

Science-Matrix

Biotechnology in Canada

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Benchmarking of Canadian
Biotechnology Patents at the National
and International Levels, 1990-2003

Prepared for the
Canadian Biotechnology Secretariat

Science-Metrix

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Executive Summary

- Between 1990 and 2003, the number of patents granted by the United States Patent and Trademark Office (USPTO) in the field of biotechnology grew by almost fourfold, increasing from 1,995 to 6,839 patents.
- Overall, Canada, together with the UK, ranks fourth in biotechnology at the world level. Canadian inventors are wholly or partly responsible for 2,579 inventions in biotechnology.
- Close to 2,100 patents in biotechnology are wholly or partly owned by Canada, and 88% of these patents are owned by institutions. The net outflow of intellectual property from Canadian to foreign owners is about 8% ((fraction of intellectual property owned by Canada – fraction of inventions by Canada)/fraction of inventions by Canada).
- Canada specializes in the environment, human health and agricultural biotechnology.
- Canada has an opportunity to develop its leadership in the field of human health considering that it has a greater proportion of patents than the world average, that the growth rate at the world level is high and that it is higher still in Canada.
- Canada has a greater proportion of patents than the world average in environmental biotechnology. This area therefore represents a niche opportunity for Canada.
- Although Ontario and Quebec hold considerably more patents than other Canadian provinces do; Alberta performs better than Ontario, and Saskatchewan better than Quebec, when population, specialization in biotechnology and citations per patent are factored in.
- Alberta and Saskatchewan are both strong in human health.
- Ontario is strong in food processing and in testing and measurement.
- Quebec and British Columbia's biggest strength in biotechnology lies in enabling compositions, compounds, cells and molecules.
- Toronto is clearly the leading Canadian Census Metropolitan Area (CMA) in terms of the absolute number of patents and is followed by Montreal, Vancouver, Ottawa–Hull, Edmonton, Calgary and Saskatoon. Each of these CMAs has more than 100 inventions in biotechnology.
- When population is factored in, the Saskatoon CMA is the clear leader in biotechnology, followed by Edmonton and Ottawa-Hull, both of which have about half as many inventions per capita as Saskatoon does. Toronto ranks 4th, Calgary 5th, Victoria 6th, Vancouver 7th, Montreal 8th and Sherbrooke 9th.
- There are about 364 Canadian institutions with at least one patent in biotechnology.
- Twenty-four leading institutions were granted at least one patent a year on average. These institutions own about 60% of the Canadian IP held by biotechnology institutions. Eleven of these institutions are from the university sector, 8 are corporations, 3 are from the government or non-government sectors, and two are from the hospital sector.
- Leading companies come mainly from the pharmaceutical sector (e.g. Aventis, NPS, Merck Frosst).
- The leading universities are McGill University, the University of British Columbia, the University of Saskatchewan and Queen's University.
- The leading government departments or agencies are NRC and Agriculture and Agri-Food Canada.

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Methods

Patents are widely used to compute statistics despite several well-known disadvantages associated with their use:

- incompleteness: many inventions are not patented since patenting is only one way of protecting an invention;
- inconsistency in quality: the importance and value of patented inventions vary considerably;
- inconsistency across industries and fields: industries and fields vary considerably in their propensity to patent inventions;
- inconsistency across countries: inventors from different countries have a different propensity to patent inventions, and countries have different patent laws.

Despite these disadvantages, inventions are widely used to compare the level of technological development of different geographic locations. This report uses the United States Patents and Trademark Office (USPTO) database. Its data are widely used to measure invention since the USPTO is one of the largest repositories of patented inventions in the world. Because the USA is the largest market in the world, the most important inventions tend to be patented there. Although the USPTO database presents an obvious bias towards the USA, it is a potent tool for comparing other countries.

The delineation of the field of biotechnology was performed iteratively. Firstly, keywords extracted from the *Biotechnology Use and Development Survey – 2001*, produced by the Science, Innovation and Electronic Information Division of Statistics Canada, were used to perform a search in the title and abstract of patents. Subsequently, the classes from each of twenty patents selected by each keyword were extracted. From this list of US patent classes, a pre-selection of classes that were deemed relevant to the field of biotechnology was made. Finally, each of the classes was thoroughly analyzed to determine its pertinence to the field. The relevant classes were then used to construct the basic dataset used for this study. The following basic definition was used to select relevant patent classes:

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. (McNiven, C. 1999. *Canadian Biotechnology Statistics*. Ottawa: Industry Canada. p. 1)

In addition, the selection process was helped by an explanation given in an e-mail exchange between Science-Metrix and Antoine Rose from Statistics Canada. Rose mentioned that:

First and foremost, biotechnology is an ensemble of techniques that allow shifting from essentially chemical processes towards molecular biology processes in several domains. With the help of molecular biology, we have learnt how living beings work. A basic principle with biotechnology is to consider activities or processes that are based on this understanding of living matter. (24 Feb. 2002)

Patent classes were also used to produce clusters, whereby patents were categorized as belonging to either a specific sector of application (human health; agriculture and aquaculture; environment; bioinformatics; natural resources) or to a type of enabling technology (processes; testing and measurement; compositions, compounds, cells and molecules; apparatuses, articles, components and materials).

Unlike scientific publications, patents possess two fields that contain bibliographic information relevant to the calculation of where the patent originates: the inventor field and the assignee field. An inventor is necessarily a physical person, whereas an assignee can be a physical person and/or an institution. These fields are used to compute statistics on two different indicators, namely, invention and intellectual property (IP).

The inventor field contains data on the name of the inventor(s) and where he, she or they reside. The assignee field contains the name of the entity that owns the IP of the patent. When this field is empty, the inventor is the owner of the intellectual property and, in this case, the addresses contained in the inventor field are used to compute where the IP is owned. In some cases, where an individual is the owner of the IP, the address of this owner is used to compute the location of the IP. The majority of patents are owned by corporations, and their addresses, which appear in the assignee field, are used to compute the geographical location of IP ownership.

This report presents data on invention and IP and also distinguishes institutional IP from total IP. The location of inventors provides a proxy for the creativity of regions, whereas the location of IP ownership, particularly of institutional IP, provides an indicator of the potential economic impact of inventions.

Citations received for each patent were counted for the year they were granted and for the two years that followed. For patents granted in 1990, for example, citations received in 1990, 1991 and 1992 were counted.

The net flow of IP $((IP - Invention)/Invention)$ has been calculated on the basis of fractions of invention by region and the fraction of IP owned by each region. In the calculation of provincial net flow of IP, the part of invention and IP whose origin is unknown has been redistributed at the *pro rata* of invention and IP known for each province.

Otherwise, fractions are not used, which explains why some totals (n) are lower than the arithmetic sum by region. This is due to collaboration between, for example, provinces (when an inventor in British Columbia collaborates with an inventor in Newfoundland, then each province is given one patent; when this is calculated at the national level, the patent is counted only once (n)).

Data that is weighted per capita uses population statistics made by the US Census Bureau. These statistics present annual data estimated at mid-year for every country. Data from Statistics Canada has also been used to compute the number of patents held per capita by Canadian provinces and Census Metropolitan Areas.

1 Global Biotechnology Patents

This section examines the distribution of patents granted by the USPTO at the international level. Section 1.1 examines the rate of growth of patents in biotechnology. Section 1.2 examines the distribution of patents by country and by type of application (e.g. human health).

1.1 Global rate of patenting

Between 1990 and 2003, the number of patents granted by the USPTO in the field of biotechnology grew by almost fourfold, increasing from 1,995 to 6,839 per year. The percentage of biotechnology patents granted also grew considerably, increasing from 2.0% to 3.7% of patents granted by the USPTO. However, the number of patents granted started decreasing in 2000 to reach 6,839 in 2003 compared to 8,161 in 1999, the highest level achieved during the window of time covered.

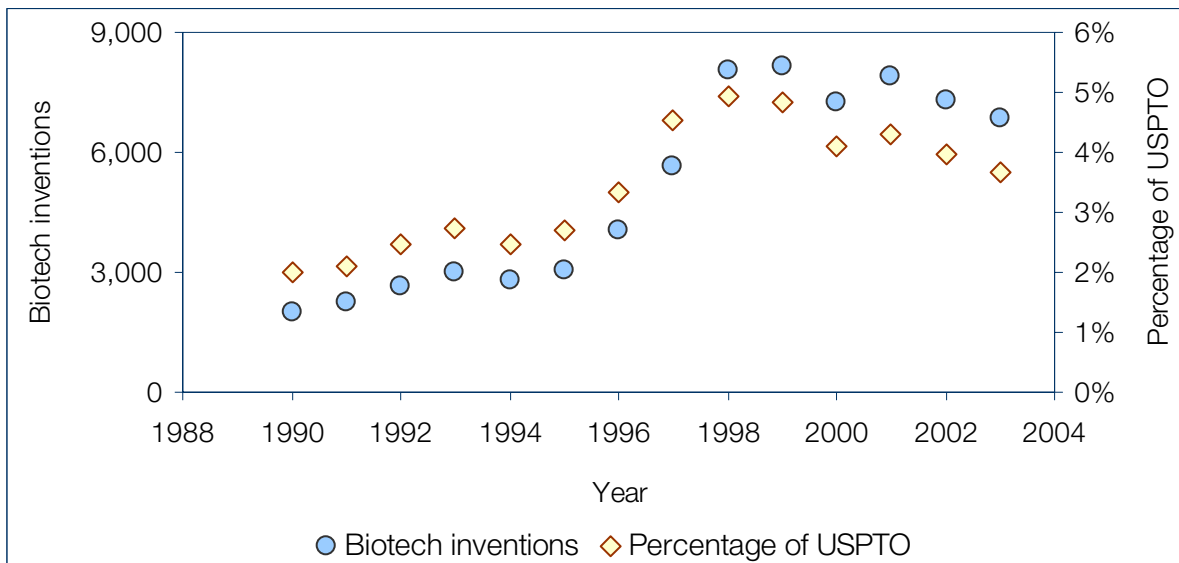


Figure 1 Global patents in biotechnology granted by the USPTO, 1990-2003

Source: Compiled by Science-Metrix from USPTO data.

Figure 2 shows that there has been important growth in the proportion of patents held by Canada in the field of biotechnology. Whereas in 1990 2.1% of patents granted were in the field of biotechnology, in 2003 the proportion had grown to 6.3%. As one can see, the slowdown observed at the world level from 2000 onward (Figure 1) also occurred in Canada (Figure 2), where the percentage of patents granted in the field of biotechnology went down from 7.8% in 1999, the highest level achieved during the window of time covered, to 6.3% in 2003, a level equivalent to that of 1997. The share of total biotechnology patents granted to Canada by the USPTO grew considerably in the 1990s – from 2.3% of total biotechnology patents in 1990 to 4% in 2003.

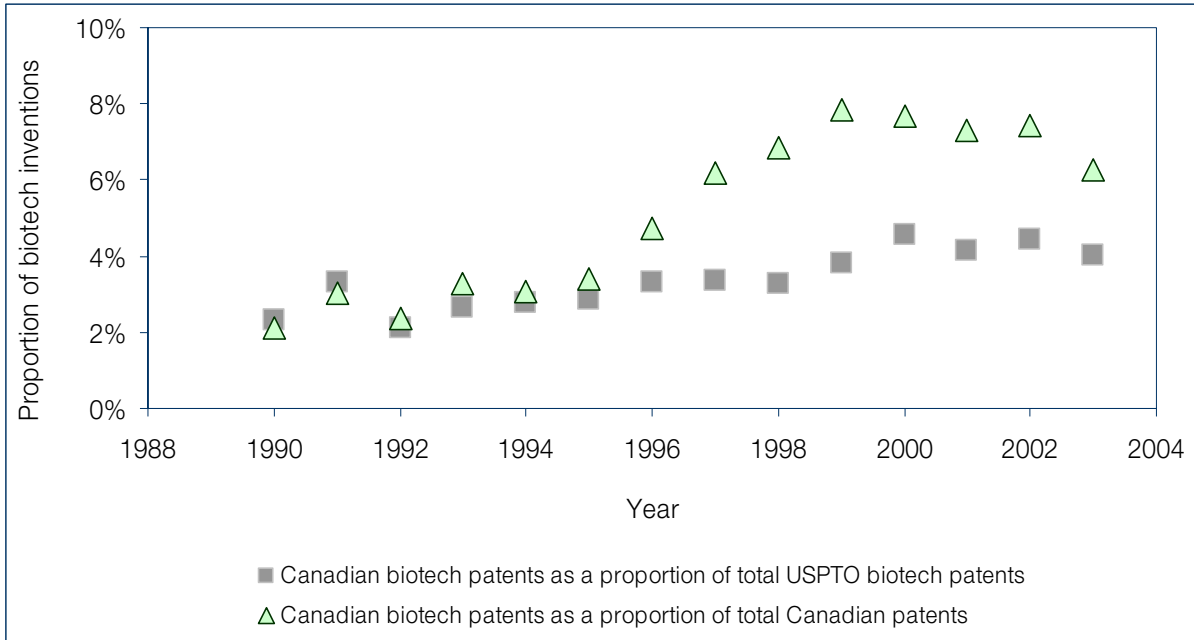


Figure 2 Biotechnology patents as a percentage of total patents (Canada versus all USPTO), 1990-2003

Source: Compiled by Science-Metrix from USPTO data.

Figure 3 and 4 shows how different application-specific and enabling biotechnologies are growing in Canada and the world level. These data reveal that patents granted in biotechnology at the world level has reached its peak around 1999 and started declining afterwards in nearly every sector except for bioinformatics.

One can see that the peak level in terms of patents granted to Canada is often lagging the world. For instance, the peak in health biotechnology patents was reached in 1999 at the world level and in 2002 in Canada. Patents in agriculture peaked in 1999 at the world level and in 2001 in Canada (Figure 3).

Agriculture is the field that had the fastest growth in the 1990s and the one that had the fastest decline afterwards except perhaps for patents in natural resources which are now returning to a similar level as in the early 1990s.

Patents in enabling biotechnologies grew rapidly in compositions, compounds, cells and molecules, and in testing and measurement at the world level. In Canada, they are growing faster still (Figure 4). Similar to application-specific biotechnology, enabling biotechnology started a decline after in 1999.

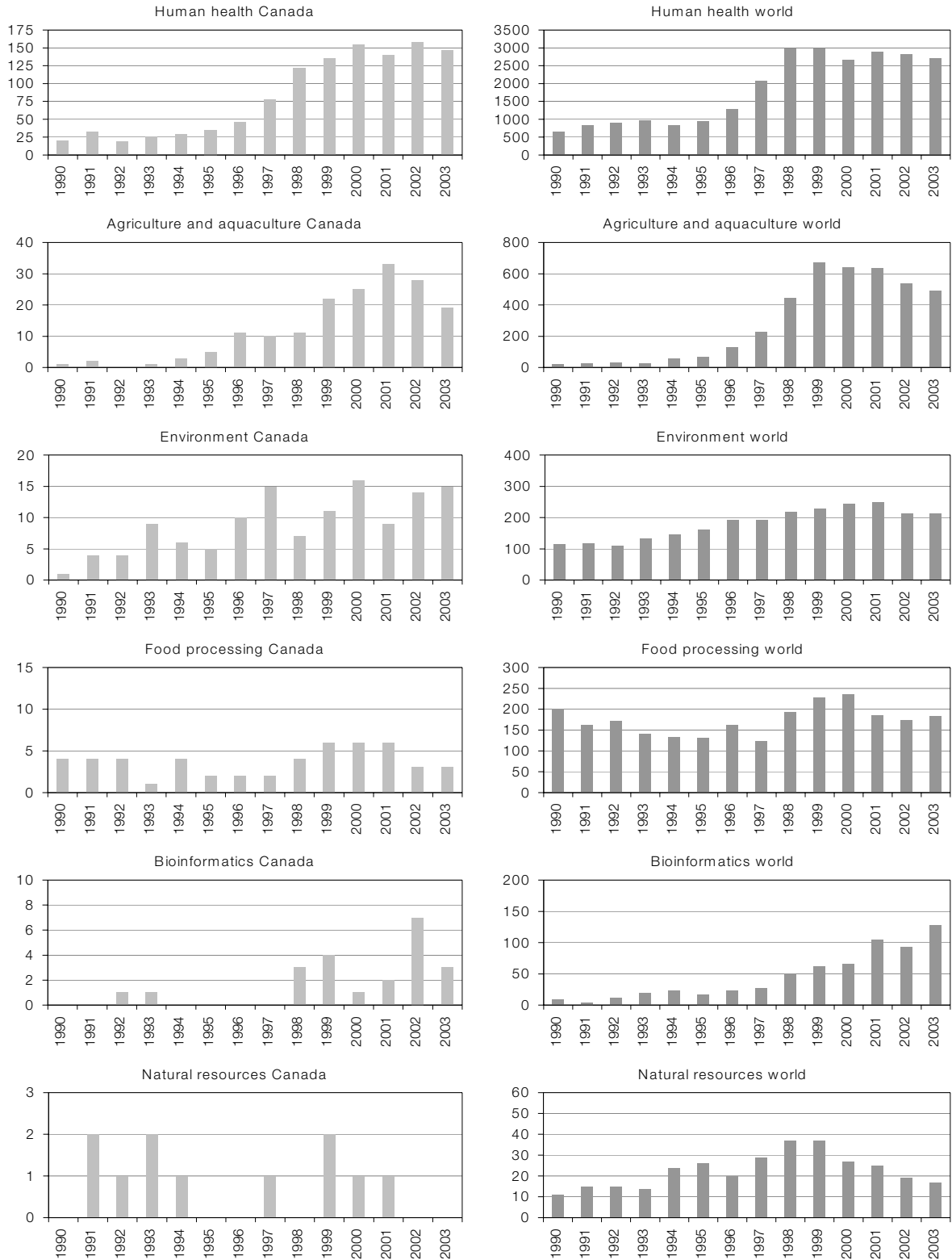


Figure 3 Patents in application-specific biotechnology in Canada and the world, 1990-2003

Source: Compiled by Science-Metrix from USPTO data.

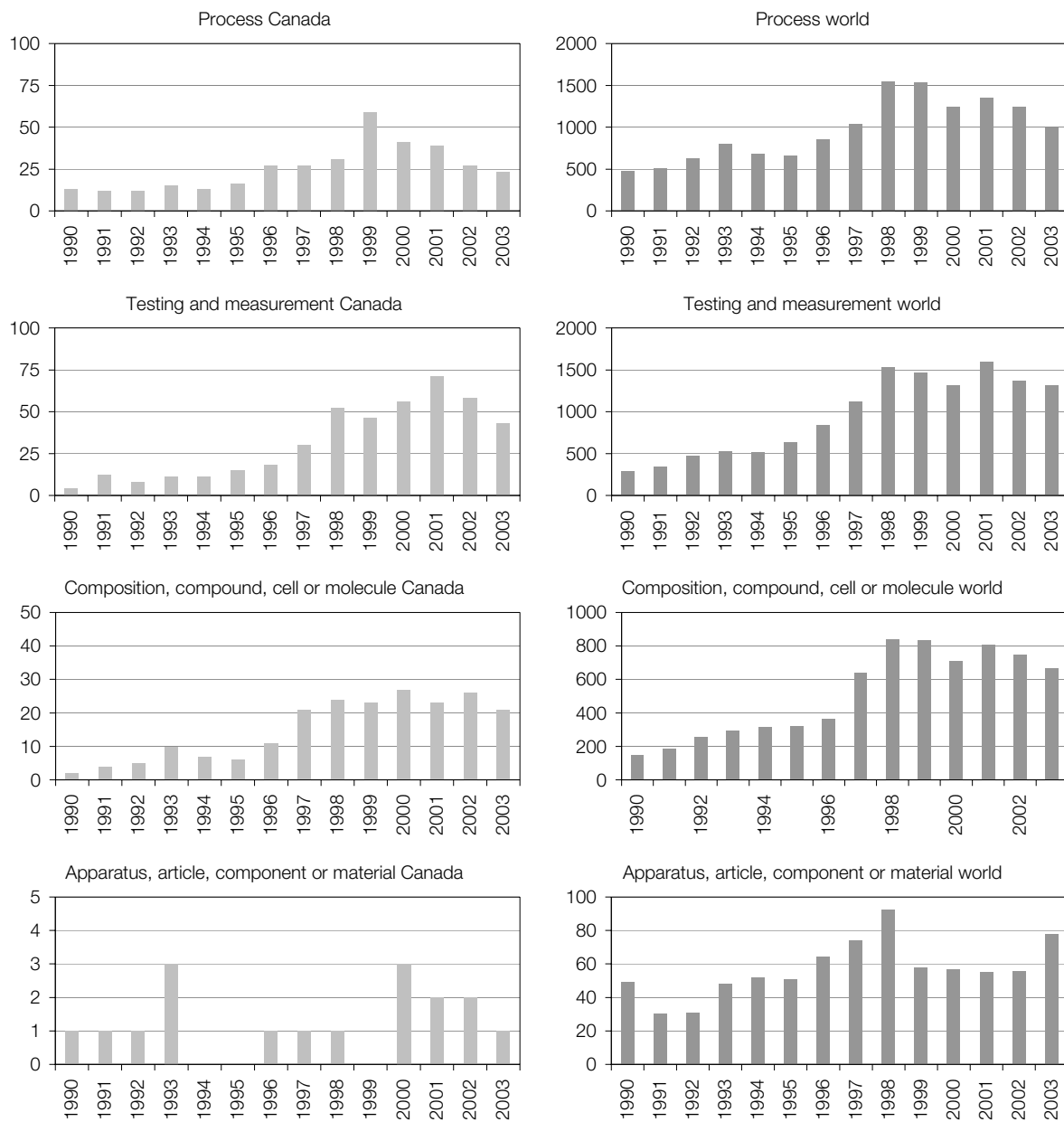


Figure 4 Patents in enabling biotechnology in Canada and the world

Source: Compiled by Science-Metrix from USPTO data.

The fact that the number of patents granted decreased from 2000 can be explained in terms of exogenous as well as endogenous factors. One exogenous factor that may have slowed growth is the cautious stance of the US and UK governments towards patents concerning the genome. Because the Blair and Clinton administrations were already actively discussing this matter in 1999, it is likely that patent examiners in the USPTO adopted a prudent stance and did not grant patents whose legitimacy could be contested afterwards. Another potential exogenous cause for the lower

number of patents granted from 2000 is a technical problem plaguing the US patent office, that is, the outstanding number of filings for patents covering expressed sequence tags in the late 1990s:

The number of patents issued or being applied for by genomics companies is mind-boggling. Over 2,000 patents on full-length genes have already been granted by the U.S. Patent and Trademark Office (USPTO). But the number of patent applications runs into the millions. The USPTO confesses that they have no idea how many patents applications are pending on expressed sequence tags (EST's) which are "signatures" or parts specific to each gene - since they "quit tracking them" about four [now six] years ago, at which time they had about half a million. In the past 200 years, the USPTO has processed six million patent applications. Based on company disclosures, there are currently over three million patent applications on ESTs alone. (<http://www.biotech-info.net/geno-types.html>).

Hence, the burst observed between 1997 and 1999 is likely due to an artefact induced by the race to patent expressed sequence tags. A third exogenous factor that might have contributed to a lower number of patents granted in biotechnology is the stock market meltdown that occurred from 2000 onward which likely slowed application that year and thus resulted in a decline in the number of patents granted from 2002 onward.

There are endogenous factors that could have influenced the observed slowdown. Firstly, there has been a substantial amount of acquisition and merger in the industry in the late 1990s. Since small firm often have to build up their patent portfolio to acquire a value that entices venture-capitalists and other potential investor, there is likely to have a slowdown of activity after acquisitions. Another endogenous factor might be a natural maturing of the field after 25 years of activity. Perhaps that the creative phase has ended and that the industry is going to invest more on production and less in research in the future. More qualitative research is needed to identify the reasons behinds the slowdown in the number of granted patents.

1.2 Leading countries in biotechnology inventions

Overall, Canada, together with the UK, ranks fourth in the field of biotechnology at the world level when the following indicators are considered: number of patents, patents per inhabitant, percentage of biotechnology patents to total patents by country and average citation per patent (Table I).

With 2,579 (3.6%) inventions in biotechnology, Canada ranks 5th at the world level, following the USA, Japan, Germany and the UK. When the population of these countries is factored in, Canada ranks 6th. Denmark has the largest average number of patents per inhabitant per year – 14.4 versus 6.1 in Canada. Other countries that fare well when population size is taken into account are the USA, Switzerland, Israel and Sweden.

Compared to other leading countries, Canada does not obtain a high proportion of patents in the field of biotechnology relative to the total number of patents. In fact, compared to Denmark, which has 16.5% of its US patents in the field of biotechnology, only 5.6% of Canadian patents are for biotechnology inventions, therefore pushing it into 12th place when this indicator is considered.

Nevertheless, Canada has a higher proportion of patents in this field than the US (4.4%) and the world as a whole (3.6%). Aside from Denmark, countries with a large proportion of inventions in biotechnology include India, Hungary, Australia and New Zealand.

Canada ranks 7th at the world level in terms of citations per patent. Canadian patents are cited 0.45 times on average, which is slightly below the world average (0.51 cites per patent). Countries whose biotechnology patents are often cited include the USA, Switzerland, Russia, Norway, the UK and Sweden.

Table I Ranking of leading countries in biotechnology patents, 1990-2003

Country	Biotechnology inventions	Biotech patents per year/million habitants	Biotech/ Σ Inventions	Average citations per patent	Average rank of leading countries
Denmark	1 060	14,4	16,5%	0,425	1
USA	48 383	12,8	4,4%	0,577	2
Switzerland	1 145	11,4	5,2%	0,573	3
UK	3 167	3,8	6,1%	0,454	4
Canada	2 579	6,1	5,6%	0,447	4
Netherlands	1 163	5,3	6,1%	0,429	6
Israel	793	10,4	7,7%	0,373	7
Sweden	846	6,9	4,7%	0,449	8
Belgium	733	5,2	7,3%	0,389	9
Australia	942	3,7	8,7%	0,343	10
Austria	398	3,5	5,5%	0,440	11
Japan	6 773	3,9	1,7%	0,349	12
Germany	3 818	3,3	2,9%	0,386	13
Finland	364	5,1	4,5%	0,437	13
Russia	171	0,1	7,7%	0,515	15
France	2 577	3,1	4,7%	0,331	16
Norway	155	2,5	5,2%	0,484	17
Hungary	90	0,6	9,6%	0,411	18
Spain	242	0,4	6,1%	0,368	19
New Zealand	130	2,5	8,0%	0,185	20
India	215	0,0	11,4%	0,186	21
Italy	789	1,0	3,3%	0,308	22
Rep. of Korea	448	0,7	1,4%	0,288	23
Taiwan	225	0,7	0,5%	0,164	24
China	115	0,0	3,8%	0,296	25
World (n)	70 950	0,9	3,6%	0,51	

Source: Compiled by Science-Metrix from USPTO data.

Since patents contain data on inventors and assignees, it is possible to look not only at inventions but also at intellectual property. Table II shows that 2,100 patents are partly or fully owned by Canada (6th rank). Globally, 93% of biotechnology IP is owned by various types of institutions (companies, governments, universities, foundations, etc). In Canada, this figure is slightly lower,

since 88% of patents are owned by institutions. Table II also presents data on the net flow of IP (invention and IP calculated fractionally) in leading countries. Most leading countries have a net deficit in IP: their inventors make a larger contribution than what they actually own. The Netherlands, Switzerland, the USA, Denmark and Norway have a positive inflow, whereas Canada has a slight outflow of IP – 7.6% of Canadian inventions are owned by foreign countries. This is due to the presence of subsidiaries of foreign firms carrying out R&D in Canada. Canada's outflow of IP in biotechnology is similar to the overall pattern of outflow (7.6% in biotechnology versus 7.4% overall from 1990 to 2003). Canada ranks 10th overall in net flow of IP within the group of 25 leading countries.

Table II IP ownership of biotechnology patents in leading countries, 1990-2003

Country	Institutional IP	Total IP	% of IP owned by institutions	Estimated net flow of IP
USA	44,753	47,927	93%	+2.6%
Japan	5,993	6,240	96%	-3.1%
Germany	2,831	3,160	90%	-2.1%
UK	2,117	2,249	94%	-14.7%
France	1,978	2,116	93%	-4.8%
Canada	1,854	2,100	88%	-7.6%
Netherlands	1,090	1,122	97%	+15.1%
Denmark	870	945	92%	+2.5%
Switzerland	840	911	92%	+13.0%
Australia	647	701	92%	-11.6%
Sweden	481	616	78%	-10.7%
Italy	521	563	93%	-12.2%
Israel	491	545	90%	-18.0%
Belgium	360	383	94%	-35.5%
Rep. of Korea	293	357	82%	-6.9%
Finland	228	290	79%	-8.2%
Austria	176	218	81%	-34.9%
Taiwan	153	179	85%	-8.6%
India	127	141	90%	-19.3%
Norway	113	135	84%	+1.3%
Spain	99	109	91%	-29.7%
New Zealand	81	88	92%	-15.7%
China	40	60	67%	-30.7%
Hungary	48	58	83%	-23.2%
Russia	20	40	50%	-72.8%
World (n)	66,106	70,950	93%	0%

Source: Compiled by Science-Metrix from USPTO data.

Table III presents the distribution of inventions by sector of application and by type of enabling technology. With 36% of patents, human health is by far the most common sector of application in the world. With 44% of inventions, this sector is even more developed in Canada. Following at some distance, agriculture and aquaculture is the second most important sector of application in the world, with 5.7% of inventions – 6.6% in the case of Canada.

The environment, with 3.6% of inventions, is third in importance at the world level – Canada has 4.8% of its inventions in this sector. Food processing has almost the same importance as environmental inventions at the world level, considering that 3.4% of inventions are in this sector. However, the sector is relatively less developed in Canada with only 2% of patents. Bioinformatics and natural resources are not very important with 0.9% and 0.4% of patents globally, and 0.8% and 0.4% in Canada.

Table IV presents the average number of citations received per patent for up to two years after it was granted, according to the type of application and the type of enabling technology. The table presents data in the form of indices, whereby a score above one means that a country receives more patent citations in a particular area than others do, and, conversely, a score below one indicates that its patents are cited less often. Canadian patents that are more cited than others cover apparatuses, articles, components and materials. Canadian patents in application sectors such as human health, agriculture & aquaculture, environment, food processing, bioinformatics and natural resources are cited less often than the world average. Of these, health and environment are most often cited while agriculture is least cited.

The data presented in this section reveal that Canada has an opportunity to develop a leadership position in the field of human health, considering that it has a greater proportion of patents in this field than the world average (see Table III), that the growth rate at the world level is high and that it is higher still in Canada (Table IV). Similarly, Canada can also exert its leadership in environmental biotechnology. The growth rate at the world level has been modest however this is an area where Canada has more patents by percentage than the global average..

Although Canada has a smaller proportion of patents in testing and measurement and in compositions, compounds, cells and molecules than the world as a whole, the growth rate is high at the world level and higher still in Canada, thus revealing a potential for Canada to catch up and eventually exercise leadership in these fields.

Table III Distribution of inventions by type in leading countries, 1990-2003

Country	Sector						Enabling Technology				Unknown
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	Compositions, compounds, cells and molecules	Apparatuses, articles, components and materials	
USA	17,431 36%	3,041 6%	1,508 3%	1,334 3%	472 1%	197 0.4%	8,389 17%	9,787 20%	5,165 11%	491 1%	568 1%
Japan	1,985 29%	205 3%	279 4%	324 5%	61 1%	37 1%	2,040 30%	1,030 15%	643 9%	112 2%	57 1%
Germany	1,291 34%	173 5%	177 5%	114 3%	31 1%	12 0.3%	832 22%	724 19%	386 10%	35 1%	43 1%
UK	1,195 38%	155 5%	73 2%	79 2%	25 1%	14 0.4%	590 19%	607 19%	329 10%	34 1%	66 2%
Canada	1,138 44%	171 7%	126 5%	51 2%	22 1%	11 0.4%	355 14%	435 17%	210 8%	17 1%	43 2%
France	1,066 41%	112 4%	87 3%	121 5%	7 0.3%	14 1%	464 18%	397 15%	260 10%	21 1%	28 1%
Netherlands	357 31%	78 7%	62 5%	115 10%	4 0.3%	9 1%	310 27%	127 11%	77 7%	4 0.3%	20 2%
Switzerland	397 35%	36 3%	27 2%	89 8%	5 0.4%	4 0.3%	297 26%	154 13%	105 9%	18 2%	13 1%
Denmark	269 25%	39 4%	30 3%	80 8%	2 0.2%	21 2%	381 36%	103 10%	118 11%	3 0.3%	14 1%
Australia	403 43%	60 6%	32 3%	31 3%	- -	1 0.1%	134 14%	146 15%	105 11%	12 1%	18 2%
Sweden	388 46%	22 3%	24 3%	33 4%	6 1%	4 0.5%	132 16%	131 15%	90 11%	7 1%	9 1%
Israel	389 49%	35 4%	27 3%	12 2%	17 2%	3 0.4%	127 16%	99 12%	64 8%	8 1%	12 2%
Italy	404 51%	22 3%	14 2%	28 4%	1 0.1%	5 1%	163 21%	68 9%	71 9%	8 1%	5 1%
Belgium	272 37%	79 11%	8 1%	27 4%	1 0.1%	1 0.1%	120 16%	119 16%	94 13%	3 0.4%	9 1%
Rep. of Korea	122 27%	34 8%	28 6%	40 9%	2 0.4%	3 1%	124 28%	35 8%	44 10%	12 3%	4 1%
Austria	187 47%	21 5%	13 3%	4 1%	4 1%	- -	71 18%	51 13%	34 9%	11 3%	2 1%
Finland	76 21%	12 3%	16 4%	33 9%	2 1%	12 3%	80 22%	93 26%	31 9%	5 1%	4 1%
Spain	102 42%	13 5%	5 2%	12 5%	1 0.4%	- -	68 28%	24 10%	15 6%	1 0.4%	1 0.4%
Taiwan	73 32%	17 8%	15 7%	7 3%	1 0.4%	- -	62 28%	29 13%	16 7%	4 2%	1 0.4%
India	84 39%	20 9%	7 3%	9 4%	- -	2 1%	43 20%	34 16%	13 6%	1 0.5%	2 1%
Russia	83 49%	4 2%	7 4%	- -	1 1%	4 2%	30 18%	31 18%	9 5%	2 1%	- -
Norway	52 34%	9 6%	7 5%	11 7%	- -	1 1%	15 10%	43 28%	16 10%	1 1%	- -
New Zealand	70 54%	20 15%	1 1%	6 5%	- -	2 2%	9 7%	8 6%	13 10%	1 1%	- -
China	49 43%	13 11%	4 3%	3 3%	1 1%	- -	18 16%	19 17%	5 4%	1 1%	2 2%
Hungary	37 41%	8 9%	4 4%	6 7%	1 1%	2 2%	21 23%	7 8%	3 3%	- -	1 1%
World (n)	25,433 36%	4,014 6%	2,528 4%	2,416 3%	635 1%	316 0.4%	13,528 19%	13,312 19%	7,147 10%	795 1%	826 1%

Source: Compiled by Science-Metrix from USPTO data.

Table IV Citations by type of patent in leading countries, 1990-2003

Country	Sector						Enabling Technology			
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	Compositions, compounds, cells and molecules	Apparatuses, articles, components and materials
USA	1.1	1.0	1.2	1.3	1.1	1.2	1.2	1.1	1.1	1.1
Japan	0.7	0.2	0.7	0.7	0.7	0.3	0.7	0.6	0.7	1.1
Germany	0.9	0.3	0.9	0.7	0.4	1.0	0.7	0.6	0.8	0.4
UK	0.8	1.4	0.6	0.8	0.9	1.3	0.9	1.0	0.8	1.3
Canada	0.9	0.3	0.9	0.7	0.6	0.8	1.0	0.8	0.6	1.2
France	0.8	0.4	0.7	0.5	0.3	1.5	0.6	0.4	0.8	0.3
Netherlands	0.9	0.1	0.8	0.6	0.5	0.7	1.2	0.5	0.7	1.6
Switzerland	1.2	0.4	0.9	0.6	1.6	1.1	1.4	1.3	1.0	0.9
Denmark	0.7	0.1	1.0	0.4	-	0.8	1.0	1.0	1.2	0.4
Australia	0.6	0.2	0.9	0.7	-	-	0.6	0.7	0.7	0.9
Sweden	1.0	0.4	0.4	0.7	1.2	-	1.0	0.7	0.9	0.7
Israel	0.7	0.1	0.5	0.7	1.6	1.0	0.5	0.8	1.4	0.5
Italy	0.6	0.2	0.4	0.5	3.1	0.3	1.0	0.3	0.6	0.3
Belgium	0.7	0.4	0.1	0.8	2.1	-	1.0	0.8	0.8	-
Rep. of Korea	0.4	0.1	0.7	0.8	1.0	-	0.6	0.7	0.4	0.6
Austria	0.9	0.3	0.6	1.3	1.0	-	0.8	0.6	1.9	0.7
Finland	0.5	0.2	1.0	1.3	2.1	0.6	0.6	0.9	0.7	0.8
Spain	1.0	0.3	-	0.3	-	-	0.8	0.5	0.2	-
Taiwan	0.3	0.1	0.9	-	-	-	0.4	0.1	0.3	0.3
India	0.5	0.1	-	0.4	-	-	0.2	0.3	0.2	2.5
Russia	1.0	0.3	0.5	-	2.1	1.1	1.2	1.1	1.0	-
Norway	1.7	0.6	0.2	0.8	-	1.5	0.3	0.7	0.6	-
New Zealand	0.4	0.2	-	-	-	-	0.5	0.4	0.4	1.3
China	0.6	0.2	0.3	-	-	-	1.0	0.5	0.9	-
Hungary	0.6	0.3	2.4	0.8	-	0.7	0.9	0.9	-	-

Source: Compiled by Science-Metrix from USPTO data.

2 Biotechnology Patents in Canada

This part examines the distribution of patents in Canada at the provincial, regional and institutional levels. Section 2.1 examines the growth of biotechnology inventions by province and by type of application. Section 2.2 presents statistics on US patents granted to inventors located in Canadian Census Metropolitan Areas (CMA). Finally, Section 2.3 presents statistics on US patents owned by Canadian institutions.

2.1 Biotechnology patents by province

Figure 5 shows the total number of biotechnology patents in Canada from 1990 to 2003 broken down by province. This figure reveals that Ontario and Quebec exert a clear leadership in terms of inventions in biotechnology. Ontario has the largest number of patents by far –1,261, whereas Quebec has half as many. Alberta and British Columbia have about a quarter of the inventions of Ontario; Saskatchewan a tenth.

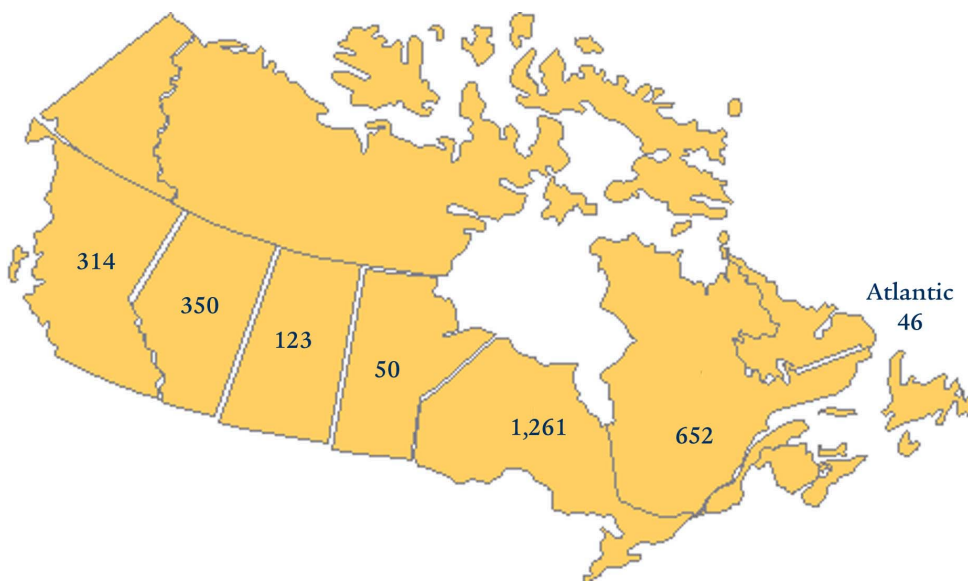


Figure 5 Inventions in biotechnology by province, 1990-2003
Source: Compiled by Science-Metrix from USPTO data.

Table V reveals that when a variety of indicators are taken into account, Alberta ranks first among the leading provinces in Canada (provinces with more than 100 patents in the field of biotechnology). Alberta is followed by Ontario, Saskatchewan, Quebec and British Columbia. Other provinces are not really in the race, neither in terms of the absolute number of patents or the number of patents per capita. Alberta is the leader in terms of patents per capita, followed closely by Saskatchewan. Saskatchewan is also the province most specialized in biotechnology, since 13% of its patents are in this field. On average, Alberta receives more citations per patent than other

leading provinces. Prince Edward Island and Newfoundland receive many citations per patent, but their very small number of patents suggests that this average may not be statistically significant.

Table V Ranking of Canadian provinces in biotechnology patents, 1990-2003

Province	Biotechnology inventions	Biotech patents per year/ million habitants	Biotech/ Σ Inventions	Average citations per patent	Average rank of leading provinces
Alberta	350	8.8	8.1%	0.61	1
Ontario	1,261	8.0	5.2%	0.45	2
Saskatchewan	123	8.7	13.3%	0.37	3
Quebec	652	6.4	7.4%	0.35	4
British Columbia	314	5.9	5.5%	0.44	5
Manitoba	50	3.2	4.3%	0.30	
Nova Scotia	27	2.1	7.3%	0.48	
New Brunswick	8	0.8	1.8%	0.38	
Newfoundland	6	0.8	5.3%	0.67	
Prince Edward Island	5	2.6	11.6%	2.20	
Unknown	98		4.0%	0.35	
Canada (n)	2,579	6.2	5.6%	0.45	

Source: Compiled by Science-Metrix from USPTO data.

Table VI, using IP as an indicator, confirms Ontario's leadership in biotechnology. The proportion of IP of the leading provinces is, by and large, the same as for inventions. The percentage of IP owned by institutions is similar for leading provinces—between 85% and 89%. However, smaller provinces have a lower percentage of patents owned by institutions—77% in the case of Nova Scotia, 67% in Newfoundland, 66% in Manitoba and 50% in Prince Edward Island. New Brunswick does not own any patents in biotechnology.

The outflow of IP by province is high in the Atlantic Provinces, except for Prince Edward Island, which has the smallest outflow of all the provinces (6.4%). Quebec loses more than 15% of its IP, Alberta and Saskatchewan 17% and British Columbia 18%. One-third of patents by inventors in Manitoba are owned outside the province. With a net outflow of 7.5%, Ontario performs relatively better than most of the provinces.

Table VI IP of Canadian provinces in biotechnology patents, 1990-2003

Province	Institutional IP	Total IP	% of IP owned by institutions	Estimated net flow of IP
Ontario	844	953	89%	-7.5%
Quebec	389	440	88%	-15.7%
Alberta	194	229	85%	-17.2%
British Columbia	183	213	86%	-18.1%
Saskatchewan	78	88	89%	-17.1%
Manitoba	19	29	66%	-33.6%
Nova Scotia	10	13	77%	-38.1%
Prince Edward Island	2	4	50%	-6.4%
Newfoundland	2	3	67%	-47.1%
New Brunswick	-	-	-	-100.0%
Unknown	156	173	90%	-
Canada (n)	1,854	2,100	88%	-7.6%

Source: Compiled by Science-Metrix from USPTO data.

Table VII presents Canadian inventions in biotechnology either by type of application or by type of enabling technology. Alberta specializes in human health (with 50% of patents vs. 44% for Canada) and, in terms of enabling technologies, has a slightly larger percentage of patents in processes and compositions, compounds, cells and molecules. Ontario has a slightly larger percentage of patents in agriculture, bioinformatics and testing and measurement than Canada as a whole. Saskatchewan specializes in human health and on agricultural biotechnology. Quebec's distribution of patents closely follows that of Canada, except for its specialization in human health and compositions, compounds, cells and molecules. Finally, among leading provinces, British Columbia specializes in processes and in testing and measurement.

Table VII Distribution of inventions by type in Canadian provinces, 1990-2003

Province	Sector						Enabling Technology				Unknown
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	Compositions, compounds, cells and molecules	Apparatuses, articles, components and materials	
Alberta	175 50%	22 6%	20 6%	3 1%	2 1%	1 0.3%	52 15%	35 10%	32 9%	2 1%	6 2%
Ontario	515 41%	101 8%	61 5%	30 2%	19 2%	5 0.4%	182 14%	224 18%	87 7%	12 1%	25 2%
Saskatchewan	64 52%	22 18%	1 1%	2 2%	- -	- -	16 13%	10 8%	6 5%	- -	2 2%
Quebec	300 46%	29 4%	31 5%	9 1%	2 0.3%	4 1%	80 12%	113 17%	72 11%	2 0.3%	10 2%
British Columbia	129 41%	20 6%	13 4%	6 2%	- -	2 1%	49 16%	62 20%	26 8%	3 1%	4 1%
Manitoba	22 44%	6 12%	- -	2 4%	- -	- -	4 8%	7 14%	7 14%	1 2%	1 2%
Nova Scotia	18 67%	1 4%	2 7%	2 7%	- -	- -	1 4%	1 4%	1 4%	- -	1 4%
New Brunswick	4 50%	1 13%	1 13%	- -	- -	2 25%	- -	- -	- -	- -	- -
Newfoundland	- -	- -	- -	2 33%	- -	- -	1 17%	2 33%	- -	- -	1 17%
Prince Edward Island	1 20%	- -	1 20%	1 20%	- -	- -	- -	2 40%	- -	- -	- -
Unknown	41 42%	7 7%	5 5%	2 2%	- -	- -	12 12%	23 23%	7 7%	1 1%	- -
Canada (n)	1,138 44%	171 7%	126 5%	51 2%	22 1%	11 0.4%	355 14%	435 17%	210 8%	17 1%	43 2%

Source: Compiled by Science-Metrix from USPTO data.

Table VIII presents the number of citations received for inventions by leading Canadian provinces. Here a value above one denotes that patents of a particular type are cited more often than the Canadian average. Alberta's patents are cited at least as often as the Canadian average except in agriculture and the environment. Ontario's patents in natural resources, food processing, environment, agriculture, processes and testing and measurement are cited more frequently than Canadian patents on average in these sectors of application. Saskatchewan's patents are cited more frequently in human health and Quebec's patents in agriculture, apparatus, articles, components and materials and compositions, compounds, cells and molecules receive more citations than the Canadian average. Patents from British Columbia in the environment, compositions, compounds, cells and molecules and in agriculture are cited relatively more frequently than others.

Table VIII Citations of inventions by type in Canadian provinces, 1990-2003

Province	Sector						Enabling Technology			
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	Compositions, compounds, cells and molecules	Apparatuses, articles, components and materials
Alberta	1.4	0.6	0.9	1.7	3.4	1.8	1.5	1.6	1.4	-
Ontario	0.9	1.1	1.2	1.3	0.8	1.5	1.1	1.1	0.8	0.9
Saskatchewan	1.2	1.0	-	-	-	-	0.6	0.6	-	-
Quebec	0.8	1.2	0.7	0.8	-	0.5	0.6	0.6	1.3	2.7
British Columbia	1.0	1.1	1.6	-	-	0.9	1.0	0.8	1.4	0.7

Source: Compiled by Science-Metrix from USPTO data.

Although Ontario and Quebec have considerably more patents than other Canadian provinces, Alberta performs better than Ontario and Saskatchewan better than Quebec when population, specialization in biotechnology and citations per patent are taken in account. Although their absolute number of patents is relatively low compared to the central provinces, Alberta and Saskatchewan are strong in human health. Ontario is strong in food processing and in testing and measurement. Quebec and British Columbia's biggest strength in biotechnology lies in enabling compositions, compounds, cells and molecules.

2.2 Biotechnology patents by Canadian CMA

In this section, data is presented for CMAs where inventors have obtained more than one patent per year during the 1990-2003 period. Toronto is clearly the leading Canadian CMA in terms of the absolute number of patents. The city is followed by Montreal, Vancouver, Ottawa–Hull, Edmonton, Calgary and Saskatoon (Figure 6). Each of these CMAs has more than 100 inventions.

When population is factored in¹, Saskatoon is the clear leader in biotechnology, followed by Edmonton and Ottawa-Hull, which have about half as many inventions per capita. Toronto ranks 4th, Calgary 5th, Victoria 6th, Vancouver 7th, Montreal 8th and Sherbrooke 9th.

Toronto specializes in testing and measurement, whereas Montreal is strong in compositions, compounds, cells and molecules. Vancouver is generally strong in enabling technologies and particularly specialized in processes. Ottawa specializes in agricultural biotechnology. In Alberta, Edmonton specializes in human health, but Calgary has noticeable strengths in environment and compositions, compounds, cells and molecules. Finally, Saskatoon is particularly strong in agriculture but also in human health.

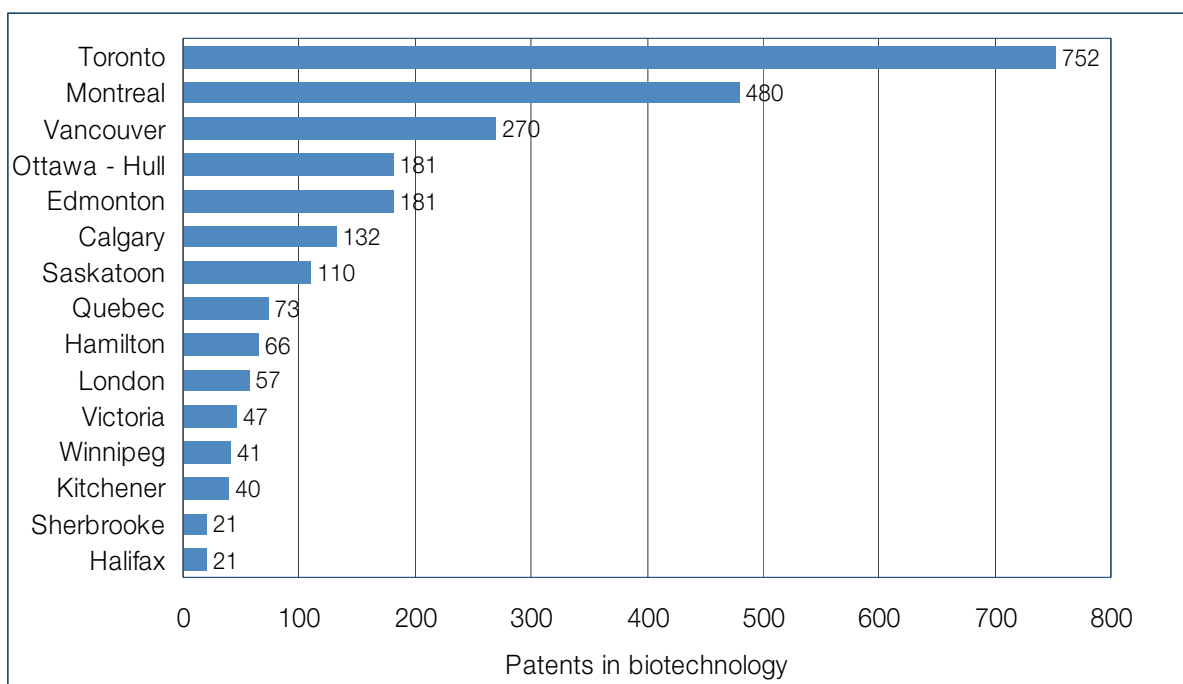


Figure 6 Number of inventions by leading CMAs, 1990-2003

Source: Compiled by Science-Metrix from USPTO data.

¹ Population statistics for CMAs for 2003 were not available in Statistics Canada's database. Consequently, population statistics for 2002 were also used for 2003.

2.3 Biotechnology patents by Canadian institutions

This section presents aggregate data on IP according to the type of institution and desegregated data on institutions that had at least one patent per year on average during the 1990-2003 period.

There are 364 Canadian institutions with at least one patent in biotechnology. Table IX shows that corporations hold the lion share of biotechnology patents in Canada: 266 corporations produced 1051 patents. Nearly half of these patents are in human health, with 126 institutions owing 521 patents. With 519 patents, universities are important owners of IP. In contrast to firms, who on average hold relatively few patents (4.0 patents per corporation), the 38 university institutions with patents in this field have an average of 13.7 patents per institution. Governmental institutions are third in terms of patents in biotechnology, with 185 patents owned by 17 governmental and non-governmental organizations.

In terms of specialization, firms have proportionately more patents in human health and in testing and measurement than other types of institution do. Universities specialize in enabling technologies and agriculture. Governmental institutions specialize in agriculture and aquaculture, environment and apparatuses, articles, components and materials. Finally, hospitals specialize in all enabling technologies apart from apparatuses, articles, components and materials.

Table IX IP by type of institution, 1990-2003

Economic sector	Sector						Enabling Technology				Unknown	Total
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	Compositions, compounds, cells and molecules	Apparatuses, articles, components and materials		
Corporation IP	521	29	46	25	13	4	136	185	83	2	7	1,051
Institutions	126	18	32	13	6	4	51	76	38	2	7	266
University IP	229	30	13	4	4	2	84	91	50	3	9	519
Institutions	22	12	7	4	3	2	18	21	18	2	8	38
Government IP	76	33	10	1		2	25	20	11	1	6	185
Institutions	10	4	6	1		1	6	6	4	1	3	17
Health & Hospital IP	45	2		2	1		20	33	17		6	126
Institutions	13	2		1	1		7	14	4		2	20
Other IP	17	2	2	1			8	1	2		1	34
Institutions	13	2	2	1			4	2	2		1	23
Canada (n)	863	88	69	32	18	8	269	316	159	6	26	1,854
<i>Institutions</i>	<i>184</i>	<i>38</i>	<i>47</i>	<i>20</i>	<i>10</i>	<i>7</i>	<i>86</i>	<i>119</i>	<i>66</i>	<i>5</i>	<i>21</i>	<i>364</i>

Source: Compiled by Science-Metrix from USPTO data.

Table X presents the leading institutions. These 24 leading institutions own about 60% of the Canadian IP owned by biotechnology institutions. These data show that leadership in the field of biotechnology involves all kinds of institutions: eleven are from the university sector, eight are companies, three are from the governmental or non-governmental sectors, and two are from the hospital sector. Not surprisingly, most of the leading companies are from the pharmaceutical sector (e.g., Aventis, NPS Allelix, Merck Frosst). This is not surprising since 44% of Canadian inventions and 47% of institutional IP are in human health.

The leading universities are McGill University, the University of British Columbia, the University of Saskatchewan and Queen's University. Leading government departments and agencies include NRC and Agriculture and Agri-Food Canada.

Table X IP by type in leading Canadian institutions, 1990-2003

Institution	Sector						Enabling Technology				Unknown	Total
	Human health	Agriculture & aquaculture	Environment	Food processing	Bioinformatics	Natural resources	Processes	Testing and measurement	compounds, cells and molecules	Apparatuses, articles, components and materials		
Aventis	114	2		1			21	4	9			151
McGill University	36	3	1				10	23	15	2	2	92
University of British Columbia	38	2	1	1			23	12	8	1	1	87
National Research Council	24	8	5	1		2	16	7	7		2	72
NPS Allelix Corp.	26						19	11	11			67
University of Saskatchewan	44	3					7	2	2			58
Hospital for Sick Children, Toronto	16	1		2			7	11	13		1	51
Queen's University at Kingston	20	7			2		7	8	1			45
University Tech. International Inc.	20						9	5	7			41
Agriculture and Agri-Food	6	24	1				4	2	1		3	41
Visible Genetics Inc.					8		4	28				40
University of Alberta	17	4					11	4	2		1	39
Merck Frosst Canada Inc.	10						7	10	11			38
Boehringer Ingelheim Ltd.	27						1	3				31
Université de Montréal	10	1			1		1	11	3		2	29
Alberta Research Council	23						3		2			28
Université Laval	15	2		1			4	4	1			27
Mount Sinai Hospital Corp.	11	1			1		5	6				24
University of Guelph	5	3		1	1		4	7			1	22
Spectral Diagnostics Inc.	3			1			2	13	1			20
University Health Network	4						2	3	2		5	16
University of Ottawa	5		1				3	3	3			15
Generex Pharmaceuticals Inc.	14											14
Adherex Technologies Inc.	13							1				14
<i>All Institutions (n)</i>	863	88	69	32	18	8	269	316	159	6	26	1 854
	47%	5%	4%	2%	1%	0,4%	15%	17%	9%	0,3%	1%	100%

Source: Compiled by Science-Metrix from USPTO data.

3 **C**onclusion

The field of biotechnology has experienced important growth in the 14-year period studied here (1990-2003). In fact, the number of patents granted grew from 2,000 to 7,000 per year – almost a fourfold increase. There are two variables that might affect the number of patents granted in the near future: 1) the effect of the stock market slowdown experienced in 2000 and the years that followed; 2) the ruling on the lawfulness of patents associated with the genome. Whereas the first factor likely had an adverse effect on the number of patents granted in 2002 and 2003 and could continue to do so in the near future, the second may provoke an explosion in the number of patents granted if all the various national offices address the backlog representing the millions of expressed sequence tags already filed.

Canada occupies a leading position in genomics since it is fourth with the UK at the world level in a multi-criteria ranking. Canadian inventors are wholly or partly responsible for 2,579 inventions in biotechnology, and Canada partly or fully owns 2,100 patents. Canada ranks 10th in the net outflow of ownership of patents from at 7.6%. This figure is only slightly higher than the general outflow of IP from Canada, is 7.4% regardless of field. Within the field of biotechnology, Canada specializes in human health, agricultural and environmental biotechnology.

Although Ontario and Quebec hold considerably more patents than other Canadian provinces, Alberta performs better than Ontario, and Saskatchewan better than Quebec, when population, specialization in biotechnology and citations per patent are factored in. Alberta and Saskatchewan are both strong in human health; Ontario is strong in food processing and in testing and measurement. Quebec and British Columbia's biggest strength in biotechnology lies in enabling compositions, compounds, cells and molecules.

Toronto is clearly the leading Canadian Census Metropolitan Area (CMA) in terms of the absolute number of patents and is followed by Montreal, Vancouver, Ottawa-Hull, Edmonton, Calgary and Saskatoon. Each of these CMAs filed more than 100 inventions in biotechnology between 1990 and 2003. When population is factored in, the Saskatoon CMA is the clear leader in biotechnology, followed by Edmonton and Ottawa-Hull, which have about half as many inventions per capita. Toronto ranks 4th, Calgary 5th, Victoria 6th, Vancouver 7th, Montreal 8th and Sherbrooke 9th.

At the institutional level, there are 364 Canadian institutions with at least one patent in biotechnology. 24 leading institutions received at least one patent by year on average. They own about 60% of the Canadian IP owned by biotechnology institutions. Eleven of these are from the university sector, eight are companies, three are from the government or non-government sectors, and two are from the hospital sector. In terms of IP in biotechnology, leading companies are mainly from the pharmaceutical sector (e.g. Aventis, NPS Allelix, Merck Frosst). The leading universities in biotechnology are McGill University, the University of British Columbia, the University of Saskatchewan and Queen's University, and leading government departments or agencies include the NRC and Agriculture and Agri-Food Canada.