected Biotechnology-Related Characteristics of Core Biotechnology Firms By Sector (1999)

	Revenue ($000,000)	R&D ($000,000)	Exports ($000,000)	Biotech Employees	Products (All stages)
Human Health	1,036	703	410	5,487	3,435
Agriculture	524	66	233	985	5,557
Natural Resources	113	24	..	149	162
Environment	45	..	3	323	233
Aquaculture	19	4	2	..	48
BioInformatics	20	20	5	227	7,249
Food Processing	185	7	51	338	785
Other	7	..	..	..	103
TOTAL	**1,948**	**827**	**718**	**7,748**	**17,574**

1) Source: Statistics Canada 2) .. data not available

Two sub-groups are explored in this paper, users[1] of biotechnology and non-users[2] of biotechnology. The users group is comprised of firms that use biotechnology in their day to day operations, and do not consider biotechnology central to their activities. If used in research and development, biotechnology is an adjunct activity not the central R&D activity[3]. The non-users group does not use biotechnology, but did provide information on the reasons why they do not use biotechnology. These responses may provide insight into the barriers to using biotechnology. The two sub-groups are from NAICS[4] codes where the possibility of using biotechnology had been identified in previous surveys supplemented by expert opinion and consultation from industry, government and academia.

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 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[5] (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." The survey, however, uses a list-based definition of biotechnology that is in fact question 1 of the questionnaire. The survey is found in Appendix 1.

This survey is the latest in a series of initiatives, including contributions to international organizations on biotechnology statistics, intended to develop a biotechnology statistics program and internationally comparable data. Statistics Canada administered two previous surveys dedicated to biotechnologies. The first, the *Biotechnology Use Survey – 1996* examined the use of biotechnologies in selected Canadian industries. Discussions of the results from this survey can be found in Rose (1998) and Arundel (1999). The second, the *Biotechnology Firm Survey-1997* was aimed at those firms actively conducting biotechnology research and development and considered to be core biotechnology firms.

[1] This group answered Questions 1, 3, 4, 5, 6, 7 & 8 (a screening question) of the questionnaire.
[2] This group answered Questions 1 & 2 of the questionnaire. They completed and returned the survey and should not be confused with non-respondents.
[3] Possible confusion arising from core firms R&D activities and the users group conducting R&D using biotechnology can be explained this way. The users group employs biotechnology in R&D activities as one method or step to achieve a goal or end result (product or process) that is not necessarily related to biotechnology or where the end product is not a new biotechnology product or process. The core group may use biotechnology in the same way, but also with an aim to create new biotechnology based products or processes and also consider biotechnology R&D central to their activities.
[4] *North American Industry Classification System Canada 1997* (1998). Statistics Canada, Ottawa.
[5] Canadian Biotechnology Advisory Committee, Annual Report 1999-2000

Results from this survey can be found in McNiven (1999) and revised data and accompanying analysis in Traoré (2001).

The *Biotechnology Use and Development Survey – 1999* combines elements and the legacy of those surveys. It addresses questions such as who is using biotechnologies and why are they using biotechnologies, who develops biotechnologies and what is being developed[6]. This survey in conjunction with studies examining the supply and demand of capital, as well the growth of biotechnology firms and workshops[7] contributes to a more comprehensive portrait of Canada's biotechnology activities. The Science Innovation and Electronic Information Division also produces other biotechnology data and a listing of these publications can be found in Appendix 3.

Use of Biotechnologies: The Users Perspective

The survey provides a statistical portrayal of biotechnology in Canada from three perspectives: core biotechnology firms, users of biotechnology and non-users of biotechnology. Data on firms that use biotechnology in their day-to-day operations, but do not develop new biotechnology products or processes, they use biotechnology as they would use any other factor of production is first discussed. Biotechnologies are simply an expedient way of conducting business. The paper then looks at the 'non-users' of biotechnologies, these firms provided information on why they did not use biotechnologies.

Firms provided information on their current use of biotechnologies, the purpose of using biotechnology, number of years using the biotechnology, and, if they were not using a particular biotechnology[8], if they planned to use that biotechnology within 3 years. These sections discuss results for the users group and then core biotechnology firms by focusing on the four major categories; DNA based, Biochemistry/Immunochemistry, Bioprocessing based and Environment biotechnologies. These four sections are made up of 17 different biotechnologies.

An estimated 784 unique firms use biotechnologies. This group, about 8% of total firms from the selected NAICS codes combined for 1492 incidences of current use. The primary current use was in production with 824 incidences of use, followed by R&D purposes with 606 and environmental purposes with 301. Some firms reported more than one biotechnology used and reported some biotechnologies used for more than one purpose.

[6]Statistics Canada (1998) *Science & Technology Activity and Impacts: A Framework for a Statistical Information System* for an overview of the underlying conceptual framework.
[7]For a summary of the latest workshop proceedings see: *The Economic & Social Dynamics of Biotechnology* (2000). J. de la Mothe & J. Niosi (eds.) Kluwer, Boston.
[8] See Question 1, page 2 of the questionnaire found in Appendix 1.

The 1996[9] survey revealed a penetration rate of biotechnologies into the selected industries of about 14%, compared to the 8% in this survey. Over the next three years only 2% of firms intend to adopt the use of biotechnologies, suggesting a plateau of biotechnology adoption, given current technical levels. Many of the biotechnologies used have been in use for a decade or more, for example bioprocessing based biotechnologies have the least planned adoption and the greatest average number of years in use.

The type and intensity of biotechnologies used ranged from a high of 702 incidences of use in the biochemistry/immunochemistry category mainly for current production (66%), to 463 uses in the bioprocessing category again used mainly for current production.

The environment group totalled 182 incidences of use, not surprisingly used for environmental purposes 62% of the time. The most common use of biotechnology in the environment category was the bioremediation/biofiltration/phytoremediation category, accounting for 153 of the 182 incidents of use and used for environmental purposes by 67% of the firms. The least used was the DNA based grouping with 145 incidences of use. This group was on average in use for less than 4 years and this reflected in the fact that 77% of its use was directed towards R&D purposes.

Users & Core Group Perspective

Combining the core group and the users group creates a more complete picture of biotechnology use. There are a total of 1,142 firms using biotechnologies and together they use 3,241 biotechnologies. Collectively these 1,142 firms represent the penetration rate of biotechnology into Canadian industry.

There were a total of 423 instances of the 358 core biotechnology firms[10] using DNA based biotechnologies, with research and development (R&D) emerging as the primary use, reported in 416 cases. This far outstripped their use in current production. Perhaps not surprising data is not published for DNA based biotechnologies used for environmental purposes due to low level of use. With an average use of 4 years, DNA based biotechnologies is the youngest of the different sectors. It includes bioinformatics used for an average of 3 years by the 83 firms reporting its use, almost entirely for R&D purposes. This was the lowest average time of use of any biotechnology.

Genetic engineering/DNA sequencing/synthesis/amplification sub-grouping was the most popular biotechnology with 140 firms reporting its use primarily for R&D. Growth in the use of these biotechnologies is anticipated[11], with 151 new users of DNA based biotechnologies expected within the next 3 years.

The eight biotechnologies found in biochemistry/immunochemistry section were the most frequently used biotechnologies with cumulative 795 occurrences, mainly for R&D

[9]Readers should use caution in direct comparisons between the various surveys since frames, methodologies and questions vary between the surveys.

[10] Firms provided multiple responses to biotechnologies used.

[11] Note To Readers: Projections for future use of biotechnologies and other forecasts used in this and other papers were provided by respondents and are not forecasts created by Statistics Canada.

purposes (700), but also for production (243) and environmental (78) purposes. Some firms used biotechnologies for more than 1 purpose. Its average time of use had the greatest range from 4.2 years to 10.6 years. 171 firms currently used the microbiology/virology/microbial/ecology sub-group for R&D, production and environmental purposes, averaging 10.6 years in use. This was one of the longest average periods a biotechnology was used.

As group, bioprocessing based biotechnologies have been used for the longest period with an average period of 8.5 years. As well it has the highest number of firms using it in current production. This may reflect its maturity, and it may have, as a group, shifted from a research and development focus to a more standardized process. Only 35 more firms plan to introduce these technologies in the next 3 years. The final group is the environmental biotechnologies, where again the focus is on R&D, but with a significant number of firms reporting using these techniques in current production stage. Only 10 firms plan to introduce environmental biotechnologies to their operations before 2002.

Biotechnology Use and North American Industrial Classification System (NAICS)
Table 5 provides data on the use of biotechnologies by NAICS codes. Not surprisingly, given the distinct nature of biotechnology activity, biotechnology use is spread over a diverse range of NAICS codes. There are 16 different codes where biotechnologies are found, and with the exception of 3, all are at the four-digit level. In addition there is a group for firms with no assigned NAICS code at the time of the survey. Codes range through industries from aquaculture (NAICS 1125) to oil & gas extraction (NAICS 2111) to medical & diagnostics laboratories. There are a large number of suppressed cells due to high coefficient of variation (C.V.) and confidentiality issues.

The most intense use of biotechnologies is found in food processing (311), where 256 instances of bioprocessing based biotechnologies are used mainly in current production, and 203 biochemistry/immunochemistry biotechnologies are used mainly for current production and to a lesser extend for product/process R&D. In chemical manufacturing (NAICS 325) firms cited 101 bioprocessing based uses of biotechnology, mainly for product/process R&D purposes. Given the diversity of NAICS codes where biotechnologies found and the range of purposes for biotechnology, it is not surprising that biotechnology is viewed as an activity rather than a distinct industry.

Benefits From Using Biotechnologies
Firms rated the improvement of product quality as the number one benefit derived from using biotechnologies. It was the 2nd highest benefit in the 1996 survey. Interesting enough, lower cost factors were rated low as benefits from using biotechnologies. This stands in contrast to the results of the 1996 survey were lower production costs rated as the greatest positive influence in introducing biotechnologies to a firm. A benefit of increased production flexibility was rated highly by firms, as was increased sales. Table 6 contains complete data on the benefits of using biotechnologies.

Sources of Information on Biotechnology

"The activities of innovation and technology do not take place in isolation"[12]. Biotechnology is no exception and firms rely on a variety of sources to obtain information. Among the most important are the internal resources of a firm, with 29% of firms attaching a high importance to internal sources, staff or associated firm. In contrast only 4% rate data retrieval services as important. Government sources were considered of high importance by 10% of firms, behind academic journals, academic institutions, tacit knowledge and other companies. Government sources were rated by at least 35% of firms as low importance as information sources. Firms rely on numerous sources of information. Table 7 contains full data on information sources.

Human Resources/Contracting Out

The 784 biotechnology user firms employ 6,151 persons with biotechnology related responsibilities. This represents 3% of the total of 192,079 people working in firms that use biotechnology. Of those biotechnology employees, the majority is found in the production category followed by technicians/engineering and finance/marketing. Biotechnology scientific/research direction is fourth on the list with just over 200 employees. The number of dedicated biotechnology production staff dropped by almost a quarter between 1998 and 1999, but is predicted to rise to over 1,800 employees by 2002.

Firms reported few unfilled biotechnology positions so, consequently, user firms reported little difficulty in recruiting biotechnology staff. However, in order to find biotechnology staff, user firms used In-house training as the prime method in filling positions, followed by university recruitment and networking as methods used in recruiting biotech staff. The use of students is limited with only 233 students employed with biotechnology related responsibility. Technical/Trade/College students accounted for 64 positions, undergraduates another 97 spots and the final 72 were graduate level students. Data for unfilled positions is unpublished due to confidentiality and quality issues.

In addition to employees with biotechnology responsibilities, user firms contracted out $323 million in biotechnology related contracts. There were 108 research & development contracts, worth $218 million, leading the 4 categories. 45 Regulatory/clinical affairs contracts averaging $1.7 million per contract followed. Details are available in tables 8-11.

'Non Users' of Biotechnologies and Barriers to Their Using Biotechnologies

As important as it is to develop knowledge about the characteristics of firms using or developing biotechnologies, information about firms not using biotechnology and their reasons for not using biotechnology can contribute to a greater understanding of some of the barriers to biotechnology adoption.

An estimated 8,455 firms from the selected NAICS codes **do not use** biotechnology. This represents about 92% of the firms in the NAICS codes surveyed. In comparison, using different methodology but a similar universe, the *Biotechnology Use by Canadian*

[12] Rose (1998) p11

Industry Survey[13] found that about 14% of the sample used at least one biotechnology in the 1996 fiscal year. Of the 8,455 non-users, only 184 firms plan to introduce biotechnologies within three years. 100 firms cited environmental biotechnologies in future plans, representing an increase of 54% in the environment use sector. This is followed by biochemistry/immunochemistry and then DNA based biotechnologies. Collectively this represents an adoption rate of 2% in industries known to use biotechnologies.

Among firms responding to issues beyond the Not Applicable category, the main barriers to using biotechnology were attributed to cost factors by 50% of firms, followed by lack of qualified staff by 41% of firms and then public acceptance cited by 36% of firms. The cost factors were the cost to implement/integrate biotechnologies, high cost of equipment and cost of capital. The 1996 survey found that the primary impediments to using biotechnology among non-users were lack of financial justification, lack of information, biotechnologies not sufficiently developed, insufficient market for products and lack of scientific and technical information. See table 12

Summary

This is the final of 3 papers providing data and an overview of the results of the Biotechnology Use & Development Survey – 1999. Readers are encouraged to use the data.

[13] For complete survey details and results see: Rose, A. (1998). *Biotechnology Use By Canadian Industry – 1996*. Working Paper Series, Statistics Canada, Ottawa.

Data Tables

Table 3
Number & Distribution of Biotechnologies Used by User Firms - 1999

Biotechnologies	Currently Used in Operations	R&D Product/Process	Current Production	Environmental Purposes	Years in Use
DNA Based					
Gene Probes/DNA Markers	..	..	7*	..	3.5*
Bio-informatics	..	..	..	..	3.2
Genomics/Pharmacogenetics	..	..	..	..	3.9
Genetic Engineering/DNA Sequencing/Synthesis/Amplification	63*	..	20*	..	2.8
Any DNA Based	145	111	29	9*	
Biochemistry/Immunochemistry					
Vaccines/Immune Stimulants	133	..	123	..	13.8
Drug Design/Delivery	28*	4*	18*	..	4.5
Diagnostic Tests/Antibodies	103	28	85	5*	7.1
Peptide/Protein Sequencing/Synthesis	..	..	..	..	3.2
Cell Receptors/Signalling/Pheromones/Structural Biology	..	..	..	..	2.4
Combinatorial Chemistry/3D molecular Modeling	..	..	..	..	1.5
Biomaterials	74	..	33	13*	14.7*
Microbiology/Virology/Microbial Ecology	254	126	190	57	9.0
Any Biochemistry/Immunochemistry	702	303	463	91	
Bioprocessing Based					
Cell/Tissue/Embryo Culture Manipulation	25*	..	13*	..	7.4
Extraction/Purification/Separation	138*	64*	89*	..	11.0
Fermentation/Bioprocessing/Biotransformation/Natural Products Chemistry	300	79*	192	..	13.0
Any Bioprocessing Based	463	155*	294	88	
Environment					
Bioleaching/Biopulping/Biobleaching/Biodesulphurization	28*	..	..	..	9.8*
Bioremediation/Biofiltration/Phytoremediation	153	..	25*	102*	7.7
Any Environment	182	38	38	114	
Total	1492	606	824	301	

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 4

Number & Distribution of Biotechnologies Used by Core Biotechnology Firms - 1999

Biotechnologies	Currently Used in Operations	Current Use of Biotechnology: Product/Process R&D	Current Use of Biotechnology: Current Production	Current Use of Biotechnology: Environmental Purposes	Number of Years in Use	Plan to Use in Next 3 Yrs
	Number of Firms					
DNA Based						
Gene Probes/DNA Markers	130	127	25	..	4.8	34
Bio-informatics	83	83	9	..	3	35
Genomics/Pharmacogenetics	70	70	7	..	3.5	48
Genetic Engineering/DNA Sequencing/Synthesis/Amplification	140	136	31	..	4.6	34
Any DNA Based	423	416	72	..	4	151
Biochemistry/Immunochemistry						
Vaccines/Immune Stimulants	83	63	29	7	8.7	23
Drug Design/Delivery	102	100	25	..	6	20
Diagnostic Tests/Antibodies	138	122	52	12	6.6	15
Peptide/Protein Sequencing/Synthesis	103	94	21	..	4.5	34
Cell Receptors/Signalling/Pheromones/Structural Biology	82	79	6	..	4.2	28
Combinatorial Chemistry/3D molecular Modeling	54	54	6	..	4.8	43
Biomaterials	62	44	31	11	6.1	..
Microbiology/Virology/Microbial Ecology	171	145	73	42	10.6	..
Any Biochemistry/Immunochemistry	795	700	243	78	6.4	185
Bioprocessing Based						
Cell/Tissue/Embryo Culture Manipulation	163	151	54	8*	6.7	3*
Extraction/Purification/Separation	204	177	101	19	8.2	14
Fermentation/Bioprocessing/Biotransformation/Natural Products Chemistry	180	141	98	38	10.6	21
Any Bioprocessing Based	547	469	254	57	8.5	35
Environment						
Bioleaching/Biopulping/Biobleaching/Biodesulphurization	18	15	9	4*	5.7	3*
Bioremediation/Biofiltration/Phytoremediation	46	36	15	36	8.9	7
Any Environment	64	51	24	40	7.3	10
Other	24	14	20	..	9.7	..

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

.. Figures not available

* Use with caution, unreliable due to high coefficient of variation

Table 5
Biotechnology Use by NAICS

	Currently used	Product/Process R&D	Current production	Environmental purposes
NAICS 1125 Aquaculture				
DNA Based	10*	..	7*	..
Biochemistry/Immunochemistry	62	16*	59	..
Environment	14*	..	14*	..
Bioprocessing Based	8*	..	..	..
NAICS 1132 Forest Nurseries				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	..	..	..	..
Environment	..	..	..	..
Bioprocessing Based	..	..	..	..
NAICS 2111 Oil and Gas Extraction				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	..	..	..	..
Environment	62	..	3	62
Bioprocessing Based	..	..	..	..
NAICS 2122 Metal Ore Mining				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	..	..	..	..
Environment	9	3*	4*	4
Bioprocessing Based	..	..	..	..
NAICS 2123 Non-Metallic Mineral Mining				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	..	..	..	..
Environment	..	..	..	..
Bioprocessing Based	..	..	..	..
NAICS 311 Food Manufacturing				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	203	99	160	38*
Environment	..	..	..	..
Bioprocessing Based	256	65*	182	..
NAICS 3121 Beverage Manufacturing				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	39*	27	30	9
Environment	..	..	..	..
Bioprocessing Based	66	24	66	..
NAICS 3221 Pulp, Paper and Paperboard Mills				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	8*	..	..	..
Environment	12	..	4*	6*
Bioprocessing Based	4	..	..	..

	Currently used	Product/Process R&D	Current production	Environmental purposes
NAICS 3241 Petroleum and Coal Products Manufacturing				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	..	..	..	..
Environment	..	..	..	..
Bioprocessing Based	..	..	..	..
NAICS 325 Chemical Manufacturing				
DNA Based	25	25	5	..
Biochemistry/Immunochemistry	76	65	40	15
Environment	38	23*	..	26*
Bioprocessing Based	101	71	40	25*
NAICS 3254 Pharmaceutical and Medicine Manufacturing				
DNA Based	4	3*	3	..
Biochemistry/Immunochemistry	41	32	34	..
Environment	..	..	..	..
Bioprocessing Based	40	36	27	..
NAICS 4145 Pharmaceutical, Toiletries, Cosmetics and Sundries Wholesaler				
DNA Based	..	..	..	..
Biochemistry/Immunochemistry	19*	..	7*	..
Environment	..	..	..	..
Bioprocessing Based	..	..	..	..
NAICS 4183 Agriculture Supplies				
DNA Based	31*	8*	20*	..
Biochemistry/Immunochemistry	23*	5*	..	..
Environment	..	..	..	..
Bioprocessing Based	..	..	..	..
NAICS 54 Professional, Scientific and Technical Services				
DNA Based	10	10	..	..
Biochemistry/Immunochemistry	17	17	9	4*
Environment	10	7	..	6
Bioprocessing Based	18	17	10	..
NAICS 5417 Scientific Research and Development Services				
DNA Based	57	57	11	..
Biochemistry/Immunochemistry	74	69	36	11
Environment	5	65	..	2
Bioprocessing Based	70	8	31	8
NAICS 6215 Medical and Diagnostic Laboratories				
DNA Based	35	33	13	..
Biochemistry/Immunochemistry	45	40	19	10
Environment	..	..	..	..
Bioprocessing Based	35	35	23	4
No NAICS				
DNA Based	26	24	13	3
Biochemistry/Immunochemistry	36	34	20	9
Environment	12	7	2	7
Bioprocessing Based	38	34	25	6

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 6

Benefits of Using Biotechnology

	Low Importance		Neutral	High Importance	
	1	2	3	4	5
Lower labour costs	11*	30	43	54*	282
Lower capital costs	13	29*	18*	42	299
Lower energy costs	12*	23	37	46*	311
Develop new product or processes	..	21	46*	71	201
Extend product range	..	19	61	76	304
Improvement in product quality	14*	119*	59	214	81
Increase production flexibility	..	52	133*	48	177
Lower maintenance expenses	17*	58	49*	47	260
Cleaner production/pollution reduction	17*	20	34	118	257
Improve market position	25*	22*	41	82	285
Increase sales	22*	19*	49	111	270
Reduced time to market/Faster delivery time	11	58*	33	54	289
Other	..	..	..	10	..

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 7

Sources of Information on Biotechnology

	Low Importance		Neutral	High Importance	
	1	2	3	4	5
Internal Resources/Staff or Parent /Subsidiary Firm	93	46	115	120	228
Academic Journals/Trade Publications	131*	94	167	133	137
Universities/Colleges/Private Training Institutions	181	99	60	157	116
Federal Government Department/Agency	278	75	125	60	79
Personal Contact With Others (Tacit Knowledge)	128*	71	157	204	107
Other Companies	164*	102	126	130	113
Provincial Government Department/Agency	286	115	93	54	75
Professional/Industry Associations	198	100	136	163	77
Library/Literature Searches	215	66	112	155	59
Database Retrieval Services	299	93	76	92	28
Conferences/Workshops/Trade Shows	160	82	157	132	86

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 8

Total Employees in User Firms & Biotechnology

	Total Employees	Biotechnology Employees
British Columbia	32,940*	288
Alberta	25,450	376
Saskatchewan	4,164	160*
Manitoba	10,741*	..
Ontario	50,985	1,931*
Quebec	22,445	343
New Brunswick	2,957	146
Newfoundland	..	..
Nova Scotia	5,367	268
P.E.I	..	..
Total	**192,079**	**6,151**

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 9

Full/Part-Time Biotech Employees and Estimated Number by 2002

Position	Full-Time	Part-Time	2002
Scientific/Research direction	194	205	251
Technicians/Engineering	218	377	446
Regulatory/Clinical affairs	26	99	103
Production	1268	978	1843
Finance/Marketing	152	249	341
Management/Licensing/Administration	65	188	176
Total	**1922**	**2096**	**3160**

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 10

Contracting Out of Biotechnology Activities

Purpose	Number of Firms	Value of Contracts ($000,000) Total
Research and development	108	218
Regulatory/Clinical Affairs	45	78
Marketing/Distribution	22*	..
Management/Licensing/Administration	14*	..
Total	**189**	**324**

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 11

Methods Used In Recruiting Biotechnology Staff

Method of recruiting	% of firms
Internet resources	11
University recruitment	30
Use under-qualified staff	4
Temporary/contract staff	17
Employment agencies	10
In-house training	41
User over-qualified staff	5
Networking	28
Newpaper/journal ads	24
Professional associations	12
Other	12

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Table 12

Barriers to Using Biotechnology Among Non-user Firms (% of firms)

	Low Importance		Neutral	High Importance	
	1	**2**	**3**	**4**	5
Barriers					
Small market size	30	6	19	15	29
High cost of equipment	13	4	7	25	50
High cost to implement/integrate biotechnology	13	..	9	23	52
Cost of capital	13	5	15	19	48
Shortage of skilled or trained staff	33	8	11	7	40
Worker resistance	37	19	22	3	6
Increased labour costs	21	8	18	18	26
Government regulations	22	20	19	12	27
Public acceptance/perception of biotechnology	21	20	11	9	39
Biotechnology not sufficiently developed	25	8	18	26	24
Lack of external technical expertise/support	20	9	24	21	27

Source: Statistics Canada, Biotechnology Use and Development Survey - 1999

Preliminary Data

* Use with caution, unreliable due to high coefficient of variation

.. Figures not available

Methodology

The survey was mailed to 3,377 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 a 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 less 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 yoghurt making. The new biotechnologies build on the advances in science in the 1970's and 80's. This survey does not attempt to reconcile that debate, but did actively seek out the new biotechnologies, as opposed to the more traditional biotechnologies such as fermentation.

As part of its ongoing initiatives, the Division is actively involved with the OECD where consensus has been reached on a provisional list based definition for biotechnology. This definition, adopted after the administration of this survey, is a revision of the list of biotechnologies developed by Statistics Canada and other countries and used in Question 1. The OECD definition will be incorporated into the next survey. Several methods of defining biotechnology were attempted prior to the survey 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 series of reports uses a series of classifications in data tables. These are firm size, sector and geography.

Geography is the standard geography classifications of Statistics Canada[14]

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. Results from the 1997 Biotechnology Firm Survey have been revised to facilitate comparisons between 1997 and 1999 data[15].

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, was 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.

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

[15] For additional details see: Traoré, Namatié (2001) *The Canadian Biotechnology Sector: Features From the 1997 Biotechnology Survey*. Working Paper Series, Statistics Canada, Ottawa.

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 use biotechnologies, by responding 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. 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 was the focus of the two prior papers.

Appendix I -- Copy of Questionnaire

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

5-4900-500.1: 2000-01-13 STC/SAT-430-75177

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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_____

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_____

_____

Thank you for your co-operation

Please return the questionnaire in the return prepaid envelope.

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