BIOTECHNOLOGY USE BY CANADIAN INDUSTRY - 1996

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THE INFORMATION SYSTEM FOR SCIENCE AND TECHNOLOGY PROJECT

The purpose of this project is to develop useful indicators of activity and a framework to tie them together into a coherent picture of science and technology in Canada.

To achieve the purpose, statistical measurements are being developed in five key areas: innovation systems; innovation; government S&T activities; industry; and human resources, including employment and higher education. The work is being done at Statistics Canada, in collaboration with Industry Canada and with 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 and potentially misleading picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and more work has to be done to understand the characteristics of innovative, and non-innovative firms, especially in the service sector which dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries which 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 how much the federal government spends and where it spends it. The current report, Federal Scientific Activities (Catalogue 88-204), released early in 1997, begins to show what the S&T money is spent on with the new Socio-Economic Objectives indicators. As well as offering a basis for a public debate on the priorities of government spending, all of this information will provide a context for reports of individual departments and agencies on performance measures which focus on outcomes at the level of individual projects.

By the final year of the Project in 1998-99, there will be enough information in place to report on the Canadian system on innovation and show the role of the federal government in that system. As well, there will be new measures in place which will provide a more complete and realistic picture of science and technology activity in Canada.

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Working Papers

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

Report on the Survey of Biotechnology Use in Canadian Industries – 1996

The overall objective of this survey was to measure the use of biotechnology by firms. The firms were chosen among industries where there was a reasonable likelyhood of finding biotechnology users. The second part of the questionnaire looked at various factors influencing biotechnology adoption.

Highlights

Of the firms surveyed by Statistics Canada, 14 % indicated they used at least one of the biotechnology listed in the questionnaire in their activities. In most cases, biotechnology had been in use for five to ten years.

The primary motivations for the use of biotechnology were a better market position and the development of new products or processes.

The main difficulties encountered in adopting biotechnologies were linked to human resources: problems of training and availability of qualified personnel.

The principal results observed following the adoption of biotechnologies were improved quality, greater production flexibility, improved productivity, a lower product rejection rate and reduced environmental damage.

As for those who do not use biotechnology, there were major obstacles linked to the need for information: lack of market data, insufficient development of biotechnologies, insufficient markets and a lack of scientific and technical information.

Introduction

The modification of living organisms to satisfy human needs is nothing new. The Pharaohs of Ancient Egypt used yeast in the preparation of beer. For centuries, plants and animals have been modified through selection for agricultural and breeding purposes. What has changed with the new biotechnologies is the reliance on science and engineering not only to understand, but also to decode, reproduce or modify living organisms or parts of living organisms in order to provide new products and services.

Biotechnologies are also generic technologies in that they cover a wide range of applications and sectors, making it possible to create new goods and services and alter production processes, consumer behaviour and improve living conditions. Some authors even feel that biotechnology will trigger the next technological revolution, and will be comparable to what is being achieved as a result of information technology.

This first Survey of Biotechnology Use in Canadian Industries was an attempt to understand present and expected use, as well as factors influencing a firm's decision to use biotechnologies. Such factors may be linked to technology, human resources, training, costs, sources of information or research and development (R&D) activities.

There is still no universally recognized and understood definition of biotechnology. The use of biotechnologies is above all an activity. In the survey, respondents were invited to indicate the use or planned use of particular biotechnologies in a list provided.

The survey was prepared from a list of 22 biotechnologies ranging from older techniques such as fermentation to more advanced techniques such as gene therapy or rational drug design. Biotechnologies were broken down into three categories: "selection and/or modification of biological material", where the components and processes of living organisms are analysed in order to understand or modify their characteristics; "culture and/or use of biological material", where living organisms or parts of living organisms are used in production processes; finally, "environmental biotechnologies", where micro-organisms are put to special use in the treatment of industrial waste. The list of biotechnologies was established by a committee of specialists representing federal departments (Industry Canada and Environment Canada) and the National Research Council of Canada.

The survey was carried out in the spring of 1996 among 3,400 establishments in primary and manufacturing industries. The industries were chosen on the basis of expert opinion on their probable use of biotechnologies. Efforts were made to target industries belonging to the following sectors: aquaculture and forestry, manufacturing aspects of agro-industry, wood as well as pulp and paper products, coal as well as oil and gas products (extraction and refining), and the chemical industry, including pharmaceuticals.

Use of Biotechnologies

In 1996, 272 firms, i.e. 14 % of the 2,010 firms responding, indicated that they use at least one form of biotechnology. Taken together, these firms accounted for 53 % of revenues and 43 % of total employment. A total of 65 firms also indicated that they expected to use biotechnologies in the next two years. Among these, 39 firms were already using at least one form of biotechnology, whereas 26 firms expected to join the ranks of users. The 272 firms then using biotechnologies were also classified according to the type of biotechnology used. This information is summarised in Table 1.

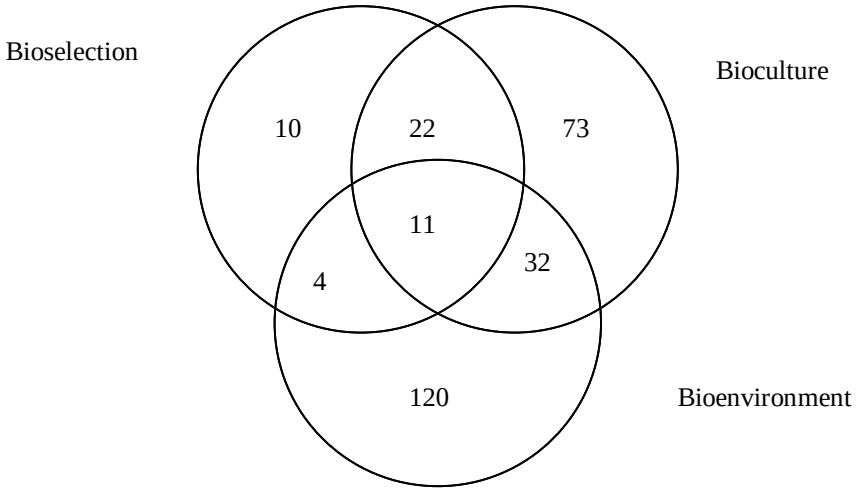
Table 1
Number of firms using biotechnologies - 1996

	Number of firms	% of firms number	% of total revenue	% of total employment
Firms using at least one biotechnology	272	14%	53%	43%
Bio-selection	47	2%	9%	7%
Bio-environment	167	8%	39%	24%
Bio-culture	138	7%	25%	26%
Biotechnology planned use within two years	65	3%	9%	10%
Already using biotechnologies	39	2%	5%	6%
Non-users of biotechnologies	26	1%	3%	4%

Source: Statistics Canada

It can be seen that few firms are involved in selection or modification biotechnologies, while more firms are active in bioculture and bioenvironment activities. Biotechnologies linked to bioselection are generally more advanced, and require greater knowledge for their use. It is therefore not surprising that fewer firms are involved in bioselection. Likewise, the apparently disproportionate share of revenues accounted for by firms involved in bioenvironment activities can be explained by the presence of a majority of the large businesses.

There are of course firms which use more than one biotechnology in more than one sector. The following figure shows combinations of the three types of biotechnology and the number of firms involved in each combination. This figure also points to a number of preferred orientations. Thus, firms involved in environmental biotechnology appear to be more concentrated, and when they reach into another sector, it is more likely to be linked to bioculture. Conversely, firms involved in bioselection are more dispersed, three quarters of them being active in more than one sector, and appear to be more interested in bioculture. Firms involved in bioculture appear to be a key link between the two other groups.



Duration and Frequency of Use

Utilization of 17 of the 22 biotechnologies under consideration is a fairly recent process, with most of them ranging between five and ten years of use (Table 2). The oldest biotechnology surveyed was biological processing with a mean period of use of 30 years. However, it is important to compare this information on the period of utilization with information on the stage of utilization, as shown in Table 3, which indicates that bioselection-type biotechnologies, though they have been used on the average for more than five years, are mostly at the research stage.

On the other hand, information on the expected use of biotechnologies provides interesting data about areas that are of greater interest to businesses (Table 2). As a rule, for example, greater use will be made of environmental and culture biotechnologies. Based on the number of businesses expecting to use them, bioremediation, the use of bioreactors and biosensing were the most popular.

With respect to the number of biotechnologies used by businesses, it can be seen that half the firms use two or more biotechnologies (Table 4). Businesses using at least one biotechnology within the bioselection group, which is more advanced, were also more likely to use more than a single biotechnology. Firms involved in bioculture activities had a tendency to be more specialized and used a single biotechnology.

Penetration by Industry

Given the low total number of businesses involved in biotechnology, there can be no detailed industrial distribution of the users of biotechnologies. Nevertheless, an analysis of Table 5 does lead to some interesting observations. Depending on the number of businesses, the proportion of revenues or employment, penetration rates varied greatly, though this can be explained if we also look at the type of biotechnology used. Thus, industries linked to oil, gas and coal as well as metal mines all showed significant

penetration rates, but essentially in terms of environmental biotechnology. The same applies, though to a lesser degree, to the wood and pulp and paper industries.

If we look at the penetration of firms into the bioselection group of biotechnologies, agro-food and pharmaceutical industries are clearly visible. If we compare the number of agro-food businesses involved in biotechnology with the penetration rates, the latter might appear to be low. It must be understood however that the agro-food sector includes a large number of businesses of varying size. However, the much higher penetration rates, based on the revenues or employment of the firms using biotechnologies, are an indication of the presence of large businesses. It must also be recognized that the agro-food sector shows a balanced presence in all three types of biotechnologies, something that does not apply to the other sectors.

The pharmaceutical sector might seem surprising. Given the focus on the benefits of biotechnology in the health area, firms might have been expected to be more involved in biotechnology. What is not surprising is the fact that those firms that are involved are active in bioselection and bioculture and practically absent from the bioenvironmental group.

Impact of Size

Generally speaking, large businesses are relatively more involved in biotechnology (Table 6), in terms of both numbers and the scale of revenues and employment. This is essentially due to the involvement of large businesses in environmental biotechnologies. In fact, 60 % of firms showing earnings of $500 million or more make use of biotechnology. However, half of the large businesses (47 %) are active within the bioenvironmental group, as compared to 26 % for bioculture and only 10 % for bioselection.

In terms of relative weight, large businesses retain a dominant presence in bioselection. However, they are numerically outperformed by smaller businesses, since, of the 47 firms involved in bioselection, 26 show earnings of less than $25 million.

Staff Structure

Table 7 compares the staff structure of users and non-users of biotechnologies. There is no indication of a truly significant difference in the relative makeup of the staff. On the whole, the proportion of university, college and other graduates is similar. The principal difference in terms of staff is related to the industrial sector. The only sectors in which there is a notable difference are those of oil, gas and mining, where the proportion of university graduates is clearly higher among users of biotechnology.

Investments

The survey was used to measure expenses linked to biotechnological equipment and software. Results are shown in Table 8. Environmental equipment is more substantial

(purification tanks, etc.) than that required in other sectors, and this had an impact on the results, with 23 firms in that sector alone indicating investments of more than one million dollars. In fact, ten firms showed investments of more than $10 million. In comparison, the bioselection and bioculture groups showed no investments exceeding $5 million. Most investments were less than one million dollars.

Factors which have Impact on the Use of Biotechnologies

Tables 9, 10 , 11 and 12 deal with factors that have an impact on the use of biotechnologies. The first three refer only to users of biotechnology, and the fourth deals with all the respondents.

Factors which had a positive impact on the decision to use biotechnologies varied widely in terms of bioselection and bioculture on the one hand, and bioenvironment on the other hand.

As far as bioselection and bioculture are concerned, the dominant factors were a better market position and the development of new products or processes. In both cases, there was a clear orientation. In terms of both research and development, biotechnology helped businesses position themselves through new products that were better targeted. The next factor was the need to lower production costs or to extend product range.

Environmental biotechnologies were used for other reasons, such as lowering production costs and maintenance expenses. Product development and a better market position came far behind. The “Other” category also held considerable importance for 35 % of the respondents, indicating that one or several major factors for this type of biotechnology were not covered. Some possibilities might be the need to reduce environmental damage or meet regulatory requirements.

Users also encountered some difficulty in implementing biotechnologies (Table 10). Generally speaking, there were difficulties linked to human resources, such as education and training problems and the availability of qualified personnel. There was also the need for increased expertise. To this must be added the expressed desire for more advice and information.

Another point raised by users in the bioselection and bioenvironment groups, and to a lesser extent in the bioculture group, was the matter of regulatory constraints. The context was different for the former. In bioselection, there was a regulatory requirement to have new products approved and certified, whereas in the environmental area, regulatory constraints were related to clean-up requirements. Results must be looked at from this standpoint.

The third series of questions dealt with the results of introducing biotechnologies (Table 11). Analysis must follow the same pattern used for the first series of factors, which means that bioselection and bioculture must be dealt with separately from environmental biotechnologies.

At the top of the list were improvements linked to products and production, e.g. quality, flexibility, productivity, fewer rejects. Regarding environmental biotechnologies, the first impact was reduced damage. For all types of biotechnologies, increased skill requirements were a recurring theme, reflecting what has already been observed for factors having an impact on the decision to adopt biotechnologies. The third item was increased capital requirements.

All respondents were asked about impediments to biotechnology acquisition, and the response was divided into two categories to reflect the situation for users and non-users of biotechnologies. Thus, before looking at the results, it is important to emphasize that, among non-users, 89 % of respondents indicated "not applicable" for all choices related to possible impediments. As for users of biotechnology, the figure was 21 %.

These responses may indicates a wish not to answer the question. However, the fact remains that a significant number of firms consider that biotechnology is not applicable to their situation. The message then is one of awareness.

In fact, this whole question of awareness and knowledge of biotechnology affects the way in which the two groups, users and non-users, assess the various impediments to acquisition. There are reasons related to financial matters such as the availability of capital and financial justification. The cost of equipment was foremost among concerns raised by users of biotechnology, but ranked eleventh among non-users. Three of the first four choices of users were related to financial matters (cost of equipment, lack of financial justification and lack of funds). Among non-users, only one of the first four choices was financial (lack of financial justification).

Other important factors were linked to information and the business environment (biotechnologies not sufficiently developed, technical information, lack of information about markets, regulations). Users of biotechnology ranked regulations second among their concerns and insufficient development of biotechnologies fifth. Among non-users, the need for information was foremost: lack of information about markets (ranked second), biotechnologies not sufficiently developed (ranked third), insufficient markets (ranked fourth) and lack of scientific and technical information (ranked fifth). Non-users of biotechnology did not seem to have sufficient information about biotechnology and possible markets to go on to the second stage of feasibility analysis.

Sources of Information about Biotechnology

The activities of innovation and technology use do not take place in isolation. In this respect, the survey involved questions about sources of information, R&D work and the use of partnerships within alliances for R&D work. The results are shown in Tables 13 and 14.

Table 13 deals with internal and external sources of information for biotechnology acquisition. These questions were only asked of biotechnology users, and were classified

according to the type of biotechnology used. For users involved in bioselection, where most biotechnologies have reached the R&D stage (Table 3), the sources of information were consistent; the principal internal sources were experimental research and development, and the external sources were publications, universities, trade fairs and conferences.

Similar tendencies can be observed for the other two types of biotechnology, i.e. bioculture and bioenvironment, though to a lesser degree. Again the relationship with the utilization stage (Table 3) is interesting. With respect to bioculture, biotechnologies were used in R&D (25 %) or production (plant and product, 68 %), i.e. at a stage of R&D that is less advanced than for bioselection, but more oriented towards implementation. Among sources of information, those related to R&D were internally less significant than operating staff. As for bioenvironment, the significance of R&D in biotechnology was even less pronounced (10 %), and the same was true for sources of information linked to R&D. Interestingly, bioenvironment firms used as their principal external source of information consultants and service firms (54 %), possibly indicating a lower level of sophistication and therefore a wider dissemination of biotechnologies, with enterprises feeling less of a need to develop internal expertise.

Research and Development

Users of biotechnology were more active in R&D than non-users. Among users of biotechnology, more than half of the firms (53 %) indicated they were doing R&D on a continuous basis, as compared to one third (33 %) among non-users (Table 14). Likewise, the likelihood of being involved in alliances aimed at R&D was more than double among users (56 % versus 21 %). The breakdown among Canadian and foreign partners was similar.

Among the types of partners involved, users of biotechnology paid more attention to universities (61 %), research institutes (46 %) and government laboratories (43 %). R&D alliances for this group clearly showed a greater willingness to look outside the commercial business sector and an interest in more diversified sources of information and knowledge.

Comparisons with Competitors

Table 15 compares the perceptions of businesses in terms of their Canadian and foreign competitors. Generally speaking, all firms considered themselves to be slightly more advanced than their Canadian competitors and less advanced than their foreign competitors. This tendency was the same for users of biotechnology and non-users, with one exception, namely those firms involved in bioselection, which felt even more advanced than their Canadian competitors. Since the perception with respect to foreign competitors depends on the amount of information available about the latter, it is conceivable that Canadian enterprises have a tendency to overestimate the degree to which foreign competitors have advanced.

Methodology

The questionnaire on biotechnology use was sent in March 1996 to 3,400 establishments within preselected industries. The sample was drawn from the Business Register of Statistics Canada. The list of industries selected and the number of establishments surveyed is on Table 16. From the Business Register, the 3,400 establishments with earnings of more than $5 million were selected, which means that the sample was biased in favour of large firms. Also included were those biotechnology R&D firms identified in the Research and Development in Canadian Industry survey.

The survey database was constructed for firms rather than for establishments to allow for those firms with many establishments that had submitted consolidated responses. This was accepted as it reduced the burden of response substantially and allowed respondents to concentrate on answering questions on biotechnology which were completely new to them. The response rate, based on firms, was over 87% and non-response was due principally to firms that had gone out of business, merged, or changed classification.

Table 2
Use of biotechnologies - 1996

	Currently used	Plan to use within next 2 years	Approximate number of years in use
	(Number of utilization)	(Number of utilization)	(years)
Bio-Selection	**107**	**23**	
Recombinant DNA and Gene Therapy	18	4	4.7
Antibodies/Antigens	31	3	10.1
Peptide Synthesis	7	3	7.6
Rational Drug Design	7	2	9.1
Monoclonal Antibodies	21	5	7.3
Gene Probe	11	2	6.8
DNA Amplification	12	4	6.1
Bio-Environment	**280**	**46**	
Bioaugmentation	61	6	10.4
Bioremediation	111	18	9.1
Bio-reactors	73	13	9.6
Phytoremediation	26	6	11.8
Biological Gaz Cleaning	9	3	7.5
Bio-Culture	**198**	**49**	
Tissue Culture	31	5	9
Somatic Embryo-Genesis	4	5	2
Bio-Pesticide	13	5	4.4
Classical/Traditional Breeding	22	2	10.2
Bioprocessing	80	8	29.8
Bio Sensing	28	12	7.4
Bio-bleaching	4	3	5.3
Bio-leaching	5	3	6.5
Microbio-inoculants	11	6	9.9
Total	**585**	**118**	

Source: Statistics Canada

Table 3
Use of biotechnologies, by utilization stage - 1996

	Utilization stage				
	R&D	**Factory**	**Product**	**Environ-ment**	**Non-available**
Bio-Selection	**52**	**25**	**25**	**0**	**5**
	49%	*23%*	*23%*	*0%*	*5%*
Recombinant DNA and Gene Therapy	10	3	5		
Antibodies/Antigens	9	10	11	x	x
Peptide Synthesis	5	x	x	x	x
Rational Drug Design	6	x	x	x	x
Monoclonal Antibodies	6	7	8	x	x
Gene Probe	7	x	x	x	x
DNA Amplification	9	x	x	x	x
Bio-Environment	**29**	**36**	**10**	**198**	**7**
	10%	*13%*	*4%*	*71%*	*3%*
Bioaugmentation	7	12	4	38	
Bioremediation	10	6	3	88	4
Bio-reactors	6	14	x	51	x
Phytoremediation and Biological Gas Cleaning	6	4	x	16	x
Bio-Culture	**50**	**106**	**27**	**10**	**5**
	25%	*54%*	*14%*	*5%*	*3%*
Tissue Culture	11	18	x	x	x
Somatic Embryo-Genesis	3	x	x	x	x
Bio-Pesticide	4	3	6		
Classsical/Traditional Breeding	8	10	3	x	x
Bioprocessing	8	55	12	3	2
Bio Sensing	10	13	x	4	x
Bio-bleaching		4			
Bio-leaching	3	x	x	x	x
Microbio-inoculants	3	x	3	x	x
Total	**131**	**167**	**62**	**208**	**17**

Source: Statistics Canada
x: confidential to meet secrecy requirements of the Statistics Act

Table 4
Number of biotechnologies used by the firms, by type of biotechnology - 1996

Number of utilization	Number of firms	Percentage
Biotech-utilization (maximum 22)		
1	140	51%
2	54	20%
3	38	14%
4	21	8%
5	6	2%
6+	13	5%
	272	100%
Bio-Selection (maximum 8)		
1	19	40%
2	16	34%
3	5	11%
4+	7	15%
	47	100%
Bio-Environment (maximum 5)		
1	96	57%
2	38	23%
3	25	15%
4+	8	5%
	167	100%
Bio-Culture (maximum 9)		
1	97	70%
2	27	20%
3	10	7%
4+	4	3%
	138	100%

Source: Statistics Canada

Table 5
Penetration Rate, by industry, of the biotechnologies users - 1996

	Penetration rate[1]			Number of firms			
	# Firms	Revenues	Employees	Biotech	Selection	Environ-	Culture
Bio-Industries			Total			ment	
Agri-food	16%	55%	50%	117	24	45	87
Other industries	2%	7%	4%	8	4	2	5
Wood and pulp and paper	13%	54%	48%	52	x	49	12
Petroleum and gaz (extraction)	27%	62%	41%	33	x	33	x
Petroleum and gaz (refining)	31%	94%	79%	11	x	10	x
Chemical industry	8%	26%	19%	19	4	13	8
Pharmaceutical industry	31%	25%	38%	19	14	3	17
Metal mining	27%	39%	31%	13	0	12	5
Total	**14%**	**53%**	**43%**	**272**	**46**	**167**	**134**

Source: Statistics Canada

1. Penetration rate: % of biotech user over total number of firms.

x: confidential to meet secrecy requirements of the Statistics Act

Table 6
Distribution of firms by size and their use of biotechnologies - 1996

Size	# firms	% of total firms	% of total revenue	% of total employment
		In the revenue size class		
Biotech >0				
< 5 millions	24	10%	7%	5%
5 millions < X < 25 millions	67	7%	7%	9%
25 millions < X < 100 millions	63	12%	15%	16%
100 millions < X < 500 millions	66	30%	32%	30%
500 millions et plus	52	60%	71%	64%
Bio-selection >0				
< 5 millions	14	6%	4%	3%
5 millions < X < 25 millions	12	1%	1%	2%
25 millions < X < 100 millions	7	1%	1%	3%
100 millions < X < 500 millions	5	2%	2%	2%
500 millions et plus	9	10%	13%	11%
Bio-environment >0				
< 5 millions	6	3%	2%	1%
5 millions < X < 25 millions	26	3%	3%	4%
25 millions < X < 100 millions	47	9%	11%	11%
100 millions < X < 500 millions	48	22%	23%	20%
500 millions et plus	40	47%	53%	34%
Bio-culture >0				
< 5 millions	19	8%	6%	4%
5 millions < X < 25 millions	46	5%	5%	6%
25 millions < X < 100 millions	26	5%	6%	9%
100 millions < X < 500 millions	25	12%	12%	13%
500 millions et plus	22	26%	34%	40%
Biotech =0				
< 5 millions	215	90%	93%	95%
5 millions < X < 25 millions	895	93%	93%	91%
25 millions < X < 100 millions	443	88%	85%	84%
100 millions < X < 500 millions	151	70%	68%	70%
500 millions et plus	34	40%	29%	36%
Total Biotech				
< 5 millions	239	100%	100%	100%
5 millions < X < 25 millions	962	100%	100%	100%
25 millions < X < 100 millions	506	100%	100%	100%
100 millions < X < 500 millions	217	100%	100%	100%
500 millions et plus	86	100%	100%	100%

Source: Statistics Canada

Table 7
Personnel composition of surveyed firms,
by type of bio-industry and by level of diploma, 1996

Biotechnologies Users

Bio-Industry	Total personnel ratio of the industry	% Universities	% Colleges	% Others
Agri-food	50%	7%	10%	83%
Other industries	4%	24%	5%	70%
Wood and pulp and paper	48%	8%	10%	82%
Petroleum and gaz (extraction)	41%	33%	17%	50%
Chemical industry	19%	16%	12%	72%
Pharmaceutical industry	38%	37%	12%	50%
Metal mining	31%	17%	9%	74%
Pétroleum and gaz (refining)	79%	17%	12%	71%
Total	**43%**	**11%**	**10%**	**78%**

Non-users of biotechnologies

Bio-Industry	Total personnel ratio of the industry	% Universities	% Colleges	% Others
Agri-food	50%	7%	7%	86%
Other industries	96%	15%	13%	72%
Wood and pulp and paper	52%	10%	11%	79%
Petroleum and gaz (extraction)	59%	25%	13%	62%
Chemical industry	81%	16%	11%	73%
Pharmaceutical industry	62%	38%	15%	47%
Metal mining	69%	8%	4%	88%
Petroleum and gaz (refining)	21%	8%	19%	74%
Total	**57%**	**12%**	**10%**	**79%**

Source: Statistics Canada

Table 8
Capital investments in biotechnology

Investments brackets		
Bio-Selection	**# Firms**	%
< 100 000$	29	62%
> 100 000$, < 1 000 000$	7	15%
> 1 000 000$, < 5 000 000$	5	11%
> 5 000 000$, < 10 000 000$	x	x
> 10 000 000$	x	x
Not applicable or no-response	5	11%
Total	**47**	**100%**
Bio-Culture	**# Firms**	
< 100 000$	81	59%
> 100 000$, < 1 000 000$	17	12%
> 1 000 000$, < 5 000 000$	8	6%
> 5 000 000$, < 10 000 000$	x	x
> 10 000 000$	x	x
Not applicable	19	14%
No response	10	7%
Total	**138**	**100%**
Bio-Environment	**# Firms**	
< 100 000$	79	47%
> 100 000$, < 1 000 000$	30	18%
> 1 000 000$, < 5 000 000$	13	8%
> 5 000 000$, < 10 000 000$	0	0%
> 10 000 000$	10	6%
Not applicable	24	14%
No response	11	7%
Total	**167**	**100%**

Source : Statistics Canada
x: confidential to meet secrecy requirements of the Statistics Act

Table 9
Positive factors having particular significance in the decision to adopt one of the biotechnologies listed in the survey (1996)

Bio-Selection	
Better market position	53%
Develop new products	51%
Internal familiarity	47%
Lower production cost	45%
Extend product range	45%
Increase production	34%
Other positive factors	23%
Faster Delivery	21%
Lower maintenance	15%
Bio-Culture	
Develop new products	47%
Better market position	39%
Lower production cost	37%
Extend product range	34%
Internal familiarity	33%
Increase production	24%
Other positive factors	23%
Lower maintenance	18%
Faster Delivery	14%
Bio-Environment	
Lower production cost	36%
Other positive factors	35%
Lower maintenance	34%
Internal familiarity	27%
Better market position	19%
Develop new products	17%
Extend product range	17%
Increase production	17%
Faster delivery	5%

Source: Statistics Canada

Table 10
Difficulties met in implementing the biotechnologies

Bio-Selection	
Skill availability	34%
Regulatory constraints	32%
Training	30%
Need for information	15%
Adapting to norms	11%
Adaptability to technologies	9%
Increased maintenance expense	9%
Lack of technical support	9%
Insufficient market	6%
Other difficulties	4%
No difficulties	34%
Bio-Culture	
Training	25%
Skill Availability	23%
Need for information	19%
Regulatory constraints	19%
Adapting to norms	14%
Increased maintenance expense	12%
Adaptability to technologies	9%
Other difficulties	7%
Insufficient market	7%
Lack of technical support	7%
No difficulties	40%
Bio-Environment	
Regulatory constraints	29%
Need for information	28%
Increased maintenance expense	26%
Skill Availability	22%
Training	20%
Adapting to norms	20%
Adaptability to technologies	14%
Other difficulties	14%
Lack of technical support	12%
Insufficient market	3%
No difficulties	32%

Source: Statistics Canada

Table 11
Results following the adoption of biotechnologies

Bio-Selection	
Improvement in product quality	38%
Increased skill requirements	34%
Greater product flexibility	32%
Improved productivity	28%
Reduced product rejection rate	26%
Increased capital requirements	21%
Reduced labour requirements	19%
Reduced material consumption	17%
Improved working conditions	15%
Reduced environmental damage	15%
Increased equipment utilization	15%
Reduced energy consumption	9%
Other results	9%
Reduced capital investments	4%
Lower inventory	4%
Reduced skill requirements	2%
No results	13%
Bio-Culture	
Improvement in product quality	45%
Improved productivity	30%
Greater product flexibility	23%
Reduced product rejection rate	22%
Increased skill requirements	22%
Increased capital requirements	17%
Reduced material consumption	17%
Reduced environmental damage	14%
Improved working conditions	13%
Increased equipment utilization	12%
Other results	10%
Reduced energy consumption	9%
Reduced labour requirements	8%
Reduced capital investments	7%
Lower inventory	6%
Reduced skill requirements	4%
No results	19%
Bio-Environment	
Reduced environmental damage	65%
Increased skill requirements	20%
Increased capital requirements	20%
Material consumption	17%
Energy consumption	17%
Improved productivity	16%
Labour requirements	12%
Reduced capital investments	12%
Improvement in product quality	11%
Improved working conditions	10%
Greater product flexibility	9%
Increased equipment utilization	9%
Product rejection rate	8%
Other results	7%
Reduced skill requirements	4%
Lower inventory	1%
No results	7%

Source: Statistics Canada

Table 12
Impediments to biotechnology acquisition

Users of biotechnologies

	Index[1]	Rank	Non-response	N/A
Cost-Related Problems				
High Cost of Biotechnology Equipment	3.18	1	5%	40%
Lack of equity capital for implementation of new biotechnology acquisition	2.99	4	5%	50%
Lack of financial justification	3.01	3	5%	44%
Cost of training	2.22	14	5%	47%
Increased maintenance expenses	2.39	11	5%	47%
Insufficient market for product	2.60	8	5%	60%
Government regulations / standards	3.13	2	5%	42%
Availability of inputs				
Lack of equity capital for investment in biotechnologies	2.74	6	5%	51%
Lack of outside capital for investment in biotechnologies	2.42	10	5%	56%
Shortage of skills	2.28	13	5%	46%
Training difficulties	2.14	18	5%	47%
Organizational problems				
Difficulties in introducing important changes to the organization	2.16	17	5%	47%
Internal resistance to biotechnologies	1.92	19	5%	47%
Worker resistance	1.68	20	5%	47%
Other problems				
Lack of scientific and technical information	2.49	9	5%	39%
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	2.31	12	6%	42%
Lack of technical support from vendors	2.22	15	5%	44%
Biotechnologies not sufficiently developped	2.83	5	6%	41%
Lack of information about potential markets	2.64	7	6%	56%
Other	2.17	16	18%	71%
Number of respondents which indicated "Not applicable" to all items				21%

Source: Statistics Canada

1.Respondents used a graduated scale from 1 (Insignificant) to 5 (Crucial) to qualify the importance of each factor. The indexes are an aggregation of all responses.

Table 12 (con't)
Impediments to biotechnology acquisition

Non-users of biotechnologies

	Index[1]	Rank	Non-response	N/A
Cost-Related Problems				
High Cost of Biotechnology Equipment	3.02	10	2%	93%
Lack of equity capital for implementation of new biotechnology acquisition	3.06	6	2%	93%
Lack of financial justification	3.55	1	2%	93%
Cost of training	2.86	14	2%	93%
Increased maintenance expenses	2.92	13	2%	94%
Insufficient market for product	3.38	4	2%	94%
Government regulations / standards	3.01	11	2%	94%
Availability of inputs				
Lack of equity capital for investment in biotechnologies	3.04	9	2%	94%
Lack of outside capital for investment in biotechnologies	3.04	7	2%	94%
Shortage of skills	3.00	12	2%	94%
Training difficulties	2.79	17	2%	94%
Organizational problems				
Difficulties in introducing important changes to the organization	2.51	18	2%	94%
Internal resistance to biotechnologies	2.31	19	2%	94%
Worker resistance	2.09	20	2%	94%
Other problems				
Lack of scientific and technical information	3.07	5	2%	92%
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	3.04	8	2%	93%
Lack of technical support from vendors	2.82	15	2%	93%
Biotechnologies not sufficiently developped	3.46	3	2%	93%
Lack of information about potential markets	3.53	2	2%	93%
Other	2.81	16	3%	95%
Number of respondents which indicated "Not applicable" to all items				89%

Source: Statistics Canada

1.Respondents used a graduated scale from 1 (Insignificant) to 5 (Crucial) to qualify the importance of each factor. The indexes are an aggregation of all responses.

Table 13

Internal sources of information for the adoption of biotechnologies		External sources of information for the adoption of biotechnologies	
Bio-Selection		**Bio-Selection**	
Research	60%	A related firm	23%
Experimental development	47%	An unrelated firm	30%
Design work	26%	Federal research organizations	32%
Production engineering	19%	Universities	49%
Operating staff	21%	Provincial research organizations	15%
Management	36%	Federal information programs	13%
Corporate Head Office	28%	Research consortia	11%
Other internal sources	13%	Consultants and service firms	32%
		Joint ventures and strategic alliances	34%
		Publications	60%
		Trade fairs, conferences	49%
		Customer firms	19%
		Supplier firms	38%
		Other sources	2%
		No external input	13%
Bio-Culture		**Bio-Culture**	
Research	46%	A related firm	25%
Experimental development	43%	An unrelated firm	25%
Design work	20%	Federal research organizations	30%
Production engineering	19%	Universities	38%
Operating staff	31%	Provincial research organizations	15%
Management	33%	Federal information programs	13%
Corporate Head Office	24%	Research consortia	13%
Other internal sources	11%	Consultants and service firms	28%
		Joint ventures and strategic alliances	18%
		Publications	49%
		Trade fairs, conferences	33%
		Customer firms	12%
		Supplier firms	42%
		Other sources	6%
		No external input	14%
Bio-Environment		**Bio-Environment**	
Research	35%	A related firm	19%
Experimental development	32%	An unrelated firm	32%
Design work	18%	Federal research organizations	22%
Production engineering	25%	Universities	32%
Operating staff	30%	Provincial research organizations	18%
Management	29%	Federal information programs	8%
Corporate Head Office	30%	Research consortia	20%
Other internal sources	13%	Consultants and service firms	54%
		Joint ventures and strategic alliances	11%
		Publications	46%
		Trade fairs, conferences	35%
		Customer firms	4%
		Supplier firms	32%
		Other sources	4%
		No external input	12%

Source: Statistics Canada

Table 14
R&D Activities and Alliances for R&D Purposes

	# firms	%
Users of biotechnologies	**272**	
R&D Performers	193	71%
Continuous basis	145	53%
Alliances with other partners	105	39%
Occasional basis	48	18%
Alliances with other partners	33	12%
R&D Non-Performers	79	29%
Alliances with other partners	13	5%
Total Alliances	151	56%
Canadian Partners	147	54%
Abroad Partners	78	29%
Partners Types (% on 151 firms)	Canada	Abroad
Competitors	17%	9%
Suppliers	37%	21%
Clients	20%	17%
Consultants	44%	19%
Other firms within group	24%	24%
Other firms not listed above	11%	9%
Government	43%	4%
Universities	61%	13%
Research Institutes	46%	13%
	# firms	**%**
Non-Users of biotechnologies	**1738**	
R&D Performers	758	44%
Continuous basis	568	33%
Alliances with other partners	261	15%
Occasional basis	188	11%
Alliances with other partners	70	4%
R&D Non-Performers	980	56%
Alliances with other partners	40	2%
Total Alliances	371	21%
Canadian Partners	318	18%
Abroad Partners	178	10%
Partners Types (% on 151 firms)	Canada	Abroad
Competitors	9%	4%
Suppliers	38%	18%
Clients	25%	15%
Consultants	27%	9%
Other firms within group	20%	16%
Other firms not listed above	11%	7%
Government	16%	2%
Universities	29%	6%
Research Institutes	23%	7%

Source: Statistics Canada

Table 15
Comparison of the production technology with that of the competitors in Canada and outside of Canada who are using or not biotechnologies

Canadian producers	Biotech>0	Bio-selection>0	Bio-culture>0	Bio-environ-ment>0
Much less advanced	2%	4%	3%	1%
Less advanced	10%	4%	10%	11%
About the same	53%	32%	49%	56%
More advanced	26%	43%	28%	24%
Much more advanced	5%	11%	6%	4%
No-response	5%	6%	4%	5%
Total of firms	272	47	138	167
Composite index	3.24	3.55	3.24	3.2
Producers abroad				
Much less advanced	3%	6%	6%	2%
Less advanced	11%	11%	9%	10%
About the same	53%	51%	54%	57%
More advanced	20%	19%	18%	18%
Much more advanced	5%	6%	8%	5%
No-response	8%	6%	6%	8%
Total of firms	272	47	138	167
Composite index	3.14	3.09	3.15	3.15

Canadian producers	Biotech=0
Much less advanced	1%
Less advanced	6%
About the same	49%
More advanced	21%
Much more advanced	6%
No-response	17%
Total of firms	1738
Composite index	3.29
Producers abroad	
Much less advanced	1%
Less advanced	10%
About the same	49%
More advanced	17%
Much more advanced	4%
No-response	20%
Total of firms	1738
Composite index	3.15

Source: Statistics Canada

Table 16
Concordance between Bio-Industries used in this report and the SIC-1980

SIC	SIC Description - English	Number of respondents covered by this report
Agri-Food		
0321	Services Incidental to Fishing	4
1011	Meat and Meat Products Industries (Except Poultry)	128
1012	Poultry Products Industry	33
1021	Fish Products Industry	88
1031	Canned and Preserved Fruit and Vegetable Industry	43
1032	Frozen Fruit and Vegetable Industry	9
1041	Fluid Milk Industry	30
1049	Other Dairy Products Industries	37
1051	Cereal Grain Flour Industry	10
1052	Prepared Flour Mixes and Prepared Cereal Foods Industry	11
1053	Feed Industry	108
1061	Vegetable Oils Mills (Except Corn Oil)	2
1071	Biscuit Industry	14
1072	Bread and Other Bakery Products Industry	32
1081	Cane and Beet Sugar Industry	5
1082	Chewing Gum Industry	3
1083	Sugar and Chocolate Confectionery Industry	17
1091	Tea and Coffee Industry	9
1092	Dry Pasta Products Industry	5
1093	Potato Chip, Pretzel and Popcorn Industry	9
1094	Malt and Malt Flour Industry	2
1099	Other Food Products Industries n.e.c.	83
1111	Soft Drink Industry	25
1121	Distillery Products Industry	9
1131	Brewery Products Industry	15
1141	Wine Industry	7
1211	Leaf Tobacco Industry	3
1221	Tobacco Products Industry	5
Wood and Pulp & Paper		
0511	Forestry Services Industry	6
2591	Wood Preservation Industry	16
2592	Particle Board Industry	10
2593	Wafer Board Industry	6
2599	Other Wood Industries n.e.c.	15
2711	Pulp Industry	27
2712	Newsprint Industry	19
2713	Paperboard Industry	14
2714	Building Board Industry	6
2719	Other Paper Industries	8
2791	Coated and Treated Paper Industry	19
2792	Stationery Paper Products Industry	12
2793	Paper Consumer Products Industry	6
2799	Other Converted Paper Products Industries n.e.c.	37
2811	Business Forms Printing Industry	27
2819	Other Commercial Printing Industries	181

Source : Statistics Canada

Table 16 (con't)
Concordance between Bio-Industries used in this report and the SIC-1980

SIC	SIC Description - English	Number of respondents covered by this report
Metal mining		
0611	Gold Mines	28
0612	Copper and Copper-Zinc Mines	10
0613	Nickel-Copper Mines	1
0614	Silver-Lead-Zinc Mines	1
0615	Molybdenum Mines	1
0616	Uranium Mines	5
0617	Iron Mines	2
0619	Other Metal Mines	1
Crude Petroleum and Gaz		
0711	Conventional Crude Oil and Natural Gas Industry	122
0712	Non-Conventional Crude Oil Industry	2
Petroleum and gaz refining		
3611	Refined Petroleum Products Industry (Except Lubricating Oil and Grease)	11
3612	Lubricating Oil and Grease Industry	12
3699	Other Petroleum and Coal Products Industries	13
Pharmaceuticals		
3741	Pharmaceutical and Medicine Industry	61
Chemicals (without Pharmaceuticals)		
3712	Industrial Organic Chemical Industries n.e.c.	25
3721	Chemical Fertilizer and Fertilizer Materials Industry	8
3722	Mixed Fertilizer Industry	13
3729	Other Agricultural Chemical Industries	5
3751	Paint and Varnish Industry	47
3761	Soap and Cleaning Compounds Industry	24
3771	Toilet Preparations Industry	19
3791	Printing Ink Industry	13
3792	Adhesives Industry	12
3799	Other Chemical Products Industries n.e.c.	68
Other industries		
1711	Leather Tanneries	5
1719	Other Leather and Allied Products Industries	5
1811	Man-Made Fibre and Filament Yarn Industry	9
1821	Wool Yarn and Woven Cloth Industry	9
1829	Other Spun Yarn and Woven Cloth Industries	28
1831	Broad Knitted Fabric Industry	21
1911	Natural Fibres Processing and Felt Products Industry	14
1931	Canvas and Related Products Industry	8
1992	Contract Textile Dyeing and Finishing Industry	13
1994	Hygiene Products of Textile Materials Industry	3
1999	Other Textile Products Industries n.e.c.	25
3042	Metal Closure and Container Industry	18
3911	Indicating, Recording and Controlling Instruments Industry	47
3912	Other Instruments and Related Products Industry	53
3914	Ophthalmic Goods Industry	6
3931	Sporting Goods Industry	30
3999	Other Manufactured Products Industries n.e.c.	57

Source : Statistics Canada

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Survey of Biotechnology Use in Canadian Industries - 1996

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Collected under the authority of the Statistics Act, Revised Statutes of Canada, 1985, Chapter S19.

In all correspondence concerning this questionnaire, please quote this nine-digit reference number

Si vous péférez ce questionnaire en français, veuillez appeler un des bureaux de Statistisque Canada inscrits à la page 11.

Please correct name and address, if necessary

Purpose

Statistics Canada is undertaking this survey to measure and develop a better understanding of the emerging contribution of biotechnology to the Canadian economy. The information from the survey can be used by businesses for market analysis, by trade associations to study performance and other characteristics of their industries, by government to develop national and regional economic policies, and by other users involved in research or policy making. Statistics Canada will create a database combining individual survey responses with existing Revenue Canada and Statistics Canada data records.

Authority

Collected under authority of Statistics Act, Revised Statutes of Canada, 1985, Chapter S19

Confidentiality

Statistics Canada is prohibited by law from publishing or releasing, in any manner, any statistics which would divulge information obtained from this survey relating to any identifiable business. The data reported on the survey questionnaire will be treated in strict confidence, used for statistical purposes and released in aggregate form only.

Questions?

If you require assistance in the completion of this questionnaire or have any questions regarding this survey, please phone one of the Statistics Canada regional office listed on page 11.

Survey Contact

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

Name	Title
Telephone Number ___ – ___ – ____	Fax Number ___ – ___ – ____

Company Information

Please report data for 1996 or the latest fiscal year available. **Exclude GST and all other taxes collected by you for remittance to a government agency. Do not include sales and operations of your subsidiaries located abroad.**

	Year	Amount
A1. **Operating revenue** ($000)	A1A	A1B
A2. **Sales to other provinces** (as % of operating revenue)		A2A %
A3. **Exports to the United States and Mexico** (as % of operating revenue)		A3A %
A4. **Exports to other countries in rest of World** (as % of operating revenue)		A4A %
A5. **Number of employees (average for the year)**		A5A
a) Full time		A5B
b) Part time		A5C
c) Contract		A5D
d) Total		

	Total	Working with biotechnologie
A6. **Number of employees, by level of education**		
a) University graduates	A6A	A6D
b) College graduates	A6B	A6E
c) All other employees	A6C	A6F

5-4700-40.1: 1996-12-16 SQC/SAT 465-75092

Use of Biotechnologies

B1 For each item or biotechnology listed below, please indicate (√) which description best reflects its function within your business activities.

Biotechnology	Currently Used in operations	Approximate number of years in use	UTILIZATION: Research stage
SELECTION AND/OR MODIFICATION OF BIOLOGICAL MATERIAL			
Recombinant DNA Procedure used to join together DNA segments outside a cell. Also referred to as genetic engineering.	B1AA ○ Yes ○ No ▶	B1AB	B1AC ○
Antibodies / antigens Proteins produced in the body in response to the introduction of foreign molecules called antigens.	B1BA ○ Yes ○ No ▶	B1BB	B1BC ○
Peptide synthesis Procedure to link two or more amino acids joined by a linkage called a peptide bond.	B1CA ○ Yes ○ No ▶	B1CB	B1CC ○
Rational drug design Analysis of the structures of active sites of enzymes and receptors in order to design pharmacologically active synthetic molecules that will fit these analyzed structures.	B1DA ○ Yes ○ No ▶	B1DB	B1DC ○
Monoclonal antibodies A monoclonal antibody is a highly specific antibody which is derived from one line of cells and which recognizes only one specific complimentary antigen.	B1EA ○ Yes ○ No ▶	B1EB	B1EC ○
Gene probe A section of DNA of known structure or function which is marked with a radioactive isotope, dye or enzyme so that it can be used to detect the presence of specific sequences of bases in another DNA molecule.	B1FA ○ Yes ○ No ▶	B1FB	B1FC ○
Gene therapy Replacement of a defective gene in an organism suffering from a genetic disease.	B1GA ○ Yes ○ No ▶	B1GB	B1GC ○
DNA amplification Process of increasing the number of copies of a particular gene or chromosomal sequence.	B1HA ○ Yes ○ No ▶	B1HB	B1HC ○
ENVIRONMENTAL BIOTECHNOLOGIES			
Bioaugmentation Is the process of increasing the efficiency of the naturally occurring microbial population to concentrate or accumulate specific compounds. This is usually achieved by adding nutrients, oxygen or water.	B1IA ○ Yes ○ No ▶	B1IB	B1IC ○
Bioremediation Is a process that involves the use of naturally occurring or genetically modified micro-organisms to breakdown or degrade hazardous substances into less hazardous or non-toxic substances.	B1JA ○ Yes ○ No ▶	B1JB	B1JC ○
Bio-reactors Are enclosed containers in which micro-organisms are maintained under controlled conditions for the purpose of creating or destroying specific compounds.	B1KA ○ Yes ○ No ▶	B1KB	B1KC ○
Phytoremediation Is the use of vegetative species for the purposes of site remediation.	B1LA ○ Yes ○ No ▶	B1LB	B1LC ○
Biological gas cleaning Is the use of micro-organisms to break-down or degrade hazardous substances in a gas stream into less hazardous or non-toxic substances.	B1MA ○ Yes ○ No ▶	B1MB	B1MC ○

Purposes for Using Biotechnologies

B1 For each item or biotechnology listed below, please indicate (√) which description best reflects its function within your business activities. – Continued

STAGE

Part of the production process	Part of the product sold	Pollution control system	Plan to use within next 2 years	No plans to use	
				No application	Not cost effective
B1AD ○	B1AE ○	B1AF ○			
			B1AG 1 ○	2 ○	3 ○
B1BD ○	B1BE ○	B1BF ○			
			B1BG 1 ○	2 ○	3 ○
B1CD ○	B1CE ○	B1CF ○			
			B1CG 1 ○	2 ○	3 ○
B1DD ○	B1DE ○	B1DF ○			
			B1DG 1 ○	2 ○	3 ○
B1ED ○	B1EE ○	B1EF ○			
			B1EG 1 ○	2 ○	3 ○
B1FD ○	B1FE ○	B1FF ○			
			B1FG 1 ○	2 ○	3 ○
B1GD ○	B1GE ○	B1GF ○			
			B1GG 1 ○	2 ○	3 ○
B1HD ○	B1HE ○	B1HF ○			
			B1HG 1 ○	2 ○	3 ○
B1ID ○	B1IE ○	B1IF ○			
			B1IG 1 ○	2 ○	3 ○
B1JD ○	B1JE ○	B1JF ○			
			B1JG 1 ○	2 ○	3 ○
B1KD ○	B1KE ○	B1KF ○			
			B1KG 1 ○	2 ○	3 ○
B1LD ○	B1LE ○	B1LF ○			
			B1LG 1 ○	2 ○	3 ○
B1MD ○	B1ME ○	B1MF ○			
			B1MG 1 ○	2 ○	3 ○

Use of Biotechnologies – Continued

B1 For each item or biotechnology listed below, please indicate (√) which description best reflects its function within your business activities. – Continued

Biotechnology	Currently used in operations	Approximate number of years in use	**UTILIZATION** Research stage
CULTURE AND/OR USE OF BIOLOGICAL MATERIAL			
Tissue culture Propagation or growth of cells which are isolated from organisms in a nutrient medium in a laboratory environment.	B1NA ○ Yes ○ No ▶	B1NB	B1NC ○
Somatic embryo-genesis Propagation of genetically desirable plant and tree lineages by tissue culture methods.	B1OA ○ Yes ○ No ▶	B1OB	B1OC ○
Bio-pesticide Biological pest control through the use of naturally occurring microbes or bacteria.	B1PA ○ Yes ○ No ▶	B1PB	B1PC ○
Classical/traditional breeding Genetic improvement of animals or plants by breeding selected individuals.	B1QA ○ Yes ○ No ▶	B1QB	B1QC ○
Bioprocessing Production stages that include fermentation, recovery, and purification.	B1RA ○ Yes ○ No ▶	B1RB	B1RC ○
Bio sensing Use of a biological molecule e.g. enzymes, antibodies in conjunction with a transducer to low level detection of substances such as sugars and proteins in body fluids, pollutants in water etc.	B1SA ○ Yes ○ No ▶	B1SB	B1SC ○
Bio-bleaching Use of micro-organisms to bleach pulp.	B1TA ○ Yes ○ No ▶	B1TB	B1TC ○
Bio-leaching Use of micro-organisms to leach metals from ore.	B1UA ○ Yes ○ No ▶	B1UB	B1UC ○
Microbio-inoculants Naturally occuring bacterial inoculants used to promote plant growth.	B1VA ○ Yes ○ No ▶	B1VB	B1VC ○

If you do not use any of the biotechnologies listed above, please go to question C4, D3 and following.

Purposes for Using Biotechnologies – Continued

B1 For each item or biotechnology listed below, please indicate (√) which description best reflects its function within your business activities. – Continued

STAGE

Part of the production process	Part of the product sold	Pollution control system	Plan to use within next 2 years	No plans to use	
				No application	Not cost effective
B1ND ◯	B1NE ◯	BINF ◯			
			B1NG 1 ◯	2 ◯	3 ◯
B1OD ◯	B1OE ◯	B1OF ◯			
			B1OG 1 ◯	2 ◯	3 ◯
B1PD ◯	B1PE ◯	B1PF ◯			
			B1PG 1 ◯	2 ◯	3 ◯
B1QD ◯	B1QE ◯	B1QF ◯			
			B1QG 1 ◯	2 ◯	3 ◯
B1RD ◯	B1RE ◯	B1RF ◯			
			B1RG 1 ◯	2 ◯	3 ◯
B1SD ◯	B1SE ◯	B1SF ◯			
			B1SG 1 ◯	2 ◯	3 ◯
B1TD ◯	B1TE ◯	B1TF ◯			
			B1TG 1 ◯	2 ◯	3 ◯
B1UD ◯	B1UE ◯	B1UF ◯			
			B1UG 1 ◯	2 ◯	3 ◯
B1VD ◯	B1VE ◯	B1VF ◯			
			B1VG 1 ◯	2 ◯	3 ◯

Purposes for Using Biotechnologies - Continued

B2 Please indicate (√) the range that best reflects this plant's total capital investment in biotechnology equipment and software for 1996 or latest fiscal year available. Please **exclude** education and training but **include** plant modifications, construction, integration, and equipment and software purchased or developed.

Please Answer Separately for Each Functional Group.

Cost Category	Selection and/or Modification of Biological Material B2A	Culture and/or Use of Biological Material B2B	Environmental Biotechnologies B2C
Less than $100,000	1 ◯	1 ◯	1 ◯
$100,000 to less than $1 million	2 ◯	2 ◯	2 ◯
$1 million to less than $5 million	3 ◯	3 ◯	3 ◯
$5 million to less than $10 million	4 ◯	4 ◯	4 ◯
$10 million or more	5 ◯	5 ◯	5 ◯
Not applicable	6 ◯	6 ◯	6 ◯

Factors Affecting the Use of Biotechnologies

C1 Please indicate (√) any **positive factors** that have particular significance in the **decision** of your firm to use biotechnologies or biotechnology equipment.

Please Answer Separately for Each Functional Group.

Factors	Selection and/or Modification of Biological Material	Culture and/or Use of Biological Material	Environmental Biotechnologies
Lower production cost	C1A1 ◯	C1B1 ◯	C1C1 ◯
Internal familiarity with the technology	C1A2 ◯	C1B2 ◯	C1C2 ◯
Develop new products or processes	C1A3 ◯	C1B3 ◯	C1C3 ◯
Extend product range	C1A4 ◯	C1B4 ◯	C1C4 ◯
Acquire a better market position	C1A5 ◯	C1B5 ◯	C1C5 ◯
Increase production flexibility	C1A6 ◯	C1B6 ◯	C1C6 ◯
Lower maintenance expense	C1A7 ◯	C1B7 ◯	C1C7 ◯
Faster delivery time	C1A8 ◯	C1B8 ◯	C1C8 ◯
Other	C1A9 ◯	C1B9 ◯	C1C9 ◯

C2 Please indicate (√) any **difficulties** that had particular significance in **implementing** your biotechnology processes.

Please Answer Separately for Each Functional Group.

Difficulties	Selection and/or Modification of Biological Material	Culture and/or Use of Biological Material	Environmental Biotechnologies
Training	C2A1 ◯	C2B1 ◯	C2C1 ◯
Skill availability	C2A2 ◯	C2B2 ◯	C2C2 ◯
Adaptability to other technologies	C2A3 ◯	C2B3 ◯	C2C3 ◯
Adapting to norms and standards	C2A4 ◯	C2B4 ◯	C2C4 ◯
Need for advice and information	C2A5 ◯	C2B5 ◯	C2C5 ◯
Increased maintenance expense	C2A6 ◯	C2B6 ◯	C2C6 ◯
Insufficient market for product	C2A7 ◯	C2B7 ◯	C2C7 ◯
Lack of technical support from vendors	C2A8 ◯	C2B8 ◯	C2C8 ◯
Regulatory constraints	C2A9 ◯	C2B9 ◯	C2C9 ◯
Other	C2A10 ◯	C2B10 ◯	C2C10 ◯
There were no barriers	C2A11 ◯	C2B11 ◯	C2C11 ◯

C3 Please indicate (√) whether the adoption of biotechnologies and biotechnology equipment **led to** any of the following **results**.

Please Answer Separately for Each Functional Group.

Results	Selection and/or Modification of Biological Material	Culture and/or Use of Biological Material	Environmental Biotechnologies
An improvement in productivity	C3A1 ◯	C3B1 ◯	C3C1 ◯
Lower Production Costs by Reducing:			
Labour requirements	C3A2 ◯	C3B2 ◯	C3C2 ◯
Material consumption	C3A3 ◯	C3B3 ◯	C3C3 ◯
Energy consumption	C3A4 ◯	C3B4 ◯	C3C4 ◯
Product rejection rate	C3A5 ◯	C3B5 ◯	C3C5 ◯
Other Improvements:			
Improvement in product quality	C3A6 ◯	C3B6 ◯	C3C6 ◯
Greater product flexibility	C3A7 ◯	C3B7 ◯	C3C7 ◯
Improved working conditions	C3A8 ◯	C3B8 ◯	C3C8 ◯
Reduced environmental damage	C3A9 ◯	C3B9 ◯	C3C9 ◯
Reduced skill requirements	C3A10 ◯	C3B10 ◯	C3C10 ◯
Reduced capital investments	C3A11 ◯	C3B11 ◯	C3C11 ◯
Increased skill requirements	C3A12 ◯	C3B12 ◯	C3C12 ◯
Increased capital requirements	C3A13 ◯	C3B13 ◯	C3C13 ◯
Increased equipment utilization rate	C3A14 ◯	C3B14 ◯	C3C14 ◯
Lower inventory	C3A15 ◯	C3B15 ◯	C3C15 ◯
Other	C3A16 ◯	C3B16 ◯	C3C16 ◯
There were no improvements	C3A17 ◯	C3B17 ◯	C3C17 ◯

C4 Please indicate (√) which of the following factors have particular significance to your firm as **impediments** to biotechnology acquisition.

	Insignificant	Slightly insignificant	Moderately significant	Very significant	Crucial	Not applicable
Cost-Related Problems						
High cost of biotechnology equipment - (C41)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of equity capital for implementation of new biotechnology acquisition - (C42)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of financial justification - (C43)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Cost of training - (C44)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Increased maintenance expenses - (C45)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Insufficient market for product - (C46)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Government regulations/standards - (C47)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Availability of Inputs						
Lack of equity capital for investment in biotechnologies - (C48)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of outside capital for investment in biotechnologies - (C49)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Shortage of skills - (C410)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Training difficulties - (C411)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Organizational Problems						
Difficulties in introducing important changes to the organization - (C412)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Internal resistance to biotechnologies - (C413)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Worker resistance - (C414)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Other Problems						
Lack of scientific and technical information - (C415)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of technological services (e.g. technical and scientific consulting, tests, standards) - (C416)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of technical support from vendors - (C417)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Biotechnologies not sufficiently developed - (C418)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Lack of information about potential markets - (C419)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
Other - (C420)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
There were no impediments - (C421)	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯

Sources of Information

D1 Please indicate (√) your principal **internal** sources of information for the adoption of biotechnologies or biotechnology equipment.

Please Answer Separately for Each Functional Group.

Internal Source	Selection and/or Modification of Biological Material	Culture and/or Use of Biological Material	Environmental Biotechnologies
Research	D1A1 ◯	D1B1 ◯	D1C1 ◯
Experimental development	D1A2 ◯	D1B2 ◯	D1C2 ◯
Design work	D1A3 ◯	D1B3 ◯	D1C3 ◯
Production engineering	D1A4 ◯	D1B4 ◯	D1C4 ◯
Operating staff	D1A5 ◯	D1B5 ◯	D1C5 ◯
Management	D1A6 ◯	D1B6 ◯	D1C6 ◯
Corporate Head Office	D1A7 ◯	D1B7 ◯	D1C7 ◯
Other	D1A8 ◯	D1B8 ◯	D1C8 ◯

D2 Please indicate (√) your principal **external** sources of information for the adoption of biotechnologies or biotechnology equipment.

Please Answer Separately for Each Functional Group.

External Source	Selection and/or Modification of Biological Material	Culture and/or Use of Biological Material	Environmental Biotechnologies
A related firm (with same parent firm)	D2A1 ◯	D2B1 ◯	D2C1 ◯
An unrelated firm	D2A2 ◯	D2B2 ◯	D2C2 ◯
Federal research organizations	D2A3 ◯	D2B3 ◯	D2C3 ◯
Universities	D2A4 ◯	D2B4 ◯	D2C4 ◯
Provincial research organizations	D2A5 ◯	D2B5 ◯	D2C5 ◯
Federal information programs	D2A6 ◯	D2B6 ◯	D2C6 ◯
Research consortia	D2A7 ◯	D2B7 ◯	D2C7 ◯
Consultants and service firms	D2A8 ◯	D2B8 ◯	D2C8 ◯
Joint ventures and strategic alliances	D2A9 ◯	D2B9 ◯	D2C9 ◯
Publications	D2A10 ◯	D2B10 ◯	D2C10 ◯
Trade fairs, conferences	D2A11 ◯	D2B11 ◯	D2C11 ◯
Customer firms	D2A12 ◯	D2B12 ◯	D2C12 ◯
Supplier firms	D2A13 ◯	D2B13 ◯	D2C13 ◯
There was no significant external input	D2A14 ◯	D2B14 ◯	D2C14 ◯
Other	D2A15 ◯	D2B15 ◯	D2C15 ◯

Sources of Information - Continued

D3 How would you compare your production technology with that of your most significant competitors in Canada and outside of Canada?

Please Answer Separately for Each Functional Group.

		Much less advanced	Less advanced	About the same	More advanced	Much more advanced
Competitors						
Other Canadian producers	D3A	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯
Producers abroad	D3B	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯

D4 Did your firm engage in Research &Development activities in 1996? → 1 ◯ Yes 2 ◯ No

D5 Does your firm engage in R&D on a continuous or occasional basis? → 1 ◯ Continuous 2 ◯ Occasional

D6 Did your firm engaged, in the year 1996, in alliances for R&D purposes with other firms or organizations? → 1 ◯ Yes 2 ◯ No

D7 If yes, please check the type of organizations and country of partner.

	Canada	Abroad
Competitors	D71	D72
Suppliers	D73	D74
Clients	D75	D76
Consultants	D77	D78
Other firms within group	D79	D710
Other firms not listed above	D711	D712
Government	D713	D714
University	D715	D716
Research Institutes	D717	D718

Comments

NOTE : Should you have questions please contact your nearest Statistics Canada regional office.

	Local	Toll Free	FAX
Montréal	283-5724	1-800-363-6720	1-514-283-7969
Toronto	954-9072	1-800-565-2635	1-406-973-6524
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Thank you for your co-operation