Economic Profile of the Biotechnology Sector

Prepared for

The Canadian Biotechnology Advisory Committee Project Steering Committee Intellectual Property and the Patenting of Higher Life Forms

By

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March 31, 2000

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Table of Contents

Economic Profile of the Canadian Biotechnology Sector

Highlights

- Biotechnology uses living organisms, or parts of living organisms, to make new products or provide new methods of production.

- A wide array of industries use biotechnology processes in either production or research in Canada. Industries utilizing biotechnologies include:
  - Petroleum refining
  - Pharmaceuticals
  - Crude petroleum
  - Mining
  - Wood, pulp and paper
  - Food, drink and tobacco
  - Non-pharma chemicals

- The Canadian biotechnology industry consists of approximately 300 companies. One quarter of these companies are publicly traded.

- Biotechnology firms are located in all the regions of Canada, with the highest number located in Quebec, followed by Ontario and British Columbia.

- Three-quarters of Canadian biotechnology firms are concentrated in the health and/or the agri-food sector.

- The Canadian biotechnology industry generates about $1 billion in sales, $400 million in exports and 10,000 jobs.

- Biotechnology is a strong research-based sector with 1997 R&D expenditures of about $600 million.

- The biotechnology industry has a long development cycle of about 10 years. Many firms are not yet generating sales (and hence profits), making it difficult to attract investors.

- Venture capital provides a significant proportion of financing for biotechnology firms. Proportionately, Canadian firms are utilizing venture capital sources at a higher rate than the Americans.

- While equity markets are highly volatile, especially for technology-related stocks, biotechnology indices have performed as well as the more

traditional market exchange indices in Canada and the United States, including the TSE 300 and the Dow Jones Industrial.

- $ Countries and companies around the world are investing billions of dollars in research and development to produce new products and processes.

- $ As a key enabling technology for many areas of the Canadian economy, biotechnology can improve the quality and volume of products in the agriculture, fisheries and forest industries.

- $ Biotechnology also has application in many other areas of Canadian society. It can improve the quality of life by providing new medicines, new tools for health surveillance and diagnosis, new foods, and solutions to problems as significant as climate change.

- $ Biotechnology is one of the world's fastest growing industries; it is expanding 4 times faster than the average for the economy. Global demand is expected to reach $50 billion by 2005.

- $ About three quarters of world biotechnology demand will continue to be in the health sector with most of the remaining demand for biotechnology products to be in the agri-food sector.

- $ Within the health care segment, biopharmaceuticals shows considerable promise. Currently, biopharmaceuticals represents 5% of world prescription drug sales. It is expected that by 2005, this percentage will have risen to 15%.

- $ Agri-foods is also expected to show strong growth, especially in veterinary drugs and vaccines, followed by transgenic produce, plant diagnostics and animal feed.

- $ Canada has strengths to build upon in both the health and agri-food areas.

Economic Profile of the Canadian Biotechnology Sector:

I. Background

Statistical Sources

This report provides an economic profile of the Canadian biotechnology sector. The Canadian data is based on information prepared by Statistics Canada on:

- The extent Canadian industries utilize biotechnologies in their production processes.
- Specific tombstone data from 300 biotechnology companies, which are considered to be representative of the Canadian industry.

The venture capital data is based on the work of Macdonald and Associates. The equity market indices are based on data published by Globe Investor, a division of The Globe and Mail.

In March 1999, Statistics Canada published the report, *Canadian Biotechnology Statistics*. This report provided an overview of the biotechnology industry based upon the following sources:

- Arundel, Anthony, 1999, *Diffusion of Biotechnology in Canada: Results from the Survey of Biotechnology Use in Canadian Industries* – 1996. Science and Technology Redesign Project, Ottawa: Statistics Canada Catalogue # 88F-0017-MPB No. 6.
- Groote, J. P. Hough and R. Walter, 1999, *Canadian Biotechnoloy'98: Success from Excellence*, BIOTECanada's First Report on the Canadian Biotechnology Industry.
- Rose, Antoine, 1998, *Biotechnology Use by Canadian Industry – 1996*, Statistics Canada - 1996. Science and Technology Redesign Project, Ottawa: Statistics Canada Catalogue # ST-998-05
- Statistics Canada, 1997, *Biotechnology Research and Development in Canadian Industry*. Science Statistics 21(11), Statistics Canada Catalogue # 88-001-XPB.
- Statistics Canada, 1998, *Biotechnology Scientific Ac-*

tivities in Selected Activities in Selected Federal Government Departments and Agencies 1997-98. Science Statistics 22(4), Statistics Canada Catalogue # 88-001-XPB.

- Statistics Canada, 1998, *Biotechnology Firm Survey*, Data Release, The Daily, August 19, 1998.

The reports by Arundel and Rose were based upon data from a survey for 1996 of biotechnology use or diffusion amongst 2000 firms in Canada. This survey is referred to as the *Biotechnology Use Survey* in this report.

The *Biotechnology Firm Survey* released August 19, 1998 was a survey of tombstone data based on 1997 for 300 core biotechnology companies. The firm survey reported on sales, exports, R&D, employment, capital raised, and regional distribution. This survey is reported as the *Biotechnology Firm Survey* in this report.

The international data on the biotechnology industry in the United States and Europe has been sourced from the following Ernst and Young's reports:

- *Biotech '99: Bridging the Gap*, 13Th Biotechnology Industry Annual Report.
- *European Life Sciences '99*: 6Th Annual Report – *Communicating Value.*

What is Biotechnology?

Biotechnology is an umbrella term that covers a broad spectrum of scientific tools and techniques, ranging from traditional uses of living organisms such as yeast in bread to more advanced techniques such as genetic engineering. It incorporates a number of enabling technologies, which are used by firms when conducting their research and development and manufacturing activities.

Biotechnology is defined as the application of science and engineering in the direct or indirect use of living organisms or parts of organisms in their natural or modified forms in an innovative manner in the production of goods and services or to improve existing processes. [1]

The Canadian biotechnology industry is growing rapidly and is dominated by small and medium-

1. Statistics Canada, *Canadian Biotechnology Statistics*, Science and Technology Redesign Project, March 1999.

sized companies. Compared to other industries, the time frame and costs from basic research to commercialization are extremely long and expensive due to the highly complex and innovative products and processes and the resulting requirements to ensure product safety and efficacy. The industry is evolving from an almost exclusive focus on R&D to work in clinical trials/field testing, manufacturing and marketing.

As a key enabling technology, biotechnology can improve the quality and volume of products in the agriculture, fisheries and forest industries. Biotechnology has application in many areas of Canadian society. Biotechnology improves the quality of life as it provides new medicines, new tools for health surveillance and diagnosis, new foods, and solutions to problems as significant as climate change.

Biotechnology Use by Canadian Industry

Statistics Canada's *Biotechnology Use Survey* measured the diffusion of biotechnology by a wide range of firms in the Canadian economy for 1996. Over 2000 firms were surveyed, of which 14% indicated that they used at least one form of biotechnology in their production process and or research or development program.

Biotechnologies were employed primarily to establish a better market position for products or for the development of new products or processes.

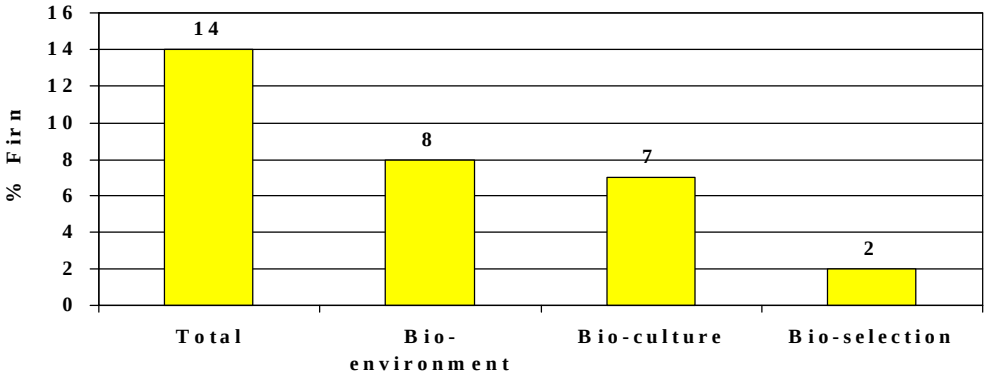
The adoption of biotechnologies generally resulted in *improved quality, greater production flexibility, improved productivity, a lower product rejection rate and reduced environmental damage.* [2]

Figure 1 shows the percentage of firms using various types of biotechnologies. The most significant biotechnology used was bio-environment technologies (8%), followed by bio-culture technologies (7%) and bio-selection (2%). (The percentages exceed 14% as some firms employ more than one biotechnology.)

Figure 2 identifies the percentage distribution of those firms using biotechnology, by sector. Petroleum refining and pharmaceuticals were the largest users of biotechnology.

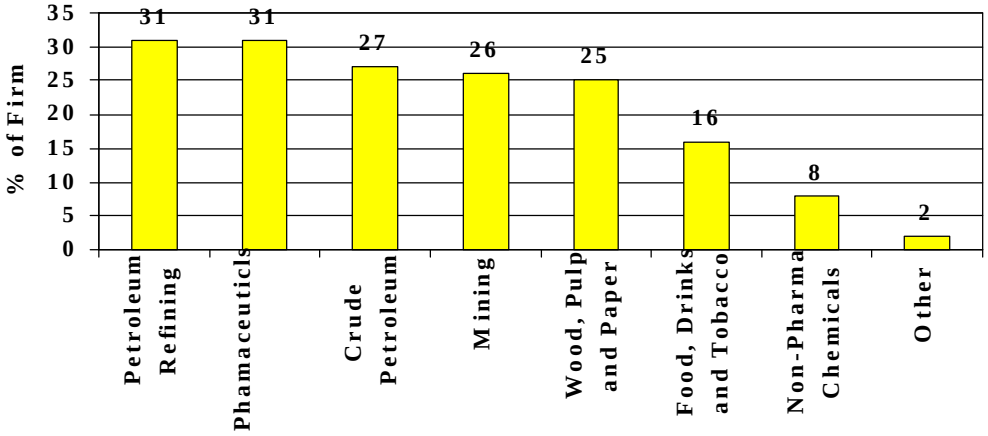
2. Rose, Antoine, 1998, *Biotechnology Use by Canadian Industry – 1996,* Statistics Canada - 1996. Catalogue # ST-998-05.

Figure 1: Percentage of Firms Using Biotechnologies, 1996



Source: Statistics Canada, *Canadian Biotechnology Statistics*, 1999

Figure 2: Percentage of Firms Using Biotechnology, 1996 by Sector



Source: Statistics Canada, *Canadian Biotechnology Statistics*, 1999

Opportunities and Challenges

A variety of genetically modified crops are now being produced in Canada. By the end of 1999, Canadian regulatory authorities had approved 42 genetic modifications to food crops, textile crops and animal feeds. Genetically modifications have occurred for cheese, corn, soybeans, canola, tomatoes, potatoes, tobacco, squash, melons, sugar beets, flax and milk. [3]

The types of genetic modifications include herbicides, viral resistance, insect resistance and increased shelf life.

Foods are being developed or are awaiting regulatory approval, which will provide additional nutrients or deliver vaccines when ingested. For example, rice can be produced with increased vitamin A and iron content. Potatoes can be genetically modified to provide hepatitis B vaccine and tobacco plants can produce proteins to be used to treat diabetes.

Genetically modified crops are the subject of considerable debate by proponents and opponents of the technique. Those in favor of genetically modified crops argue that the technique helps farmers by increasing yields and quality of crops as well as reducing the need for fertilizers, herbicides, pesticides and water usage. It is also argued that genetically modified crops improve health levels through improved nutrients and a more efficient delivery mechanism for vaccines.

Critics argue that genetically modified crops benefit multinational enterprises when they gain market share and control of the modified seeds. Critics also argue that the longer-term impacts of genetically modified crops are unknown and increased usage may result in undesirable hybrids being produced.

In additions to the potential rewards and risks associated with genetically modified crops, a number of genetically based interventions in humans are raising a number of scientific, economic and social concerns.

Examples include stem cell research and therapy, cloning and xenotransplantation, which is the transplantation of cells, tissues or organs from one species to another.

3. Canadian Biotechnology Advisory Committee, *Program Plan 2000*, February 21, 2000.

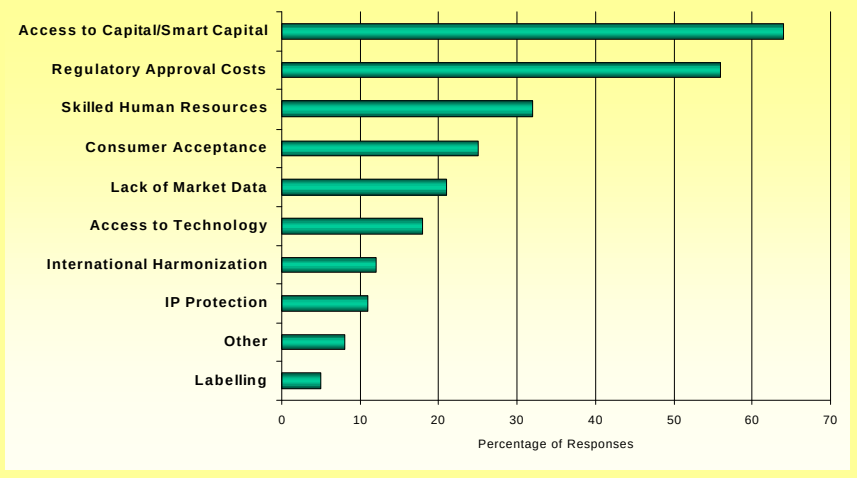
Heart valves from pigs have been used in humans for some time. Animal organs may be used to keep a patient alive until a suitable donor organ is found.

The *Biotechnology Firm Survey* asked firms to identify hurdles or barriers that needed to be overcome during the product development cycle.

Figure 3 shows the hurdles to commercialization that were raised by respondents to the *Biotechnology Firm Survey*. Access to capital was considered to be the most substantial hurdle. The cost and time needed to obtain regulatory approval was also identified as a serious hurdle to overcome. Other significant barriers to commercialization were: skilled human resources; consumer acceptance; lack of market information; access to technology; and, international harmonization.

While both consumer acceptance and labeling were included in the list of commercial hurdles, the responses identifying these areas were smaller than one might expect given the consumer concern over genetically engineered products. Consumer acceptance was identified as a hurdle by 25% of respondents and labeling by only 5%.

Figure 3: Hurdles to Commercialization



Source: BIOTECanada, *Canadian Biotechnology'98, Success from Excellence*, 1999.

The regulatory system is an important determinant of competitiveness for the Canadian biotechnology sector and for maintaining a reputation of product safety. Resources are required to ensure expeditious approval times, since delays can have a significant impact on company profitability. Resources are also required to ensure scientific parity within this fast-moving industry and to provide information to the public on how the system functions.

Regulatory policies, ideally, should reflect Canadian values, support the growth of the biotechnology industry in an ethical manner and maximize the benefits to Canadians.

The increasing number and complexity of commercial biotechnology products will continue to place strains on regulatory authorities.

II. Industry Performance

Key Industry Data

The Canadian biotechnology sector consists of about 300 biotechnology firms, one quarter of which are publicly traded.

Small, entrepreneurial companies represent the mainstay of the industry. Québec has the largest number of companies, followed by Ontario and British Columbia. Three quarters of these companies are concentrated in the health or agri-food sectors.

In addition, industries such as pharmaceutical and agri-food are increasingly focusing on gene-based research to develop new products. Other resource-based industries such as forestry and fisheries are also beginning to utilize biotechnology to improve their productivity, product quality and sustainability.

Figures 4 and 5 provide information on key industry data by company size and by sector.

There are approximately 300 firms in Canada, employing almost 10,000 people (with 2,000 unfilled jobs) and generating $1 billion in sales, of which 40% are exported.

The predominant number of firms was either small or medium sized. Seventy-two percent had 50 employees or less. Fifteen percent had between 51 and 150 employees. Thirteen percent had 151 employees or more.

Figure 4: Key Industry Data by Company Size, 1997 ($ Millions)

	Small (1-50)	Medium (51-150)	Large (151+)	Total
No. of Firms	204	43	35	282
Biotech Sales	$183	$137	$698	$1,017
Other Revenue	$49	$47	$23	$119
Biotech Revenue	$231	$183	$721	$1,135
R&D	$192	$153	$240	$585
Exports	$95	$43	$275	$413
Employees	3,125	2,397	4,302	9,823
Unfilled Positions	1,031	281	587	1,899
Total Positions	4,155	2,678	4,890	11,723

Source: BIOTECanada, *Canadian Biotechnology'98, Success from Excellence*, 1999.

Figure 5: Key Industry Data by Sector, 1997 Per Cent)

	Companies %	Biotech Sales %	R&D %	Exports %
Health Care	46	50	87	58
Agriculture	22	23	5	21
Environment	11	3	1	1
Food Processing	7	21	2	18
Aquaculture	4	1	0	1
Bio-Informatics	3	0	2	0
Other	7	2	3	1
Total	100	100	100	100

Source: BIOTECanada, *Canadian Biotechnology'98, Success from Excellence*, 1999

Revenues

The Canadian biotechnology industry's overall revenues exceeded one billion dollars in 1997 of which 90 percent came from biotechnology sales. The health and agri-food sectors accounted for almost 95 percent of Canadian biotechnology sales (other sources of revenue include royalties, investment income and contract research).

The majority of biotechnology firms are not yet generating sales. They are still developing products and conducting R&D. Therefore, gauging the size of the biotechnology industry on the basis of revenues alone, understates its true potential.

Exports

The Canadian biotechnology industry has grown tremendously in recent years and exports of Canadian biotechnology products have almost doubled from 1993 to 1997.

Out of a total of $1.0 billion in sales of biotechnology products in 1997, $413 million (37 percent) were generated by exports, which were primarily agri-food (58 percent) and health care (39 percent) related products. In the agri-food sector, genetically modified canola, soybeans and corn made up the bulk of exported products, and in health care, it was vaccines, diagnostics and contract research services.

Canada is emerging as a major player in the biotechnology field, along with the United States, Germany and Japan.

Foreign Investment in Canada

While venture capital and other financial sources are vital to the growth and development of biotechnology small and medium sized enterprises (SMEs), a viable and sustainable sector also requires the participation of well-funded multinational companies to invest in clinical trials, take equity positions or develop various types of R&D or market alliances with Canadian biotechnology companies.

Canadian companies need to be able to invest in basic research in institutions; build research facilities; or build or expand mandates in Canadian subsidiaries for product development and manufacturing. Past performance indicates that the health and agricultural biotechnology sectors are those most likely to attract foreign investment. Potential receptor ca-

pacity for Canadian biotechnology expertise is also seen in Canada's resource industries where biotechnology can be used to develop more environmentally friendly processes.

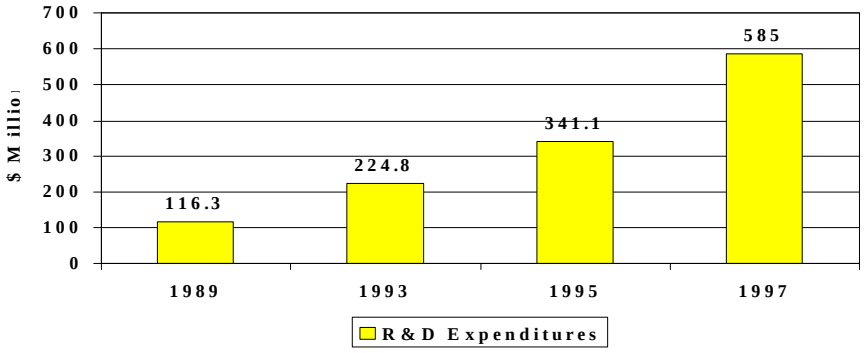
Research and Development

Biotechnology is a research-based industry. Almost 95 percent of the industry's firms conduct biotechnology research. Overall R&D expenditures are in the $600 million range (90% in the health sector). Figure 6 shows R&D expenditures for 1989, 1993 1995 and 1997. The growth in R&D expenditures has been strong, especially in health and services.

Over half of the firms are using state of the art technologies such as DNA-based technologies, bioinformatics, genomics and molecular modeling.

About 10 percent of the government's research budget is devoted to biotechnology. In FY 1997-98, the Federal Government spent $314 million on biotechnology research and development. The largest players were the Medical Research Council ($104 million), Natural Sciences and Engineering Research Council ($90 million), the National Research Council ($60 million) and Agriculture and Agri-Food Canada ($40 million). [4]

Figure 6: Biotechnology R&D Expenditures, by Sector, 1989-97



Source: Statistics Canada, *Canadian Biotechnology Statistics*, 1999

4. Statistics Canada, *Canadian Biotechnology Statistics*, Science and Technology Redesign Project, March 1999.

Human Resources

Biotechnology jobs are highly skilled with high wages. Three hundred companies employ 10,000 people. Another two thousand positions could not be filled. Industry employment is expected to continue to grow at ten percent per year.

One of the major hurdles to growing the Canadian biotechnology sector is the human resources and skills gap. The Paget Report, published in 1996, highlighted coming shortages of skilled business managers and regulatory affairs specialists and predicted shortages in several technical disciplines (e.g. genomics and bioinformatics) as well. [5]

The science underpinning the industry is evolving rapidly. For example, in the 1980's, most human health diagnostics were based on antibody technology and they are now based primarily on gene technology. In addition, the industry itself is evolving from an almost exclusive focus on R&D to clinical trials/field testing, manufacturing and marketing which demands new and different skill sets. The areas of application are expanding rapidly from primarily health to agri-food, environment, forestry, aquaculture, mining and energy.

The skills and knowledge required are changing and expected to continue to evolve. Industry leaders have identified the lack of senior skilled managers with an understanding of science, marketing, financing and regulatory systems.

About one fifth of potential employment in the industry goes unfilled because of problems experienced in recruiting the right skill sets (e.g., scientific, R&D, technical, regulatory, clinical, finance, and marketing skills) at a senior management level. Many of the unfilled positions require multi-disciplinary backgrounds, combining two or more of these skills.

Many biotechnology companies are concentrating more on human resource issues as financing (their initial priority) becomes available. As companies expand, they need to build the human resource infrastructure required to move them along their growth path. People with experience in

5. Paget Consulting Group Inc, *Canadian Human Resources Study in Biotechnology*, prepared for Human Resources Development Canada (HRDC), May 1996.

conducting critical trials, regulatory affairs, marketing, and distribution systems are needed. Attracting quality human resource capital is as important to a company's success as is the availability of financing.

When financial institutions invest in a biotechnology company, in addition to the quality of its technology, they are interested in the quality of the human resource infrastructure as well as its management practices expertise. Management practices are critically important to a company's success. People that are able to develop and work with a business plan and make good strategic decisions are especially needed. Failure is more likely to be caused by poor decision-making than by technology-related factors. [6]

The best and the brightest people are always in strong demand. These talented performers need to be involved in making important company decisions and need to work in a nurturing and rewarding environment.

Given the strong growth of the biotechnology industry in the United States, Canadians firms must offer workers similar monetary and other incentives as American firms if they are to keep them. A large influx of highly skilled Canadian workers moving to the United States would have serious consequences on the biotechnology industry in Canada.

III. Firm Location and Regional Dynamics

Biotechnology companies are located in all of Canada's regions. Quebec, Ontario and British Columbia have strong expertise in health care. Saskatchewan's expertise is in agriculture biotechnology. Atlantic Canada's biotechnology expertise is in aquaculture, forestry and biodiversity.

Québec has the largest number of companies (31%), followed by Ontario (25%) and British Columbia (20%). Manitoba, Saskatchewan and Alberta have 18% and the Atlantic region has the remaining 6% of the biotechnology firms.

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6. Biotechnology Human Resource Council, *The Biotech HR Pulse*, Vol. 1, Issue 20, April 6, 2000.

Figure 7: Key Industry Data by Region, 1997 (Per Cent)

	Companies %	Biotech Sales %	R&D %	Exports %
Quebec	31	34	24	25
Ontario	25	36	42	42
British Columbia	20	4	18	9
Saskatchewan	8	9	4	0
Alberta	7	9	8	19
Nfld., NB, PEI	3	0	0	1
Nova Scotia	3	2	2	3
Manitoba	3	6	2	1
Total	100	100	100	100

Source: BIOTECanada, *Canadian Biotechnology'98, Success from Excellence*, 1999

IV. Financial Markets

Access to Capital

The most obvious barometer of how well the industry is doing is to look at how the capital markets are judging it. [7]

The Canadian biotechnology industry is composed primarily of small, early-stage companies involved in a rapidly growing, capital and research-intensive industry where the development cycle is ten years or more. As a result, many firms are not yet generating sales.

Canadian biotechnology companies are reliant on sources of capital, beyond the ordinary revenue streams created by product sales and retained earnings.

The reliance on capital markets and the cash squeeze situation facing most biotechnology companies in Canada encourages them to sell their intellectual property early and let large, established companies do the development.

7. Ernst and Young, *European Life Sciences '99*: 6Th Annual Report C*ommunicating Value.*

The main problem for biotechnology companies is that potential investors, especially in an uncertain and volatile market environment are more likely to support high tech companies with stronger shorter-term cash flow and profitability expectations. Biotechnology companies must endure a long and expensive development cycle before becoming profitable.

The *Biotechnology Firm Survey* found that 37% of respondents raised capital in 1997. Fifty-six percent of firms expected to raise capital in 1998.

The potential sources of capital included:

- Private Placement
- Venture Capital
- Angels/Friends
- Strategic Alliance Partners
- Secondary Public Offering
- Initial Public Offering

In 1997, $280 million was raised. In 1998, firms expected to raise $631 million. Figure 8 shows that in 1997, 62% of the firms raising capital used it for R&D projects; 17% was for process scale-up; 7% for regulatory process; and, 14% for other areas.

On a sector basis, Figure 9 shows that three-quarters of the capital raised in 1997 was used for bio-health projects; 13% was used for agri-bio projects.

Figure 8: Capital Utilization, by Firm, 1997

Purpose for Capital	Raised Capital %
R&D	62
Process Scale-up	17
Regulatory Process	7
Other	14
Total	100

Source: Statistics Canada, *Canadian Biotechnology Statistics*, 1999

Figure 9: Raising capital for 1997, by Sector

Sector	Raised Capital %
Agri-Bio	13.2
Aquaculture	1.4
Environment	0.4
Food Processing	1.8
Human Health - Bio	75.7
Other	7.5
Total	100.0

Source: Statistics Canada, *Canadian Biotechnology Statistics*, 1999

In 1998, about $600 million was disbursed to the biotechnology industry in Canada (based on expectations from the biotechnology firm survey). Venture capital accounted for a large share of the total capital acquired.

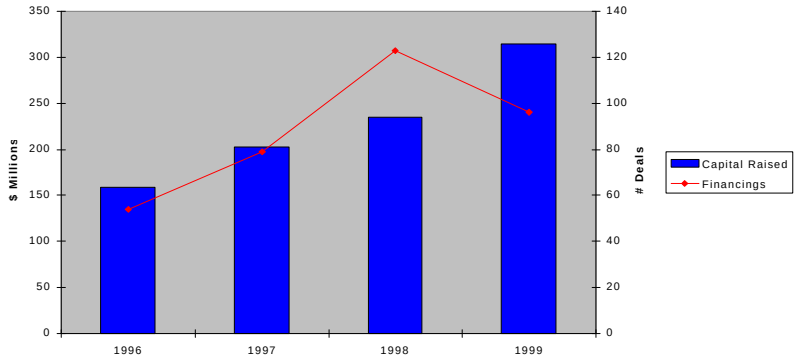
As venture capital disbursements increased by about one-third in 1999, it is likely that total disbursements increased by roughly the same proportion, which would put the 1999 amount raised to approximately $800 million.

Venture Capital

The biotechnology survey reported that private placement and venture capital were the most likely venue for firms to raise capital. In 1997, 37% of firms raised capital through private placements and 24% used the venture capital route to raise funds.

Overall, the Canadian venture capital industry had a very strong performance in 1999.

Figure 10: Canadian Biotechnology Venture Capital Investment, 1996 to 1999



Source: Macdonald & Associates Ltd ,*Venture Capital and Life Sciences*, 1999, March, 2000

A total of $2.7 billion of capital was raised, of which $315 million or 12% was disbursed to the biotechnology industry (Figure 10).

While venture capital investments rose in 1999, a higher proportion of the funds are flowing to a smaller pool of companies, which suggests that biotechnology entrepreneurs are maturing and becoming more sophisticated.

The average biotechnology deal in 1999 was $3.3 million compared to $1.9 million in 1998. In 1999, biotechnology disbursements rose by 34% while the number of deals or investments dropped by 22%.

Over 80% of the biotechnology disbursements in 1999 were for medical biotechnology projects, mostly in Ontario, British Columbia and Quebec, which received the largest share of total projects (Figure 11).

While biotechnology venture capital disbursements have grown significantly over the past few years, large transactions in communication, Internet and other information technologies have outpaced biotechnology transactions. Biotechnology's share of total venture capital disbursements dropped from 14% in 1998 to 12% in 1999.

Canadian biotechnology disbursements, however, are outpacing that of the United States on a relative basis. In 1999, after currency exchange rates are accounted for, Canada's biotechnology disbursements were 16% of the amount invested in this industry by Americans. For the overall life sciences industry, this proportion was 9% in 1999.

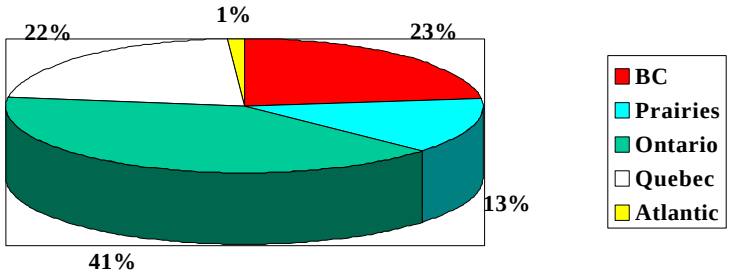
In the United States, only 30% of life sciences capital disbursements flowed to biotechnology companies in 1999 compared to 66% in Canada.

Initial Public Offerings

Initial Public Offerings (IPOs) are not often used by smaller firms to raise capital. The *Biotechnology Firm Survey* reported that in 1997, only 1% of firms raised capital through IPOs. Larger corporations are more likely to raise capital through IPOs. Figure 12 shows the number of IPOs and dollar amounts for the biotechnology industry for 1997, 1998 and 1999.

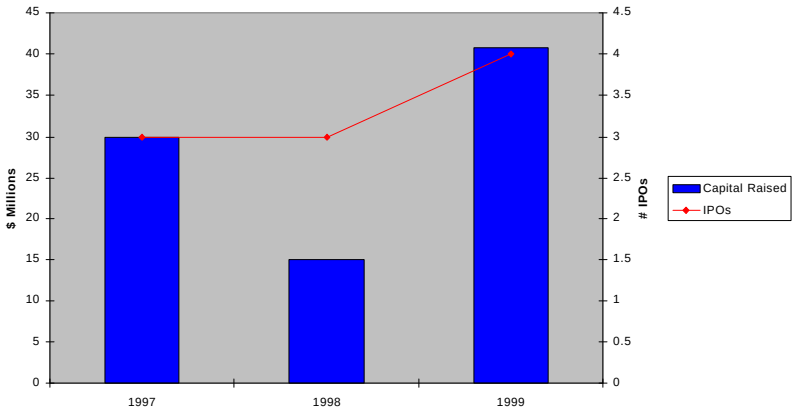
In 1999, $40.8 million in biotechnology-related capital was raised by IPOs compared to $15.0 million in 1998 and $29.9 million in 1997.

Figure 11: Biotechnology Venture Capital Invested by Region, 1999



Source: Macdonald & Associates Ltd ,*Venture Capital and Life Sciences*, 1999, March, 2000

Figure 12: Canadian Biotechnology Initial Public Offerings (IPOs)



Source: Industry Canada based on data from SEDAR

Equity Markets

Ernst and Young report that while the biotechnology industry is gaining in real value, particularly in health care, public equity markets are often unwilling to invest heavily in this area. [8]

The problem is that there are very long lead times before biotechnology projects are successful in commercial markets and expenses, particularly for R&D, are very high.

The biotechnology industry must obtain regulatory approvals before its products can be sold to the public.

Biotechnology profits have not been high enough to compensate investors for the high risks and long lead times.

Figure 13 provides historical data for various market indices for both the Toronto Stock Exchange (TSE) and the NASDAQ from 1996 to March 31, 2000.

8. Ernst and Young, *Biotech 99: Bridging the Gap*, 13Th Biotechnology Annual Review.

Both the TSE and the NASDAQ biotechnology indices rose considerably to early March 2000, and then declined sharply.

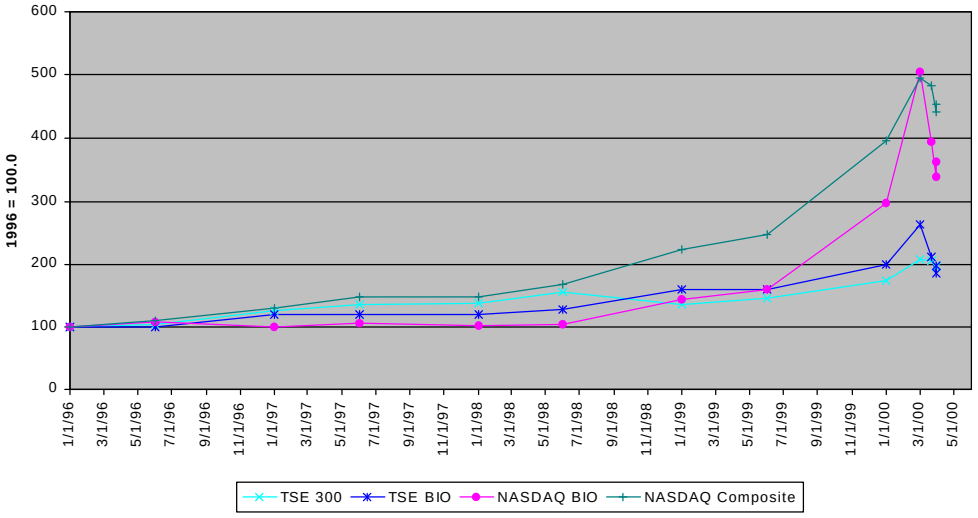
Figure 14 shows the market growth rates for various equity indices from 1996 to March 31, 2000 from the TSE, NASDAQ and the Dow Jones.

The strongest performers have been the NASDAQ computer index and the TSE technology hardware index, which grew by 675% and 614% respectively since 1996.

The companies and financial data, which are included in the TSE biotechnology index, are outlined in Annex A. The TSE biotechnology index has grown by 198% since 1996, a rate slightly lower than the TSE 300.

The NASDAQ biotechnology index has grown by 362%, which is below that of the NASDAQ composite index, but greater than the Dow Jones industrial or the S&P 500.

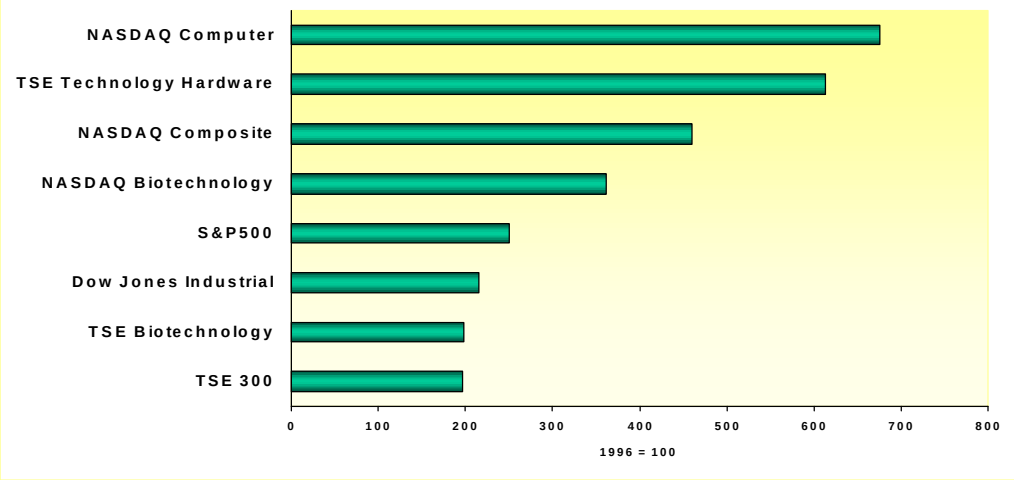
Figure 13: TSE and NASDAQ Biotechnology and Other Market Indices, Semi-Annually, 1996 to 2000, 1996 = 100.0



The period covered is January 2, 1996 to March 31, 2000. Source: Globe Investor.Com.

Figure 14: Growth in TSE and NASDAQ Market Indices, 1996 to 2000

(January 2, 1996 = 100.0)



The period covered is January 2, 1996 to March 31, 2000. Source: Globe Investor.Com.

V. Global Context

Canadian firms have a small, but growing share of the global biotechnology market. Other major players are mainly in the United States, Europe and Japan.

It is difficult to make definitive comparisons between the size and magnitude of the Canadian industry to that in the United States and Europe due to definitional and methodological differences between countries. However, reports by Ernst and Young on the biotechnology industry in the United States and Europe provide order of magnitude comparisons.

A brief discussion on the biotechnology industry in the United States and Europe follows.

<u>United States Biotechnology Industry</u>

In the United States, Ernst and Young report that the biotechnology industry generates $27.6 billion in revenues, $14.7 billion in R&D and employs 153,000 people. [9]

9. Ernst and Young, *Biotech 99: Bridging the Gap*, 13Th Biotechnology Annual Review

The industry is relying more on venture capital and private sources of capital in order to finance growth than traditional equity markets. In 1999, venture capital accounted for 24% of total equity financings compared to only 9% in 1997. Similarly, private placements increased from 27% to 40% in the same period .[10] (See Figure 15.)

European Biotechnology Industry

Ernst and Young report that in 1998, 46,000 people worked in biotechnology industries in Europe, which represented a 17% growth rate from 1997.[11] (See Figure 16.)

Germany and the United Kingdom, both have significant biotechnology industries. There are an estimated 300 firms in each country.

Figure 15: The U.S. Biotechnology Industry

	1999 $ Canadian, Billions	1998 $ Canadian, Billions	Percent Change
Revenue	27.6	23.7	14
R&D	14.7	12.6	14
Net Income (Loss)	(7.6)	(5.0)	34
Market Capitalization	144.1	137.9	4
Employees	153,000	140,000	8

Source: Ernst & Young, Biotech 99: *Bridging the Gap, 13th Biotechnology Industry Annual Report*

10. Ernst and Young, *Biotech 99: Bridging the Gap*, 13Th Biotechnology Annual Review.

11. Ernst and Young, *European Life Sciences '99*: 6Th Annual Report C*ommunicating Value.*

In addition to Germany and the United Kingdom, France, Italy, the Netherlands, Sweden and Belgium have significant biotechnology capabilities. [12]

Germany's biotechnology industry has grown by 150% in 3 years. The industry in Germany, however, is still at an early stage with a number of companies being involved with just one technology.

Until recently, Germany had very tough laws regulating genetic engineering, which inhibited growth. With government support, a number of start-up companies have been formed. These companies, however, are generally at earlier stages of development than the Americans.

The social climate for biotechnology is changing in Europe. The European Commission and Germany are building infrastructure to support the development of a continental biotechnology industry.

Figure 16: European Biotechnology Industry

	1998 $ Canadian, Billions	1997 $ Canadian, Billions	Percent Change
Turnover (Revenues minus intermediate inputs)	6.2	4.3	31
R&D	3.9	3.0	23
Net Income (Loss)	(3.5)	(3.2)	10
Employees	45,823	39,045	17

Source: Ernst & Young, *European Life Sciences 99, Sixth Annual Report*

Industry Prospects

Biotechnology is one of the world's fasted growing industries. It is expanding 4 times faster than the average for the economy. Global demand is expected to reach $50 billion by 2005. [13]

About three quarters of world biotechnology demand will continue to be in the health sector with most of the remaining demand for biotechnology products in the agri-food sector.

Within the health care segment, biopharmaceuticals shows considerable promise. This key area has developed medicines, vaccines and other health related devices, which are helping to eradicate many diseases and to improve life expectancy.

Agri-foods is also expected to show strong growth, especially in veterinary drugs and vaccines, followed by transgenic produce, plant diagnostics and animal feed.

Industrial enzymes are another important growth industry. About 50% of industrial enzymes are manufactured through genetic engineering processes. Critical applications in the industrial enzymes area are detergents, textiles, mineral leaching, pulp and paper processing and mill effluent treatments.

Aquaculture may play a critical role over the next 25 years in helping to feed the world as the wild fish stocks diminish. The World Food and Agriculture Organization have estimated that by 2025 the annual demand for seafood will exceed the capacity of the wild fishery by 55 million tonnes. This shortfall would have to be met through fish farming operations, where biotechnology is emerging as a major enabling technology. [14]

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12. The Globe and Mail, April 18 2000, *Germany grabs top ranking in Europe's biotech industry*.

13. Human Resources Development Canada, *The Biotechnology Industry in Canada*, 1998.

14. Ibid.

Annex A: TSE Biotechnology / Pharmaceuticals Index Companies and Key Data

Company	Date of Balance Sheet	Revenues ($000)	Market Capitalization ($000)	Assets ($000)	Employees #
Angiotech Pharmaceuticals	30-Sept/99	4,454	558,000	35,364	35
BioChem Pharma	31-Dec/98	347,601	3,313,000	629,990	1,000
Biomira Inc.	31-Dec./98	5,965	382,000	63,486	263
Biovail	31-Dec/99	179,316	4,232,000	635,137	715
Canadian Medical Laboratories	30-Sept./99	130,361	367,000	229,768	1,200
MDS Inc.	31-Oct./99	1,198,200	2,288,000	1,279,200	8,467
Patheon Inc.	31-Oct./99	127,395	344,000	160,364	1,037
Phoenix Int'l Life Sciences	31-Aug./99	262,800	427,000	389,200	2,200
QLT Phototherapy	31-Dec./98	7,575	5,224,000	103,223	209
TLC Laser Eye Cenres	31-May/99	149,007	425,000	286,850	745

Source: Globeinvestor.com and Contact Canada, Canadian Biotechnology, 1999 Directory