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Features of Canadian biotechnology innovative firms: results from the biotechnology use and development survey - 2001

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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/cgi-bin/downpub/research.cgi?subject=193.

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Acknowledgements

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Highlights

- In 2001, there were 375 innovative biotechnology firms in Canada, an increase of 5% compared with 1999.
- The number of firms declaring biotechnology revenues as well as the amount of biotechnology revenues declared has risen significantly between 1997 and 2001. Biotechnology revenues reached $3.6 billion in 2001, compared with $1.9 billion in 1999 and $813 million in 1997. Though 69% of innovative firms declaring biotechnology revenues are small firms, they only reported 15% of the total biotechnology revenues, while large firms contributed 62% of the total amount.
- Spending on biotechnology research and development (R&D) nearly tripled between 1997 and 2001, from $494 million in 1997 to more than $1.3 billion in 2001.
- The Human Health sector performed 92% of all biotechnology R&D, and also spent the largest share of total R&D on biotechnology R&D.
- In 2001, Canadian biotechnology innovative firms' had 9,661 products/processes on the market compared with 6,597 in 1999 and 1,752 in 1997. This translates into more firms generating biotechnology revenues. In 2001, 67% of all biotechnology innovative firms generated biotechnology revenues compared to 64% in 1999 and 52% in 1997.
- Canadian biotechnology firms raised $980 million in capital in 2001 for biotechnology activities. Though small firms raised 53% of this total, only 50% of small firms successfully reached their financing target, compared with 80% of medium-sized firms and 66% of large firms.
- Canadian venture capitalists provided the largest share of funds for small and medium-sized firms, while conventional sources (e.g. banks) and the government were the principal sources of financing for large firms.
- In 2001, innovative biotechnology firms had 11,987 employees with biotechnology-related responsibilities. This represents 19% of their total workforce in 2001, compared with 17% in 1999 and 28% in 1997.
- Highly skilled workers characterize innovative Canadian biotechnology firms. In 2001, 49% of biotechnology jobs were in the scientific research/direction and technician categories.
- Biotechnology employment among small firms was modest (growth of 7% in biotechnology employment between 1999 and 2001), however it grew significantly for medium-sized firms from 1,343 employees in 1999 to 3,230 in 2001.


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Introduction

The Biotechnology Use and Development Survey – 2001 is the latest in a series of surveys administered by Statistics Canada and partners in order to contribute information on Canadian biotechnology activities. It reports on the activities of firms using biotechnologies and firms developing biotechnologies in Canada for the 2001 reference year. Biotechnology cuts across industrial sectors and activities and rather than being thought of as a single industry, it has been explored as cross-sector activities. The survey did not collect data from contract research organizations (CRO) or from the public and not-for-profit sectors. The methodology of the survey reflects this and is explained in-depth in the Methodology Section.

This report provides information on "*innovative biotechnology firms*". In previous survey reports, this group of firms was referred to as "core biotechnology firms". This change in terminology was made to reflect the criteria used to select this sub-population amongst all users of biotechnology. Biotechnology is a set of techniques used by firms for various purposes, including the generation of new knowledge. This survey uses questions that are similar to questions found in innovation surveys conducted using the guidelines of the Oslo Manual (OECD/Eurostat 1997).

In this report, an "innovative biotechnology firm" is a firm that uses biotechnology for the purpose of developing new products or processes and is engaged in biotechnology related R&D activities. Biotechnology is not confined to a particular industry. It is a dynamic activity characterized by its use in various applications in a range of sectors: Human Health, Agriculture, Natural Resources, the Environment, Aquaculture, Bioinformatics and Food Processing.

There have been 3 previous surveys. The first, the Biotechnology Use Survey - 1996, examined the use of biotechnologies in selected Canadian industries. The second, the Biotechnology Firm Survey - 1997, was aimed at firms actively conducting research and development and considered to be the core biotechnology firms. The third, the Biotechnology Use and Development Survey - 1999, had the same objectives as the 2001 survey. Both combine elements of the previous surveys (1996 and 1997) in order to provide statistics on biotechnology. The Biotechnology Use and Development Survey - 2001 provides data on Canadian biotechnology firms from two perspectives: biotechnology innovators and biotechnology users.

This paper contains data tables and brief descriptive analysis designed to help readers and data users understand the concepts and context of the data. Readers are advised to review the concepts and context in order to understand and to interpret the data. Biotechnology employee figures are an example; biotechnology innovative firms have 11,897 biotechnology employees. This is a subset of the total number of employees. Employees in biotechnology innovative firms may also be engaged in activities not related to biotechnology.

Distribution of Firms

There were 375 innovative biotechnology firms in Canada in 2001, compared to 358 firms in 1999 and 282 firms in 1997.

Distribution by Sector

The change in the number of firms in a sector between 1999 and 2001 can be attributed to firms entering or leaving the sector and to mergers of firms, which may also result in a change of sector. Firms entering a sector may be new firms, or firms transferred from another sector. Similarly, firms leaving a sector may have ceased operation, or moved to another sector, or are no longer classified as 'innovative biotechnology firms'. The figures given are net of all these changes. A sector is a domain of applications for the biotechnology products and processes developed by firms. For instance, the Human Health sector includes firms involved in diagnostic, therapeutic and drug delivery products[1].

The Human Health sector grew from 150 firms to 197 firms, representing 53% of biotechnology firms in 2001 compared to 42% in 1999. The Agriculture sector declined from 90 firms in 1999 to 65 in 2001. This decline can be attributed to several factors. The first is consolidation of firms, the second, firms shifting from the Agriculture sector to the Food Processing sector, and finally to a lesser degree a number of firms that ceased operations. The Food Processing sector increased in size from 29 firms to 48 firms. The Natural Resources sector showed a decline from 18 to 10 firms. Some of the decline is explained by a number of firms moving from developing new biotechnology products or processes to using those biotechnology products or processes in their day to day activities. As biotechnology matures this is an expected process and natural resource biotechnology products are amongst the oldest in use. The number of firms in the Bioinformatics sector also declined, but some of these firms shifted to the Human Health sector.

Distribution by Province

In total, Quebec has more biotechnology firms than any other province and also experienced the greatest growth in firms, increasing 21% from 107 firms to 130 firms. Growth was also observed in Manitoba, Saskatchewan and the Atlantic Provinces. Declines were also noted. The number of firms in Ontario declined from 110 firms to 101 firms, while British Columbia and Alberta had small decreases in the number of firms.

Distribution by Employment Size

Small firms (less than 50 employees) accounted for 71% of the total. Medium firms (50 to 149 employees) accounted for 17% and large firms the final 12%. The small category declined from 270 (in 1999) to 267 firms in 2001, a contraction of 4% of the small category between 1999 and 2001, in part attributable to the growth of medium-sized firms. The medium category increased in size by 11 firms representing 17% of firms, up from 14% in 1999. As firms reach the market it is

[1] The sectors are defined in question 10 of the questionnaire. Firms are assigned to their sector based on their primary product. The questionnaire is given in Appendix 1.

expected that their size would increase. Large firms (150 or more employees) accounted for 12% of the total in 2001, an increase from 11% in 1999.

Table 1: Distribution of Biotechnology Firms by Sector, Province and Size, 2001

Number of Biotechnology Firms by Sector	
	Number of firms
Human Health	197
Agriculture Biotechnology	65
Natural Resources	10
Environment	33
Aquaculture	11
BioInformatics	11
Food Processing	48
Other	0
Total	**375**

Number of Biotechnology Firms by Province	
	Number of firms
Atlantic	23
Quebec	130
Ontario	101
Manitoba	11
Saskatchewan	17
Alberta	24
British Columbia	69
Canada	**375**

Number of Biotechnology Firms by Size	
	Number of firms
Small (Less than 50 employees)	267
Medium (50-149 employees)	62
Large (150 or more employees)	46
Total	**375**

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

E: use with caution

F: too unreliable to be published

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0: Zero

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

Biotechnology Revenues

Number of Firms Declaring Biotechnology Revenues

Overall, 252 out of 375 or 67% of innovative firms reported biotechnology revenues in 2001. These firms come from all firm categories: 175 are small firms, 41 are medium-sized, and 36 are large firms. Thus, two thirds of both small and medium-sized firms earned revenues from their biotechnology activities in 2001. This figure was 78% for large firms. In absolute terms, the number of firms reporting biotechnology revenues is greater than in both 1997, 176, and in 1999, 225. This suggests that over the years, in all firm categories, a larger number of firms were able to bring biotechnology products onto the market.

About 46% of the firms declaring biotechnology revenues in 2001 came from Human Health. The Agriculture and Food Processing sectors followed with 54 and 34 firms, respectively. Twenty-seven of the firms in the Environment reported biotechnology revenues in 2001. Together, the Natural Resources sector, the Aquaculture sector, and the Bioinformatics sector accounted for 23 of the 252 biotechnology income earning firms.

Firms from all the provinces earned biotechnology revenues with Quebec leading the way. Over one in every 3 firms that declared biotechnology revenues in 2001 came from Quebec, making it the province with the highest number of firms reporting biotechnology revenues. Ontario and British Columbia are second and third with respectively 65 and 43 firms. Alberta and Saskatchewan are home to 17 and 15 firms, respectively; 7 are located in Manitoba and 12 in the Atlantic region.

When all the revenue sources are taken into account, the number of firms declaring revenues is 288, over three-quarters of the 375 firms in 2001. All the large firms belong to this group, as compared to 191 or 72% of small firms and 51 or 82% of medium-sized firms. Thus, in relative terms, small firms are less likely than other firm categories to have any revenues of their own. In contrast to large and medium-sized firms, which may be resourceful enough to diversify their activities, small firms are more likely to concentrate on their biotechnology activities. These activities, in particular, biotechnology R&D, takes a long time to materialize into actual products and processes for commercialization. Second, because of the regulatory process that may be time consuming and costly due to long testing processes involved, not many small firms are able to get their products onto the market as quickly as other firm categories. Most small firms in biotechnology are at an early stage of development. Only 42% of small firms have products on the market. Medium and large firms either have products on the market or are well established firms with diversified activities and have adopted biotechnologies.

Like for biotechnology revenues, the Human Health sector has the largest number of firms with revenues, 137, i.e. almost half the number of such firms. Agriculture, Food Processing, and Environment are other revenue earning sectors. Together, they account for 127 firms.

The geographical concentration of revenue earning firms parallels that of biotechnology revenues, with Quebec, Ontario, and British Columbia having the lion’s share with respectively

101, 75, and 54 firms. The Prairies provinces are home to 34 firms that earned revenues and the Atlantic have 16.

Biotechnology Revenues and Total Revenues

Biotechnology revenue is only part of total revenue generated by firms. This section shows the comparisons between biotechnology revenues and total revenues. Biotechnology revenues amounted to $3.6 billion in 2001, an 83% increase over 1999, and a 343% increase over 1997. Sixty one per cent of this amount or $2.2 billion were made by large firms, whereas $849 million came from medium-sized firms and $521 million from small firms.

Firms in the Human Health sector are making much more revenue from their biotechnology activities than firms in any other sector. They accounted for $2.5 billion or 71% of all the biotechnology revenues in 2001. The Food Processing sector followed with $581 million, the Environment sector with $268 million, Agriculture with $246 million. Thus, even though the Agricultural sector comes second in terms of the number of biotechnology revenue earning firms, it lies fourth in terms of revenues, implying that firms in this sector, on average, make less revenue from their biotechnology activities. The reverse is true for the Environment and the Food Processing sectors. Natural Resources, Aquaculture, and Bioinformatics lie far behind the other sectors as their biotechnology revenues are much smaller, $13 million in total.

Biotechnology revenues from firms in Quebec and Ontario amounted to $1.5 billion and $1.4 billion, respectively. In this respect, they remain the major players. They are followed in decreasing order by British Columbia with $414 million, Alberta with $122 million, Manitoba at $99 million, the Atlantic at $22 million, and Saskatchewan at $20 million.

When accounting for all sources, revenues jumped from $3.6 billion to $27 billion, an almost 8-fold increase. Large firms contributed the bulk of this increase with $24.3 billion, against $1.5 billion for medium-sized firms and $1.2 billion for small firms. When compared with biotechnology revenues, these amounts are much higher; biotechnology revenues represent only 6% and 9% of total revenues from medium-sized and large firm categories, respectively. In contrast, they make 45% of all revenues from small firms, 7.5 times more than for the medium-sized category, and 5 times more than the large size category. This finding supports the contention that small firms are more likely to specialize in biotechnology, whereas large firm and medium-sized firms may have a more diversified portfolio of activities.

Sector comparison shows Environment and Agriculture leading the other sectors with $8.9 billion and $8.7 billion in total revenues, respectively. The Human Health sector comes third with $5 billion. This finding, in addition to previous results showing that biotechnology revenues from Human Health are the largest among the sectors, may be an indication of a greater ability of firms in this sector to bring more of their products onto the markets or to develop products or processes that are commercial successes. Food Processing is the fourth most important revenue-making sector with $4.3 billion in total revenues. Comparatively, the other sectors, namely, Natural Resources, Aquaculture, and Bioinformatics remain marginal players.

Firms in Quebec brought in $10.5 billion in total revenues in 2001, 3 times as much as those in Ontario, $3.5 billion. Ontario lies behind British Columbia, which reported $7 billion in total revenues. However, when these figures are compared to biotechnology revenues, it is evident that

39% of all revenues are biotechnology related in Ontario, whereas, only 14% are in Quebec, and 5% are in British Columbia. Given that Ontario was found to be the second largest biotechnology revenue maker among the provinces, this result suggests a greater role played by biotechnology activities in this province's firms' portfolio. A larger share of this portfolio may be made of biotechnology products and processes, or biotechnology products and processes that get to the commercialization stage bring much more revenues than other products. Firms in the other provinces did report smaller amounts of revenues: Manitoba earned $759 million and those in Alberta $132 million.

Table 2: Number of Innovative Firms Declaring Biotech Revenues and Revenues by Sector, Province and Size, 2001

	Number of Innovative Firms Declaring Biotech Revenues	Number of Innovative Firms Declaring Revenues
Canada	**252**	**288**
Sector		
Human Health	115	137
Agriculture Biotechnology	54	58
Natural Resources	9	9
Environment	27	31
Aquaculture	8	9
BioInformatics	6	6
Food Processing	34	38
Province		
Atlantic	12	16
Quebec	92	101
Ontario	65	75
Manitoba	7	9
Saskatchewan	15	16
Alberta	17	18
British Columbia	43	54
Size		
Small (Less than 50 employees)	175	191
Medium (50-149 employees)	41	51
Large (150 or more employees)	36	46

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

E: use with caution

F: too unreliable to be published

.. : not available for the 2001 reference period

0: Zero

X: suppressed to meet confidentiality requirements of the *Statistics Act*

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

Table 3: Biotech Revenues and Total Revenues by Sector, Province and Size, 2001

	Biotech Revenues[P]	Total Revenues[P]
	(000,000)	(000,000)
Canada	**3,569**	**27,066**
Sector		
Human Health	2,461	5,074
Agriculture Biotechnology	245	8,666
Natural Resources	7	64
Environment	268	8,900
Aquaculture	5	27
BioInformatics	2	3
Food Processing	581	4,332
Province		
Atlantic	22	F
Quebec	1,515	10,511
Ontario	1,376	3,485
Manitoba	99	759
Saskatchewan	21	F
Alberta	122	132
British Columbia	414	7,118
Size		
Small (Less than 50 employees)	521	1,169
Medium (50-149 employees)	849	1,504
Large (150 or more employees)	2,199	24,392

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

P: Preliminary Data

E: use with caution

F: too unreliable to be published

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Biotechnology R&D

Overall, $1.3 billion were spent on biotechnology R&D in 2001, a 57% increase over 1999, and an 81% increase over 1997. Medium-sized firms contributed $600 million or 46% of this amount. Small firms with $433 million followed them. Large firms spent $303 million, i.e. less than one third of total biotechnology R&D spending in 2001. When R&D expenditures are compared to biotechnology revenues, it can be seen that, proportionately, small firms spend more on R&D compared to their revenues, 83%, than medium-sized firms, 71%, and large firms, 14%. Since most of small and medium biotechnology firms were recently created for the purpose of developing biotechnology products and process, it is not surprising to observe that these firms allocate large share of their total R&D efforts to R&D in biotechnology. Large firms are older and often involved in other activities than biotechnology. They are adopting biotechnology, but, since their other ongoing R&D activities still exists, the share of their total R&D devoted to biotechnology tends to be smaller.

The Human Health sector is the most research intensive of the sectors as firms in the sector spent $1.2 billion on biotechnology R&D in 2001. This is 92% of all biotechnology R&D expenditures for the year. No other sector has spent nearly as much. In fact, all together, the other sectors account for only 8% of the 2001 biotechnology R&D expenditures, with Agriculture and Food Processing spending $58.7 million and $48 million, respectively. They are followed in decreasing order by Bioinformatics at about $21 million, Environment at $16 million, Natural Resources at about $13 million, and Aquaculture at $3.5 million.

Firms in British Columbia spent about $420 million on biotechnology R&D in 2001, more than any other province. They are closely followed by firms in Ontario, with $395 million, and those in Quebec with $348 million. Given that British Columbia is third behind these two provinces in the number of firms, these figures suggest that, on average, firms in the province spend much more in biotechnology related R&D than firms in the latter two provinces. Biotechnology R&D expenditures amounted to $118 million in Alberta in 2001. The other provinces spent around $55 million, with about $31 million coming from Manitoba, $14 million from the Atlantic, and $10 million from Saskatchewan.

When all the R&D activities are taken into account, total R&D expenditures amounted to $2.2 billion in 2001, up from $1.2 billion in 1999, and $926 million in 1997. Small firms contributed $649 million to this amount, medium-sized firms, $690 million, and large firms, $901 million. When compared to biotechnology R&D expenditures, we notice that in 2001, over two-thirds of all R&D expenditures by small firms went to biotechnology activities. This figure was 87% for medium-sized firms, and only 35% for large firms. This may indicate future enhanced revenue earning capacity for these firms as research gets translated into products and processes that will reach markets.

Seventy-three percent (73%) or $1.6 billion of all R&D expenditures in 2001 came from the Human Health sector. Agriculture spent $200 million and Food Processing $118 million. Bioinformatics and Aquaculture spent respectively $21 million and $3.7 million. Quebec's firms spent $884 million, outpacing those in Ontario, which spent $574 million. British Columbia closely followed with $575 million. However, Quebec comes third in terms of the share of overall R&D expenditures that goes to biotechnology research, 39%. British Columbia is first

with 73%, and Ontario, second with 69%. This finding would suggest that firms in Quebec have a more diversified R&D portfolio. Thus, even though they spent more on overall R&D, Quebec's firms seem to have opted for a different business strategy by diversifying their research activities. In contrast, firms in British Columbia and Ontario are more biotechnology oriented and are willing to spend a great deal of their R&D monies on this activity. Overall, Alberta spent $119 million on R&D, and was followed in decreasing order by Saskatchewan, $41 million, Manitoba, $33 million, and the Atlantic, $15 million.

Table 4: Biotech R&D and Total R&D Expenditures by Sector, Province and Size, 2001

	Biotech R&D Expenditures	Total R&D Expenditures
	(000,000)	(000,000)
Canada	**1,337**	**2,241**
Sector		
Human Health	1,177	1,506
Agriculture Biotechnology	59	200
Natural Resources	13	66
Environment	16	326
Aquaculture	3	4
BioInformatics	21	21
Food Processing	48	118
Province		
Atlantic	14	15
Quebec	349	884
Ontario	395	574
Manitoba	31	33
Saskatchewan	10	41
Alberta	118	119
British Columbia	420	575
Size		
Small (Less than 50 employees)	433	649
Medium (50-149 employees)	601	690
Large (150 or more employees)	303	901

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Preliminary data

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Financing Capital

Amount of Financing Capital Raised

Overall, biotechnology firms raised $980 million in financing capital in 2001 for biotechnology activities. Of this amount, small firms raised $517 million, i.e. 53% of the total followed by medium-sized firms, $374 million, and large firms, $89 million. These figures should not be interpreted as meaning that small firms are more successful in raising financing capital than other firm size categories, rather that, as their activities are concentrated in biotechnology, a larger amount of the capital small firms raise is dedicated to that activity. This contention is supported by the percentage of firms that reached their financing targets in 2001: only 50% of small firms was able to reach this target, as compared to 80% for medium-sized firms, and 66% for large firms.

Firms in the Human Health sector raised the largest amount of capital dedicated to biotechnology activities, $858 million. The Agricultural sector was a distant second with $47 million, whereas, the Food Processing sector came third with $25 million. However, firms in this latter sector had the highest success rate in reaching their financing goals, with 66% of them reaching their targets, in contrast to a little over half of firms in the Human Health and the Agriculture sectors.

Firms in Quebec lead the way in raising financing capital in 2001 with $467 million. This is more than twice for Ontario, $216 million. Alberta and British Columbia raised $139 million and $127 million, respectively. Quebec also detained the highest rate for firms that reached their financing capital goal in 2001: 64%. It is followed in decreasing order by firms in Ontario, 58%, British Columbia, 53%, Alberta, 50%. Only a quarter of firms in Saskatchewan acknowledged reaching their financing target in 2001.

Sources of Financing Capital

Canadian venture capital provided 37% of all financing capital raised in 2001 by biotechnology firms. Fifteen per cent (15%) and 13% came from Angel Investors/Family and Government sources, respectively. American venture capital provided 6% and conventional sources such as banks, 7%. The Other sources[2] is also an important financing source for biotechnology firms. In fact, these sources provided 23% of all the capital raised in 2001.

Canadian venture capital provided the largest share of funds to small and medium-sized firms, 37% and 46%, respectively. The Other source is the second in importance for capital for these two firm categories. Together, conventional and Government sources provided 54% of large firms' funding. They obtained no funding from American venture capital and only 14% came of their funds from Canadian based venture capital. At issue here is the control that comes with funding from venture capitalists. These figures suggest that large firms are less likely to forgo part of their decision making power in exchange for funding. This may be because they are more resourceful and have the necessary clout and notoriety to secure funding from sources that will not necessarily have a say in the day to day running of the firm, namely conventional sources like banks and Government sources. Small and medium-sized firms do not have such assets and

[2] Other sources include Private placement, public offerings, collaborative partners, European venture capital

therefore have to accept some type of managerial interference from venture capitalists in exchange for funding.

The Human Health and the Food Processing sectors benefited the most from funding from Canadian venture capital, 42% and 34% of all the funds they raised in 2001, respectively. The prime source of funding for the Agriculture sector was the Other sources, 38%. Firms in the Environment sector also had a large share of their funding coming from the Other sources, 31%, even though funds from Governments constituted the bulk of financing capital, 39%.

Firms from Manitoba, Quebec, and British Columbia received the bulk of their financing from Canadian venture capital, 62%, 51%, and 49% respectively. A little over a quarter of funds raised by firms in Ontario were secured from this source. In Saskatchewan, Government sources and Other sources are the largest providers of funds. Together, they provided two thirds of financing capital to firms in the province. In Alberta, most of funds are secured from Angel Investors/Family.

Reasons for Lenders Limiting or Refusing Request for Capital

In total, 102 firms or 27% of biotechnology firms secured financing capital from Canadian-based venture capital in 2001, as compared to 25 in 1997 and 51 in 1999. Sixty obtained funds from Government sources, 59 from Other sources, 56 from Angel Investors/Family. Conventional sources provided capital to 27 firms and 21 others obtained funding from American based venture capital. The number of firms receiving funding from each source of capital is greater for the Human Health sector than other sectors, suggesting that firms from this sector are more likely to raise financing capital than their counterparts. Firms from Quebec are more likely to have successfully raised financing capital than firms from other provinces.

The limited success of biotechnology firms in raising financing capital, mainly from venture capitalists and conventional lenders (e.g. banks), 27% and 7% success rates respectively, was due, in 78 cases, to the unavailability of financing capital because of market conditions. In 43 cases, lenders needed further product development or proof of concept and in 42 other cases, biotechnology product/process was deemed not sufficiently developed to warrant financing. Other important reasons why financing was denied related to lenders not funding development projects, 28 cases. Limited biotechnology product line or portfolio in scope and insufficient specific management skills/expertise were the reasons why financing was denied to 13 and 12 firms, respectively. Other reasons accounted to 26 refusals.

Small firms suffered the most from these refusals. In fact, they were denied funding for all sort of reasons. However, three main reasons stand out: 68 of the 78 that were denied funding because of market conditions were small firms. This figure was 37 out of 43 for the requirement of further product development or proof of concept, and 37 out of 42 for biotechnology product/process not sufficiently developed. Even though in smaller numbers, medium-sized firms were denied funding mostly for the same three reasons.

The limiting or refusing of funding because of i) lack of capital due to market conditions, ii) requirement of further product development or proof of concept, and iii) insufficient development of biotechnology product/process affected firms across all the provinces and sectors. These results are in line with Niosi (2000), who found that of 1,200 firms that received funding from venture capitalists in 1998, only 60 were biotechnology firms. These results also support biotechnology firms' claim that they have a hard time attracting funding from Canadian venture capitalists. Thus, given that easy access to capital is found to be a key enabler of rapid growth in biotechnology (Niosi, 2000), these results would suggest that future growth of biotechnology firms may be hindered unless their ability to secure funding from venture capital is improved or other sources of capital can fill the capital slack.

Table 5: Amount of Capital Raised and Percentage of Firms that Reached Target by Sector, Province and Size, 2001

	Amount of Capital Raised	Percentage of firms that reached target
	$'000,000's	%
Canada	**980**	56
Sector		
Human Health	858	54
Agriculture Biotechnology	47	46
Natural Resources	..	..
Environment	x	x
Aquaculture	x	x
BioInformatics	x	x
Food Processing	25	66
Province		
Atlantic	11 E	21
Quebec	467	64
Ontario	216	58
Manitoba	x	x
Saskatchewan	F	26
Alberta	139 E	50
British Columbia	127	53
Size		
Small (Less than 50 employees)	517	51
Medium (50-149 employees)	374	81
Large (150 or more employees)	89	67

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Preliminary data

E: use with caution

F: too unreliable to be published

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0: Zero

X: suppressed to meet confidentiality requirements of the *Statistics Act*

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

Table 6: Sources of Funding & Percentage of Funds from each Source by Sector, Province and Size, 2001

	Average					
	Canadian Based Venture Capital	American Based Venture Capital	Conventional Sources	Angel Investors/ Family	Government Sources	Other
	%	%	%	%	%	%
Canada	**37**	**6**	**7**	**15**	**13**	**23**
Sector						
Human Health	42	7	6	18	7	20
Agriculture Biotechnology	17	0	9	16	18	41
Natural Resources	x	x	x	x	x	x
Environment	22	F	F	F	37	28
Aquaculture	x	x	x	x	x	x
BioInformatics	x	x	x	x	x	x
Food Processing	34	F	19	4	18	22
Province						
Atlantic	..	..	..	42	22	35
Quebec	51	5	10	9	8	17
Ontario	27	8	10	10	12	33
Manitoba	62	..	..	35	F	..
Saskatchewan	14	F	..	F	33	32
Alberta	F	F	..	37	F	24
British Columbia	49	F	..	19	21	9
Size						
Small (Less than 50 employees)	37	6	6	16	13	22
Medium (50-149 employees)	46	8	F	F	F	32
Large (150 or more employees)	14	0	29	F	25	15

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Preliminary data

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

Table 7: Number of Firms that were Refused or Limited Access to Capital, Canada, 2001

	Number
Canada	
Biotechnology product/process not sufficiently developed	42
Biotechnology product line or portfolio limited in scope	13
Insufficient specific management skills/expertise	12
Capital not available due to market conditions	78
Further product development or proof of concept required	43
Lender does not fund development projects	28
Other	26

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

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

Human Resources in Industrial Biotechnology

According to data from the *Biotechnology Use and Development Survey - 2001*, Canada had 11,897 employees working in biotechnology-related activities. This section provides an overview of the general characteristics of human resources in biotechnology innovators for 2001 and presents possible explanations for changes in employment patterns between 1999 and 2001.

Biotechnology, like any other knowledge-based activity, involves competition in the realm of intellectual property and ideas (Savard, 2002). Thus, highly skilled human resources are what give firms their comparative advantage. The *Biotechnology Use and Development Survey - 2001* confirms that biotechnology is a heavy user of highly skilled human resources with research responsibilities, as 49% of biotechnology jobs in Canada were in the scientific research/direction and technician categories.

Canada

Biotechnology is a heavy user of highly skilled labour, a fact reflected in the survey data. In 2001, 49% of biotechnology jobs were in the scientific research/direction and technician categories. The production and finance/marketing categories ranked second and third with 16% and 15% of the jobs. The breakdown is similar for total employment and full-time employment but different for part-time employment, in which the production category accounts for the largest share of the jobs (30%), followed by technicians and engineering. In general, then, companies tend to hire production staff on a part-time basis and more highly skilled workers (scientific research/direction and technicians) on a full-time basis. In Canada, in the biotechnology employment, managerial, marketing and regulatory positions always rank lowest in full-time employment, part-time employment or the two combined. For the most part, these activities tend to be integrated vertically in larger companies and sublicensed or subcontracted in small firms.

If we compare the distribution of employment within the various position categories between 1999 and 2001, we find that the marketing/finance category has been gaining ground since 1999, when it accounted for only 9% of total biotechnology employment. Other categories have shrunk since 1999 owing to the addition in 2001 of an "other" category to cover some types of service positions (support, informatics, quality control, etc.). Nevertheless, skill-intensive positions continue to make up the bulk of biotechnology employment (52% in 1999 and 49% in 2001).

Sector

In 2001, biotechnology firms had a total of 11,897 people working in biotechnology, 19% of their total workforce. Of those biotechnology workers, 73% were employed in the Human Health sector, 11% in Agriculture and 8% in Food Processing. The Human Health sector is also the heaviest user of biotechnology human resources, as the latter makes up 54% of the sector's total workforce. Although biotechnology jobs account for only 1% of total employment in Aquaculture and Bio-informatics, the biotechnology personnel are relatively important because employment intensity[3] for those sectors is 45% and 49% respectively.

[3] Employment intensity is measured as the ratio of biotechnology employment over total employment.

With regard to the distribution of jobs within the position categories, the Human Health sector is the most homogeneous (relative dispersion of 51%), followed by the environmental sector (66%). The least homogeneous sector is Aquaculture. In fact, the majority of biotechnology employees from this sector are technicians, followed by employees that have responsibilities related to scientific research/direction. This indicates that highly skilled labour is heavily used in this sector.

Province

Quebec has the largest share of total biotechnology employment (40%), followed by Ontario (28%) and British Columbia (15%). However, Ontario employs a larger proportion of its total workforce in biotechnology (47%) than Quebec (15%). The majority of biotechnology employees in Quebec work in the Human Health sector; they account for 38% of the sector's total workforce. Ontario ranks second with 32%.

Quebec companies employ 57% of the biotechnology workforce in scientific research/direction and technician jobs; these categories account for only 33% of total employment in Ontario.

Size

The relative dispersion (standard deviation over mean) indicates that the larger the company is, the more homogeneous the distribution of employees within the various types of positions is for full-time jobs and total jobs. The opposite is true for part-time employment: the distribution within the various job types is more homogeneous for small firms. Small companies tend to hire mostly for scientific research and engineering positions and this is also related to the early stage development status of small firms. These companies usually enter in collaborations for Management functions or contract them out. Small companies tend not to devote much of their workforce to regulatory activities, which are often expensive, added to the fact that several firms have not yet reached the regulatory stage.

Large companies rank first in total employment, with 46%, but last in intensity, with only 10%. Conversely, small firms rank last in total employment, with 26%, but 80% of their jobs involve biotechnology. Thus, while large firms employ the majority of biotechnology human resources, their intensity in total employment is only 10%. Consequently, the relative importance of highly skilled labour is higher in small companies. In 2001, scientific research/direction and technician/engineering jobs accounted for 59% of total employment in small companies and 39% in large companies.

Recruiting practices

In 2001, Canadian biotechnology companies had 953 vacant biotechnology positions; most of them were in Quebec (58%), Ontario (19%) and British Columbia (12%). In Quebec, the greatest need was for employees to fill technician positions (28%) and other positions (27%), while in Ontario, employees were needed for scientific research/direction positions (46%). Of the total vacancies for Canada, 86% were in the Human Health sector, which was attempting to fill highly skilled positions (48%). Companies operating in the Human Health sector managed to hire 136 people for biotechnology activities in 2001, which represents 16% of what they needed. The

Agriculture and Food Processing sectors were able to meet 80% of their human resources requirements, which were mostly to fill technician and finance/marketing jobs in the former sector and scientific research/direction positions in the latter. The principal recruitment source for most biotechnology companies is the universities. Biotechnology is dynamic and knowledge-intensive, and it is generally students who have those two characteristics. "Students are important for the future [of biotechnology firms] since they will be developing an in-depth knowledge of biotechnology and may have the opportunity to make a contribution" (McNiven, 1999).

Small companies have proportionally the largest number of vacant biotechnology positions, but they also had the most success in meeting their human resources needs, hiring 160 people in 2001. According to the survey, 68% of the employees who left their companies in 2001 were working in small firms. This loss of employees seems to have been offset by their success in recruiting new staff members as, overall, biotechnology employment remained fairly steady in small firms between 1999 and 2001 (7% growth) but increased substantially in medium-sized companies (140%). Biotech jobs may be shifting from small to medium-sized firms; the effect would be felt mostly in the regulatory/clinical affairs positions followed by the scientific research/direction, which declined by 11% and 1% respectively among small companies over the two-year period. Small firms generally hire workers in the scientific research and engineering categories but often fail to meet the candidates' salary requirements (see Table 12). As a result, workers who have gained experience in small firms may tend to move to larger companies. In fact, Medium-sized firms used other biotechnology companies as recruitment source to a larger degree than their counterparts in 2001.

Trends in human resources

Between 1997 and 2001, all the main indicators for biotechnology firms except employment exhibited the same trend and were stable over time. Employment in biotechnology slumped 15% between 1997 and 1999 despite an increase in revenues and the number of firms. The dip in employment has been attributed to a possible shift in employment rather than an actual decline. Findings have shown that "firms that formed joint ventures or contracted-out regulatory/clinical affairs and marketing/distribution activities were more likely to have seen personnel leave in 1999" (Traoré, 2002, page 32), suggesting that biotechnology personnel that left in 1999 were mostly involved in marketing/distribution activities and regulatory/clinical affairs.

Volatility of human resources

The results of the *Biotechnology Use and Development Survey - 2001* indicate that human resources in biotechnology are volatile and mobile, as they were up 54% from 1999. In addition, a tendency on the part of younger companies to mature is beginning to show up in the data, pointing to a shift from small to medium-sized firms. This increase in employment has a real component, since the number of employees with biotechnology activities continues to climb in proportion to the firm's total workforce. Employment intensity (ratio of biotechnology jobs to total jobs) was 12% in 1999 and 19% in 2001. In 1997 it was 28%, which is an indication that employment figures are still volatile.

It is important to note that full time biotechnology employees refers to those employees, who dedicate 50% or more of their time to biotechnology activities, while part time biotechnology employees refers to those employees who dedicate less than 50% of their time to biotechnology activities. The use of full-time or part-time concepts in this report is not related to the working status of the employees. Most of the increase in biotechnology employment between 1999 and 2001 came in from employees mostly engage in biotechnology activities. Full-time biotechnology employment was up 72% and was responsible for the increase in total employment, as part-time biotechnology employment was down sharply by 40%. While scientific research/direction and technician positions together made up 50% of total employment in 2001, employment in related services accounted for most of the increase in full-time employment. The increase likely originated from the management/licensing/administration category, which grew by 153%, followed by the production category (152%) and the regulatory/clinical affairs category (117%).

The distribution of full-time positions was almost the same in the two years, except for the finance/marketing category, which accounted for 8% of full-time employment in 1999 and 16% in 2001. In analyzing the 1999 survey data, we attributed the employment decrease to a possible shift in human resources toward services. The 1999 results suggested that biotechnology personnel who left in 1999 were chiefly involved in marketing/distribution and regulatory/clinical affairs (Traoré et al., 2002). In 2001, however, it was mostly those job types that accounted for the increase in biotechnology personnel. Thus, the jobs lost in 1999 were recovered in 2001, which could explain this reversal or trend resumption. Biotech firms decided to do this kind of work themselves rather than contract it out or subcontract it. This may reflect a degree of maturity in biotechnology firms.

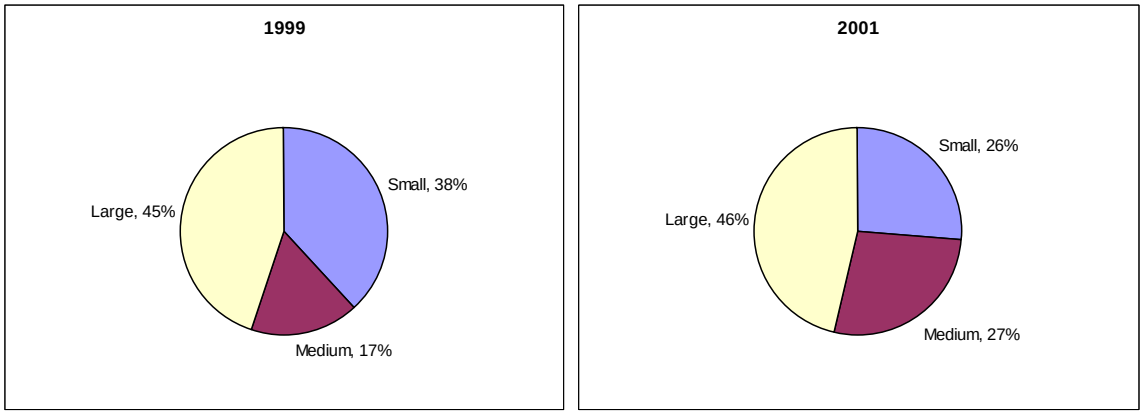
The environmental sector contributed 404 new jobs in 2001, 125% more than in 1999. The Food Processing sector also created 635 biotechnology jobs, a 188% increase. The two sectors contributed 10% and 15% of the total rise in biotechnology employment. The employment growth rate was 59% in the Health sector, which contributed 77% of the employment growth in 2001. It would be worth taking a closer look at employment activity in this sector.

The growth rate for biotechnology jobs in the Health sector was 99% in Quebec (from 1,672 to 3,321). The increase in the number of biotechnology employees in the health sector in Quebec accounted for 51% of total biotechnology employment growth in the sector. Quebec had 23 new biotechnology companies in 2001 (up 21%); they made up 164% of the new firms in Canada and generated additional biotechnology revenues of $961 million, a 174% gain over 1999.

Increasing maturity of younger companies

Medium-sized and large companies accounted for most of the human resources growth between 1999 and 2001, contributing 45% and 49% of the increase, respectively. Small firms experienced only 7% growth in biotechnology employment over the two-year period, while medium-sized companies reported a 140% increase. Among medium-sized firms, the scientific research and technician/engineering categories together accounted for 60% of the increase in employees. In contrast, small companies recorded a 1% decline in jobs in the scientific research/direction category between 1999 and 2001. According to the figure below, the distribution of biotechnology jobs by company size remained almost unchanged for large firms but showed some variation for small and medium-sized companies. The proportion of biotechnology jobs decreased for small companies (from 38% to 26%) and rose for medium-sized firms (from 17% to 27%).

Figure 1: Distribution of Biotech-related Employment, by Size, 1999 and 2001



Thus, the increasing maturity of younger companies is beginning to show up in the data. This trend may be due either to a transfer of biotechnology employees from small to medium-sized firms, possibly for scientific research/direction positions (see section on Recruiting Practices), or to the fact that some firms changed their size category by boosting their capacity and becoming medium-sized, in fact 15% of small firms in 1999 reported as medium firms in 2001.

The number of products/processes that reached the marketing stage also increased for small companies, from 4,014 in 1999 to 6,667 in 2001. As a result, those firms may have decided to divert their scientific research staff to sales activities without necessarily hiring new employees.

Table 8: Total Number of Employees and Biotech Employees by Sector, Province and Size, 2001

	Total Number of Canadian Employees	Number of Employees in Biotechnology-related Responsibilities
Canada Total	**62,242**	**11,897**
Sector		
Human Health	16,145	8,675
Agriculture Biotechnology	9,670	1,311
Natural Resources	669 E	55
Environment	22,689 E	709
Aquaculture	172	78
BioInformatics	235	116
Food Processing	12,662	953
Province		
Atlantic	1,539 E	402 E
Quebec	31,054	4,710
Ontario	7,141	3,346
Manitoba	1,469	936 E
Saskatchewan	5,272 E	262
Alberta	719	494
British Columbia	15,049 E	1,746
Size		
Small (Less than 50 employees)	3,910	3,144
Medium (50-149 employees)	5,268	3,230
Large (150 or more employees)	53,065	5,523

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

E: use with caution

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X: suppressed to meet confidentiality requirements of the *Statistics Act*

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

Table 9: Number of Full and Part Time Employees by Sector, 2001

	Scientific Research & Direction Full Time	Scientific Research & Direction Part Time	Technicians Full Time	Technicians Part Time	Regulatory/ Clinical Affairs Full Time	Regulatory/ Clinical Affairs Part Time	Production Full Time	Production Part Time	Finance/ Marketing Full Time	Finance/ Marketing Part Time	Manage-ment Full Time	Manage-ment Part Time	Other Full Time	Other Part Time	Total Full Time	Total Part Time
Human Health	2,064	50	1,905	150[E]	683	37	871	177[E]	1,555	50	651	38	446	22	**8,176**	**523**
Agriculture Biotechnology	468	15	358	33	26	9[E]	76	20	84	X	82	9	43	F	**1,137**	**112**
Natural Resources	24	0	14[E]	0	1	0	7	0	4[E]	0	3	F	0	0	**54**	**F**
Environment	124	17	158	20	F	F	179[E]	28[E]	44	F	64	9[E]	F	0	**643**	**84[E]**
Aquaculture	12	F	28	8[E]	3[E]	0	6[E]	F	F	F	F	F	0	0	**X**	**F**
BioInformatics	40	F	32	F	0	0	F	0	3[E]	F	X	0	0	0	**111**	**4**
Food Processing	161	F	150	8	F	0	467	3[E]	58	6	X	9	0	0	**945**	**28**

Table 10: Number of Full and Part Time Employees by Province, 2001

	Scientific Research & Direction Full Time	Scientific Research & Direction Part Time	Technicians Full Time	Technicians Part Time	Regulatory/ Clinical Affairs Full Time	Regulatory/ Clinical Affairs Part Time	Production Full Time	Production Part Time	Finance/ Marketing Full Time	Finance/ Marketing Part Time	Manage-ment Full Time	Manage-ment Part Time	Other Full Time	Other Part Time	Total Full Time	Total Part Time
Atlantic	76	1	46	5[E]	F	0	F	F	F	F	23	6[E]	0	0	**383[E]**	**19**
Quebec	983	23	1,546	145[E]	168	X	707	181[E]	321	11	371	22	220[E]	F	**4,315**	**395**
Ontario	570	25	463	41	356	28[E]	287	6[E]	1217[E]	30[E]	247	9	62	5[E]	**3,202**	**144**
Manitoba	503[E]	F	79	F	27[E]	0	239[E]	0	30[E]	0	43	0	X	0	**X**	**F**
Saskatchewan	81	6[E]	70	F	X	0	26[E]	0	14	3[E]	19	X	F	22[E]	**226**	**35**
Alberta	146	6[E]	141	4[E]	F	0	56	F	23	6	44[E]	X	X	0	**457**	**37[E]**
British Columbia	533	30	300	23	220	16	139	25[E]	131	15	122	21	159	12	**1,604**	**142**
Canada	**2,893**	**92**	**2,646**	**221**	**833**	**55**	**1,639**	**232**	**1,751**	**66**	**869**	**68**	**491**	**43**	**11,121**	**776**

Table 11: Number of Full and Part Time Employees by Size, 2001

	Scientific Research & Direction Full Time	Scientific Research & Direction Part Time	Technicians Full Time	Technicians Part Time	Regulatory/ Clinical Affairs Full Time	Regulatory/ Clinical Affairs Part Time	Production Full Time	Production Part Time	Finance/ Marketing Full Time	Finance/ Marketing Part Time	Manage-ment Full Time	Manage-ment Part Time	Other Full Time	Other Part Time	Total Full Time	Total Part Time
Small	921	54	934	72	86	8	362	28	229	26	282	38	66	37	**2,881**	**263**
Medium	955	10[E]	749	13	189	6[E]	372	19[E]	453	16	348	X	93	F	**3,159**	**71**
Large	1,016	28	964	135[E]	558	41	904	185[E]	1069[E]	24[E]	239	24	331	4	**5,082**	**442**

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

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

Table 12: Impact of Factors on Efforts in Filling Biotechnology-related Vacancies, 2001

	Importance				
	Low	Medium Low	Medium	Medium High	High
	%	%	%	%	%
Small (Less than 50 employees)					
Candidate Factors					
Compensation requirements by candidates too high	11	19	34	22	14
Candidates unwilling to relocate	28	24	22	13	13
Lack of experience	8	15	27	27	23
Firm Factors					
Capital/resources insufficient to attract candidates	15	11	29	19	26
External Factors					
Lack of qualified candidates	12	16	32	22	19
Competition for qualified candidates	12	13	37	28	10
Other	0	0	31 E	0	69
Medium (50-149 employees)					
Candidate Factors					
Compensation requirements by candidates too high	25	23	26	23	3
Candidates unwilling to relocate	28	19	7	26	20
Lack of experience	20	23	25	26	7
Firm Factors					
Capital/resources insufficient to attract candidates	25	36	23	16	0
External Factors					
Lack of qualified candidates	13	22	10	16	39
Competition for qualified candidates	13	10	22	26	29
Other	0	0	0	0	0
Large (150 or more employees)					
Candidate Factors					
Compensation requirements by candidates too high	24	19	20	29	8
Candidates unwilling to relocate	31	12	20	17	20
Lack of experience	6	0	35	39 E	20
Firm Factors					
Capital/resources insufficient to attract candidates	36	12	18	28 E	5
External Factors					
Lack of qualified candidates	18	6	12	40 E	23
Competition for qualified candidates	37	12	8	11	33 E
Other	X	X	X	X	X

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

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

Table 13: Number of Unfilled Biotech Positions by Sector, Province and Size, 2001

By Sector

	Human Health	Agriculture	Natural Resources	Environment	Aquaculture	BioInformatic	Food Processing
Scientific Research & Direction	195	6	X	4	X	5 E	16
Technicians	204	13	X	18 E	X	8 E	6 E
Regulatory/Clinical	79	4	X	0	X	F	F
Production	88	4 E	X	F	X	X	F
Finance/Marketing	74	9	X	F	X	0	6
Management	X	4	X	F	X	0	0
Other	F	0	X	0	X	0	0
Total	**822**	42	**X**	**33 E**	**X**	**18 E**	**31**

By Province

	Canada	Atlantic	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
Scientific Research & Direction	227	5	90	83	12 E	X	F	30
Technicians	251	F	157	47	F	X	F	27
Regulatory/Clinical	86	F	26	23	4 E	X	5 E	26
Production	106	F	73	6	16 E	X	3 E	5 E
Finance/Marketing	90	3 E	48	14	F	X	F	14
Management	X	4	X	X	4 E	X	5 E	7
Other	F	0	F	F	0	X	F	3 E
Total	**953**	**19**	**554**	**182**	**57 E**	**X**	**23 E**	**112**

By Size

	Less than 50 employees	50-149 employees	150 or more employees
Scientific Research & Direction	103	96	27
Technicians	95	73	82
Regulatory/Clinical	31	35	20
Production	41	32	32
Finance/Marketing	43	21	27
Management	X	24	X
Other	F	10	F
Total	**343**	**291**	**318**

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

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0: Zero

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

Table 14: Number of Biotechnology-related Positions Hired in 2001 by Sector, Province and and Size

By Sector	Number
Human Health	1,210
Agriculture Biotechnology	124
Natural Resources	X
Environment	43
Aquaculture	7 E
BioInformatic	53
Food Processing	61
By Province	**Number**
Canada	1,500
Atlantic	22
Quebec	767
Ontario	219
Manitoba	73 E
Saskatchewan	21
Alberta	58
British Columbia	340
By Size	**Number**
Small (Less than 50 employees)	518
Medium (50-149 employees)	600
Large (150 or more employees)	382

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

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The Product Pipeline: Biotechnology Products/Processes Profile

The distribution of biotechnology is not limited to any singular 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. Some of these are subject to intense regulatory processes while others are not. A significant measure of the vitality of biotechnology activities is the products pipeline i.e. the products in development for the marketplace.

Further, the product pipeline[4] is a significant indicator of the future growth of a sector. Significant time and cost factors as well as a high attrition rate in bringing a single product to market characterize biotechnology. 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[5] and that few products even reach the market. A healthy pipeline is essential for the future of biotechnology activities.

Biotechnology firms reported more than 18,000 biotechnology products/processes at all stages[6] of development and on market. Of these, about 1/3 was in the research and development stage, and over 50% were approved, in the market or in production. Poised to enter the market soon are almost 2,400 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. The anticipated revenue increase is in part dependent on these new products entering the market place.

Quebec leads the country in number of products, with over 11,000 products at all stages. Ontario and Manitoba follow this with about 13% each. Small firms dominate with close to 60% of the total number of products/processes, followed by medium then large firms.

[4] The pipeline is the total number of unique products and/or processes reported by each firm, and includes regulated and nonregulated products and/or processes.
[5] U.S. Office of Technology Assessment.
[6] The questionnaire used the following 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. Examples of what is included in each sector can be found in the questionnaire, question 10, page 8, Appendix 1.

Table 15: Number of Biotech Products/Processes by Development Stage, by Sector, Province and Size, 2001

	Number of Biotechnology products/processes by development stage				
	Research & Development	Preclinical trials/Confined field trials	Regulatory phase/Unconfined release assessment	Approved/On market/In production	Total
Canada	**5,964**	**732**	**1,663**	**9,661**	**18,020**
Sector					
Human Health	2,017	346	121	6,619	9,103 E
Agriculture Biotechnology	3,498	300 E	1,476 E	652	5,926
Natural Resources	35	6	F	X	53
Environment	137	9	16 E	102	264
Aquaculture	36	8 E	F	18	X
BioInformatics	74	10	F	F	F
Food Processing	167	53	40	359	620
Province					
Atlantic	63	23	15	38	139
Quebec	1,885	X	F	8,087 E	11,072
Ontario	1,810 E	101	60	405	2,376
Manitoba	F	F	662 E	24 E	2,346 E
Saskatchewan	X	X	F	41 E	167
Alberta	76	23	15 E	18	131
British Columbia	576	120	45	1,048	1,789
Size					
Small (Less than 50 employees)	2,243	X	F	6,667 E	10,144
Medium (50-149 employees)	2,044 E	82	225 E	2,727 E	5,078
Large (150 or more employees)	1,677 E	X E	F	267	2,798

Source: Statistics Canada, Biotechnology Use & Development Survey - 2001

Revised data

E: use with caution

F: too unreliable to be published

.. : not available for the 2001 reference period

0: Zero

X: suppressed to meet confidentiality requirements of the *Statistics Act*

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

Methodology

Questionnaire Description and Administration

In contrast to the 1997 and 1999 surveys, the 2001 *Biotechnology Use and Development Survey*[7] (BUDS) used a two-stage surveying methodology. This was intended to tap into a larger pool of firms with the ultimate goal of capturing innovative firms in biotechnology that were not surveyed previously or that were created after the 1999 survey. The first stage was a short questionnaire designed to identify firms involved in biotechnology, while the second stage collected detailed information. Both questionnaires were tested with potential respondents.

The Stage 1 questionnaire was sent by mail during the Winter of 2002 to a sample of 11,262 firms from selected North American Industrial Classification System (NAICS) codes from the Business Registrar (BR) of Statistics Canada. The NAICS codes were selected on the basis of the possibility of biotechnology use. The response rate was 70% for Stage 1. The Stage 2 detailed questionnaire was mailed in Spring of 2002 to 900 firms and had a response rate of 84%

Not-for-profit organizations, universities, government laboratories, hospitals, and contract research organizations (CRO's) were excluded from the survey. These entities, even though closely related to biotechnology firms through spin-off creation, or the provision of research services, do not meet the main criterion of the biotechnology survey which is to provide information on the firms that use biotechnology to develop new products and processes.

Also excluded from the survey were firms with less than 5 employees and spending less than $100,000 in R&D. This exclusion was intended to alleviate respondents' burden. Based on past experience this exclusion is not expected to affect the quality of the data as these firms contribute very little to biotechnology R&D expenditures, biotechnology revenues, the number of products in the pipeline, or to human resources.

Definitions and Data Strata

Biotechnology is defined by using an operational definition, a list based definition centered around 5 pillars: 1) DNA (the coding), 2) Proteins and molecules (the functional blocks), 3) Cell and tissue culture and engineering, 4) Process biotechnologies, and 5) Sub-cellular organisms. Question 1 is the definition. The OECD, to facilitate international comparisons of biotechnology statistics, has adopted this definition. Firms are organized in 3 strata: size, sector of activity, and province of location.

Summary

Additional data from the survey is available on request. Research papers are under way comparing 1999 and 2001 data sets, and providing in-depth analysis of human resources, venture capital, and collaborative arrangements.

[7] Both questionnaires are given in Appendix 1


ELECTRONIC PUBLICATIONS AVAILABLE AT
www.statcan.ca

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Appendix 1 -- Questionnaires 1 and 2

Science, Innovation and Electronic Information Division

Biotechnology Use and Development Survey - 2001

Confidential once completed

Collected under the authority of the Statistics Act, Revised Statutes of Canada, 1985, Chapter S19. Completion of this questionnaire is a legal requirement under the Statistics Act.

Version française au verso

Information for the Respondent

Purpose of Survey

Statistics Canada is conducting this survey in order to develop information on biotechnology and related technologies such as functional foods, nutraceutical and bioproducts by identifying industry sectors where these activities take place. Please report on *Canadian activities of your firm in biotechnology, functional foods, nutraceutical or bioproducts*. Your firm may have responded to biotechnology questions in previous surveys, but there is also an increasing demand for information on other technologies and their impact on the Canadian economy.

Authority

Collected under the authority of the *Statistics Act*, Revised Statutes of Canada, 1985, Chapter S19. Completion of this questionnaire is a legal requirement under the *Statistics Act*.

Confidentiality

Statistics Canada is prohibited from publishing any statistics that would divulge information obtained from this survey that relates to any identifiable business, institution or individual. Data is 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.

Federal-Provincial Agreement

In order to avoid duplication of enquiry, reduce the cost of collection, and provide consistent statistics, Statistics Canada has entered into an agreement with the Institut de la Statistique du Québec, under Section 11 of the *Statistics Act*. Data collected from Québec firms in this survey will be transmitted to the Institut de la Statistique du Québec. The *Statistics Act* of Quebec includes the same provisions for confidentiality and penalties for disclosure of information as the Federal Statistics Act.

Instruction

A knowledgeable senior person in your firm, such as an R&D manager or production manager, can quickly complete this questionnaire. Please fill in the contact information below, answer all 3 questions and return the completed questionnaire in the accompanying self addressed prepaid envelope to Statistics Canada by March 7, 2002.

Assistance

If you have questions or require assistance please contact:

Claire Racine-Lebel
7th floor, RHCoats Building
Statistics Canada

Telephone: 613-951-6309
Fax: 613-951-9920
E-mail: Sieidinfo@statcan.ca

Please provide the following information:

Name of person completing this form	Telephone number Area code ___ – ___ – ____
Title	Fax number ___ – ____
Web address	E-mail

5-4900-505: 2001-01-24 STC/SAT-465-75330

1. Does your firm currently use or develop biotechnology in its activities?

- ○ Yes
- ○ No

Examples of biotechnologies:

DNA genomics, pharmaco-genetics gene probes, DNA sequencing/synthesis/amplification, genetic engineering. Protein/peptide sequencing/synthesis, lipid/protein engineering, proteomics, hormones and growth factors, cell receptors/signalling/pheromones, cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/immune stimulants, embryo manipulation, bioreactors, fermentation, bioprocessing, bioleaching, bio-pulping, bio-bleaching, biodesulphurization, bioremediation, biofiltration, gene therapy, viral vectors, bioinformatics, other.

2. Does your firm currently make or develop functional foods or nutraceutical products?

- ○ Yes
- ○ No

Functional food

is a conventional food, beverage, or ingredient enriched with functional components beneficial in disease prevention or disease-risk management, beyond basic nutritional functions. A food, beverage or ingredient may be made functional through a variety of means, such as the addition of components, extraction, fractionation, processing, plant or livestock breeding, livestock feeding techniques, genetic modification, other.

Nutraceutical

is a product isolated or purified from foods (includes herbs and botanicals) that is generally sold in medicinal forms not usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease.

3. Does your firm currently make or develop a bioproduct?

- ○ Yes
- ○ No

Bioproduct

a commercial or industrial product (other than food and feed) made with biological or renewable domestic agricultural (plant, animal), marine or forestry materials, such as, bio-energy (heating and electricity), bio-fuels (ethanol and bio-diesel), biochemicals, fiberboard, textiles and bio-plastics, other.

Thank you for your cooperation

Please return the completed questionnaire
in the accompanying self addressed prepaid envelope

Science, Innovation and Electronic Information Division

Biotechnology Use and Development Survey - 2001

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 ☐

Information for the Respondent

Survey Purpose

Statistics Canada is undertaking this survey to produce a profile of firms engaged in biotechnology activities in Canada. The survey focuses on the characteristics and activities of firms that use or develop biotechnology as part of their company's activity.

Biotechnology is an emerging sector of the Canadian economy and its impact has the potential to be felt through all parts of Canada's 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 by the academic community for research purposes. Statistics Canada may create a database by combining survey data with existing Statistics Canada data records.

Please report 2001 on Canadian biotechnology activities of your firm unless a specific question indicates otherwise. Complete a separate questionnaire for each company engaged in biotechnology activities in Canada.

Confidentiality

Statistics Canada is prohibited from publishing any statistics that would divulge information obtained from this survey that relates to any identifiable business, institution or individual. Data is 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.

Federal-Provincial Agreement

In order to avoid duplication of enquiry, reduce the cost of collection and provide consistent statistics, Statistics Canada has entered into an agreement with the Institute de la Statistique du Québec. Under Section 11 of the Statistics Act data collected from Quebec firms in this survey will be transmitted to the Institut de la Statistique du Québec. The Statistics Act of Quebec includes the same provisions for confidentiality and penalties for disclosure of information as the Federal Statistics Act.

Who Should Complete This Questionnaire?

A senior manager, scientist/researcher or production manager should complete this questionnaire.

Assistance

If you have questions or require assistance please contact:

Claire Racine-Lebel
Science, Innovation and Electronic Information Division
Statistics Canada
Tunneys Pasture
Ottawa K1A 0T6

Telephone: 613-951-6309 (Call collect)
Fax: 613-951-9920
E-mail: Sieidinfo@statcan.ca

Please provide the following information:

Name of person completing this form	Telephone number Area code ___ – ___ – ____
Title	Fax number ___ – ____
Web address	E-mail

5-5300-500.1: 2002-02-06 STC/SAT-430-75177

Section 1 - Biotechnologies in Use

This section measures the use of biotechnologies in your firm.

1. Using the table below, please indicate the use your firm makes of each type of biotechnology listed. Check the applicable circle or circles.

	Biotechnologies	Currently Used in Operation	If currently using, do you use them for			Number of Years in Use	If **No** ▼ Do you plan to use within 3 years?
			Product/ Process Development	Current Production	Environmental Purposes		
		0	1	2	3	4	5
	DNA - the coding						
1000	Genomics/Pharmaco-genetics	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1010	Gene probes	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1020	DNA sequencing synthesis amplification, Genetic Engineering	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
	Proteins and Molecules - the functional blocks						
1100	Protein/peptide sequencing/ synthesis	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1110	Lipid/protein engineering	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1120	Proteomics	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1130	Hormones, growth factors, pheromones	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1140	Cell receptors signalling	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
	Cell and Tissue Culture, and Engineering						
1200	Cell/ tissue culture, Embryo manipulation	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1210	Tissue engineering	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1220	Hybridization	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1230	Cellular fusion	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1240	Vaccine/immune stimulants	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
	Process Biotechnologies						
1300	Bioreactors	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No
1310	Fermentation, Bioprocessing	○ Yes →	○	○	○	☐	
		○ No →					○ Yes ○ No

	Biotechnologies	Currently Used in Operation	If currently using, do you use them for: Product/ Process 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
1320	Bioleaching, Bio-pulping, Biobleaching, Biodesulphurization	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
1330	Bioremediation, Biofiltration	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
	Sub-Cellular Organisms						
1400	Gene Therapy	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
1410	Viral Vectors	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
	Other						
1500	Bioinformatics	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
1510	Nanobiotechnologies	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No
1520	Other, Please Specify: _____	◯ Yes →	◯	◯	◯	☐	
		◯ No →					◯ Yes ◯ No

If you use at least one of the biotechnologies listed in Question 1 ▶ **Go to Section 2**

If you do not use any of the biotechnologies listed in Question 1 ▶ **Please return the questionnaire in the accompanying prepaid return envelope.**

Thank you for your assistance.

Section 2 - The Effects of Biotechnology on Your Firm

This section measures the factors influencing the use of biotechnology in your firm and the impact of biotechnology use on your firm's performance.

2. Using the table below, please rate the level of influence of each factor on increasing your use of biotechnology.

		Importance				
		Low				High
		1	2	3	4	5
	Inputs					
2000	Access to capital	○	○	○	○	○
2010	Access to technology/information	○	○	○	○	○
2020	Access to human resources	○	○	○	○	○
	Markets					
2100	Size of Domestic Market	○	○	○	○	○
2110	Access to international markets	○	○	○	○	○
2120	Information about markets	○	○	○	○	○
2130	Distribution & marketing channels	○	○	○	○	○
	Constraints					
2200	Public perception/acceptance	○	○	○	○	○
2210	Cost of regulatory approval	○	○	○	○	○
2220	Time required for regulatory approval	○	○	○	○	○
2230	Limited international harmonization	○	○	○	○	○
2240	Patent rights held by others	○	○	○	○	○
2250	Lack of protection for intellectual property	○	○	○	○	○
2260	Other, Please specify: _____	○	○	○	○	○

3. For each of the performance factors listed below, please rate the level of impacts of biotechnology use on your firm's performance.

		Importance				
		Low				High
		1	2	3	4	5
	Increased Productivity					
3000	Labour costs	○	○	○	○	○
3010	Capital costs	○	○	○	○	○
3020	Energy costs	○	○	○	○	○
	Improved Products					
3100	New products or processes introduced	○	○	○	○	○
3110	Product range increased	○	○	○	○	○
3120	Product quality increased	○	○	○	○	○
	Knowledge Based					
3200	Developing new areas for R&D	○	○	○	○	○
3210	Increase efficiency for R&D	○	○	○	○	○
	Improved Market Performance					
3300	Market position improved	○	○	○	○	○
3310	New Market Niche Developed	○	○	○	○	○
3320	Sales increased	○	○	○	○	○
3330	Other, Please Specify: _____	○	○	○	○	○

Section 3 - Human Resources in Biotechnology

Concerns have been expressed about the availability of skilled biotechnology employees. Your cooperation in careful completion of this section is essential in developing an accurate understanding of human resources in biotechnology. For the purpose of this survey Employees are defined as those workers for whom you completed a Canada Customs and Revenue Agency T-4 statement for the 2001 tax year. Include working owners. Do not include students. Only count employees working in Canada. If '0' (zero) indicate '0'.

Number of Biotechnology Employees

4. a) How many employees does your firm employ in Canada?
Please Report Typical Employment Level for 2001. 4000

b) How many employees have biotechnology-related responsibilities?
Please Report Typical Employment Level for 2001. 4010

c) Full-time Biotechnology Employees
For each group listed below indicate how many are full-time biotechnology employees (50% or more of their time spent on biotech related activities)?
If an employee fulfils more than 1 duty, report their primary responsibility. Count each person only once. Please Report Typical Employment Level for 2001.

Position	Number of full-time
Scientific Research & Direction	4100
Technicians	4110
Regulatory/Clinical Affairs	4120
Production	4130
Finance/Marketing	4140
Management	4150
Other, Please Specify:	4160
Total Full-time employees	4170

Part-time Biotechnology Employees

d) For each group listed below indicate how many are Part-time biotechnology employees (less than 50% of their time spent on biotech related activities)?
If an employee fulfils more than 1 duty, report their primary responsibility. Count each person only once. Please Report Typical Employment Level for 2001.

Position	Number of part-time
Scientific Research & Direction	4200
Technicians	4210
Regulatory/Clinical Affairs	4220
Production	4230
Finance/Marketing	4240
Management	4250
Other, Please Specify:	4260
Total Part-time employees	4270

e) Total Number of biotechnology employees.
Total full-time and part-time employees with biotechnology-related responsibility (Box 4170 + Box 4270) 4011

This number must equal 4010 above.

Recruiting Practices

5. a) Does your firm have unfilled biotechnology-related positions?

5000 ◯ No ▶ Go to question 5b

◯ Yes ▶ In the table below indicate the number of unfilled positions by category.

Position	Number of Unfilled Positions
Scientific Research & Direction	5100
Technicians	5110
Regulatory/Clinical Affairs	5120
Production	5130
Finance/Marketing	5140
Management	5150
Other, Please Specify: _____	5160
Total unfilled positions	5170

b) Did your firm attempt to recruit any biotechnology employees in 2001?

5200 ◯ No ▶ Go to question 8

◯ Yes ▶ Were you successful?

5300 ◯ No ▶ Go to question 6

◯ Yes ▶ How many did you hire? 5310

c) What sources were successfully used in recruiting biotechnology staff?

5400 ◯ University Recruitment
5410 ◯ Temporary/Contract Staff
5420 ◯ Employment agencies/Headhunters
5430 ◯ Professional Associations
5440 ◯ Own Staff/Incentive program
5450 ◯ Other Biotechnology Firms
5460 ◯ Pharmaceutical Firms
5470 ◯ Newspaper/Journal
5480 ◯ Student Internship
5490 ◯ Internal Training of Staff

6. Please rate the impact of the following factors on your efforts in filling biotechnology-related vacancies.

	Factors	Importance: Low 1	2	3	4	High 5
	Candidate Factors					
6000	Compensation requirements by candidates too high	◯	◯	◯	◯	◯
6010	Candidates unwilling to relocate	◯	◯	◯	◯	◯
6020	Lack of experience	◯	◯	◯	◯	◯
	Firm Factors					
6100	Capital/resources insufficient to attract candidates	◯	◯	◯	◯	◯
	External Factors					
6200	Lack of qualified candidates	◯	◯	◯	◯	◯
6210	Competition for qualified candidates	◯	◯	◯	◯	◯
6220	Other, Please Specify _____	◯	◯	◯	◯	◯

7. Did you attempt to hire biotechnology staff from outside of Canada in 2001?

7000 ◯ No ▶ Go to question 8

◯ Yes ▶ Was your firm successful in hiring from outside of Canada?

7010 ◯ No ▶ Go to question 8.

◯ Yes ▶ How many staff from outside Canada did you hire? 7020

8. Did any biotechnology personnel leave your firm in 2001?

8000 ◯ No ▶ Go to question 9

◯ Yes ▶ How many? 8010

Section 4 - Biotechnology Products

This section measures the development of new biotechnology products and processes by your firm.

9. a) Do you have biotechnology products/processes on the market?

9000 ◯ No ▶ Go to question 9b)

◯ Yes ▶ What year was the most significant product first introduced? 9010

b) Is your firm currently developing products that require the use of biotechnology?

9100 ◯ No ▶ Go to question 9c)

◯ Yes ▶ What year will the most significant of these products reach market? 9110

c) Is your firm currently developing processes that require the use of biotechnology?

9200 ◯ No ▶ Go to question 9d)

◯ Yes ▶ What year will the most significant of these processes be completed? 9210

d) Do you consider biotechnology central to your firm's activities or strategies?

9300 ◯ No

◯ Yes

e) If you answered "Yes" to any Part of Question 9 ▶ **Go to Q10**

Otherwise ▶ **Please return the questionnaire in the accompanying prepaid return envelope.**

Thank you for your assistance.

10. In the table below, for each sector listed please indicate the number of biotechnology products or processes your firm currently has for 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				
10000	**Diagnostics** (e.g. biosensors, immunodiagnostics, gene probes)				
10010	**Therapeutics** (e.g. vaccines, immune stimulants, biopharmaceuticals)				
10020	**Drug Delivery**				
	Agriculture Biotechnology				
10100	**Plant Biotechnology** (e.g. tissue culture, embryogenesis, genetic markers, genetic engineering)				
10110	**Animal Biotechnology** (e.g. diagnostics, therapeutics, embryo transplantation, genetic markers, genetic engineering)				
10120	**Non-food Agriculture** (e.g. fuels, lubricants, commodity and fine chemical feedstocks, cosmetics)				
	Natural Resources				
10200	**Energy** (e.g. microbiologically enhanced petroleum recovery, industrial bioprocessing, biodesulphurization)				
10210	**Mining** (e.g. microbiologically enhanced mineral recovery, industrial bioprocessing, biodesulphurization)				
10220	**Forest Products** (e.g. biopulping, biobleaching, biopesticides, tree biotechnology, industrial bioprocessing)				
	Environment				
10300	**Air** (e.g. bioremediation, diagnostics, phytoremediation, biofiltration)				
10310	**Water** (e.g. biofiltration, diagnostics, bioremediation, phytoremediation)				
10320	**Soil** (e.g. biofiltration, diagnostics, bioremediation, phytoremediation)				
	Aquaculture				
10400	Fish health, broodstock genetics, bioextraction				
	BioInformatics				
10500	**Genomics & molecular modelling** (e.g. DNA/RNA/protein synthesising & databases for humans, plants, animals, and micro-organisms)				
10510	**Gene therapy** (e.g. gene identification, gene constructs, gene delivery)				
	Food Processing				
10600	**Bioprocessing** (e.g. using enzymes and bacteria culture)				
10610	**Functional Foods/Nutraceuticals** (e.g. probiotics, unsaturated fatty acids				
10620	Other, Please Specify _____				

11. a) What is the total time required to bring your principal biotechnology product or process from the initial development phase/proof of concept stage to the market? If still in pre-market stages provide an estimate.

11000 Years 11001 Months

b) What is the total cost to bring your principal biotechnology product or process from the initial development phase/proof of concept stage to the market? If still in pre-market stages provide an estimate.

11100 $,000

Section 5 - Business Practices

Contracting Out

12. a) Did your firm contract out biotechnology related activities in 2001?

12000 ◯ No ▶ Go to question 12d)

◯ Yes ▶ For each partner type listed below, please indicate the number and value of contracts for each group listed.

	Partner Type	Number of Contracts	Total Value of Contract in 2001 for ($,000)			
			Purpose of Contract			
			R&D	Regulatory/ clinical	Management/ Production	Other
		0	1	2	3	4
12100	Private Entities (C.R.O's / other Firms, etc)		$,000	$,000	$,000	$,000
12110	Public Entities (Universities / Government Labs.)		$,000	$,000	$,000	$,000

b) Did you contract out to organizations outside of Canada?

12200 ◯ No ▶ Go to question 13

◯ Yes ▶ For each organization listed below, please indicate the percentage (%) of your firm's total contracting out in 2001.

	Organization	% of total contracting out
12300	Private research lab	%
12310	University/Hospital	%
12320	Government lab	%
12330	Other biotechnology firm	%
12340	Other, Please Specify: _____	%

c) Rate the level of importance of each of the following reasons on your decision to contract out.

	Reasons for Contracting Out	Importance Low 1	2	3	4	High 5
12400	Knowledge not available internally	◯	◯	◯	◯	◯
12410	Access outside scientific expertise	◯	◯	◯	◯	◯
	Cost Reduction Related to:					
12420	R&D Activities	◯	◯	◯	◯	◯
12430	Regulatory/Clinical Affairs	◯	◯	◯	◯	◯
12440	Production	◯	◯	◯	◯	◯
12450	Precursor to a formal agreement	◯	◯	◯	◯	◯
12460	Reduce risk/exposure	◯	◯	◯	◯	◯
12470	Other, Please Specify: _____	◯	◯	◯	◯	◯

d) Does your firm **provide** contract services to other firms or organizations?

12500 ◯ No ▶ Go to question 13

◯ Yes ▶ For each type of contract services listed below, please indicate the number of contracts entered into in 2001 and the revenues received for each category.

	Contract Services	Number of contracts entered in 2001 (0)	Revenue received from this source in 2001 (1)
12600	Routine Lab services		$,000
12610	Specialized Lab services		$,000
12620	Production/manufacturing services		$,000
12630	Other, Please Specify: _____		$,000
12640	**Total**		$,000

Collaborative Arrangements

Cooperative and collaborative arrangements involve the active participation in projects between your company and other companies or organizations in order to develop and/or continue work on new or significantly improved biotechnology processes and/or products. **Pure contracting-out work is not regarded as collaboration.**

13. a) Was your firm involved in biotechnology-related cooperative/collaborative arrangements with other companies or organizations in 2001?

13000 ◯ No ▶ Go to question 14

◯ Yes ▶ Provide the number of arrangements by purpose and partner type

	Arrangement Purpose	Number of Arrangements by Partner Type			
		Biotech Firm (0)	Non-biotech Firm (1)	Academic Institution/ Hospital (2)	Government lab or agency (3)
13100	To conduct research & development (R&D)				
13110	Regulatory affairs				
13120	Access others' patents				
13130	Production/manufacturing				
13140	Access markets/distribution channels				
13150	Access capital				
13160	Access to Intellectual property from partner				
13170	Other, Please Specify _____				
13180	Total number				

Intellectual Property

14. a) Did your firm grant biotechnology related intellectual property (IP) rights to another firm?

14000 ◯ No ▶ Go to question 14b)

◯ Yes ▶ For each type of intellectual property instrument listed below please indicate the number of IP rights granted by country and the total income received from IP licensing in 2001.

	Intellectual Property Instrument	Number with Canadian firms 0	Number with USA firms 1	Number with other country firms 2	Revenue from IP licensing in 2001 3
14100	Licensing Agreement				$,000
14110	Patents				$,000
14120	Other, Please Specify _____				$,000

b) Did your firm obtain biotechnology related intellectual property rights from another firm?

14200 ◯ No ▶ Go to question 15

◯ Yes ▶ Complete the following table

	Intellectual Property Instrument	Number with Canadian firms 0	Number with USA firms 1	Number with other country firms 2	Cost to your firm of obtaining IP in 2001 3
14300	Licensing Agreement				$,000
14310	Patents				$,000
14320	Other, Please Specify _____				$,000

15. a) Does your firm have biotechnology related patents or pending patents?

15000 ◯ No ▶ Go to question 16

◯ Yes ▶ How many?

Indicate the distribution of biotechnology related patents and pending patents your firm has by Patent Office

		Canadian Intellectual Property Office (CIPO) 0	U.S. Patent & Trademark Office (USPTO) 1	European Patent Office 2	Other 3
15100	Existing Patents				
15110	Pending Patents				

b) Provide the number of unique patent applications your company submitted in

		Number
15200	2000	
15210	2001	

Section 6 - Firm Characteristics and Financial Profile

Revenues and Research and Development (R&D) Expenditures

16. Please complete the following table. If information is not available please provide a carefully considered estimate. Report for fiscal years and in thousands of dollars ($,000's). If '0' (ZERO) please indicate, do not leave blanks.

		2000 0	2001 1	2004 Forecast 2
16000	Total Firm Sales/Revenues (all sources)	$,000	$,000	$,000
16010	% of revenues from Biotechnology	%	%	%
16020	Total R&D spending	$,000	$,000	$,000
16030	Total spending on Biotechnology R&D	$,000	$,000	$,000
16040	% of Biotechnology R&D spending contracted out	%	%	%

17. Does your firm have sales of biotechnology products?

17000 ◯ No ▶ Go to question 18

◯ Yes ▶ What percentage of your sales of biotechnology products came from.

	%
Direct sales to consumers or distributors	17100
Products sold to other firms to be used as inputs	17110

Firm History

18. Is your firm a public firm?

18000 ◯ No ▶ Go to question 19

◯ Yes ▶ What year was the Initial Public Offering (IPO)? 18100

19. What year was your firm or spin-off established? 19000

20. Has your firm merged with another firm? (Include acquisition of another firm or by another firm)

20000 ◯ No ▶ Go to question 21

◯ Yes ▶ What year did the merge take place? 20100

21. Is your firm a subsidiary of a Multi-National Enterprise (MNE)?

21000 ◯ No ▶ Go to question 22

◯ Yes

22. a) Is your firm 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.

22000 ◯ No ▶ Go to question 23

◯ Yes ▶ Was your firm a spin-off from ▶

- ☐ University/hospital 22100
- ☐ Another Biotech company 22110
- ☐ Non-biotech firm 22120
- ☐ Government Agency/lab 22130
- ☐ Other, Please Specify 22140

Raising Capital

A great deal of attention has focused on the ability of biotechnology firms to raise capital and the challenges of raising capital. Questions in this section are intended to collect information in order to address this critical issue facing the biotechnology sector.

23. a) Did your firm attempt to raise capital for biotechnology related purposes in 2001?

23000 ◯ No ▶ Go to question 23h)

◯ Yes ▶ Were you successful in raising capital?

23100 ◯ No ▶ Go to question 23c)

◯ Yes ▶ How much 23110 $,000

b) Did you reach your target?

23200 ◯ No ▶ Go to question 23c)

◯ Yes ▶ Go to question 23d)

23. c) What reasons did the **lender** give in limiting or refusing your request for capital? Check all that apply.

- ☐ 23300 Biotechnology product/process not sufficiently developed
- ☐ 23310 Biotechnology product line or portfolio limited in scope
- ☐ 23320 Insufficient specific management skills/expertise
- ☐ 23330 Capital not available due to market conditions
- ☐ 23340 Further product development or proof of concept required
- ☐ 23350 Lender does not fund development projects
- ☐ 23360 Other, Please Specify _____

d) What sources provided funding?

	% of total raised from each source?
Canadian based Venture Capital	23400 %
American based Venture Capital	23410 %
Conventional sources (i.e. banks)	23420 %
Angel Investors/Family	23430 %
Government sources	23440 %
Other, Please Specify _____	23450 %

e) For your most important biotechnology product or process, please indicate the **current** stage of development**.**

Stage of Development

- ◯ 23500 R&D
- ◯ 23510 Pre-Clinical
- ◯ 23520 Clinical Trials
- ◯ 23530 Market Entry

For your most important biotechnology product or process, please indicate total spending since the beginning of development.

	Stage of Development	Total spending up to and including current stage
23600	R&D	$,000
23610	Pre-Clinical	$,000
23620	Clinical Trials	$,000
23630	Market Entry	$,000

For your most important biotechnology product or process, please estimate the total amount of capital required to complete each stage, as well as the total capital available.

	Stage of Development	Total additional capital required to complete stage 1	Total capital available to complete stage (include all committed funds) 2
23700	R&D	$,000	$,000
23710	Pre-Clinical	$,000	$,000
23720	Clinical Trials	$,000	$,000
23730	Market Entry	$,000	$,000

23. f) How long do you anticipate this capital (committed and on hand) lasting?

23800 ☐ Years 23810 ☐ Months

g) Why did you raise or attempt to raise capital? Indicate each category that applies to your firm

23900 ◯ R&D purposes/Expand R&D capacity

23910 ◯ Repay current investors

23920 ◯ Commercialize current R&D projects

23930 ◯ Clinical/regulatory expenses

23940 ◯ Develop production/manufacturing capability

23950 ◯ Other, Please Specify:

h) Do you plan on raising capital in 2002?

24000 ◯ No ▶ Go to question 24

◯ Yes ▶ How much do you plan to raise? ▶

- < $1,000,000 ☐ 24010
- $1,000,000-$5,000,000 ☐ 24020
- > $5,000,000 ☐ 24030

Tax Incentives

24. a) Did your firm have biotechnology R&D expenditures in any of the previous 5 years?

24100 ◯ No ▶ Go to question 26

◯ Yes ▶ In the past 5 years did your firm apply for benefits for biotechnology related activities under the Scientific Research and Experimental Development (SR&ED) tax program?

24200 ◯ Yes ▶ How much did you apply for in 2001? 24210 $,000 ▶ Go to question 24b

◯ No ▶ Why?

- Complexity of application process ☐ 24300
- Uncertainty of eligibility ☐ 24310
- Did not meet eligibility requirements ☐ 24320
- Other, Please Specify: ☐ 24330

_____

b) Have any of your SR&ED credits expired?

24400 ◯ No

◯ Yes

25. Did your firm apply for any provincial R&D tax benefit or incentive?

25000 ◯ Yes

◯ No ▶ Why did you not apply?

Complexity of application process	☐ 25100
Uncertainty of eligibility	☐ 25110
Did not meet eligibility requirements	☐ 25120
Other, Please Specify	☐ 25130

_____

Imports & Exports

26. Did your firm export biotechnology products?

26000 ◯ No ▶ Go to question 27

◯ Yes ▶ Please complete the following table. Report for fiscal years and in thousands of dollars ($,000's). If '0' (ZERO) please indicate, do not leave blanks.

		2000 0	2001 1	Forecast for 2004 2
26100	Total Exports Revenues (all sources)	$,000	$,000	$,000
26110	% export revenues from Biotechnology	%	%	%
	Regional Distribution			
26200	% export revenues to US	%	%	%
26210	% export revenues to Europe	%	%	%
26220	% export revenues to Asia	%	%	%
26230	% export revenues to other regions	%	%	%

27. Did your firm import biotechnology products?

27000 ◯ No ▶ Go to question 28

◯ Yes ▶ Please complete the following table. Report for fiscal years and in thousands of dollars ($,000's). If '0' (ZERO) please indicate, do not leave blanks.

		2000 0	2001 1	Forecast for 2004 2
27100	Total Import Expenditures (all sources)	$,000	$,000	$,000
27110	% import expenditures from Biotechnology	%	%	%
	Regional Distribution			
27200	% import expenditures to US	%	%	%
27210	% import expenditures to Europe	%	%	%
27220	% import expenditures to Asia	%	%	%
27230	% import expenditures to other regions	%	%	%

Strategies Used in 2001

28. In the table below rate the significance of each of the following strategies on your firm's performance in 2001.

		Importance Low 1	2	3	4	High 5
	Knowledge development strategies					
28000	Captured and used knowledge obtained from other industry sources such as industry associations, competitors, clients and suppliers	◯	◯	◯	◯	◯
28010	Captured and used knowledge obtained from public research institutions including universities and government laboratories	◯	◯	◯	◯	◯
28020	Used and updated databases of scientific information	◯	◯	◯	◯	◯
28030	Developed firm policies and practices for knowledge/intellectual property protection	◯	◯	◯	◯	◯
28040	Developed/encouraged staff education/upgrading	◯	◯	◯	◯	◯
28050	Conducted an Intellectual Property Audit to ensure protection of products and processes at all stages of development	◯	◯	◯	◯	◯
	Business strategies					
28100	Increased firm size through acquisition, merger or joint venture	◯	◯	◯	◯	◯
28110	Downsized operations of the firm	◯	◯	◯	◯	◯
28120	Entered product trials/adapted products or processes for increased market penetration	◯	◯	◯	◯	◯
28130	Began new research & development project	◯	◯	◯	◯	◯
28140	Expanded into foreign markets	◯	◯	◯	◯	◯
28150	Other, Please Specify: _____	◯	◯	◯	◯	◯

29 a) Does your firm develop, produce or sell **Living Modified Organisms** (LMO)?

> Living modified organism means any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology. A living organism means any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids.
>
> Source: Cartagena Protocol on Biosafety

29000 ◯ No

◯ Yes ▶ If yes, how many unique products based on living modified organisms does your firm have at each of the following stages?

Research & Development Stage	_____	29100
Clinical/Regulatory stage		29110
Market stage		29120
Total	_____	29130

b) Did your firm export living modified organisms in 2001?

29200 ◯ No

◯ Yes ▶ If yes, how many unique products based on living modified organisms did you export? _____ 29210

How many unique living modified organisms did you export to

United States		29300
Europe	_____	29310
Other	_____	29320

Comments 30000

_____

_____

_____

_____

_____

_____

_____

_____

Thank you for your assistance.

Return the questionnaire in the accompanying self addressed prepaid envelope.

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