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Biotechnology Statistics in OECD Member Countries

COMPENDIUM OF EXISTING NATIONAL STATISTICS

Brigitte van Beuzekom

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BIOTECHNOLOGY STATISTICS IN OECD MEMBER COUNTRIES: COMPENDIUM OF EXISTING NATIONAL STATISTICS

Brigitte van Beuzekom

This document reflects recent efforts made by the OECD to obtain an accurate assessment of the current state of biotechnology statistics in OECD Member and Observer countries.

This project was realised thanks in large part to a voluntary contribution provided by the Government of Canada. The Compendium was prepared by Brigitte van Beuzekom of the OECD's Directorate for Science, Technology and Industry. In addition, this Compendium benefited from the contribution of Anthony Arundel of MERIT, who served as an outside reviewer during the preparation of the Compendium and from delegates involved in the OECD *ad hoc* Meeting on Biotechnology Statistics. Thanks to Sandrine Kergroach-Connan for her help in the preparation of the Trade and Venture Capital sections.

Comments are welcome and should be sent to Brigitte van Beuzekom, c/o OECD/DSTI OECD, 2 rue André-Pascal, 75775 Paris, Cedex 16, France.

STATISTIQUES DE LA BIOTECHNOLOGIE DANS LES PAYS MEMBRES DE L'OCDE : UN RECUEIL DE DONNÉES NATIONALES

Brigitte van Beuzekom

Ce document reflète les récents efforts de l'OCDE pour établir un état des lieux précis de la disponibilité des statistiques de la biotechnologie dans les pays Membres de l'OCDE et dans les pays observateurs.

Ce projet a pu être réalisé principalement grâce à une contribution volontaire du gouvernement canadien. Ce recueil a été préparé par Brigitte van Beuzekom de la Direction de la science, de la technologie et de l'industrie de l'OCDE. Ce recueil a également été revu par Anthony Arundel de MERIT lors de sa préparation, ainsi que par les délégués impliqués dans la réunion ad hoc de l'OCDE sur les statistiques de la biotechnologie. Merci à Sandrine Kergroach-Connan pour son aide dans la préparation des sections sur le commerce et le capital-risque.

Tous commentaires sont les bienvenus et devront être adressés à Brigitte van Beuzekom, c/o OECD/DSTI OECD, 2 rue André-Pascal, 75775 Paris, Cedex 16, France.

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Background and introduction

At the request of the Working Party on Biotechnology, the OECD held a first *ad hoc* meeting on Biotechnology Statistics in March of 2000 under the aegis of the Working Party of National Experts on Science and Technology Indicators (NESTI).

One of the principal conclusions of this *ad hoc* meeting was the need to address the lack of biotechnology statistics in OECD Member (and Observer) countries. In response to this, the OECD prepared an inventory of biotechnology statistics (van Beuzekom, 2000).[1] This inventory laid the groundwork for collecting the biotechnology statistics used in this Compendium.

A draft version of this Compendium was presented at the second *ad hoc* meeting on Biotechnology Statistics in May 2001. The Compendium was well received and it was therefore decided that this paper should be re-issued as an OECD working paper once the Secretariat had addressed specific comments received from the delegates of the group. This thus allowed delegates the opportunity to change and/or complete the information presented in the draft version of the Compendium.

This Compendium presents information gathered by the Secretariat. The principal aim of this Compendium is to highlight the types of biotechnology data that are currently available and to encourage the future collection of internationally comparable statistics on biotechnology. By presenting the range of indicators that can be produced from existing statistics, this Compendium should serve as a useful contribution to the work of the *ad hoc* group on biotechnology statistics and as an instrument for better identifying user needs.

This Compendium presents information gathered by the Secretariat. The principal aim of this Compendium is to highlight the types of biotechnology data that are currently available and to encourage the future collection of internationally comparable statistics on biotechnology. By presenting the range of indicators that can be produced from existing statistics, this Compendium should serve as a useful contribution to the work of the *ad hoc* group on biotechnology statistics and as an instrument for better identifying user needs.

The Compendium also provides insight into some of the statistical and methodological problems that exist in the current data: how to define biotechnology, which sector – public or private – should be the target of measurement, differences of coverage among national surveys and the classification of biotechnology international trade and patent data.

No attempt has been made to limit the data in this Compendium to indicators that are comparable between countries. Consequently, due to the lack of data comparability and the unknown quality of some of the data, the current version of this document is severely limited as an analytical tool for benchmarking or comparing national biotechnology policies, scientific capabilities, or commercial applications of biotechnology.

The development of a range of comparable biotechnology indicators for the OECD depends on progress in three areas:

- The first requirement is a uniform set of definitions for biotechnology. Whenever possible, this Compendium provides data for advanced or "third generation" biotechnology based on recombinant DNA. But, data on other types of biotechnology are also necessary, such as for

1. van Beuzekom, Brigitte (2000), "Biotechnology Statistics in OECD Member Countries: An Inventory," OECD, *STI Working Paper* 2000/6.

environmental applications or the use of proteomics and genomics in health care. The problem is to develop a set of workable definitions that clearly identify the different forms of advanced biotechnology.

- The second requirement is to develop indicators that are useful for end users, including policy makers, scientists active in biotechnology, firm managers, and innovation economists. The Compendium includes a large variety of indicators, each of which should be of value to at least one end user. At the same time, there are many gaps in the coverage, due to a lack of systematic data collection in most countries.

- Third, standardised survey procedures are required to provide comparable indicators. Many basic indicators are available that are similar in purpose, such as biotechnology employment or the number of "core" biotechnology firms, but the definition of employment or a "core" firm varies from country-to-country. In some countries, we do not even have basic information on the definitions or descriptions of survey methodologies.

Data reliability and sources used to prepare this document

The inventory constituted the primary source for the data compiled in this document. In essence there are four main types of data:

(a) Statistics collected for regulatory or legal reasons and which provide complete coverage of a given activity. These include patent data, genetically modified organisms (GMO) field releases, and trade data. Bibliometrics data is also similar in quality, although collected privately.

(b) Government statistics obtained via surveys (*i.e.* R&D surveys, the Canadian, French, and New Zealand surveys on biotechnology).

(c) Statistics collected by publicly funded organisations or non-profit institutes. This includes data from the US NSF or NUTEK in Sweden.

(d) Statistics collected by private organisations such as Ernst and Young, Arthur Andersen, and the European Venture Capital Association. Although collected by a university, the Co-operative Agreements and Technology Indicators alliances data also fall in this group.

The most reliable data are those collected for regulatory or legal reasons, as well as those statistics collected by national statistical organisations. In contrast, data collected by private firms are presumed to be less reliable. There are three main problems with some of the available data from private sources:

(a) Inadequate information is provided on how data is collected. Some of the data is from surveys, but full details on the number of responses and survey response rates are often missing.

(b) The coverage of biotechnology in many data sources is incomplete. For example, private data sources have concentrated on measuring employment in biotechnology firms with less than 500 employees. This creates a crucial problem in Europe, where most biotechnology employment is in large agro-seed firms such as Syngenta, Aventis, and Advanta, large diversified chemical firms such as BASF, and large pharmaceutical firms such as Astra-Zeneca and GSK.

(c) Some data sources enthusiastically overstate the importance and success of biotechnology, perhaps because their purpose is to encourage the growth of the biotech sector. Although some of the data collected by these sources is of value, the data need to be carefully evaluated in order to correct errors of omission, interpretation, and other problems.

For some indicators in some countries, we had no choice but to use data that were less than ideal. Wherever possible the methodological notes point out the weaknesses of the data. However, the accuracy of the notes depends on the amount of information available in the original source, which in some cases did not provide a full description of how the data were obtained.

No effort has been made to harmonise the varying nomenclatures for sectors or the different definitions of biotechnology. It was felt that this might add a false sense of similarity and encourage inappropriate comparisons amongst countries.

Structure of the document

This document is divided into two parts. Part one provides data that allow international comparisons between at least a few countries. Methodological boxes have been included in most sections. The second part is dedicated to country profiles. These profiles are by no means exhaustive. Rather, they are intended to display the range of data available in different countries. For some countries, the only data available are lists of companies active in biotechnology (*e.g.* Ireland, Norway). For other countries (*e.g.* Japan), the data on biotechnology are dominated by traditional biotechnology. While the aim was to focus on modern biotechnology, these data have been included, along with a methodological note of their limitations.

Acknowledgements

This project was realised thanks in large part to a voluntary contribution provided by the Government of Canada. The Compendium was prepared by Brigitte van Beuzekom of the OECD's Directorate for Science, Technology and Industry. In addition, this Compendium benefited from the contribution of Anthony Arundel of MERIT, who served as an outside reviewer during the preparation of the Compendium and from delegates involved in the OECD *ad hoc* Meeting on Biotechnology Statistics. Thanks to Sandrine Kergroach-Connan for her help in the preparation of the Trade and Venture Capital sections.

BIOTECHNOLOGY STATISTICS:

INTERNATIONAL COMPARISONS

BIOTECHNOLOGY AND PATENTS

Biotechnology patents

Patenting biotechnology, particularly gene patents, can differ between patent offices.

For more information on biotechnology patenting, refer to the trilateral studies (USPTO, EPO and JPO) Web site: http://www.jpo.go.jp/saikine/tws/sr-3.htm

Biotechnology patents granted by the USPTO

Patent statistics provided in these graphs are based on the numbers of patents granted by the United States Patent and Trademark Office (USPTO).

Biotechnology patents consist of class 435 of the USPTO classification system. Class 435 (entitled "molecular biology and microbiology") includes technologies relating to the analysis and application of the genomes of all creatures, such as Recombinant DNA, Genome analysis, Combinatorial Chemistry, Clone/ cloning, Gene/genetic diagnosis, Genetic engineering, Gene amplification, Gene probes, Protein engineering, DNA vaccines, DNA Makers, DNA sequencing, DNA synthesis, cell fusion, and polymerase chain reaction (PRC). A complete definition of class 435 can be found at:
http://www.uspto.gov/web/offices/ac/ido/oeip/taf/moc/435.htm

Year: is the year of the patent grant. Country: is the country of residence of the inventor. For patents with several inventors from different countries we applied "fractional counting" (the patent is shared between the concerned countries), to avoid double counting.

Biotechnology patents at the EPO by priority date

These data are for patent applications (which may or may not be granted) to the European Patent Office (EPO), and relate to the investor's country of residence and to the priority date, which is generally considered close to the date of invention.

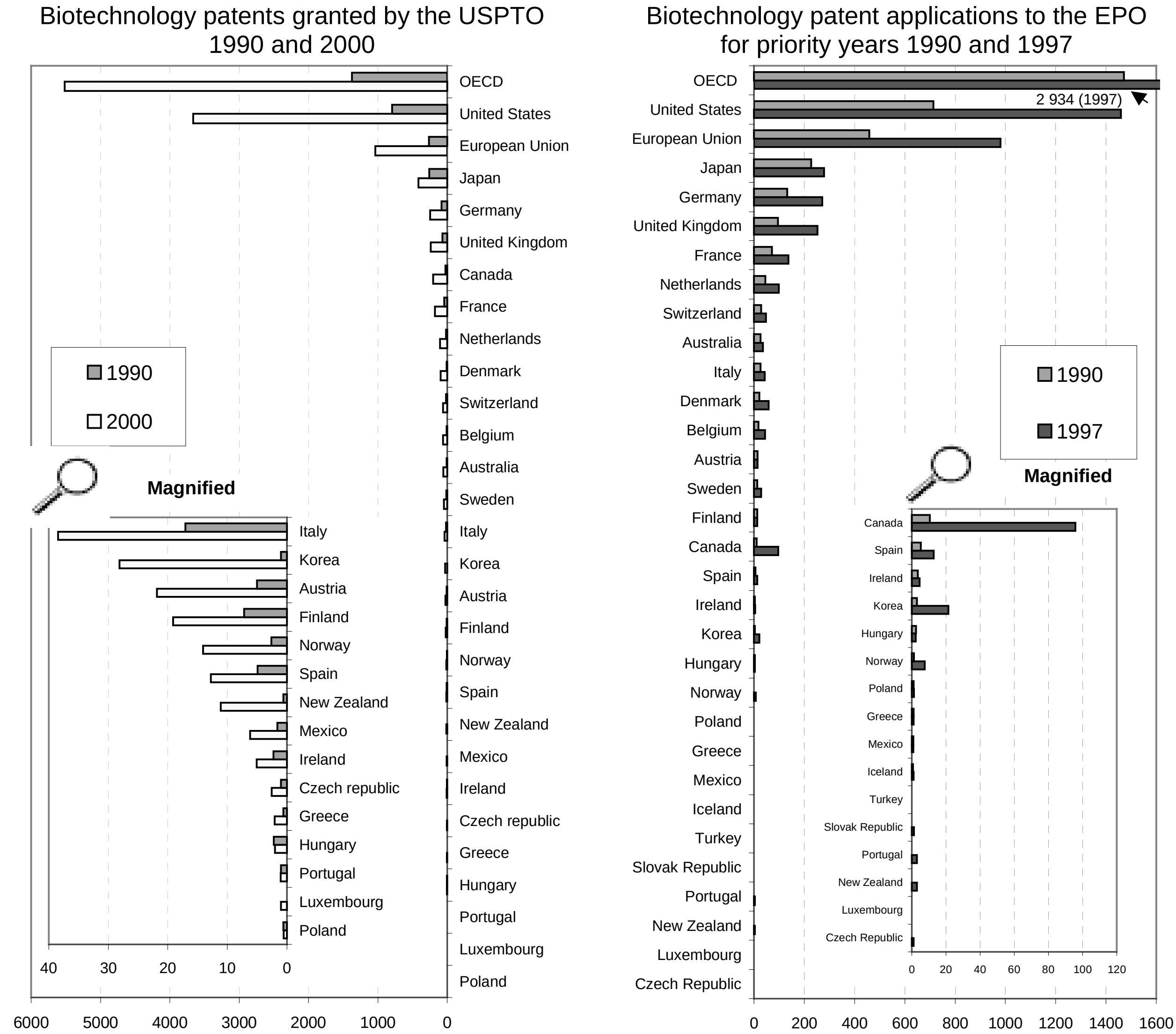
Biotechnology patents consist of five IPC codes:

C12M: Apparatus for enzymology or microbiology
C12N: Micro-organisms or enzymes; compositions thereof
C12P: Fermentation or enzyme-using processes to synthesise a desired chemical compound
C12Q: Measuring or testing processes involving enzymes or micro-organisms
C12S: Processes using enzymes or micro-organisms to liberate, separate or purify a pre-existing compound or composition

Complete definitions of these IPC codes can be found at:
http://classifications.wipo.int/fulltext/new_ipc/index.htm

Year: is the priority year of the patent application. Country: is the country of residence of the inventor. For patents with several inventors from different countries we applied "fractional counting" (the patent is shared between the concerned countries), to avoid double counting.

Figure 1. **Biotechnology and patents**

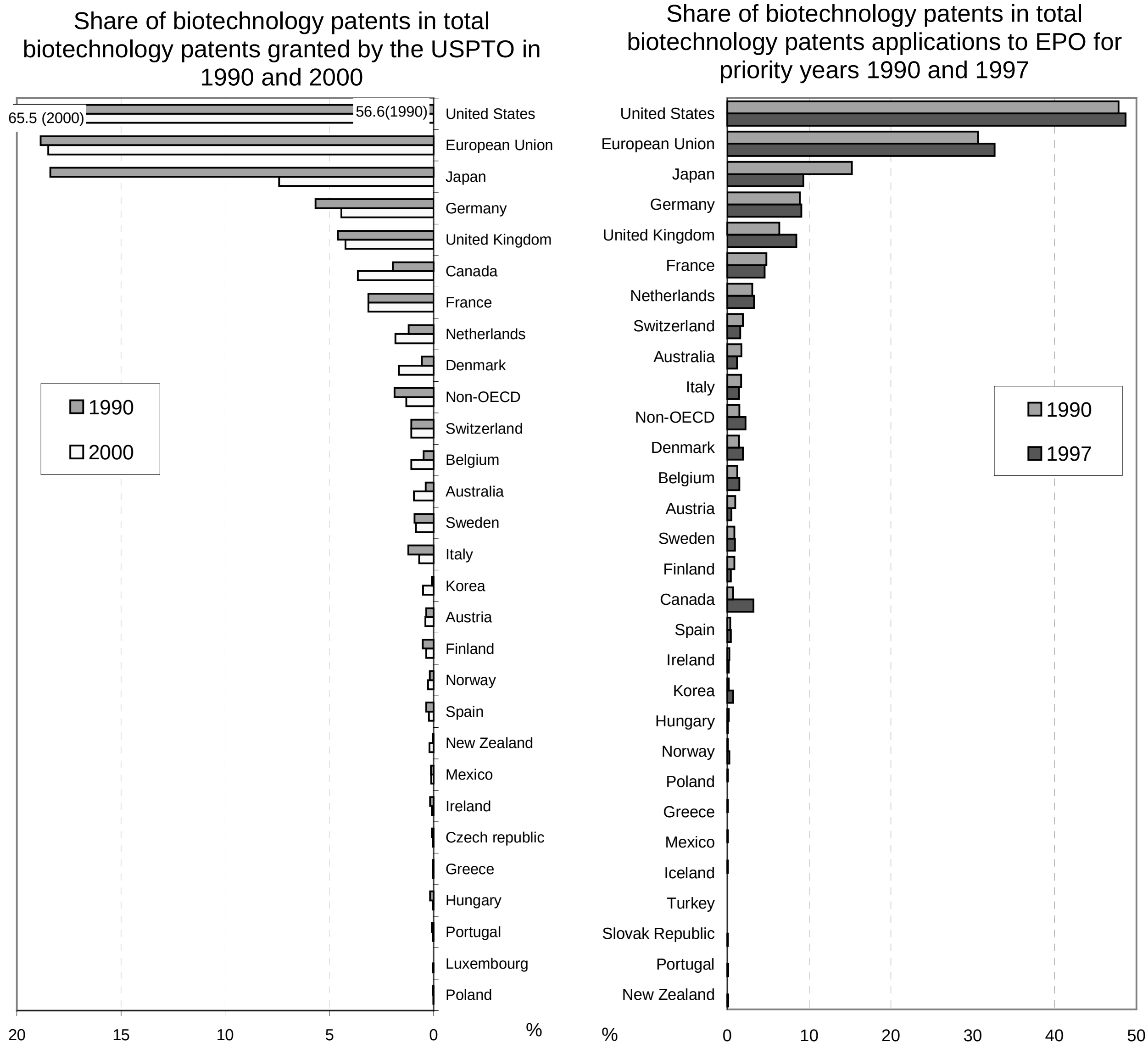


Source: OECD, calculations based on data from the USPTO and the EPO.

- The absolute number of USPTO and EPO biotechnology patents has grown substantially in comparison with the total number of patents. At the USPTO between 1990 and 2000, the number of biotechnology patents increased by 15%, compared to an increase of just 5% for patents, overall. At the EPO, biotechnology patent applications show a very similar trend: between 1990 and 1997, the number of biotechnology patents increased by 10.5%, while total patents rose by 5%.

- It is interesting to note that at both the USPTO and at the EPO the top six biotechnology "patenters" are identical. The differences start at the seventh spot where a clear geographical bias appears – at the USPTO with Canada and at the EPO with European countries.

Figure 2. **Biotechnology and patents**

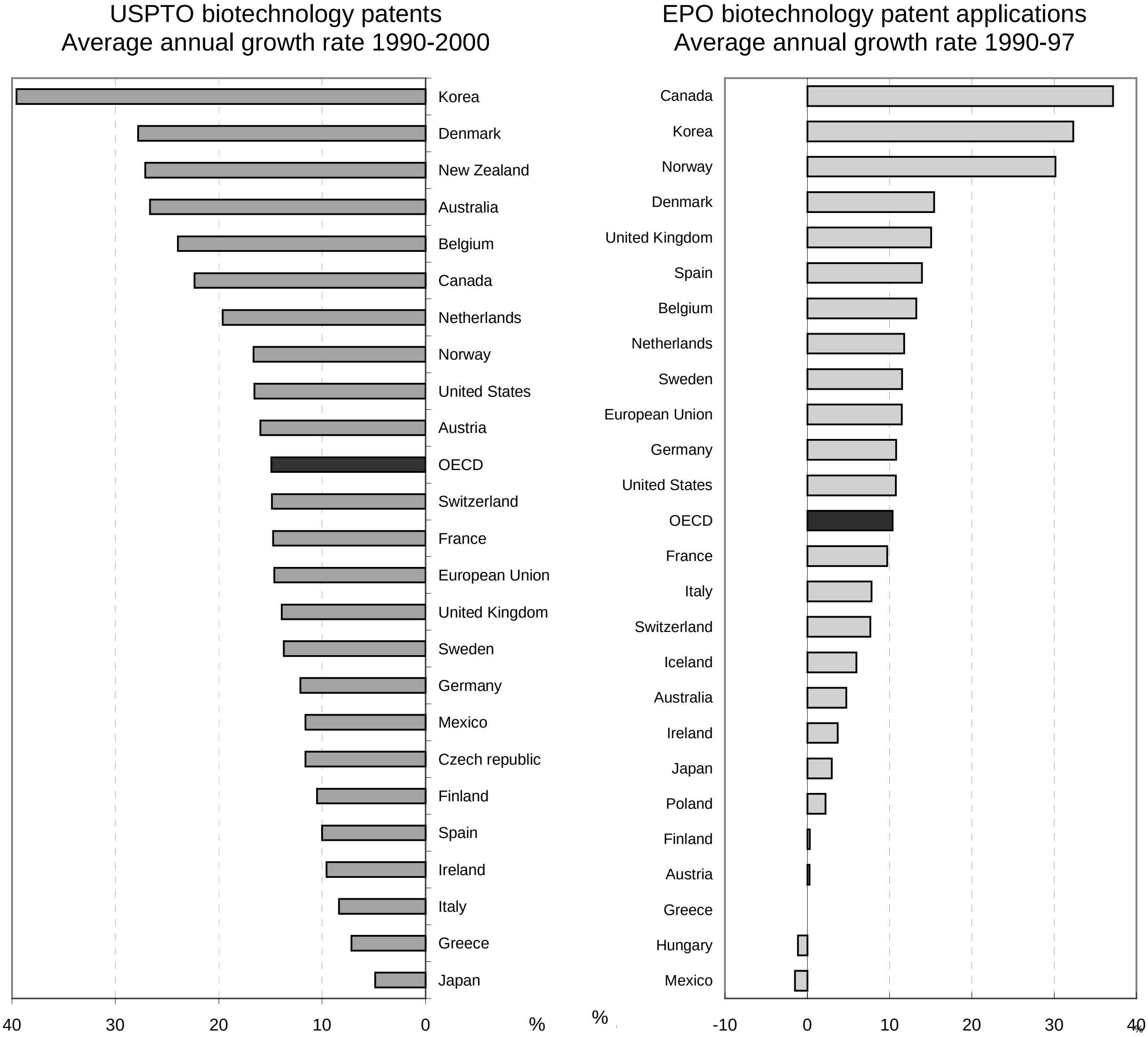


Source: OECD, calculations based on data from the USPTO and the EPO.

- Between 1990 and 2000, national shares of all biotechnology USPTO patents have only changed markedly for two countries: the United States increased its share by 9 percentage points and the share for Japan declined by 11 percentage points. Slight increases occurred for Canada (+1.7 percentage point) and Denmark (+1.1 percentage point), while Germany lost a little ground (-1.2%). The shares of all other OECD countries have remained relatively stable over this time period (less than a one percentage point change).

- Between 1990 and 1997, national shares of all biotechnology EPO patent applications has changed markedly in only Japan, with a decline of 6 percentage points. Canada has the greatest increase (+2.5 percentage points) followed by the United Kingdom (+2.1 percentage points). The shares of all other OECD countries have remained relatively stable over this time period (less than a one percentage point change).

Figure 3. **Biotechnology and patents**



Source: OECD, calculations based on data from the USPTO and the EPO.

- USPTO growth rates are positive in all countries for the 1990-2000 time period. France has the median growth rate, which means that all countries below it are patenting at a slower than average growth rate. Korea is experiencing the fastest per annum increase (close to 40%), but Korea's very small share in the amount of overall patenting (.07% in 1990 to .5% in 2000) could explain the high volatility of this number.

- EPO growth rates are positive in the majority of countries for the 1990-97 time period. Canada is experiencing the fastest per annum increase (close to 40%), followed by Korea. But – as with the USPTO – Korea's very small share in the amount of overall patenting explains the high volatility of this number.

BIOTECHNOLOGY AND BIBLIOMETRICS

The following tables and accompanying analysis were extracted from a study by NUTEK Sweden (now a part of VINNOVA). For the detailed methodology used in this study, refer to Annex 1 or the paper available at http://www.nutek.se/analys/teknik/bibliometri.pdf

The following data, which focus primarily on Sweden, provide a very good example of what can be achieved with bibliometric data, and can be used as a model for other countries.

Limitations of bibliometric data

Bibliometric data is based on publications in scientific journals and citations to journal articles. Whether or not a firm decides to publish an article in a scientific publication depends on several strategic choices. A firm could decide not to publish if it wishes to keep information secret, or it could publish to prevent its competitors from patenting. Thus, publishing papers can reflect the business strategies of corporations rather than the amount of knowledge produced. Still, assuming that publication strategies are fairly constant over time, the number of papers published by firms and their collaboration patterns can reveal interesting trends in research and development activities.

Concerning knowledge exchange, the use of bibliometric data is limited to the description of collaborations leading to scientific publications. The data therefore needs to be complemented with other types of data (*e.g.* on economic and ownership relations) and interviews if the aim is a complete picture of the interdependence between different organisations and the collaboration patterns in an innovation system. Much knowledge production results from research and development within business enterprises and is, for obvious reasons, never published. The aim is instead to develop a new product or service and the innovation process is therefore not made public until the product is put on the market or a patent application has been filed. However, when it comes to knowledge exchange between the public research organisations and industry, bibliometry is very useful since there are strong incitements in academia for publishing scientific results. Both academic positions and to some extent research grants are granted based on the scientist’s publication volume and content. The comparison of publication counts and impact factors between different subject fields, however, needs to be analysed with some precaution since the amount of work needed for one publication, the difficulty of getting published, and the impact factors, vary between scientific subject fields.

See Anna Nilsson, Ingrid Pettersson, Anna Sandström, “A Study of the Swedish Biotechnology Innovation System Using Bibliometry”, NUTEK Working Paper, January 2000.

BIOTECHNOLOGY AND BIBLIOMETRICS

Table 1. **National shares of the total number of publications in the biotechnology and applied microbiology NSIOD journal category**

	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	Mean
Belgium	1.0	1.4	1.4	1.1	1.0	1.0	1.0	1.0	1.6	1.4	1.2	1.4	1.0	1.2
Canada	9.4	10.5	8.8	7.6	6.3	6.9	6.4	5.9	5.8	6.3	5.1	5.1	3.8	8.2
Denmark	0.6	0.7	0.4	0.5	0.5	0.6	1.0	0.9	1.0	1.1	1.2	1.1	1.4	0.8
Finland	1.1	0.9	0.9	0.6	1.0	1.3	0.8	1.8	1.0	1.2	0.8	0.8	0.7	0.9
France	7.4	7.1	7.0	6.1	6.4	6.4	6.9	5.6	6.7	6.9	6.3	7.5	7.3	5.9
Germany	5.4	6.4	6.1	6.5	6.3	6.9	7.3	6.6	6.7	6.8	7.3	6.3	6.9	6.0
Italy	1.1	1.1	1.3	2.1	1.6	3.8	2.2	4.1	2.5	2.7	2.7	2.7	2.6	2.1
Japan	10.9	10.7	11.3	11.4	12.3	12.6	12.1	13.1	12.7	11.9	10.7	11.6	12.9	12.1
Netherlands	2.2	2.1	2.7	2.1	2.9	2.8	2.6	2.9	2.9	2.8	3.1	3.1	3.0	2.4
Norway	0.1	0.2	0.0	0.2	0.4	0.2	0.2	0.3	0.5	0.2	0.3	0.4	0.5	0.2
Spain	1.8	2.2	2.2	2.2	2.4	2.8	2.7	3.6	3.6	4.1	4.9	4.5	4.8	2.6
Sweden	2.0	1.4	1.7	1.9	1.9	2.2	1.4	1.3	2.0	1.5	1.4	2.0	1.9	1.8
Switzerland	1.9	1.1	1.7	1.1	1.2	1.1	1.6	1.9	1.6	1.9	1.8	1.8	1.8	1.5
United Kingdom	12.4	10.2	8.9	7.9	10.1	11.0	9.7	8.6	9.6	11.0	8.7	8.6	8.7	9.3
United States	22.9	23.8	28.8	26.5	27.0	22.8	22.2	21.8	20.5	21.2	21.5	21.8	21.0	23.9
Other countries	19.8	20.2	16.8	22.2	18.7	17.6	21.9	20.6	21.3	19	23	21.3	21.7	20.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Total number of papers	1 574	1 889	2 115	2 174	2 347	2 699	2 807	2 845	3 156	3 196	3 161	3 265	3 261	34 489

Source: OECD, based on data from NUTEK Sweden.

- One measure of scientific output by a country in a particular field such as biotechnology or applied microbiology is the share of publications in scientific journals. Table 1 shows the share of such publications for selected European countries, as well as for Canada, Japan and the United States.

- The share for most countries has remained stable over time even though the number of biotechnology articles more than doubled, from 1 574 in 1986 to 3 261 in 1998. Together, the United States and Japan account for about a third of all publications in these fields. The share in Italy, Spain, Denmark, and Japan has increased slightly while the share has declined for the United Kingdom, the United States, and most notably for Canada.

Table 2. **The relative impact by country of publications in the biotechnology and applied microbiology NSIOD journal category**

Rate above or below the mean number of citations

	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	Mean
Belgium	0.5	0.8	0.9	0.9	1.0	1.9	1.1	1.0	1.6	1.5	1.3	1.5	0.6	1.1
Canada	1.0	1.1	1.2	1.3	1.1	1.1	1.1	1.2	1.1	1.3	1.1	0.9	1.0	1.1
Denmark	0.6	1.0	1.6	1.4	2.3	1.7	1.1	1.4	1.0	1.4	1.4	1.5	0.5	1.2
Finland	1.4	2.7	1.6	1.3	1.1	1.3	2.8	1.2	1.4	1.0	0.7	1.6	2.3	1.6
France	0.6	0.8	0.8	0.8	0.9	0.9	0.8	0.9	0.7	0.7	0.8	0.9	0.6	0.9
Germany	1.0	1.1	0.9	1.3	1.0	1.4	1.1	1.1	1.1	1.4	1.4	1.4	1.5	1.3
Italy	0.9	0.8	1.0	0.5	0.8	0.6	0.9	0.7	1.2	1.3	0.7	1.0	1.5	0.9
Japan	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.7	0.8	0.8	0.9	0.8
Netherlands	1.5	2.4	1.4	1.4	1.5	1.6	1.6	1.8	1.9	1.6	1.3	2.0	1.2	1.6
Norway	0.6	2.9	0.3	3.1	1.8	0.6	1.3	1.2	1.2	1.2	0.3	1.4	1.0	1.2
Spain	0.6	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.8	0.8	1.0	0.7	0.8
Sweden	1.4	1.8	1.5	1.5	1.2	1.5	1.7	1.9	1.7	1.7	1.6	1.6	0.8	1.5
Switzerland	2.4	1.6	2.5	2.0	2.1	1.6	1.3	1.5	1.1	2.5	2.4	2.0	3.3	1.8
United Kingdom	1.0	1.2	0.8	1.4	1.1	1.1	1.3	1.2	1.3	1.2	1.3	1.1	1.3	1.1
United States	1.5	1.3	1.3	1.3	1.4	1.3	1.5	1.4	1.3	1.3	1.5	1.6	2.0	1.4

Source: OECD, based on data from NUTEK Sweden.

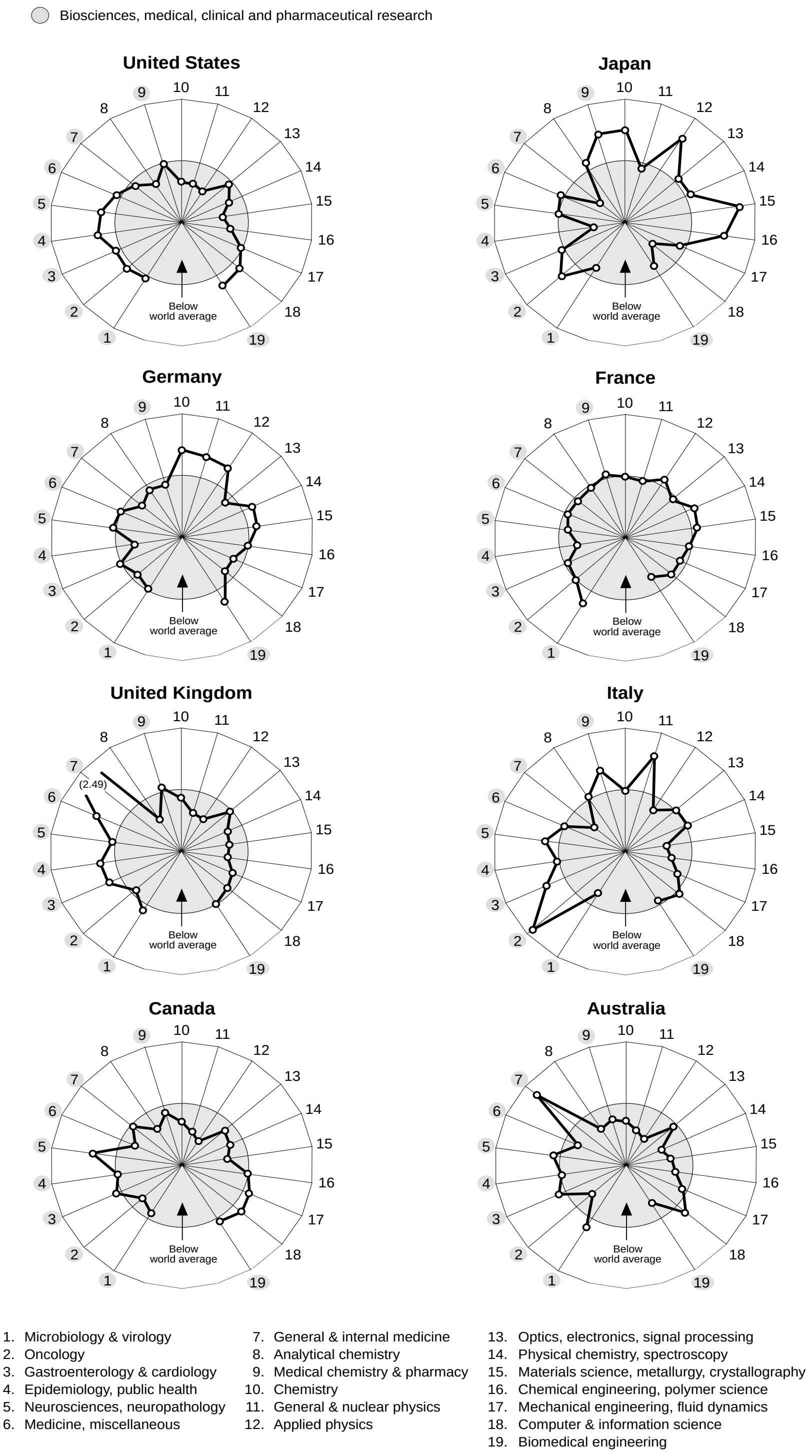
- The impact of a particular paper is based on the number of citations made to it by other published work. If a paper has more citations than the average for its field, it has an above average impact. In Table 2, the relative impact in 1986 is 0.5 for Belgium and 1.5 for the United States. On average, a Belgian paper published in 1986 received half the average number of citations, while a US paper received 50% above the average number.

- Over the 1986-98 period, Switzerland, Finland, the Netherlands, Sweden, the United States and Germany had above average impact rates for biotechnology and applied microbiology publications, ranging from 1.8 for Switzerland to 1.3 for Germany. Spain, Japan, France and Italy had below average impacts. For most countries, these trends have been relatively constant over the 12-year period.

BIOTECHNOLOGY AND BIBLIOMETRICS

Figure 1. **National profiles of relative scientific specialisation**

Based on publications, 1998



Source: OECD, Industry-Science Relationships: Interim Report, Paris 2000, Figure 7, page 19. Based on OST special tabulations of data from the Institute for Scientific Information.

- Scientific specialisation profiles can be obtained from the distribution of published articles by field and comparing this to the average. Figure 1 is based on bibliometric data obtained from OST and broken down into 19 scientific categories. Categories one through seven, nine and nineteen (shaded) are in the health, pharmaceutical and biomedical engineering fields. In those fields where the country has a better than average publication performance, the line is outside of the grey shaded circle, in those cases where it is below average, it is inside the circle.

- Each country analysed has an above average strength in at least one health/bio-medical area. The United Kingdom was the strongest across all the health/bio-medical fields, although Italy and to a lesser extent the United States were strong as well. Japan was well below average in a few of the fields.

- As for biomedical engineering, which is the field with some of the strongest links to biotechnology, the United States and Germany were above average while Japan, France, and Australia were below.

BIOTECHNOLOGY AND TRADE

There is no available trade data that is precisely limited to well-defined biotechnology products. The best available data is from the US Census Bureau, which defines "biotechnology products" as a group that is almost entirely based on biologics. This definition both includes many products that are not part of advanced biotechnology and excludes other important biotechnologies. Nevertheless, this section follows the US Census practice in referring to "biotechnology" trade. These products have a limited but increasing share of US technology trade.

- In 1999, bio-engineered products (largely biologics) accounted for barely 1% of US exports and less than 0.9% of US imports of advanced technology products.

- Because of their small share, trade in biotechnology products is highly volatile. Moreover, the lack of continuous time series makes it difficult to analyse trends. However, the limited data available suggest that:

- The pace of transactions involving biotechnology commodities has quickened over the past decade. Between 1996 and 1999, US biotechnology trade grew by 13.2% a year on average, whereas technology transactions increased by 9.5% and total trade by 6.5%.

- Trade in biotechnology may have developed slightly faster than for other advanced technology products. The share of biotechnology in US technology trade (exports and imports) grew slightly over a number of years despite the marked expansion in the share of technology in total US trade. However, this was mostly due to the intensification of US imports (with an average annual growth rate of 20% between 1996 and 1999).

The US is a net exporter of biotechnology products and remains a leader on the international market

- In 1999, US biotechnology exports to OECD countries amounted to more than USD 1.34 billion as compared to imports of USD 970 million from OECD countries. Thus, the biotechnology trade surplus exceeded USD 370 million, or 1.8% of the trade surplus generated by advanced technology products.

- The share of biotechnology in the technology trade surplus is thus twice as large as its share in technology trade (0.9%). In other words, US exports of biotechnology products exceeded imports to a greater degree than was the case for technology products overall. This durable trade surplus points to a US trade specialisation and suggests that the United States has a leading position on the international biotechnology market.

Limitations of the US trade data in the context of biotechnology

The US data are based on the definition of biotechnology in the Advanced Technology Products (ATP) list developed by the US Census Bureau (www.census.gov/foreign-trade/www/sec2.html#ATP). The list of commodities included in the biotechnology/biologics category is specified in Annex 2.

All of the biotechnology products on the ATP list appear to belong to biologics. Biologics consists of therapeutic products derived directly from living organisms; these include vaccines, human blood and plasma, proteins and monoclonal antibodies. Major biotech drugs such as humulin, interferon, epoetin, etc fall under biologics. However not all biologics are derived from biotechnology, which means that the ATP commodity list – although at the ten-digit level – is still not adequately disaggregated to permit trade data on biotechnology alone. Furthermore, this definition of biotechnology as biologics excludes other products such as scientific equipment used in biotechnology research, environmental biotechnology and agricultural biotechnology.

The trade data are extracted from the US International Trade Commission (USITC) Web site (www.usitc.gov). They are compiled from tariff and trade data from the US Department of Commerce, the US Treasury and the US International Trade Commission.

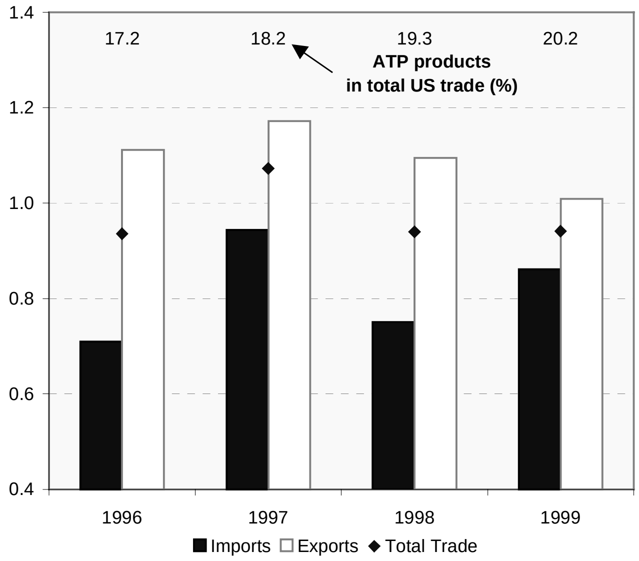
These data provide quite a reliable and consistent picture of US biotechnology trade based on biologic products and may therefore shed some light on the state of international trade in biotechnology. The United States has made a major contribution to technology trade in the OECD area over the past decades: in 1998, it was involved in 24% of imports of high-technology products and 18% of exports, but in 14% and 17%, respectively, of total OECD imports and exports of manufactured products.[1] Moreover, the United States is a traditional technology provider worldwide: historically, US trade shows a debit balance, except for technology-embodied products. It is therefore to be expected that the United States would play a prominent role in world biotechnology trade.

The USITC data overestimate the contribution of the United States' traditional trading partners (Canada, Japan) at the expense, for instance, of European countries. The impact of these distortions remains difficult to evaluate.

1. OECD, Foreign Trade Statistics database, January 2001.

Figure 1. **Share of biotechnology in US trade with the OECD area, 1996-99**

As a percentage of total US advanced technology[1] (ATP) exports and imports



1. Defined as advanced technology products: biotechnology, life science technologies, opto-electronics, computers, electronics, computer-integrated manufacturing, material design, aerospace, weapons and nuclear technology.

Source: www.usitc.gov, December 2000.

US trade in biotechnology is concentrated among a small number of countries

- In 1999, more than 80% of US biotechnology exports went to seven OECD countries, with the remainder distributed throughout the OECD area. US biotechnology imports were also restricted to seven countries, with just 16% of total US imports coming from the remaining OECD countries.
- The concentration of US technology trade is similar, although the number of countries purchasing biotechnology products may be smaller than for other technology products.

The United States' main trading partners for biotechnology are not their traditional technology trade partners

- The countries that absorbed more than 80% of US biotechnology products in 1999 accounted for 66% of US technology and non-technology exports. The top 80% of exporters of biotechnology products to the United States provided only 38% of US technology imports and 43% of all imports. The pattern of trade in biotechnology thus diverges from traditional trade patterns.
- The absence of Mexico, Korea and, to a lesser extent, Italy from the leaders is striking, as is the prominence of Belgium, Ireland and Switzerland.
- Belgium appears to be the main US partner for biotechnology, accounting at the end of the 1990s for around a quarter of all US biotechnology transactions (24% of exports and 26% of imports).

Most US biotechnology partners import or export but rarely do both

- Belgium (and to some extent the United Kingdom) stands out by being quite equally represented in US exports and imports.

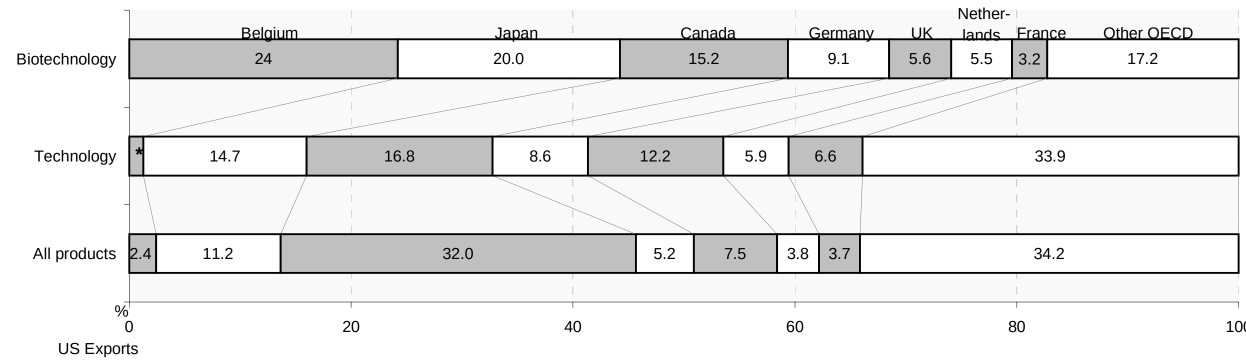
- In 1999, the other three leading destinations for US biotechnology products were Japan (20%), Germany (9.1%) and Canada (15.2%), but both Japan and Germany were not among the major providers of US imports and Canada's share was only 7.2%.

- Switzerland, Ireland and, to a lesser extent, France and the Netherlands are important exporters of biotechnology to the United States but are less significant importers. France and the Netherlands accounted for a far smaller share of US exports than of US imports (13.1% *vs.* 3.2% and 10.6% *vs.* 5.5%, respectively). Switzerland and Ireland were very significant suppliers of US imports (11.7% and 6.9%, respectively), but negligible destinations for US exports.

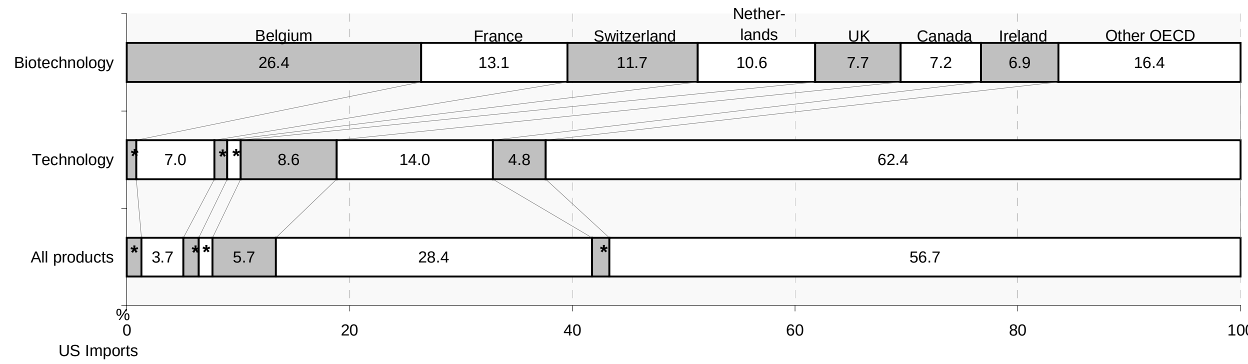
- This suggests some relative national specialisations and weak intra-industry trade.

Figure 2. **US biotechnology trade (exports and imports) across the OECD area**

Cumulative share in US biotechnology exports to the OECD area, 1999



Cumulative share in US biotechnology imports from the OECD area, 1999



* Less than 2%.

Source: www.usitc.gov, December 2000.

BIOTECHNOLOGY AND ALLIANCES

The following tables and accompanying analysis are based on the most recent publicly available data from the CATI database maintained by MERIT. These data were released in the National Science Foundation's *Science and Engineering Indicators 2000* report. This section is based on the data available in Appendix Table 2-67 of the NSF report, reproduced in Annex 3 of this document. For more information on this database, refer to the publication available at http://www.nsf.gov/sbe/srs/seind00/start.htm – Chapter 2, pp 56-57.

CATI obtains information on strategic alliances for transferring technology or for joint research from announcements or articles in newspapers and professional journals, many of which are in English. A major limitation with the data for biotechnology is that a large percentage of strategic alliances in this field involve small firms that provide contract research services in platform technologies, such as genomics, combinatorial chemistry or high throughput screening. Many of these are probably not included in CATI. This would limit the CATI alliances to major undertakings, and possibly explain why Ernst and Young reports 241 strategic alliances among European biotechnology firms in 1999 compared to the CATI estimate of 59 alliances for 1998, which is the most recent year available in CATI. Although the number of alliances fluctuates from year to year (see Table 1 below), it is highly unlikely that the total number of alliances could have jumped from the CATI estimate of 59 in 1998 to the Ernst and Young estimate of 241 in 1999.

Eighty per cent of all CATI technology alliances involve the United States, probably because CATI has a strong bias for alliances announced in English language publications. For this reason, the indicators given below are limited to alliances that involve at least one firm or other organisation based in the United States. No results are provided here for the number of intra-Japan or intra-Europe alliances, since the numbers are unlikely to be comparable with the results for the United States. The interested reader can, however, find data on intra-European biotechnology alliances in the NSF tables, reprinted in Annex 3.

Table 1 gives the number of all US technology alliances between 1980 and 1998 that were included in CATI and the number due to biotechnology. Using this data, Figure 1 gives the percentage of all US biotechnology alliances that involve a foreign partner, while Figure 2 gives the percentage of all US technology alliances for biotechnology.

Figure 1 shows that the percentage of all technology alliances in the United States based on biotechnology has followed a cyclical pattern, with an increase in the late 1980s, a decline to 1990, followed by another increase with a peak in 1997.

Other than annual fluctuations, there do not appear to be any consistent differences over time in the share of international US biotechnology alliances out of all biotechnology alliances, as shown in Figure 2. One implication is that the US lead in biotechnology has remained relatively constant. In contrast, the share of US-Europe alliances has grown while the share of US-Japan alliances has declined.

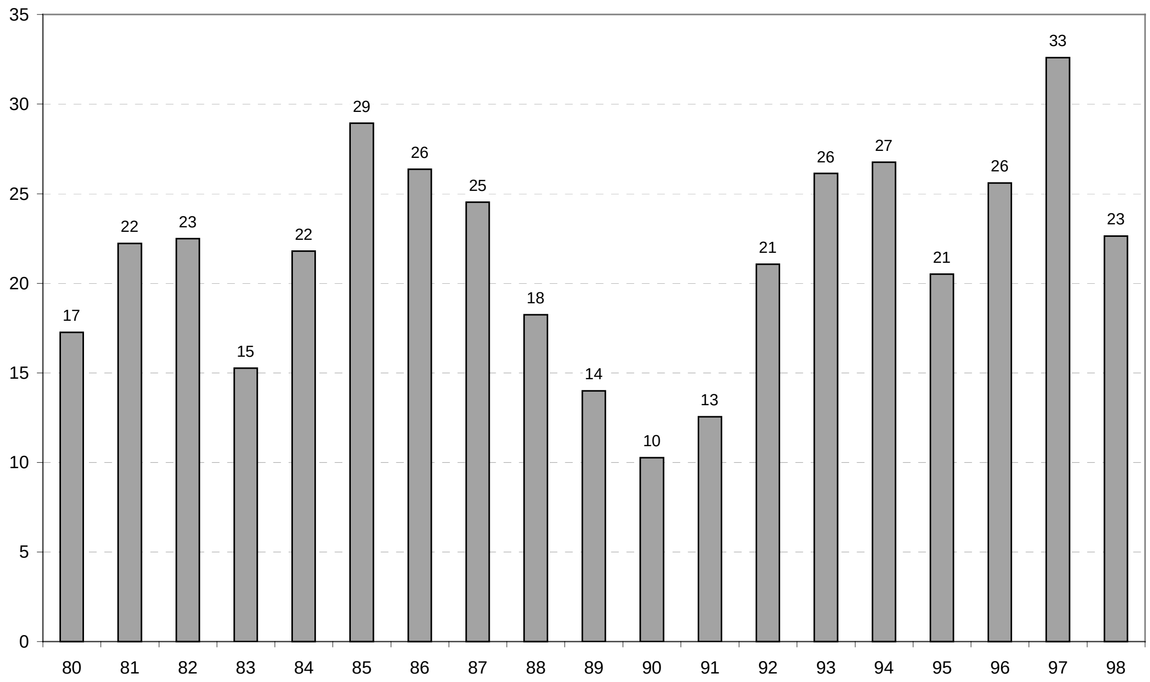
BIOTECHNOLOGY AND ALLIANCES

Table 1. **International strategic biotechnology technology alliances with at least one partner based in the United States, 1980–98**

	1980	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Total US alliances	139	126	200	177	234	235	292	318	367	357	312	287	394	444	497	639	578	497	477
US-Europe	5	6	9	7	14	22	24	28	21	16	11	18	40	42	62	59	75	49	47
US-Japan	6	8	12	7	7	16	14	11	6	6	4	1	5	10	7	6	13	14	6
US-other	3	2	1	0	2	3	0	3	4	5	4	1	5	7	6	6	7	6	2
Intra US	10	12	23	13	28	27	39	36	36	23	13	16	33	57	58	60	53	93	53
Total biotech alliances	24	28	45	27	51	68	77	78	67	50	32	36	83	116	133	131	148	162	108
of which international	14	16	22	14	23	41	38	42	31	27	19	20	50	59	75	71	95	69	55

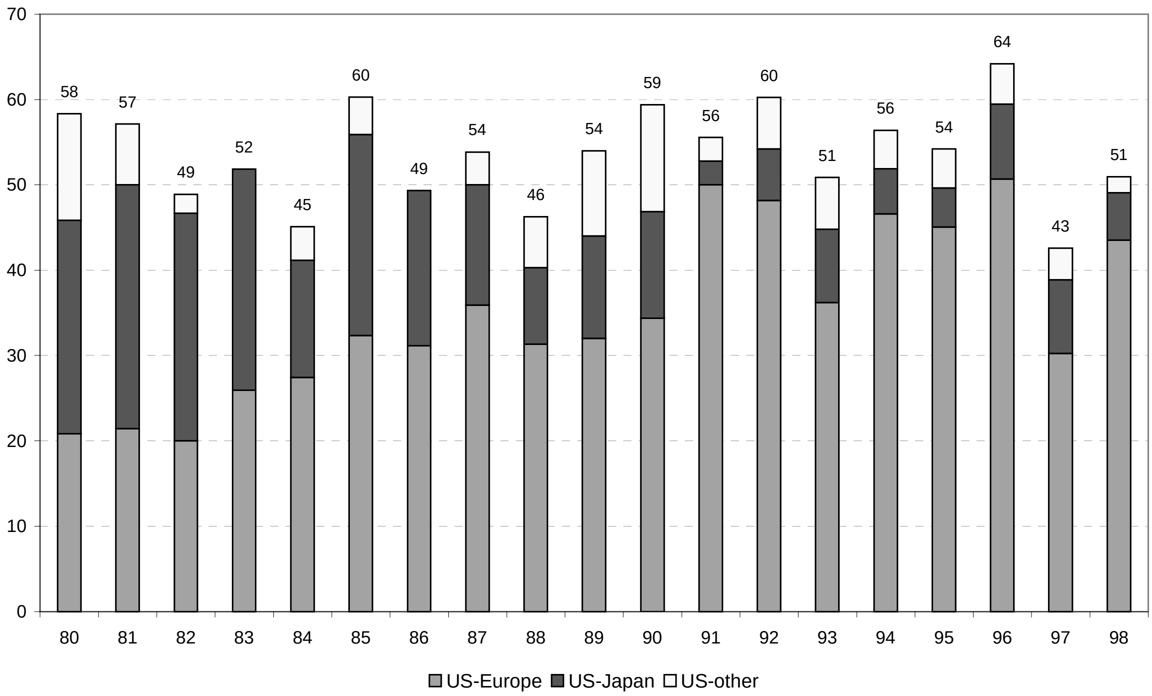
Source: OECD, NSF: Special tabulations of the CATI database at MERIT, 1999.

Figure 1. **Total biotechnology alliances as a percentage of total alliances with the United States, 1980-98**



Source: OECD, NSF: Special tabulations of the CATI database at MERIT, 1999.

Figure 2. **Share of foreign biotech alliances out of all US alliances, 1980-98**



Source: OECD, NSF: Special tabulations of the CATI database at MERIT, 1999.

BIOTECHNOLOGY AND VENTURE CAPITAL

Data on venture capital

There are two main sources of venture capital. First, specialised financial firms, which act as intermediaries between primary sources of finance (such as pension funds or banks) and firms, provide formal venture capital. Second, "business angels", usually wealthy individuals experienced in both business and finance, invest directly in firms.

The data collected by national or regional venture capital associations from their members only capture formal venture capital. Yet, according to estimates, business angels invest almost twice as much annually in new firms as venture capital funds in the United States, although the figure is probably much lower in most other OECD Member countries.

There are several stages of financing in the growth of a venture-backed company:

- Seed capital: to research, assess and develop an initial concept.
- Start-up: for product development and initial marketing. The firm may have been recently established, or may have been in business for a short time, but has not sold the product commercially.
- Expansion: for growth of a company that is breaking even or trading profitably. Capital may be used to finance increased production capacity, market or product development and/or to provide additional working capital.

The data used for the following graphs and accompanying analysis are mainly drawn from three sources: the US National Venture Capital Association (NVCA), the European Venture Capital Association (EVCA) and the Canadian Venture Capital Association (CVCA). Information on venture capital investments in Asia, unfortunately, does not allow the identification of the share of biotechnology in the overall medical sector.

Data restrictions

Comparison by sector of activity and stage of development

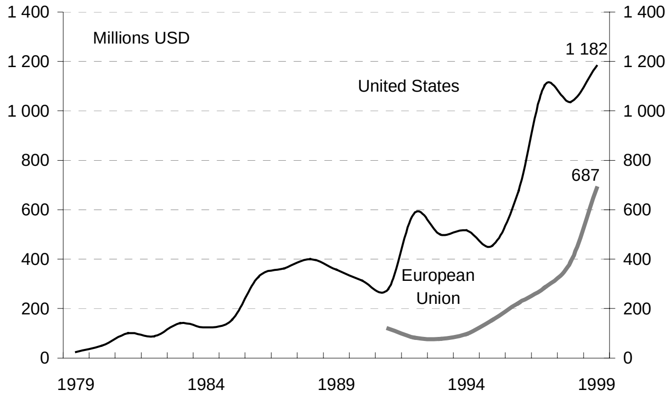
Because of the lack of data on sector of activity and stage of development, it is not possible to analyse more rigorously the impact of a firm's stage of development on the sectoral breakdown of venture capital, except for the United States. The European aggregates, published on the basis of EVCA data by the PricewaterhouseCoopers consulting group, do not provide further information on the method of calculation. However, as the results are consistent with those obtained for the US data, they may be considered relatively reliable.

Average deal size

For several countries – Poland, Norway, Ireland – the number of deals remains quite small. One big, or relatively small, deal could significantly alter the final picture.

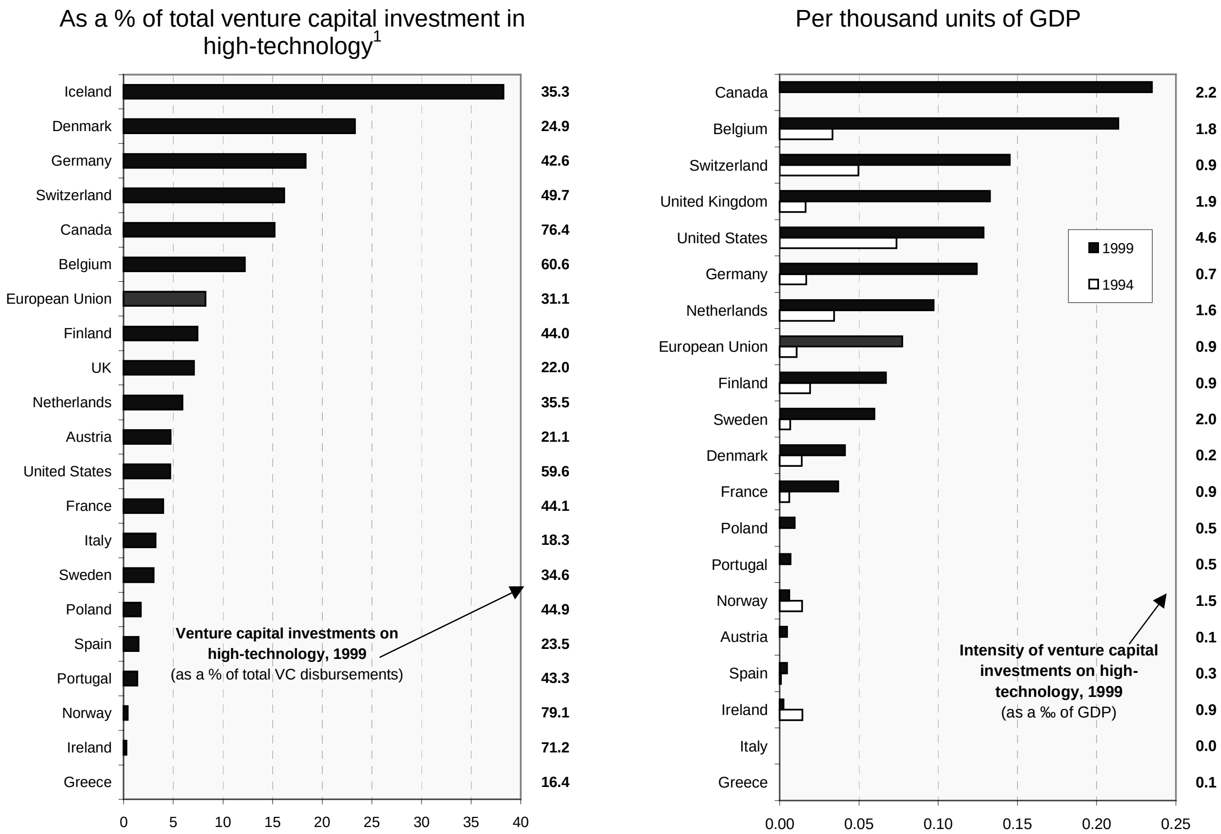
BIOTECHNOLOGY AND VENTURE CAPITAL

Figure1. **US and EU[1] venture capital disbursements for biotechnology firms, 1979-98**



1. Data for the European Union are estimates.

Figure 2. **Venture capital investments on biotechnology, 1999**



Note: Data for Poland are preliminary pilot data and are not included in the European total.
1. Includes communications, computer related, other electronics related, biotechnology and medical/health related.

Sources: For the United States, National Science Foundation, *Science and Engineering Indicators 2000* (also accessible at www.nsf.gov); the NVCA Yearbook 1999; NVCA latest news (www.nvca.com); the Venture Economics News; Thompson Financial Securities Data (www.securitiesdata.com). For European Union countries, the EVCA Yearbooks: 1996, 1998, 1999, 2000 (www.evca.com). For Canada, the CVCA (www.cvca.ca). GDP data come from the OECD S&T database.

BIOTECHNOLOGY AND VENTURE CAPITAL

The United States is the main venture capital market for biotechnology firms and drove the spectacular growth in investments over the 1990s

- Between 1991 and 1999, a total of USD 6 332 billion was invested in biotechnology in the United States and slightly under USD 2 200 billion in the European Union. In 1999, venture capital investment peaked, with investment of USD 1 180 million in the United States and of USD 690 million in the European Union. In the United States, California firms captured nearly half of US funding in the period 1980-98.

- Between 1995 and 1999, the share of the biotechnology sector in total venture capital investment grew at an annual average of 24% in the United States and 37% in the European Union.

In relative terms, the EU and Canadian venture capital markets provided more support to the biotechnology sector

- In 1999, biotechnology firms attracted less than 10% of total venture capital disbursements to high technology sectors. Only in a few European countries (Denmark, Germany, Switzerland, Belgium) and in Canada was the 10% threshold exceeded. Iceland devoted the largest share (38%) of capital directed towards high technology to biotechnology firms.

- In terms of the intensity of biotechnology venture capital, the leaders were Canada, Belgium and Switzerland, allocating 0.23, 0.21 and 0.14‰ of GDP, respectively, to the sector. US biotechnology disbursements were only 0.13‰ of GDP.

The biotechnology sector accounts for a large share of early-stage investments, a sign of the embryonic state of the sector

- In the late 1990s, communications- and software-related industries were the main targets of US and European venture capitalists. By comparison, the biotechnology sector, which represented 5-15% of total disbursements, received relatively less attention.

- In the United States, 6% of total venture capital disbursements and 12% of total seed disbursements went to biotechnology, in 1998.

- Venture capital deals involving biotechnology firms are generally smaller than the average for high-technology deals, although Belgium and Switzerland are exceptions.

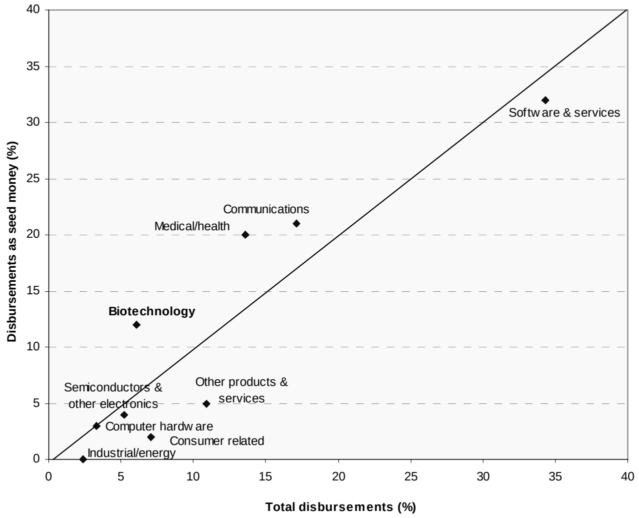
- In the United States, the average biotechnology deal represented USD 5.3 million, more than double the amount in Canada and more than four times that in the European Union (see Figure 4). The European aggregate hides large differences: in 1999, the largest numbers of biotechnology venture capital deals were in Germany (191), the United Kingdom (144) and France (56), but the average amounts of the deals were USD 2.5 million, USD 0.8 million and USD 5.8 million, respectively.

BIOTECHNOLOGY AND VENTURE CAPITAL

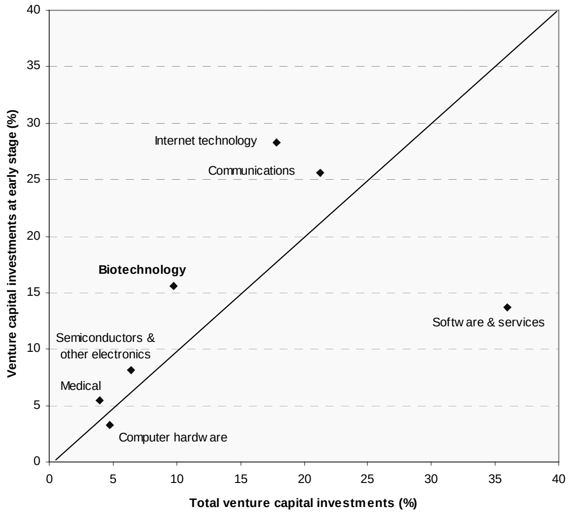
Figure 3. **Venture capital investments by sector and stage of development**

Sector share in total VC investment and in VC investment.

US venture capital, 1998

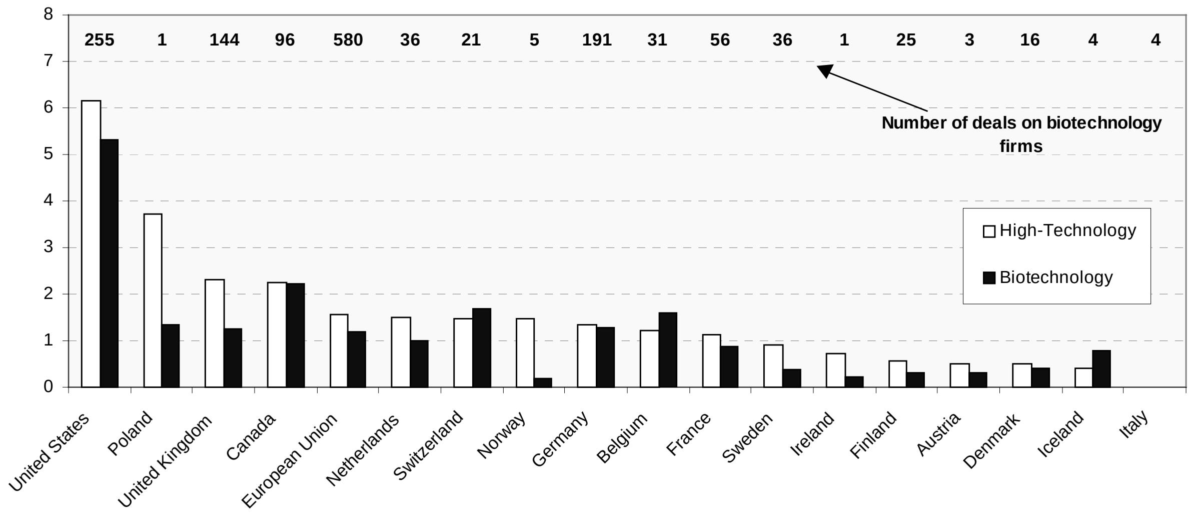


EU venture capital, 1999



Source: For the United States, National Science Foundation, *Science & Engineering Indicators* – 2000. For the European Union, PricewaterhouseCoopers, *Money for Growth: The European Technology Investment*, Report 1999, based on EVCA data.

Figure 4. **Average size of venture capital investment deals by sector, USD millions, 1999**[1]



1. 1998 for the United States.

Source: For the United States, National Science Foundation, *Science and Engineering Indicators 2000* (also accessible at www.nsf.gov). For the European Union, EVCA Yearbook 2000 (www.evca.com). For Canada, CVCA (www.cvca.ca).

BIOTECHNOLOGY IN AGRICULTURE

Plant-biotechnology is potentially one of the largest biotech applications, particularly in terms of global benefits. The indicators provided in this section cover three aspects of plant biotechnology: the adoption of genetically engineered (GE) crops (hectares of GE plantings or harvests), the diffusion of GE crops (trend data on GE plantings and harvesting), and the development of new GE crop varieties (field test results). It would also be worthwhile to have internationally comparable data on R&D investment in plant biotechnology, but such data were not available for this report.

The tables and accompanying analysis in the following two sections were extracted from a study undertaken by the OECD Directorate for Food, Agriculture and Fisheries – carried out under the 1999/2000 Programme of Work of the Committee for Agriculture – on "Modern Biotechnology and Agricultural Markets: A Discussion of Selected Issues". Available at:

http://www.oecd.org/agr/Documents/apm005fe.pdf. Data for 2000 are from the *OECD Agricultural Outlook 2001-2006* to be published in May 2001.

Adoption and diffusion of genetically engineered crop varieties

Indicators for GE crop acreage are a useful measure of the impact of agro-biotechnology on farmer acceptance, and on agricultural eco-systems. Since GE crops were first extensively commercialised in 1996, the area planted to these crops has risen dramatically, particularly in the United States and Latin America.

Table 1 provides a summary of world data on the harvest area of GE crops, based on industry estimates. These occasionally differ from government statistics. The results given here rely on industry sources to maintain comparability.[2]

In 2000, the United States accounted for about 68% of the total planted area of GE crops. In Argentina, nearly 95%of the soybean and 20-25% of the maize area were planted to genetically engineered varieties, while in Canada, herbicide resistant canola accounted for about 50% of the canola planted.[3]

The number of harvested hectares of GE crops; primarily corn, cotton, canola and soybeans, has grown rapidly since 1996 – with a 44% increase between 1998 and 1999. GE crop areas were not expected to grow by very much in the United States for 2000, although fast growth rates could have occurred in other OECD countries.

2. According to the USDA Agricultural Outlook, August 1998, in the early stages of their expansion, "the USDA does not make official estimates of GM crops planted…", p. 21. Surveys are now undertaken to estimate area planted and harvested of GM crops. The National Agricultural Statistics Service (NASS) surveys maize cotton and soybean farmers in selected States on their use of herbicide or pest-resistant seed varieties since 1998. Randomly selected plots are visited monthly from August to harvest to obtain specific counts and measurements. NASS also publishes a Prospective Plantings report in late March that reflects a survey of farmers' planting intentions and a June Acreage report that reflects a survey of farmer's actual planted acreage taken during the beginning of June.

3. For Canada, industry estimates are from the Canola Council of Canada. Industry estimates are used for Argentina.

Table 1. **Area planted worldwide of genetically engineered crops**

	1996	1997	1998	1999	2000	Share of area harvested worldwide of genetically engineered crops	
						1999	2000
	Million hectares					Percent	
Argentina	0.1	1.4	4.3	6.7	10	17	23
Australia	< 0.03	0.05	0.1	0.1	0.1	< 1	< 1
Canada	0.1	1.3	2.8	4	3	10	7
China	1.1	1.8	n.a.	0.3	0.5	< 1	1
France	0	0	< 0.1	< 0.1	..	< 1	..
Mexico	0	0	< 0.1	< 0.1	..	< 1	..
Portugal	0	0	0	< 0.1	..	< 1	..
Spain	0	0	< 0.1	< 0.1	..	< 1	..
United States[1]	1.5	8.1	20.5	28.7	30.3	72	68
World[2]	2.8	12.8	27.8	39.9	44.2	100	100

1. The US Department of Agriculture estimates differ from the above industry estimates as follows: 1996: 3.2 million hectares; 1998: 20.23 million hectares.

2. In 1998, excludes China.

Source: James, C (1997-99), "Global Review of Transgenic Crops", ISAAA Briefs, 1997-2000, The International Service for the Acquisition of Agri-biotech Applications (ISAAA), Ithaca, United States.

Table 2 shows the growth of genetically engineered crops by trait. There has been a shift from virus resistance dominance in 1996 (due to China's tobacco production) to herbicide resistance, which now accounts for over 80% of the traits expressed by genetically engineered crops.

Table 2. **Area planted worldwide of genetically engineered crops by trait**

	1996	1997	1998	1999	2000
			Percent		
Herbicide tolerant	23	54	71	71	74
Insect resistant	37	31	28	22	19
Virus resistant	40	14	<0.1	<0.1	<0.1
Herbicide tolerant and insect resistant	--	<1	1	7	7
Quality traits	<1	<1	<1	<0.1	n.a.
Total	*100*	*100*	*100*	*100*	*100*

Source: James, C (1997-2000), "Global Review of Transgenic Crops", ISAAA Briefs, 1997-2000.

Table 3 places the current use of GE crops in the OECD in perspective. It gives the percentage of GE crop hectares out of the total arable land in each OECD country. Other than Spain and Portugal, GE crop use is negligible in all other European OECD Member countries. There is no record of GE crop use for 1999 in the Czech Republic, Korea, Poland or Turkey. In total, GE crops were planted on 8.1% of the total arable land in the OECD.

Table 3. **Indicators for 1999 genetically engineered crop use in the OECD**

	1999 hectares of GE crops (‘000)[1]	1998 total arable land (‘000)[2]	Percent arable land planted to GE crops
United States	28 700	176 950	16.2%
Canada	4 010	45 560	8.8%
Australia	100	53 775	0.2%
Mexico	50	25 200	0.1%
Spain	10	14 280	0.1%
Portugal	1	1 880	0.1%
Total	*175*	*317 645*	*11.0%*
Total OECD (29 countries)	*34 871*	*429 776*	*8.1%*

1. Source: DG Agriculture, Economic Impacts of GM Crops on the Agri-Food Sector: A First Review, DG Agriculture, Brussels, 2000, Table 1.page 11. Original source: ISAAA (International Service for the Acquisition of Agri-biotech Applications): http://www.gene.ch/

2. *Source: FAO Production Yearbook, 2000*: http://apps.fao.org/ Arable land is defined as “land under temporary crops… temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). Arable land excludes permanent crops such as orchards, vineyards and permanent pasture. The data for 1998 is the most recent year available. However, the amount of error in the estimated percentage of land planted to GE crops is likely to be negligible, since the total area of arable land is relatively stable. On average, it increased in the OECD by +0.4% between 1995 and 1998, although the amount of arable land fell 0.3% between 1997 and 1998.

In addition to political and regulatory constraints, the potential for GE use is strongly determined by the types of crops that are grown in each country. The potential use of GE crops in Europe is limited because the most important European cereal is wheat, for which no GE varieties are yet available. The same constraint limits GE crop use in Australia.

Data for the United States

More detailed data is available for the United States that permit a breakdown in crop areas by both crop type and GE trait. Tables 4 and 5 provide, respectively, estimates of the area planted and the area harvested by GE crop and trait.[4]

The estimated area planted to genetically engineered varieties for the 2000 crop year, as shown in Table 4, indicate that about 54% of the soybean area, 25% of the maize area (18 to Bt varieties, 5 to HR varieties and 2 to HR-Bt stacked varieties) and 56% of the cotton area (18 to Bt varieties, 22 to HR

4. The 1998 data estimates that Bt cotton accounted for 16.8% of planted but 23% of harvested hectares for cotton, while HR soybeans accounted for 44.2% of planted but 42% of harvested hectares. These results highlight the variability of these estimates, which are unlikely to be entirely due to differences in crop losses or yields.

varieties and 16 to HR-Bt stacked varieties) was planted to GE varieties. Very preliminary estimates on canola plantings also indicate that HR varieties accounted for about 50% of the area planted, according to the Canola Council of Canada.

Table 4. **Area planted: genetically engineered crops, United States[1, 2]**

Percentage of total crop hectares planted to GE varieties

	1996	1997	1998	2000
		(percent)		
HR soybean	7.4	17	44.2	54
HR maize[3]	3	4.3	18.4	7
HR cotton	-	10.5	26.2	46
BT maize	1.4	7.6	19.1	19
BT cotton	14.6	15	16.8	35

1. Survey coverage between 1996 and 1998 averaged between 77% and 96%, depending on the year and crop variety. The results for 2000 cover 100% of the total area planted for all three crops.

2. Please note that these figures for maize and cotton do not match the data in Table 3 due to trait stacking.

3. 1996-99 Includes seed obtained by traditional breeding but developed using biotechnology techniques to identify the herbicide-tolerant genes.

Sources: 1996-98: Agricultural Resource Management Survey (ARMS), USDA, 2000: Prospective Plantings, March 31,2000,NASS, p.23-24.

The Objective Yield Survey (OYS) of the US National Agricultural Statistical Service (NASS) for 1999 estimates that herbicide resistant (HR) soybeans accounted for about 57% of the soybean area harvested, while insect resistant (Bt) maize accounted for about 30% and HR maize for 8% of total maize area harvested (see Table 5). A small portion of maize varieties is both herbicide and insect resistant. The OYS also estimates that Bt cotton accounts for 27% of the area harvested and HR varieties for 38%.[5, 6]

Table 5. **Area harvested: genetically engineered crops, United States[3]**

Percentage of total crop hectares planted to GE varieties

	1998	1999
	Objective Yield Surveys	
HR Soybean[1]	42	57
HR Maize[1,2]	9	8
HR Cotton[1,2]	33	39
Bt Maize[2]	25	29
Bt Cotton[2]	23	27

1. Herbicide resistant varieties include those developed using both biotechnology and conventional breeding techniques.
2. Includes stacked varieties. Total area harvested of GE cotton and maize varieties is not equal to the sum of HR and Bt varieties as these include stacked varieties and would result in double counting.
3. Survey coverage between 1998 and 1999 averaged between 69% and 73%, depending on the year and crop variety.

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5. Economic Research Service (1999), "Genetically engineered crops for Pest Management", October 27. http://www.econ.ag.gov/whatsnew/issues/biotech/caveats.htm

6. Crop Production, October 8, 1999, Objective Yield Survey, National Agricultural Statistical Service. http://usda.mannlib.cornell.edu/reports/nassr/field/pcp-bb/1999/crop1099.txt

Source: Objective Yield Surveys, NASS, 1998, 1999.

Field tests of GE crops

In the United States and the European Union, field tests of new GE varieties are registered as part of the regulatory process. In Europe, the regulatory system has 100% (theoretically) coverage of all GE field trials outside of greenhouse and laboratory environments. The field test data is available from the Joint Research Council from the online SNIF database.[7] In the United States, field tests of GE crops that have already received approval do not need to be registered, which decreases the comparability between Europe and the United States. Furthermore, the database for GE releases in the United States can also contain non-GE field tests.[8]

The field test data provide information on both the amount of development work on new GE crops by country and the types of GE crop traits under development. The most interesting aspect of the GE field test data is concerns the development of "second-generation" GE crops. These are plant varieties with altered quality traits such as high lysine soybeans or low phytase animal feeds. These and other quality traits, including traits for improved industrial processing, could have a major impact on the future of agro-biotechnology. They could increase the value-added of crop production, possibly lead to employment increases (whereas first generation GE crops should reduce employment in the agro-food chain), and provide environmental and social benefits.

Most second-generation GE crops have yet to reach the market, which means that their development and diffusion cannot be identified from GE crop plantings. For example, in 2000 all but 50 000 hectares of GE plantings in the United States and Canada (less than 0.2%) were for first generation crops based on agronomic characteristics such as pest resistance or herbicide resistance. The value of the field test data is that it provide an early indicator for investment in second generation GE varieties that could come onto the market in the next two to six years.

Table 6 provides GE field test data for the EU and the United States. The indicators for the EU are *i)* the number of all field trial-trait combinations between January 1, 1995 and June 30, 2000; and *ii)* the percentage of trials for second-generation quality traits. The data for the United States is limited to the number of field trial applications (notifications plus releases into the environment) over an equivalent time period.[9]

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7. Under part B of Directive 90/220/EEC, any organisation wishing to conduct an outdoor field trial of a GMO within any of the 15 EU Member States must first notify the relevant government authority in the country where the field trial is to take place. A decision on whether to permit or refuse the trial must be made within 90 days. Once the decision is taken, the government authority is required to forward the information to the European Commission. The Joint Research Council (JRC) of the European Commission collects the national field test data and provides it on-line as the Summary Notification Information Format (SNIF).

8. The USDA regulatory system is not specifically designed for GMOs, but the Web site states that "a large majority of genetically modified organisms developed for agricultural purposes in the United States fall under these regulations".

9. The results given here for the United States include both Releases and Notifications. The latter is an expedited type of release permit that is largely limited to tomato, corn, tobacco, soybean, cotton or potatoes that meet six other criteria. To our knowledge, no comparable data on second generation traits is available for the United States at this time, although this information could be extracted from the APHIS database.

Table 6. **GE field trial indicators for Europe and the United States, 1995-June 2000**

	Total GE trial-traits[1]	2nd generation	% 2nd generation
Germany	123	48	39.0%
France	507	66	13.0%
Italy	301	59	19.6%
Netherlands	85	34	40.0%
Belgium	82	6	7.3%
United Kingdom	162	48	29.6%
Ireland	4	0	0%
Denmark	26	4	15.4%
Spain	198	37	18.7%
Portugal	9	0	0%
Greece	24	2	8.3%
Austria	3	2	-
Finland	23	7	30.4%
Sweden	80	29	36.3%
Total	*1627*	*344*	*21.1%*
United States	5136	-	-

1. A trial-trait refers to each trait included in a GE variety. This counts stacked traits separately.

Source: MERIT database, using data extracted from the European Joint Research Council Summary Notification Information File; US data from ISB Environmental Release Database, see www.aphis.usda.gov

Column 2 shows that over three times as many field trials have been conducted in the United States than in Europe. This is partly because the United States is the world leader in plant biotechnology. For this reason, it is unfortunate that data on more advanced second-generation quality traits are not available for the United States at this time. The United States could also lead Europe in the development of quality traits.

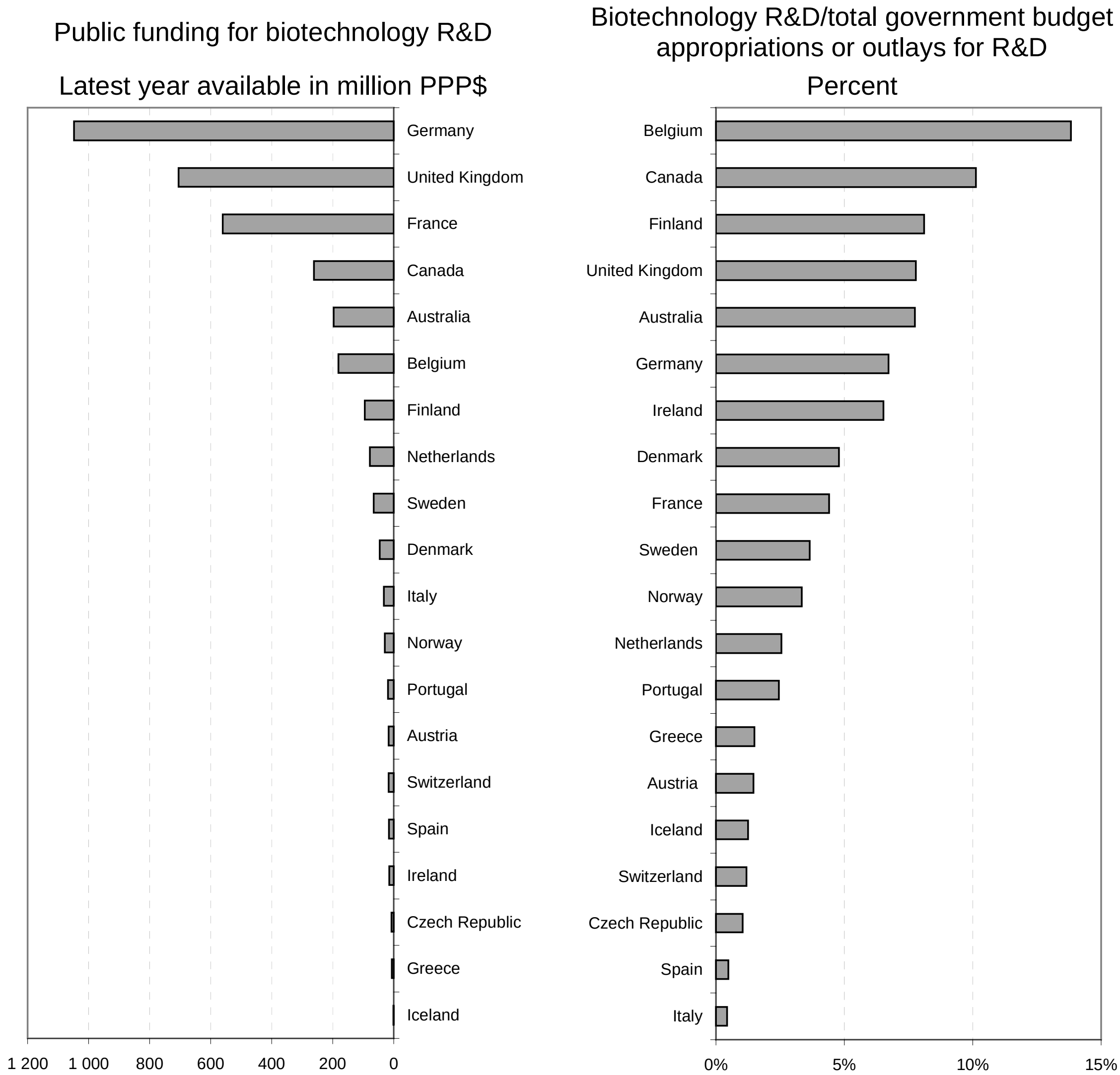
The location of trials in Europe is biased by where crops are grown, which is partly why there is a comparatively large number of trials in Italy and Spain. Many of these trials are probably conducted by seed firms based in the Netherlands and the United Kingdom.[10]

In total, 21.1% of trial-trait combinations in Europe are for second generation quality traits. The highest share of second-generation trials are in countries with major seed firms, such as the United Kingdom (29.6%), the Netherlands (40.0%), and Germany (39.0%). The low share for France is surprising, however.

10. Theoretically, it would be better to assign trials to the country that conducted the applied research to develop the GE crop, but in practice this would create additional problems. First, many local subsidiaries do this type of work and second, it is not always possible to sort out ownership, since many seed firms have local subsidiaries under different names.

BIOTECHNOLOGY AND GOVERNMENT FUNDING

Figure 1. **Public funding of research and development**



Source: OECD, based on data from the European Commission (*Inventory of public biotechnology R&D programmes in Europe*, 2000), Eurostat, Statistics Canada, and national sources and GBOARD from the OECD, MSTI database.

- These data on government appropriations provide an indication of the relative importance of biotechnology funding in different OECD Member countries. The median contribution of government budgets dedicated to biotechnology is 3.5%. However, the spread between the different OECD countries is quite large, ranging between 0.4% to 13.8%.

- Belgium spends the largest percentage of its government R&D budget on biotechnology (13.8%), followed by Canada (10.1%) and Finland (8.1%).

- In absolute PPP$ terms however, Germany spends the most on biotechnology followed by the United Kingdom and France.

Table 1. **Public funding of research and development**

		Biotechnology R&D	Total Government Budget Appropriations or Outlays for R&D (GBOARD)	R&D biotech / R&D overall
		Million PPP$		Percent
Australia	1998	196.3	2 532.5	7.8%
Austria	1997	16.8	1 146.5	1.5%
Belgium	1997	181.7	1 314.0	13.8%
Canada	1997	261.4	2 581.0	10.1%
Czech Republic	1999	7.8	749.1	1.0%
Denmark	1997	45.2	945.6	4.8%
Finland	1997	94.5	1 165.0	8.1%
France	1997	560.0	12 683.1	4.4%
Germany	1997	1 048.2	15 595.7	6.7%
Greece	1997	6.5	430.9	1.5%
Iceland	1997	0.9	68.5	1.3%
Ireland	1997	15.0	229.9	6.5%
Italy	1997	32.1	7 329.6	0.4%
Netherlands	1997	78.0	3 069.9	2.5%
Norway[1]	1997	26.8 - 32.2	880.3	3% - 3.7%
Portugal	1997	19.2	781.9	2.5%
Spain	1997	15.5	3 202.6	0.5%
Sweden[2]	1997	65.6	1 795.2	3.7%
Switzerland[2]	1997	16.4	1 379.7	1.2%
United Kingdom	1997	705.1	9 055.7	7.8%

1) These data are national estimates, hence the range.

2) GBOARD has been estimated.

Source: OECD, based on data from the European Commission (*Inventory of Public Biotechnology R&D Programmes in Europe*, 2000), Eurostat, Statistics Canada, and national sources.

BIOTECHNOLOGY STATISTICS:

COUNTRY PROFILES

Table 1. **Sources of data used for the country profiles in this document**

Australia	Based on data from "Australian Biotechnology Report 1999" by the Commonwealth Department of Industry, Science and Resources (ISR) and Ernst & Young (http://www.ey.com/global/gcr.nsf/Australia/Australian_Biotechnology_Report_1999) And based on data from the Australian Bureau of Statistics (ABS). (http://www.abs.gov.au)
Belgium	Based on data from Ernst & Young, "Biotech in Belgium, 1998". (http://www.ey.be/)
Canada	Based on data from Statistics Canada. (http://www.statcan.ca/english/researcholdbackup/scilist.htm)
Czech Republic	Based on data from the Czech Republic R&D Council.
Denmark	Based on data from the Danish Institute for Studies in Research and Research Policy (AFSK). (http://www.afsk.au.dk)
Finland	Based on data from Finnish Bioindustries. (http://www.finbio.net)
France	Based on data from MENRT (Ministère de l'éducation nationale, de la recherche et de la technologie – Bureau des études statistiques sur la recherche) and INRA/SERD (Institut National de la Recherche Agronomique). (http://biotech.education.fr/web/fr/Panorama/pme2000/index.htm)
Germany	Based on data from Ernst & Young, "Biotech in Germany, 2000". (http://www.ernst-young.de/)
Hungary	Based on Ulrike Bross- Annamária Inzelt-Thomas Reiss (1998), Bio-Technology Audit in Hungary, Guidelines, Implementation, Results, Physica-Verlag, Heidelberg: based on data from the Hungarian National Committee for Technological Development (OMBF).
Iceland	Based on data from the Icelandic Research Council (IRC), R&D survey.
Ireland	Based on data from BioResearch Ireland. (http://www.biores-irl.ie/)
Israel	Based on data from the Israeli Ministry of Trade and Commerce.
Italy	Based on data from the Italian National Statistics Institute (ISTAT) R&D survey.
Japan	Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)
Netherlands	Based on data from Statistics Netherlands (CBS). (http://www.cbs.nl/)
New Zealand	Based on data from Statistics New Zealand. (http://www.stats.govt.nz/)
Norway	Based on data from The Norwegian Biotechnology Advisory Board (BIOTEKNOLOGINEMNDA). (http://www.bion.no/)
Spain	CINDOC-CSIC (Consejo Superior de Investigaciones Cientificas Centro de Informacion y Documentacion cientifica). http://www.cindoc.csic.es/
Sweden	Based on data from NUTEK and VINNOVA Sweden. (http://www.nutek.se/ and http://www.vinnova.se/)
Switzerland	Based on data from SPP BioTech Programme Direction and Unitectra. (http://www.unitectra.ch)
United Kingdom	Based on data from Arthur Andersen. "UK Biotech 1997 – Making the Right Moves", 1997. (http://www.arthurandersen.com/)
United States	NSF: Special tabulations of the CATI database at MERIT, 1999. (http://www.nsf.gov/). And data from Stanford-in-Washington Program and Burroughs Wellcome Fund, (http://www.stanford.edu/class/siw198q/websites/genomics/entry.htm)

Table 2. **Biotechnology in numbers**

Data in this table refer to total number of companies unless otherwise specified

		Total number of companies involved in Biotech	Number of 'core' Biotech companies*	Total number of employees	Total number of SMEs	Total R&D expenditures (PPP$ million)	Total R&D expenditures on Biotech (PPP$ million)	Total turnover (PPP$ million)	Total # of public companies (on stock exchange)	Source
Australia	99	..	120	3 801	..	179	..	..	20	SRI/E&Y
Belgium	97	52	..	4 471	41	230	..	1 565.8	..	E&Y
Canada	99	..	358	7 695	321	1 034	706.4	1 663.9 [1]	..	Statistics Canada
Denmark	98	..	74	34 116	63 [3]	537	433.7	..	2	AFSK
Europe	99	..	1 351	53 511	..	3 307	..	5 610.4	68	E&Y
Finland	99	..	110	8 200	107 [4]	..	..	1 312.6	..	Finnish Bioindustries
France [5,3]	99	..	380	11 000 [6]	380	..	..	1 966.2 [6]	8	SMEs -Biofutur
Germany	99	709	279	228 845 [7]	686	..	753.0	15 662.1 [1]	..	E&Y
Ireland	99	140	50	..	..	..	..	..	3	BRI
Israel	99	..	135	3 800	171 [8,9]	..	..	600.0 [2]	..	Ministry of Trade and Commerce
Italy	99	..	45	..		..	..	..	..	E&Y
Japan	99	1 000	394	29 358 [10]	120 [11]	9 153 [10]	756.9 [10]	29 620.3 [10]	..	JBA
Netherlands	99	300	55	..	..	..	..	78.0	..	Canadian Department of Foreign Affairs and International Trade
Norway	00	..	44	10 154	..	..	..	1 889.8	..	BION
Spain	99	200	22	90 000	162	..	..	..	20	CINDOC-CSIC
Sweden	99	..	144	2 998 [4]	139	..	..	365.6 [4]	..	NUTEK
Switzerland	99	233	117	7 000	..	..	..	..	..	SPP BioTech
UK	99	..	275	13 780 [12]	..	490 [12]	..	1 078.9 [12]	40	E&Y/AA
USA [13]	99	..	1 273	162 000	..	10 700	..	16 100.0 [2]	251	E&Y

* "Core" biotechnology firms have their main activities in biotechnology, although they can be active in other fields.

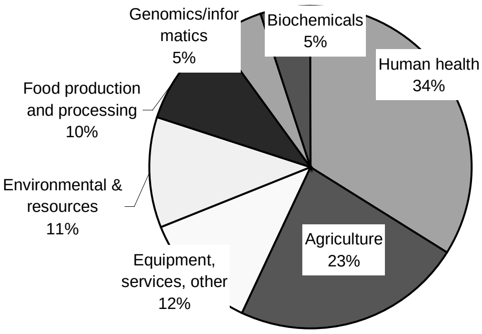
1) Only in biotech activities.
2) Sales.
3) Less than 500 employees.
4) Excludes large pharmaceutical companies.
5) Only SMEs.
6) Only covers 255 companies.
7) Covers all 709 companies.
8) Less than 100 employees.
9) Some companies may appear in more than one type, double counting may occur.
10) Only covers 210 companies.
11) Less than 1 000 employees.
12) Based on 221 companies and 1997 data.
13) Based on only the19 "core" biotech companies.

BIOTECHNOLOGY IN AUSTRALIA

(Based on a sample of 90 companies out of an estimated population of 120 "core" biotechnology companies)

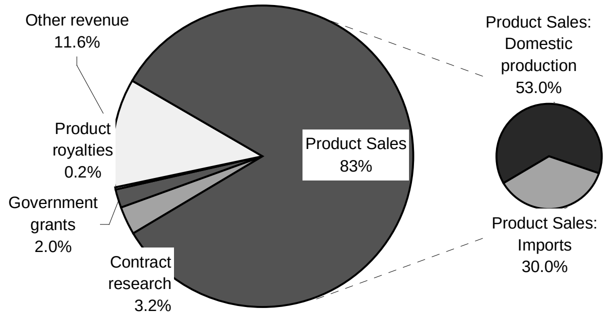
Where are the Australian biotech companies?

Industrial breakdown, 1999



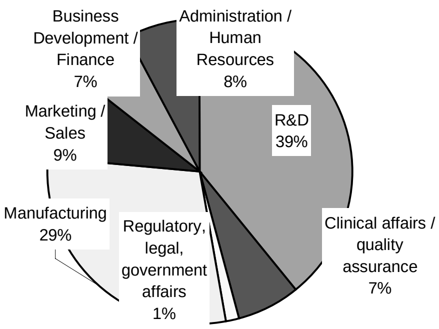
Australian biotech companies revenue by source

Distribution of 1998/99 revenues of PPP$ 737 million and 120 companies



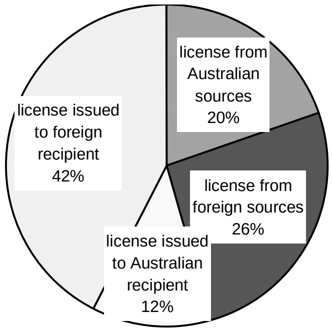
Who's doing the biotech work?

Distribution of 3 800 employees in 1998/99

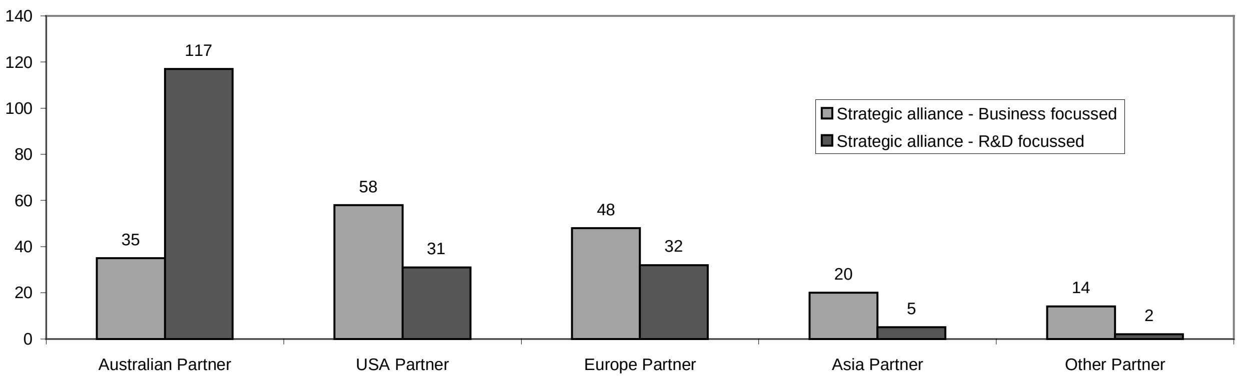


Technology licensing

Distribution of 181 licence acquisitions and 219 issued licences among 45 biotech companies reporting licensing activity



The global network of strategic alliances



Source: Based on data from "Australian Biotechnology Report 1999" co-published by the Commonwealth Department of Industry, Science and Resources (ISR)/Ernst & Young 1999. (http://www.ey.com/global/gcr.nsf/Australia/Australian_Biotechnology_Report_1999)

BIOTECHNOLOGY IN AUSTRALIA

Methodological note: In “Australian Biotechnology Report 1999”, “core biotechnology” companies are defined as those whose business is entirely or substantially biotechnology related and that have a significant commitment to technological innovation. This excludes traditional biotechnology operations such as breweries and food processing companies but could include a company producing, for instance, cheese starter cultures where novel cultures are the result of R&D activities.

The data from the E&Y report does not give a good definition of what a biotech company is, other than to use their standard “core biotechnology firm” definition. The unusually high percentage of revenues from sales, compared to other countries, suggests that many of these companies are not active in leading-edge biotechnology. The same point is made in the E&Y report, which shows that the average R&D intensity of Australian biotech companies is 24%, compared to 53% in Canada and the United States.

- Most biotechnology companies are in the health care sector (34%) followed by the Agricultural sector (23%).

- The biggest source of revenue for all companies is generated by product sales (83%) even though manufacturing personnel make up only 29% of the total. However, this can be explained by the fact that 30% of total revenues are from imports.

- Nevertheless, the majority of employees working in biotechnology is concentrated in R&D (39%).

- Note that data is collected for the category Regulatory, legal and government affairs, though its actual share in total employment (only one percent) remains small. Few countries collect these data systematically (Australia and Canada).

- Technology licensing results show that the Australian biotech sector is a net exporter of technology licenses (although we do not know their value) and that for a small economy, there is a fair bit of licensing from other Australian sources.

- Alliances that have an R&D focus are typically formed with domestic partners, although in about one-sixth of the cases partnerships are forged with firms in the United States or Europe. However, for business alliances, the United States is the location for a third of the partnerships, Europe for a little more than a quarter and Australia for only a fifth.

BIOTECHNOLOGY IN AUSTRALIA

Table 1. **Biotech R&D**

R&D expenditure by performing sector			**Human resources on R&D**	
Biotechnology	**1996**	**1998**	**1996**	**1998**
	Million PPP$		Full-time equivalent	
Business	134.4	151.0	1 188	1 224
Higher education	85.6	99.3	1 760	1 811
Private non-profit	22.6	25.7	386	374
Government	72.0	86.4	963	1 057
Total biotech	314.7	362.4	4 297	4 446
Gross Domestic Expenditure on R&D (GERD)			**Total R&D personnel**	
	Million PPP$		Full-time equivalent	
Business	3 268.5	3 048.5	26 498	24 201
Higher education	1 776.0	1 987.7	42 739	45 502
Private non-profit	133.5	140.4	2 171	2 068
Government	1 598.4	1 582.1	19 388	18 946
Total	6 776.3	6 758.7	90 796	90 717
Shares of biotech R&D in total GERD (percent)			**Shares of biotech R&D personnel in total R&D personnel (percent)**	
Business	4.1	5.0	4.5	5.1
Higher education	4.8	5.0	4.1	4.0
Private non-profit	17.0	18.3	17.8	18.1
Government	4.5	5.5	5.0	5.6
Total	4.6	5.4	4.7	4.9

Source: Based on data from the Australian Bureau of Statistics (ABS). (http://www.abs.gov.au)

Methodological note: ABS defines biotechnology as the following classes within ABS Fields of Research: 060300, Industrial Biotechnology and Food Sciences and 080200, Genetics, Molecular Biology and Biotechnology.

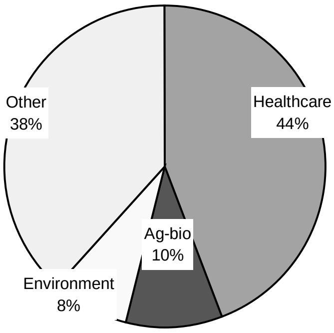
- R&D spending on biotechnology remains a small part (4.6% in 1996) of total R&D spending (GERD). The business sector contribution fell between 1996 and 1998 (43 to 42%), however this fall was offset by an increase in R&D spending by the government and higher-education sectors, thus increasing biotechnology’s share in total R&D (5.4 in 1998).

BIOTECHNOLOGY IN BELGIUM

(Based on 52 companies active in biotechnology – total population)

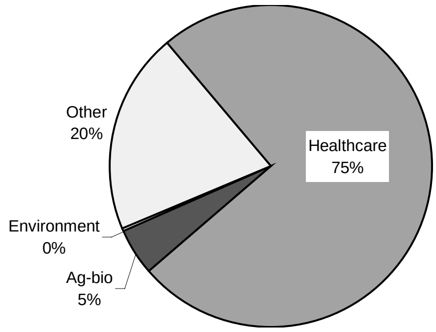
Where are the Belgian biotech companies?

Industrial breakdown, 1997



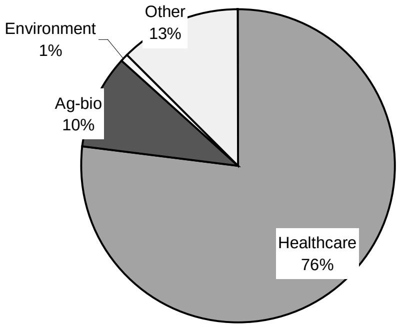
Belgian biotech companies revenue by sector

Distribution of 1997 revenues of PPP$ 1 566 million among 52 firms (entrepreneurial start-ups and large multinationals)

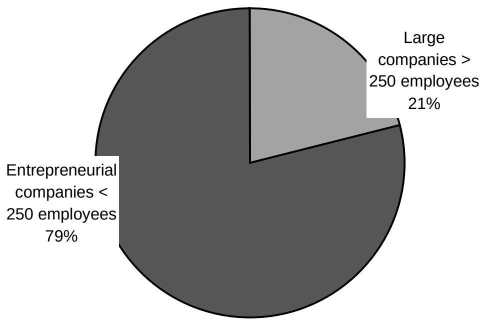


Who's doing the biotech work?

Distribution of 4 471 employees in 1997



Biotech companies by size class, 1997



Source: Based on data from Ernst & Young, "Biotech in Belgium, 1998". (http://www.ey.be/)

Methodological note: In the "Biotech in Belgium" 1998 Report, modern biotechnology has been defined as the application of biological organisms and processes to produce products for the human or animal healthcare, agro-food and environmental sectors. The scope has been limited to companies directly involved in either R&D, or production activities. The focus of the study is based on four sectors: healthcare, agro-bio, environment and other activities (biochemicals, contract research and services, etc.) These data are based on smaller entrepreneurial start-ups and large multinationals.

- Most Belgian biotechnology companies are in the health care sector, which generates three quarters of all revenue and employment. A large number of companies fall into the "other" category. This leads us to believe that most remaining companies are spread out in a diverse number of sectors. The Ag-bio sector has ten percent of employment but only 5% of revenue.

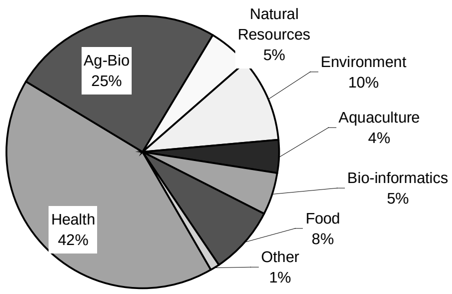
- Most firms are small, "entrepreneurial companies" with fewer than 250 employees. They account for 79% of all biotechnology firms.

BIOTECHNOLOGY IN CANADA

(Based on an estimated total population of 282 companies in 1997 and 358 in 1999)

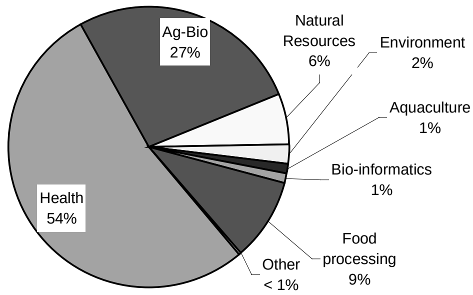
Where are the Canadian biotech companies?

Industrial breakdown, 1999



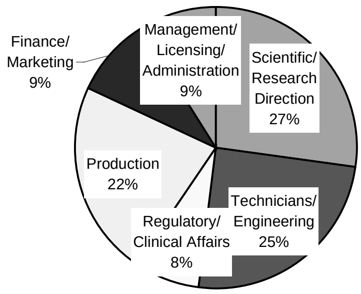
What are the Canadian biotech companies producing?

Distribution of 1999 sales of biotechnology goods and services of PPP$ 1 670 million



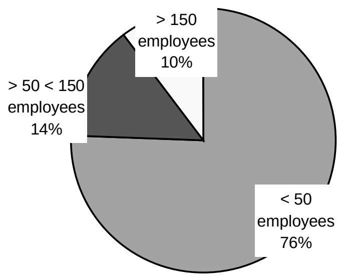
Type of biotechnology employment

Distribution of 7 695 employees, 1999



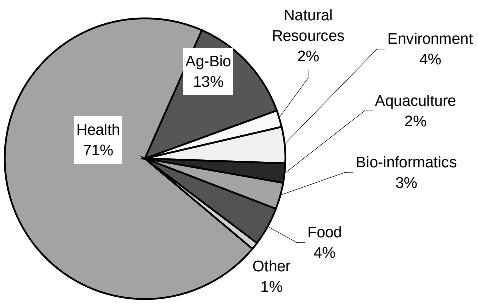
Biotech companies by size-class, 1999

size-class is determined by the number of employees



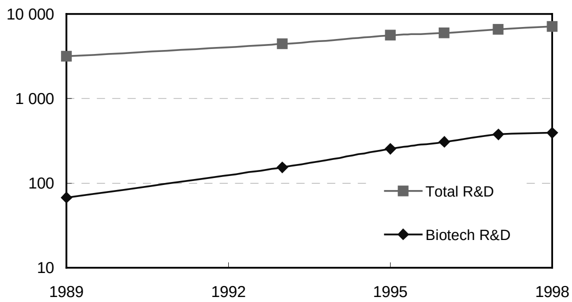
Where are biotech personnel working?

Distribution of 7 695 employees, 1999



Trend comparison of biotechnology R&D with overall R&D spending for all industries

R&D expenditure in million PPP$ (logarithmic)



Source: Based on data from Statistics Canada. (http://www.statcan.ca/english/researcholdbackup/scilist.htm and http://www.statcan.ca/cgi-bin/downpub/listpub.cgi?catno=88F0006XIB)

BIOTECHNOLOGY IN CANADA

Methodological note: Statistics Canada surveyed "core" biotech firms, as in the E&Y surveys, on their activities in 1997 and 1999. In addition, the two surveys attempted to cover all firms in Canada, regardless of their size, that performed biotech R&D. The two surveys therefore include firms for which biotech is only a small part of their total activities. The Canadian data focuses on biotech firms in the manufacturing sectors. 1999 results are given wherever possible, but some types of information are only available to date from the 1997 survey. For more information on the surveys and the definition of biotechnology, see: http://www.oecd.org/dsti/sti/s_t/biotech/stats/Inventory/canada.htm.

- In 1999, 42% of the companies active in biotechnology are active in health applications and earn 54% of all biotech sales. The Agbio sector follows with 25% of the companies and 27% of sales. Although Environment is the third largest sector with 10% of companies, it accounts for only 2% of sales. The food processing industry is the third largest revenue-producing sector with 9% of sales.

- In 1999, R&D accounts for 27% of full-time equivalent employment. Summed over all firms, 12% of total employment was in biotech related activities (see Table 7 below).

- In 1999, the health care sector leads with 71% of all biotech employment. Agbio ranks second with 13%. All other sectors have 4% or less of total biotech employment.

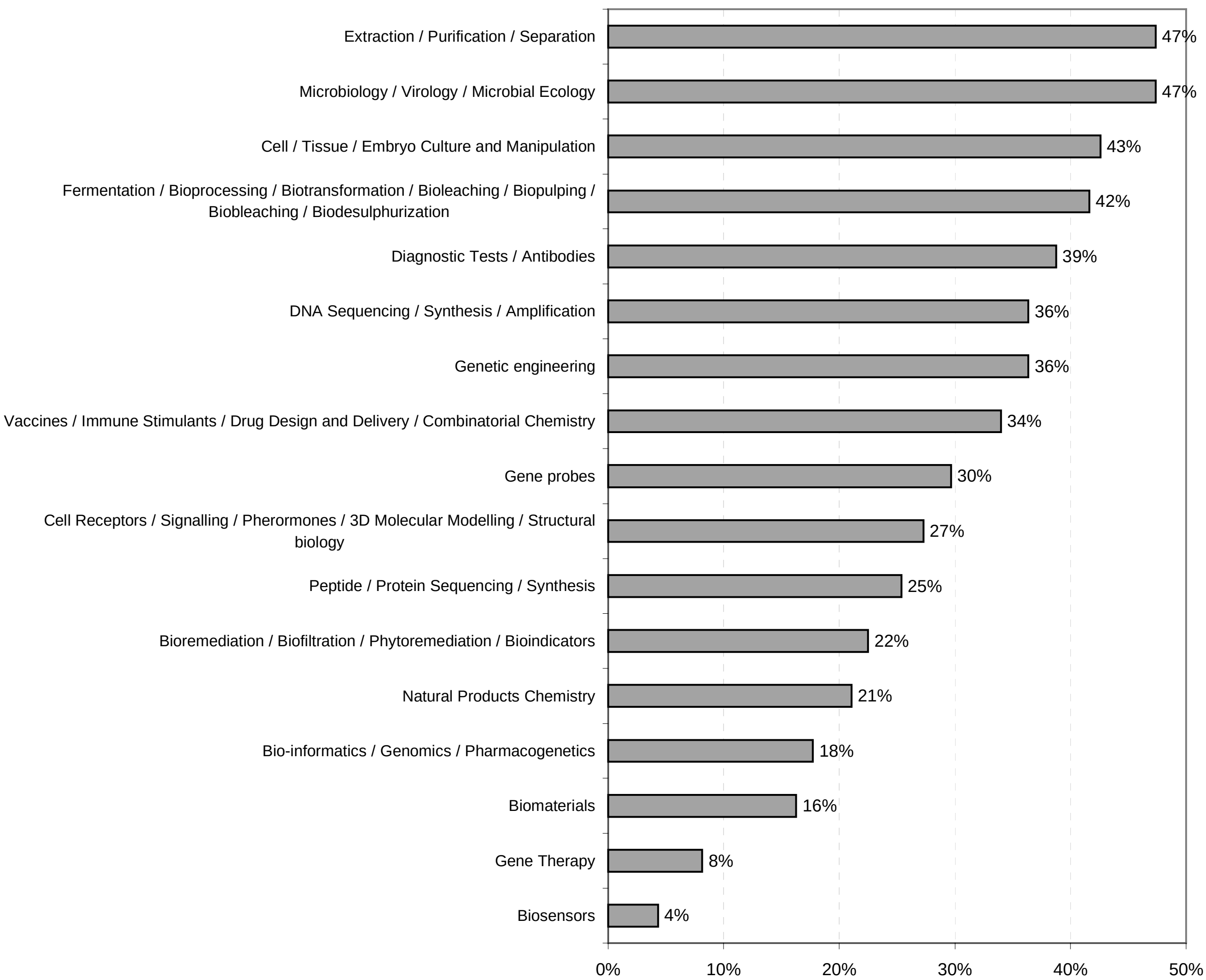
- In 1999, 76% of the firms active in biotechnology had less than 50 employees.

- In 1999, the health sector accounted for 85% of all biotechnology R&D. Although biotechnology R&D represents a small, but growing, share of total R&D (2% in 1989 to 6% in 1997), this share is increasing at a faster rate than that of total R&D overall.

BIOTECHNOLOGY IN CANADA

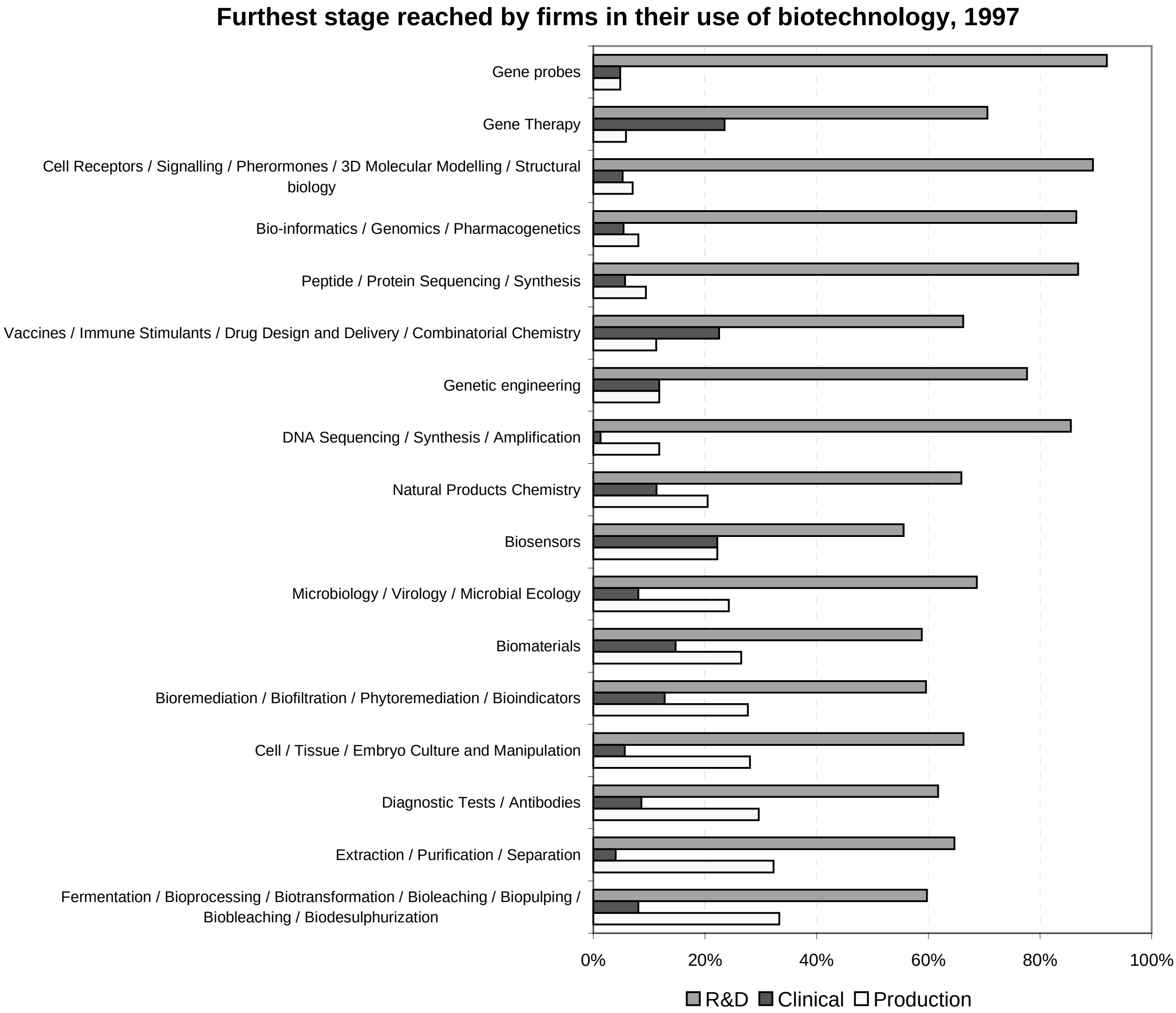
What technologies are they using?

Percent of biotech firms using each of 17 categories of biotechnology in 1997



Source: Based on data from Statistics Canada. (http://www.statcan.ca/english/researcholdbackup/scilist.htm)

BIOTECHNOLOGY IN CANADA



Source: Based on data from Statistics Canada. (http://www.statcan.ca/english/researcholdbackup/scilist.htm)

- The bars in this figure refer to the stage reached by firms active in each of these technologies. Firms that do not use a technology are not included. For example, approximately 92% of firms active in gene probes are in the research stage, 4% are in the clinical stage, and 4% use gene probes in production.

- Most Canadian firms are only in the R&D stage for the majority of the 17 different types of biotechnology listed in this figure. The highest percentage of firms that have reached the production stage are active in fermentation, etc., extraction, etc., and diagnostic tests.

BIOTECHNOLOGY IN CANADA

Financial profile

Industrial activities

Table 1. **Financial profile of biotechnology firms in 1999**[1]

	Financial data (million PPP$)								
	Total	Health	Ag-bio	Nat. resour	Environ	Aqua	Bio-Info	Food	Other
Number of firms	358	150	90	18	35	14	18	29	4
Biotech R&D expenditure	709	602	57	21	.. [2]	3	17	6	.. [2]
Total R&D expenditure	1 037	786	99	111	11	3	18	8	1
Share biotech/Total R&D (%)	68	77	57	18	.. [2]	100	95	78	.. [2]
Biotech sales	1 669	888	449	97	.. [2]	16	17	158	.. [2]
Revenues (all products)	16 047	2 729	5 718	6 897	246	19	21	410	6
Share biotech/Total sales (%)	10	33	8	1	.. [2]	86	80	39	.. [2]
Biotech exports	615	351	200	.. [2]	.. [2]	2	4	44	.. [2]
Total exports	2 168	495	991	432	5	.. [2]	5	236	.. [2]
Share biotech/Total exports (%)	28	71	20	.. [2]	.. [2]	.. [2]	83	18	.. [2]

1) Estimated data. 2) Figures not available.

Source: Canada: Biotechnology Firm Survey – 1999. (http://www.statcan.ca/)

- The financial profile of biotechnology firms shows that the health care sector accounts for 85% of all biotechnology R&D, 53% of all biotechnology sales, and 57% of all biotechnology exports.

- One of the most interesting results from this survey is that biotech sales and exports are only a small percentage of total sales and exports (10% and 28% respectively). This is due to a few very large firms that perform biotech R&D but are active in other fields.

- Another interesting result is the ratio between biotech R&D and biotech sales. In total, biotech R&D spending is less than biotech sales, with sales exceeding R&D spending by a factor of 2.4. Sectors with a higher ratio of biotech sales to biotech R&D spending could have been more successful in moving out of the R&D stage to the development of marketable products. The most successful sectors are ag-bio (sales are almost eight times R&D spending), aquaculture (sales are five times greater than R&D spending), and food (sales are 26 times R&D spending).

- Biotech R&D accounts for 68% of total R&D, but biotech sales account for only 10% of total sales. The firms are investing proportionately far more in biotech R&D than in other types of R&D that support their main income sources from sales.

BIOTECHNOLOGY IN CANADA

Investment in R&D

Federal government

Table 2. **Biotechnology R&D expenditures and personnel by department in comparison with their overall R&D in 1999 (in million PPP$)**

	Biotech R&D	Total R&D	Biotech R&D/ Total R&D (%)	Biotech R&D personnel
Agriculture and Agri-food Canada	47.4	260.8	18.2	313
Environment	1.0	160.6	0.6	4
Fisheries and Oceans	2.2	90.6	2.5	17
Health	2.6	49.1	5.2	66
Industry	24.8	209.1	11.8	1
Medical Research Council	114.1	258.1	44.2	43
National Research Council	92.2	448.4	20.6	624
Natural Resources	5.8	299.3	1.9	70
National Sciences and Engineering Research Council	33.5	412.5	8.1	17
Social Sciences and Humanities Research Council	0.6	71.6	0.8	..
Other	..	910.8	..	..
Total	324.1	3170.9	10.2	1155

Source: Based on Statistics Canada, Service Bulletin V25 n3, 2001. (http://www.statcan.ca/)

Table 3. **Biotechnology R&D by department and by performer of the R&D in 1999 (in million PPP$)**

	Intramural	Business enterprises	Higher education	Foreign	Others	Total
Agriculture and Agri-food Canada	47.4	..	..	..	..	47.4
Environment	0.5	0.3	0.3	..	..	1.0
Fisheries and Oceans	2.2	..	..	..	..	2.2
Health	2.6	..	0.0	..	0.0	2.6
Industry	..	24.8	..	..	..	24.8
Medical Research Council	5.0	..	109.2	..	..	114.1
National Research Council	87.3	4.3	..	..	0.5	92.2
Natural Resources	5.6	0.0	0.1	..	0.0	5.8
National Sciences and Engineering Research Council	1.4	0.2	30.4	0.5	1.0	33.5
Social Sciences and Humanities Research Council	0.0	..	0.5	0.0	..	0.6
Total	152.0	29.6	140.5	0.5	1.6	324.1

Source: Based on Statistics Canada, Service Bulletin V25 n3, 2001. (http://www.statcan.ca/)

BIOTECHNOLOGY IN CANADA

- The Medical Research Council provides the largest source of funding, with over 44% of its R&D funding going to biotechnology, followed by the National Sciences and Engineering Research Council (20%). Approximately 10% of the Government's R&D budget is allocated to biotechnology R&D.

- The National Research Council employs the largest share of government R&D employees in biotechnology (54%) and dedicates 20.6% of its budget to biotechnology R&D.

- Higher education is the key performer with over half of its funding coming from the Medical Research Council (78%). In total, 43.3% of federal biotech R&D is spent in the higher education sector.

- In addition to the federal government, several Canadian provincial governments also fund biotechnology R&D. No data on provincial expenditures are available at this time.

BIOTECHNOLOGY IN CANADA

Investment in R&D

Industry

Table 4. **Biotechnology R&D expenditures by industrial sectors**[1]

	R&D (in million PPP$)					Shares
	1993	**1995**	**1996**	**1997**	**1998**	1998 (percent)
Agrifood	12.7	19.1	19.8	21.1	31.4	8.0
Health	102.4	157.1	181.6	252.6	253.8	64.3
Natural resources	6.0	7.2	4.5	4.5	3.9	1.0
Services	22.5	62.2	83.9	83.0	90.1	22.8
Chemicals	7.6	5.0	5.4	6.5	6.5	1.7
Equipment and other	2.9	5.2	12.2	10.3	9.0	2.3
Total	154.0	255.8	307.4	377.9	394.7	100.0

1) Data concern large R&D performers only (large is defined as having R&D expenditures exceeding one million Canadian dollars regardless of whether this sum is spent on biotechnology or not.).

Source: Based on Statistics Canada, Service Bulletin V25 n4, 2001. (http://www.statcan.ca/)

- The majority of all biotechnology R&D spending by large R&D performers was spent on health. Although this figure was close to two-thirds of the total in 1993, the services sector has expanded to play a more significant role in the 1990s (this could be explained by improved statistical coverage of the services sectors). In 1998, health care still accounts for 64% and services 23% (up from 15% in 1993). The service sector could have expanded through an increase in contracting out to specialised service firms of basic support technologies such as DNA sequencing, etc. Most of these services would be used by firms in the health sector.

BIOTECHNOLOGY IN CANADA

Technical capacities

Industry

Table 5. **Average number of biotechnologies used by firms, 1997[1]**

By size of firms	Number of biotechnologies used (average)
50 employees and under	4.8
51 to 150 employees	5.6
More than 150 employees	5.4

By sector of application	Number of biotechnologies used (average)
Ag-bio	4.2
Aquaculture	5.9
Bio-informatics	3.5
Environment	3.6
Food processing	3.3
Human health - bio	5.9
Other	5.8

1) See page 44 for a definition of each of 17 different biotechnology categories.

Source: Canada: Biotechnology Firm Survey - 1997. (http://www.statcan.ca/)

- The average number of technologies used does not seem to be related to the size of firms. The Aquaculture and Human Health-Bio sectors are the most intensive, using the highest number of biotechnologies (average of 5.9 biotechnologies each).

BIOTECHNOLOGY IN CANADA

Human resources

Industry

Table 6. **Employment profile of biotechnology firms, 1999**

	Health	Ag-bio	Nat res	Environ	Aqua	Bio-info	Food	Other	Total
Number of firms	150	90	18	35	14	18	29	4	358
Biotech employment	5 433	985	149	323	167	227	338	74	7 695
Total employment	13 029	18 066	12 710	4 187	232	368	13 866	208	62 667
Biotech employment share (%)	42	5	1	8	72	62	24	36	12

Source: Canada: Biotechnology Firm Survey - 1999. (http://www.statcan.ca/)

- On average, 12% of the employees among biotech firms were employed in positions that involved biotechnology. The highest share of biotech employees is in aquaculture, at 72%, followed by bio-informatics at 62%. The health sector has the highest absolute number of biotech employees, accounting for 42% of total employment in this sector. The lowest rates of biotech employees are in natural resources (1%) and ag-bio (5%).

Table 7. **Employment by firm size, 1999**

	Number of firms	Total employment	Biotechnology employment	Biotech employment share (%)
50 employees and under	270	4 941	2 902	59
51 to 150 employees	51	4 693	1 323	28
More than 150 employees	37	53 033	3 470	6
Total	358	62 667	7 695	12

Source: Canada: Biotechnology Firm Survey - 1999. (http://www.statcan.ca/)

- Small biotechnology firms account for 75% of the biotech firms and 38% of total biotech employment, while large biotechnology firms account for 10% of the firms and 45% of biotech employment. However, the share of all employees that are active in biotechnology is highest among small firms, at 59%, and declines sharply to only 6% of the employees of large firms.

BIOTECHNOLOGY IN THE CZECH REPUBLIC

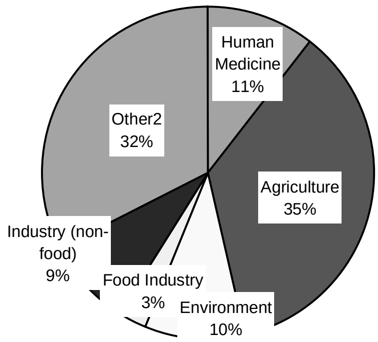
(Based on 114 projects, 1999)

State supported biotechnology projects,[1,2:] 1999

(Does not include private sector expenditures on private sector projects)

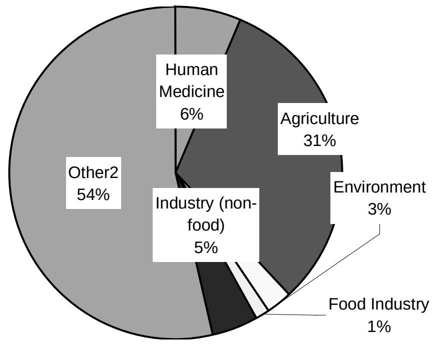
Where are the Czech Republic public biotech R&D projects?

Industrial breakdown of 114 projects, 1999



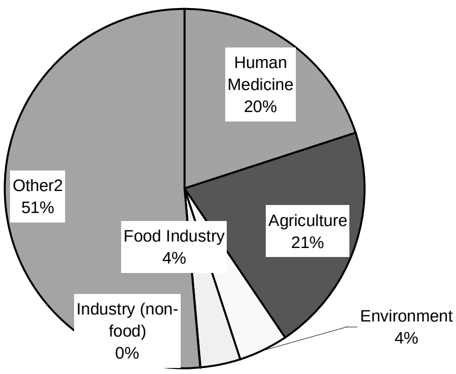
What is the state investing its R&D funding in?

Distribution of 1999 disbursements of PPP$ 10.6 million on114 projects



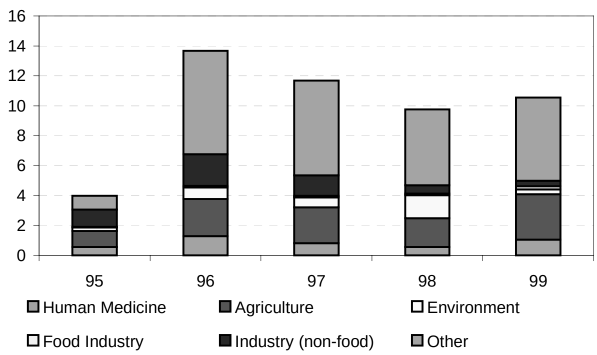
In which public biotech R&D projects is the private sector investing?

Distribution of 1999 disbursements of PPP$ 2.8 million and 114 projects



Total R&D investment, 1995-99

Million PPP$



1) R&D projects supported (fully or partially) by the state budget. Does not include R&D projects, financed only by the private sector or non-government sources. Private sector expenditures on private sector projects are not collected by the R&D Council.
2) Projects that could not be clearly included in one of the categories were included in "Other".
Source: Based on data from the Czech Republic R&D Council.

Methodological note: Unlike all other countries, with the exception of Hungary, these data cover only state supported projects. The R&D Council does not collect private sector expenditures on private sector projects.

BIOTECHNOLOGY IN THE CZECH REPUBLIC

- 35% of all projects are for agricultural biotechnology, followed by the category "other" (32%) and Human medicine (11%).
- Agricultural projects received 31% of total state funding for biotechnology. The category "other" received a remarkable 54% of all funds. Human medicine ranks third with 6% of all State funds dedicated to biotechnology.

Table 1. **State-supported biotechnology projects,[1] 1995-99**

	1995			
Category	Number of projects and long-term activities	State budget	Private sources	Total 1995
			Million PPP$	
Human medicine	7	0.4675	0.0841	0.5516
Agriculture	15	0.7201	0.3582	1.0783
Environment	7	0.1760	0.0513	0.2273
Food industry	1	0.0348	0.0000	0.0348
Industry (non-food)	9	0.9876	0.1842	1.1717
Other[2]	23	0.7187	0.1901	0.9088
Total	62	3.1046	0.8679	3.9725

	1996			
Category	Number of projects and long-term activities	State budget	Private sources	Total 1996
			Million PPP$	
Human Medicine	15	0.8356	0.4508	1.2864
Agriculture	29	2.0148	0.4689	2.4837
Environment	13	0.4339	0.3276	0.7615
Food Industry	2	0.0597	0.0586	0.1183
Industry (non-food)	18	1.6801	0.4279	2.1080
Other[2]	47	5.9036	1.0000	6.9036
Total	124	10.9276	2.7338	13.6614

1) R&D projects supported (fully or partially) by the state budget. Does not include R&D projects, financed only by the private sector or non-government sources. Private sector expenditures on private sector projects are not collected by the R&D Council.
2) Projects that could not be clearly included in one of the categories were included in "Other".
Source: Based on data from the Czech Republic R&D Council.

BIOTECHNOLOGY IN THE CZECH REPUBLIC

Table 1 (cont'd). **State-supported biotechnology projects,[1] 1995-99**

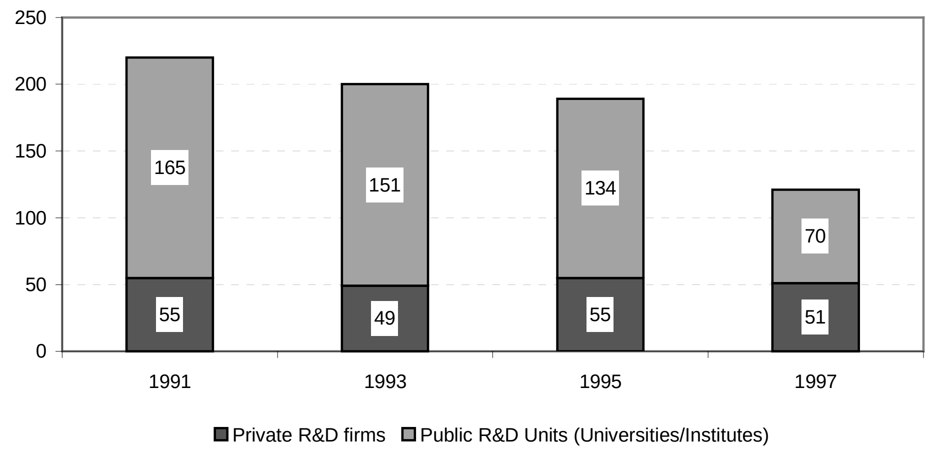
	1997			
Category	Number of projects and long-term activities	State budget	Private sources	Total 1997
			Million PPP$	
Human medicine	11	0.2590	0.5401	0.7992
Agriculture	27	1.7726	0.6437	2.4163
Environment	9	0.3493	0.3028	0.6521
Food industry	3	0.1061	0.0049	0.1110
Industry (non-food)	19	0.9960	0.3715	1.3675
Other[2]	48	5.1046	1.2219	6.3265
Total	117	8.5877	3.0850	11.6727

	1998			
Category	Number of projects and long-term activities	State budget	Private sources	Total 1998
			Million PPP$	
Human medicine	6	0.4279	0.1117	0.5396
Agriculture	28	1.7999	0.1322	1.9321
Environment	9	1.5497	0.0030	1.5527
Food industry	2	0.0927	0.0000	0.0927
Industry (non-food)	13	0.5576	0.0000	0.5576
Other[2]	36	4.6319	0.4468	5.0787
Total	94	9.0598	0.6937	9.7535

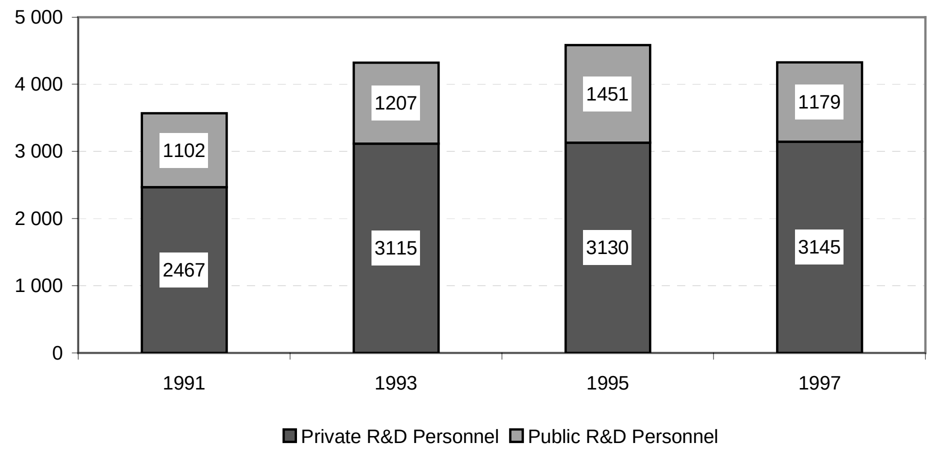
	1999			
Category	Number of projects and long-term activities	State budget	Private sources	Total 1999
			Million PPP$	
Human medicine	12	0.5043	0.5572	1.0615
Agriculture	41	2.4432	0.5731	3.0163
Environment	11	0.2053	0.1255	0.3308
Food industry	3	0.1022	0.1004	0.2027
Industry (non-food)	10	0.3534	0.0000	0.3534
Other[2]	37	4.1613	1.4322	5.5935
Total	114	7.7697	2.7884	10.5582

BIOTECHNOLOGY IN DENMARK

Number of Danish firms and public institutions active in biotechnology research



Danish R&D personnel in biotech (measured in person-years)



Source: Based on data from the Danish Institute for Studies in Research and Research Policy (AFSK). (http://www.afsk.au.dk)

Table 1. **Biotechnology R&D expenditure in Denmark**

		1991	**1993**	**1995**	**1997**
Public R&D units[1]	R&D total expenditure (million PPP$)	63.6	76.1	108.4	75.6
	R&D current expenditure (million PPP$)	56.5	69.3	100.6	69.4
Private sector firms	R&D current expenditure (million PPP$)	111.3	146.7	199.0	286.3

1) Universities, hospital departments, public research institutes, etc.
Source: Based on data from the Danish Institute for Studies in Research and Research Policy (AFSK). (http://www.afsk.au.dk)

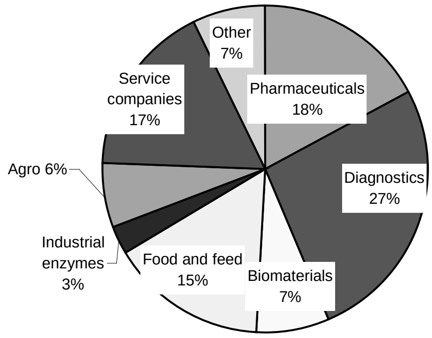
- The number of public institutions active in biotech research decreased sharply between 1991 and 1997 from 165 to 70, while the number of firms decreased from 55 to 51.
- R&D expenditure in the private sector increased between 1991 and 1997 by 157%, while employment of R&D personnel increased by only 28%.

BIOTECHNOLOGY IN FINLAND

(Based on 110 companies active in biotechnology – total population)

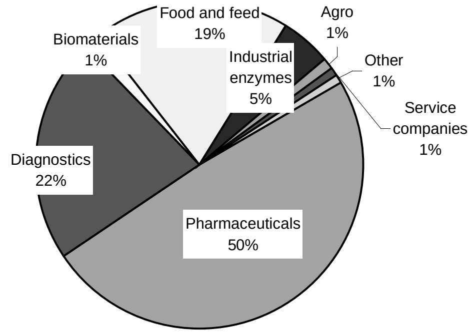
Where are the Finnish biotech companies?

Industrial breakdown, 1999



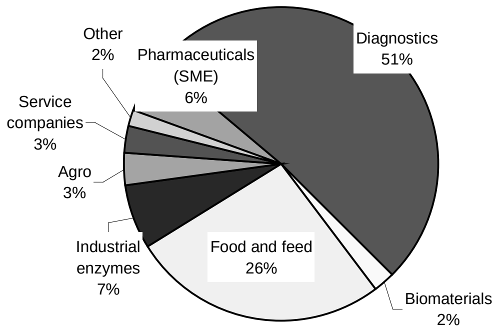
What are the Finnish biotech companies producing?

Distribution of 1999 turnover of PPP$ 1 313 million (includes large pharmaceutical)



Type of biotechnology employment

Distribution of 3 990 employees, 1999 (excludes large pharma)



Source: Based on data from Finnish Bioindustries. (http://www.finbio.net).

- Most companies are in the field of Diagnostics (27%) followed closely by Pharmaceuticals (18%).
- The reverse is true for turnover, where Pharmaceuticals accounts for half and Diagnostics for less than a quarter. Food and feed ranks third (19%).
- After excluding large pharmaceutical firms, Diagnostics firms account for 51% of all biotechnology employment, followed by Food and Feed (26%). These results exclude the large pharmaceutical companies, as these would distort the results, since most of their employees probably have nothing to do with biotech.
- Between 1998 and 1999, the number of firms has increased from 89 to 107 firms (excluding large pharmaceutical companies). Turnover and personnel have increased at a more rapid pace (31% and 28% growth per annum, respectively). Agro is the sector with the greatest growth in terms of both turnover and personnel.

BIOTECHNOLOGY IN FINLAND

Table 1. **Biotechnology companies by sector and size class: distribution in 1998 and 1999**

	Number of companies		Turnover in million PPP$		Personnel	
	1998	**1999**	**1998**	**1999**	**1998**	**1999**
Pharmaceuticals	17	19	714.1	641.6	2 640	4 430
SMEs	14	16	8.3	15.6	140	220
Large pharmaceutical	3	3	705.8	626.0	2 500	4 210
Diagnostics	28	29	201.5	293.4	1 390	2 050
Biomaterials	8	8	7.8	19.6	60	90
Food and feed	10	17	233.6	254.3	1 060	1 050
Industrial enzymes	3	3	53.5	66.5	290	270
Agro	7	7	1.7	13.7	30	130
Service companies	16	19	11.7	11.7	110	110
Other	3	8	5.8	11.7	30	70
Total	92	110	1 229.7	1 312.6	5 610	8 200
Total excluding large pharmaceutical firms	89	107	523.9	686.6	3 110	3 990

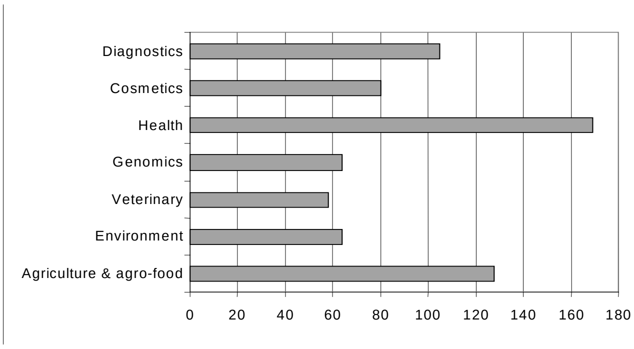
Source: Based on data from Finnish Bioindustries. (http://www.finbio.net)

BIOTECHNOLOGY IN FRANCE

(Based on data for 255 SMEs with less than 500 employees)

Where are the French biotech SMEs?[1]

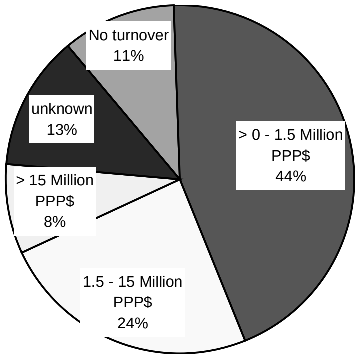
Number of firms by sector 1999



1) Some SMEs appear in more than one type.

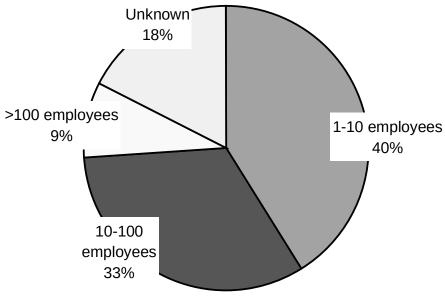
What are the French biotech SMEs producing?

Distribution of 1999 turnover of PPP$ 2 000 million



Biotech SMEs by size-class, 2000

Distribution of 234 SMEs with >= 1 employee



French biotech companies survey responses

	Survey 1999	Survey 2000
Estimated population	450	380
Number of responses [1]	221	277
Number of SMEs in the database	194	255
SMEs' response rate	46%	71%
Number of firm death	..	17
Number of firm creation	38	31

1) Includes large firms and non-profit organisations.

Source: Based on data from MENRT (Ministère de l'éducation nationale, de la recherche et de la technologie -- Bureau des études statistiques sur la recherche) and INRA/SERD (Institut National de la Recherche Agronomique). (http://biotech.education.fr/web/fr/Panorama/pme2000/index.htm)

Methodological note: The data presented in the profile are only based on SMEs (fewer than 500 employees).

- The Health sector has the greatest number of firms, followed by Agriculture and agro-food. Some SMEs may appear in more than one sector or market.
- 40% of the firms have less than ten employees, while 55% have sales less than PPP$ 1.5 million.

BIOTECHNOLOGY IN FRANCE

Table 1. **Patenting by French biotech SMEs (less than 500 employees), 1999**

By sales turnover

Patenting	0	Percent in total	> 0 - 1.5 Million PPP$	Percent in total	1.5 - 15 Million PPP$	Percent in total	> 15 Million PPP$	Percent in total	unknown	Percent in total	Total
Number of SMEs that don't patent	24	88.6%	68	61.0%	46	74.3%	13	56.7%	26	81.5%	176
Number of SMEs that patent	3	11.4%	44	39.0%	16	25.7%	10	43.3%	6	18.5%	78
Biotech SMEs number	27		112		61		23		32		255

Table 2. **Contracts with academia by French biotech SMEs, 1999**

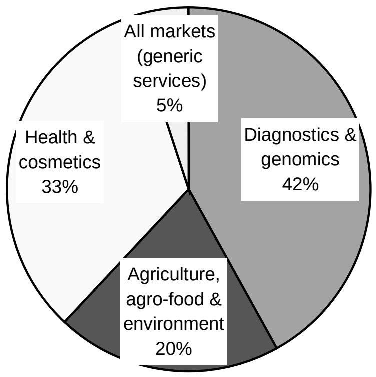
By sales turnover

Contracts with academia	0	Percent in total	> 0 - 1.5 Million PPP$	Percent in total	1.5 - 15 Million PPP$	Percent in total	> 15 Million PPP$	Percent in total	unknown	Percent in total	Total
Number of SMEs that don't have contracts with academia	15	55.2%	42	37.1%	31	50.2%	11	47.8%	15	46.8%	113
Number of SMEs that have contracts with academia	12	44.8%	70	62.9%	31	50.2%	12	52.2%	17	53.2%	142
Biotech SMEs number	27		112		61		23		32		255

Source: Based on data from MENRT (Ministère de l'éducation nationale, de la recherche et de la technologie -- Bureau des études statistiques sur la recherche) and INRA/SERD (Institut National de la Recherche Agronomique).

- Most biotechnology SMEs do not patent (69%).
- SMEs in the smallest firm size category (>0 to 1.5 million PPP$) have the highest patenting rates and a slightly higher rate of contracts with academic research institutions.
- Approximately half of all SMEs have contracts with research institutions (56%).

Target markets of French biotech SMEs, 2000



Source: Based on data from MENRT (Ministère de l'éducation nationale, de la recherche et de la technologie -- Bureau des études statistiques sur la recherche) and INRA/SERD (Institut National de la Recherche Agronomique).

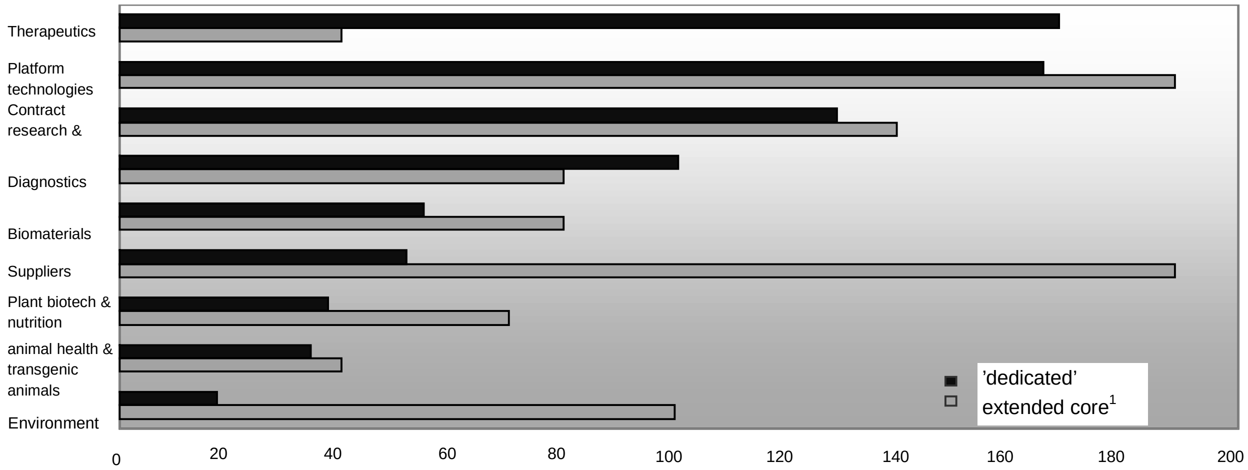
- As some firms do not yet have products or services on the market, they have been classified according to the markets they are targeting, or intend to target. In fact, most SMEs are concentrated in the service sector; only 25% of them are actually engaged in the production of goods.
- French biotechnology SMEs target the Diagnostics and genomics market (42%) followed by Health and cosmetics market (33%).

BIOTECHNOLOGY IN GERMANY

(Based on a sample of 709 companies, of which 279 "dedicated" companies)

Where are the German biotech companies?[1]

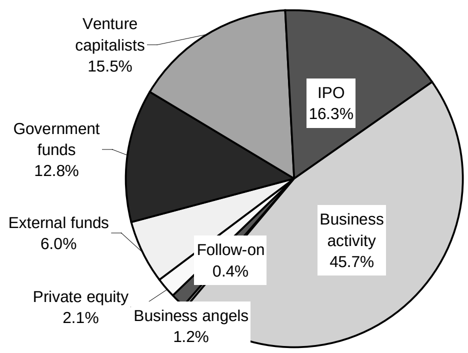
Number of "dedicated' and other biotech companies in 1999



1) Some companies appear in more than one type. "Extended core" refers to companies where Biotech represents only one segment of their activities.

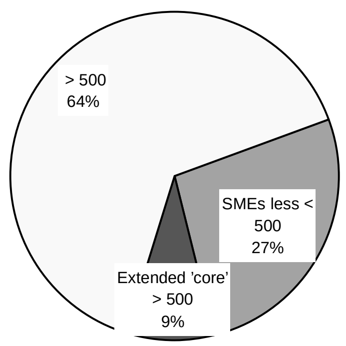
Where do biotech SMEs go in search of funds?

Resource allocation in 1999



Number of employees in biotech R&D

Number of employees in biotech R&D in 1999 is 16 382



Source: Based on data from Ernst & Young, "Biotech in Germany, 2000". (http://www.ernst-young.de/)

Methodological note: These data are based on:

Primary Data Survey: More than 1 200 companies (ELISCOs, Extended core companies, large companies, business angels, venture capitalists, and banking establishments) were approached. 371 replies received (approximately 300 from life sciences companies, the remaining part from investors).

Secondary Data Research: Analysing information concerning the remaining companies via Internet and scientific publications.

The companies surveyed were classified into three categories:

Category I: "Entrepreneurial Life Sciences Companies" (ELISCOs) SMEs (< 500 employees), whose main business purpose is to commercialise biotechnology; Category II: "Extended Core ELISCOs" (> 500 employees) which develop and sell methods, products or services using methods of modern biotechnology, but do not meet the criteria to qualify as "core" life sciences companies; Category III:

Large companies in the life sciences industry (> 500 employees), a considerable part of whose turnover is accounted for by modern biotechnology products or products for biotechnology research and production.

Of the biotechnology firms surveyed, only 40% are entirely “dedicated” to biotechnology (279), the remainder are “extended core” (407) and “large” companies (23) where biotechnology represents only one segment of their activities. For more information on the E&Y survey and the definition of biotechnology refer to: http://www.oecd.org/dsti/sti/s_t/biotech/stats/Inventory/germany.htm#Ernst & Young

- The leading biotechnology sector – of dedicated biotech firms – is therapeutics (also known as Pharmaceuticals) followed by platform technologies.
- The leading sectors for the “extended core” companies are the supplier and platform technologies sectors.
- German biotechnology firms appear to be more dependent on revenues from sales for their funding (46%), rather than on other sources such as venture capital (16%) or angel funds (1%).

BIOTECHNOLOGY IN HUNGARY

Table 1. **State-supported biotechnology projects by sector, 1991-96 combined**

Sector	Number of contracts	Funding support in million PPP$	Percent of biotech funding
Cultivation of plants	61	7.2	37%
Animal husbandry	37	3.6	18%
Food processing	2	0.3	2%
Pharmaceutical	19	5.1	26%
Health care	37	4.0	20%
Environmental protection	16	0.2	1%
Total	172	19.5	*100%*
All areas	1 425	176.0	
Biotechnology-related as a percentage of all areas	12.1%	11.5%	

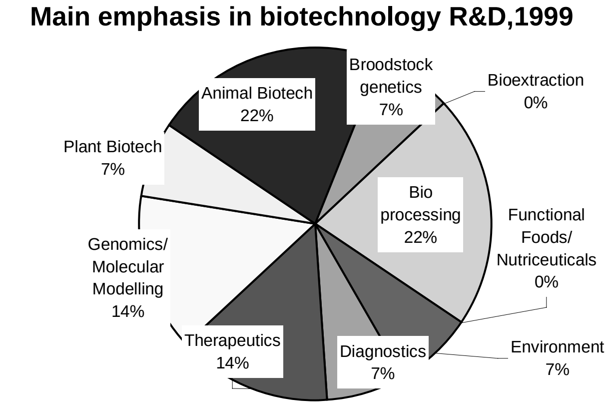
Source: Based on Ulrike Bross- Annamária Inzelt-Thomas Reiss (1998), Bio-Technology Audit in Hungary, Guidelines, Implementation, Results, Physica-Verlag, Heidelberg: based on data from the Hungarian National Committee for Technological Development (OMBF).

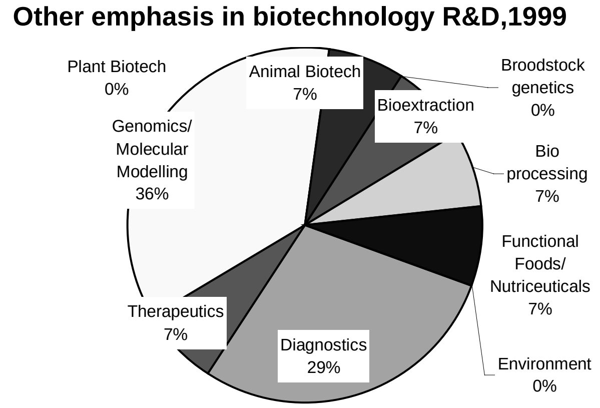
Methodological note: Unlike all other countries, with the exception of the Czech Republic, these data cover only State supported projects. These data cover the 1991-96 time period, combined.

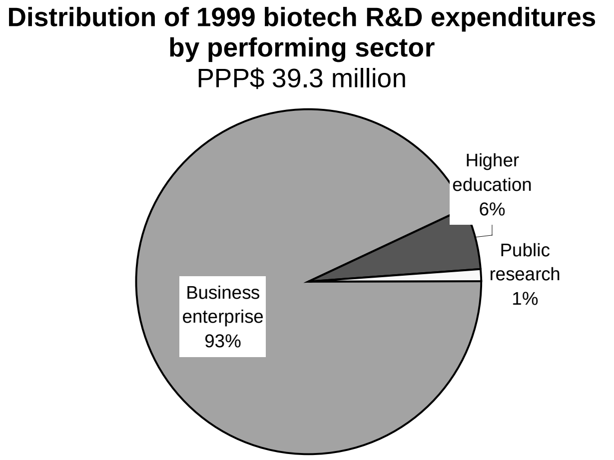
- The cultivation of plants (Agriculture) received 37% of the total state subsidies for biotechnology, followed by the Pharmaceutical and Health care sectors.

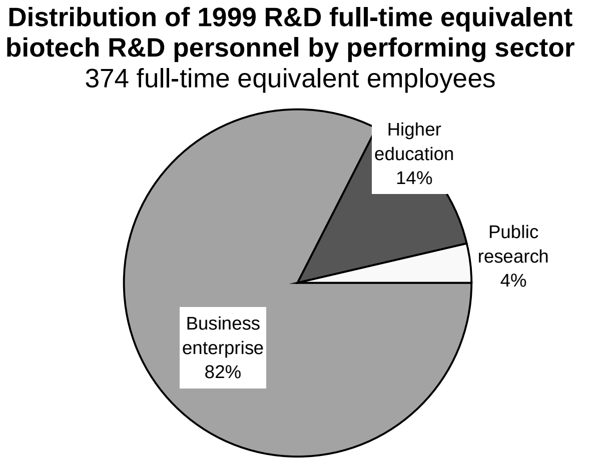
BIOTECHNOLOGY IN ICELAND

(Based on data for 11 companies active in biotechnology)









Source: Based on data from the IRC annual R&D survey.

Methodological note: As of 1999, the Icelandic Research Council (IRC), responsible for collecting and processing data on R&D in Iceland, added a section on biotechnology to their national R&D survey. The R&D survey is the best source of biotech data currently available.

- Respondents were asked to indicate the main sectors of their firm's biotechnology activities. It should be noted that this ranking is not related to the resources allocated to the above.
- Animal Biotechnology and Bioprocessing are the two main sectors of activity, followed by Genomics/Molecular Modelling and Diagnostics.
- Approximately 93% of R&D expenditures on biotechnology are made by the business enterprise sector. The business enterprise sector employs 82% of total R&D biotech personnel.

BIOTECHNOLOGY IN IRELAND

(Based on data for 26 companies active in biotechnology)

Table 1. **Where are the Irish biotech companies?**

Number of companies active in biotech in 1999

Name	Established	Sector	Staff
Elan	c. 1980	Pharmaceuticals	~1 000
Schering Plough (Brinny) Co.	1986	Production of interferons	500
Plant Technology Ltd.	1988	Plant breeding	15–20
Serology Ltd.	1988	Veterinary DNA diagnostics	<5
Fort Dodge Laboratories	1990	Animal vaccines	50–100
Biotrin Holdings Ltd.	1991	Kits for organ & tissue damage	50–100
Cambridge Diagnostics. (Irl.) Ltd	1991	Human diagnostic test kits	50–100
Enfer Laboratories	1991	Veterinary diagnostics test kits	20–50
Trinity Biotech Plc.	1992	Immunodiagnostic test kits	50–100
Bioserv	1993	Toxicology & animal cell tissue culture	<5
DubCap	1994	Plant biotechnology	5–10
Green Crop Ltd.	1994	Plant biotechnology	<5
Xenith Biomed	1995	Immunodiagnostics	10–15
Alltech	1996	Food supplements	20–50
MedNova	1996	Biomedical devices	40–50
Arqtech Laboratories	1997	DNA diagnostics	<5
BioIndustries Ltd.	1997	Environmental remediation	5–10
Eirx	1997	Apoptosis research	<5
Identigen	1997	DNA diagnostics	<5
Key Laboratories	1997	Veterinary diagnostics	<5
Surgen	1997	Cardiovascular genomics	<5
Tridelta	1997	Veterinary diagnostics	<5
Westgate Biologicals	1997	Nutriceuticals	<5
Archport	1998	DNA contract manufacture	10–15
Vistron	1998	Diagnostics	<5
Hibergen	1999	Population based genomics company	<5

Source: Based on data from BioResearch Ireland. (http://www.biores-irl.ie/)

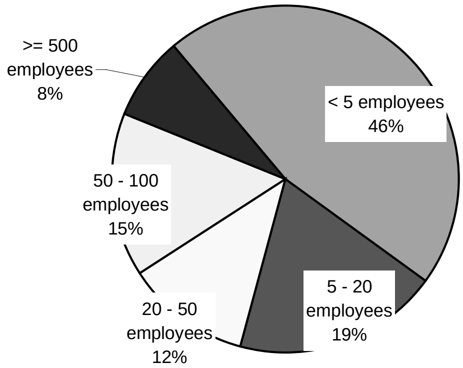
- The majority of active Irish biotechnology companies are very small (46% with less than five employees). There is only one large company (Elan) and it is in the Pharmaceuticals sector. Most of its activities do not involve biotechnology.

- Diagnostics predominate the market.

BIOTECHNOLOGY IN IRELAND

Irish biotech companies by size class, 1999

Determined by the number of employees

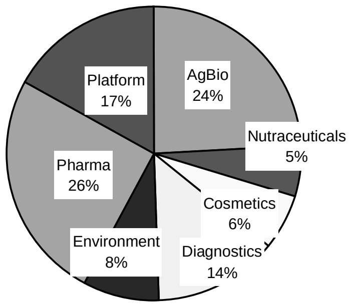


Source: Based on data from BioResearch Ireland.

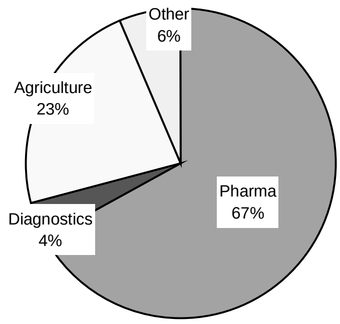
BIOTECHNOLOGY IN ISRAEL

(Based on data for 135 companies)

Where are the Israeli biotech companies?[1]
Industrial breakdown, 1999

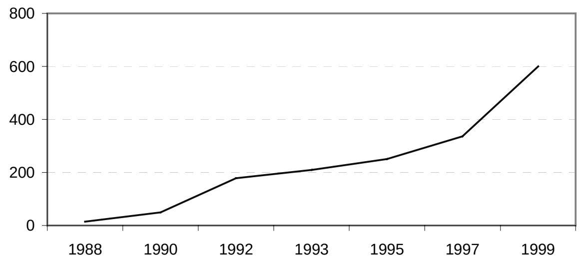


What are the Israeli biotech companies producing?
Sales, 1999

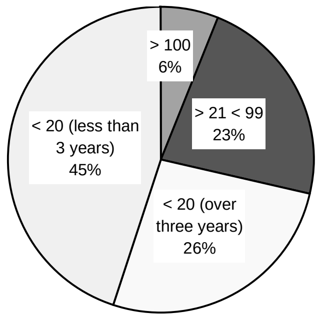


1) Some companies appear in more than one type.

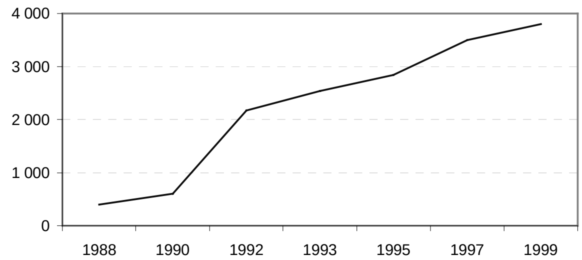
Evolution of sales
in million PPP$



Biotech companies by size class, 1999
Determined by the number of employees



Evolution of employment



Source: Based on data from the Israeli Ministry of Trade and Commerce.

- Most Israeli biotechnology firms are in the Pharmaceutical sector (26%), followed closely by the Agbio sector (24%).
- The Pharmaceutical sector generates the most revenue (67%), followed by Agriculture (23%).
- Most biotechnology companies are either start-ups (45%) or small (26%).
- Most large, medium and small-sized biotechnology companies are in Agbio, followed by Pharmaceuticals. Most start-ups are in Pharmaceuticals.

BIOTECHNOLOGY IN ISRAEL

Profile

Table 1. **Financial profile of biotechnology firms**

Financial data in million PPP$

	1988	**1990**	**1992**	**1993**	**1995**	**1997**	**1999**
Sales (million PPP$)	15	50	179	209	250	336	600
Employed persons	400	600	2 170	2 540	2 840	3 500	3 800
Number of Companies	25	30	..	63	87	100	135

Table 2. **Biotechnology sales by sector**

Percent

Percent	**1997**	**1999**
Pharma	59.6	66.9
Diagnostics	12.5	3.9
Agriculture	26.5	22.8
Other	1.4	6.4
Total	100.0	100.0

Table 3. **Biotechnology companies by sector and size class: distribution, 1999**[1]

Sector	Large	Medium	Small	Start-up	Total
AgBio	5	12	13	14	44
Nutraceuticals	1	1	1	7	10
Cosmetics	1	..	3	7	11
Diagnostics	..	8	6	11	25
Environment	..	2	7	6	15
Pharma	3	10	9	24	46
Platform	1	8	9	13	31
Total	11	41	48	82	

1) Some companies appear in more than one type. Start-up: up to 3 years and to 20 employed persons; Small: over 3 years and up to 20 employed persons; Medium: 21-99 employed persons; Large: 100 and over employed persons.

Source: Based on data from the Israeli Ministry of Trade and Commerce.

BIOTECHNOLOGY IN ISRAEL

Table 4. **Biotechnology companies by sector and size class: share of distribution, 1999**[1]

Sector	Large	Medium	Small	Start-up	Total	Total
			Percentage			firms
AgBio	11.4	27.3	29.5	31.8	100.0	44
Nutraceuticals	10.0	10.0	10.0	70.0	100.0	10
Cosmetics	9.1	..	27.3	63.6	100.0	11
Diagnostics	..	32.0	24.0	44.0	100.0	25
Environment	..	13.3	46.7	40.0	100.0	15
Pharma	6.5	21.7	19.6	52.2	100.0	46
Platform	3.2	25.8	29.0	41.9	100.0	31

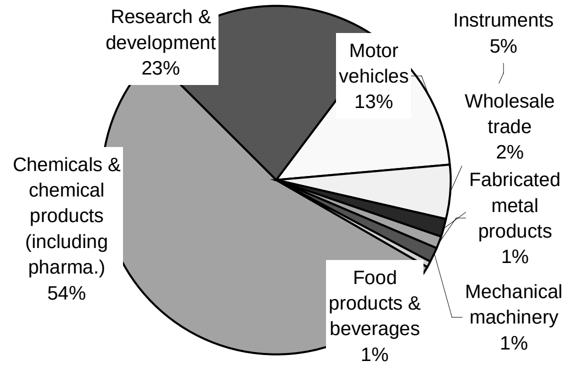
1) Some companies appear in more than one type. Start-up: up to 3 years and to 20 employed persons; Small: over 3 years and up to 20 employed persons; Medium: 21-99 employed persons; Large: 100 and over employed persons.

Source: Based on data from the Israeli Ministry of Trade and Commerce.

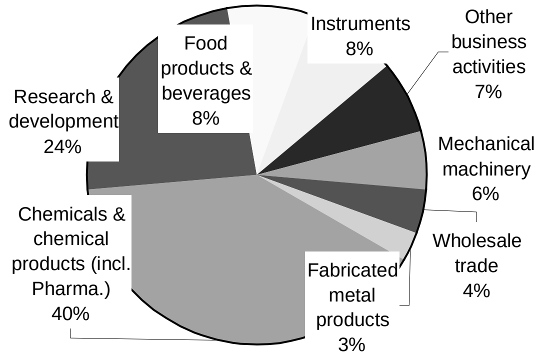
BIOTECHNOLOGY IN ITALY

(Based on data for 82 R&D performers)

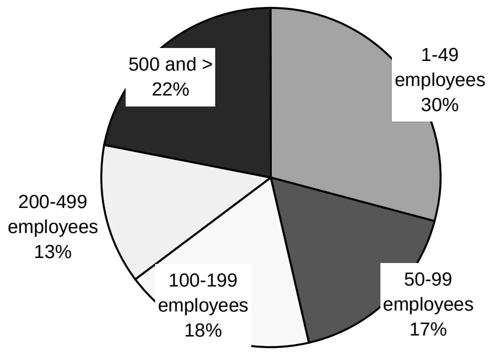
Which Italian sectors are doing R&D in biotechnology?
Top 8 sectors in 1998
Determined by R&D expenditures, totalling PPP$ 163 million



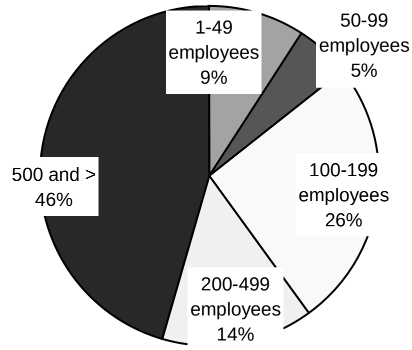
Which Italian sectors are doing R&D in biotechnology?
Top 8 sectors in 1998
Determined by the number of performers, totalling 72 performers



Biotech companies by size class, 1998
Determined by the number of employees



Distribution of biotechnology R&D by size class, 1998
Distribution of PPP$ 165 million



Source: Based on data from the ISTAT annual R&D survey.

Methodological note: The Italian National Statistics Institute (ISTAT) has not carried out a specific biotech firm survey, however as of as of 1991 two “general” questions on biotechnology were included in the annual ISTAT survey on R&D in the business enterprise sector. The main shortcoming of these data is the fact that no clear definition of biotechnology was included with the questions. In the near future a definition will be included. The R&D survey is the best source of biotech data currently available. The following data are extracted from the R&D survey.

- The most active Italian biotechnology sector is the Chemicals & chemical products sector which includes Pharmaceuticals, in terms of both R&D expenditures (54%) and number of performers (40%). Followed by the Research and Development sector accounting for 23% of total expenditures and 24% of all performers.

- It is interesting to note that although there is only one enterprise involved in biotechnology R&D in the motor vehicles industry this sector ranks third in terms of R&D expenditure (13%).

BIOTECHNOLOGY IN ITALY

- The water supply sector devoted the largest percentage of R&D expenditure to biotech activities with 12.3% of total R&D expenditure and only two enterprises (see Table 1 below).
- In 1998, 47% of the firms doing biotechnology R&D had less than 100 employees.
- Table 3 below shows biotech R&D decreased by 9.9%, between 1997 and 1998, while overall BERD increased by 2.9%. However no major changes can be identified in the size, or in the sectoral distribution of biotech R&D spending, thus confirming the extent to which biotech activities are diffused among Italian R&D performers in 1998, 47% of the firms doing biotechnology R&D had less than 100 employees.

Table 1. **R&D expenditures in comparison to overall R&D, 1998**

Sectoral breakdown in million PPP$

Selected NACE sectors	Biotech business R&D expenditure	Total BERD	Share of biotech R&D/ Total R&D (%)	Number of biotech R&D performers	Number of R&D performers	Share of biotech performers/ R&D performers (%)
15 - Food products & beverages	1.11	96	1.2	6	58	10.3
20 - Wood (not furniture)	0.08	3	2.5	1	9	11.1
21 - Pulp, paper & paper products	0.04	15	0.3	1	18	5.6
22 - Publishing & printing	0.50	5	9.4	1	6	16.7
24 - Chemicals & chemical products (incl. pharmaceuticals)	88.26	965	9.1	29	203	14.3
28 - Fabricated metal products	2.09	38	5.5	2	69	2.9
29 - Mechanical machinery	1.89	509	0.4	4	357	1.1
31 - Electrical machinery	0.42	215	0.2	2	96	2.1
33 - Instruments	7.98	191	4.2	6	106	5.7
34 - Motor vehicles	21.84	861	2.5	1	47	2.1
41 - Water supply	0.06	0	12.3	1	2	50.0
45 - Construction	0.20	25	0.8	2	15	13.3
51 - Wholesale trade	2.78	38	7.3	3	22	13.6
72 - Software consultancy	0.23	207	0.1	1	55	1.8
73 - Research & development	36.84	843	4.4	17	93	18.3
74 - Other business activities	0.44	127	0.3	5	71	7.0

Source: Based on data from the ISTAT annual R&D survey.

BIOTECHNOLOGY IN ITALY

Table 2. **Italian biotech BERD by size class, 1998**

Size classes	Biotech BERD (million PPP$)	Share on total biotech BERD (percentage)	Number of biotech R&D performers	Share on total biotech R&D performers (percentage)
1-49 employees	15	9.2	24	29.3
50-99 employees	9	5.2	14	17.1
100-199 employees	42	25.6	15	18.3
200-499 employees	24	14.5	11	13.4
500 and more employees	75	45.5	18	22.0
Total	165	100	82	100

Source: Based on data from the ISTAT annual R&D survey.

Table 3. **R&D expenditures in comparison to overall R&D: sectoral breakdown, 1997 and 1998**

Million PPP$

Selected NACE sectors	Total BERD			Biotech BERD		
	1997	1998	1997-98 change (%)	1997	1998	1997-98 change (%)
15 - Food products & beverages	72	96	33.0	4	1	-70.5
20 - Wood (not furniture)	4	3	-21.5	-	0	-
21 - Pulp, paper & paper products	13	15	17.6	-	0	-
22 - Publishing & printing	3	5	54.5	0	1	32.4
24 - Chemicals & chemical products (incl. Pharmaceuticals)	920	965	5.0	94	88	-6.1
25 - Rubber & plastic products	122	114	-7.1	0	-	-
28 - Fabricated metal products	31	38	20.7	-	2	-
29 - Mechanical machinery	752	509	-32.3	4	2	-51.1
31 - Electrical machinery	203	215	6.0	1	0	-48.3
33 - Instruments	244	191	-21.7	10	8	-20.0
34 - Motor vehicles	890	861	-3.3	22	22	0.7
41 - Water supply	1	0	-8.8	0	0	-24.9
45 - Construction	15	25	66.4	-	0	-
51 - Wholesale trade	30	38	27.3	1	3	156.5
72 - Software consultancy	148	207	40.0	1	0	-73.8
73 - Research & development	416	843	102.4	45	37	-18.2
74 - Other business activities	156	127	-18.4	1	0	-55.2
85 - Health	0	0	1367.6	0	-	-
Total	6 425	6 612	2.9	183	165	-9.9

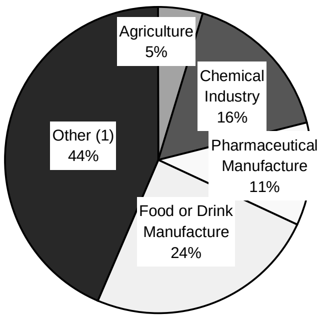
Source: Based on data from the ISTAT annual R&D survey.

BIOTECHNOLOGY IN JAPAN

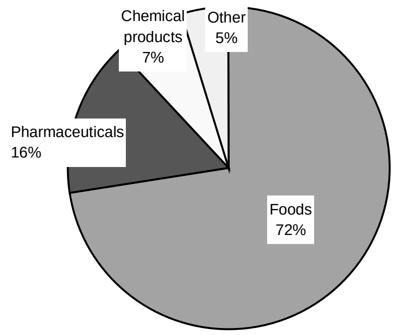
(Based on a responses from 210 companies out of an estimated total population of 394 in 1998/99)

Methodological note: Japan includes “older/traditional” biotechnology, which explains why the data are skewed towards the Food/drink sector.

Where are the Japanese biotech companies?[1]
Industrial breakdown, 1999

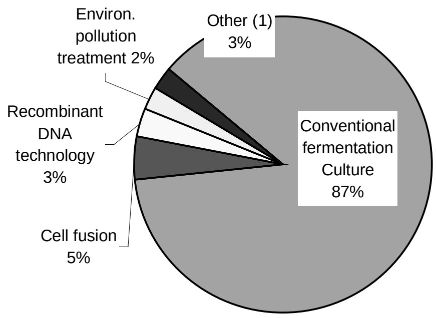


What are the Japanese biotech companies producing?
Annual domestic production shipped, 1998

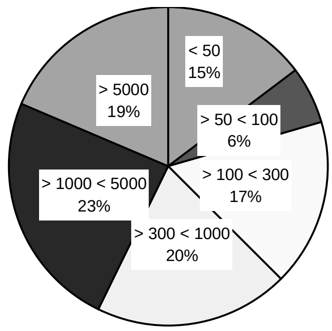


1) See table 1. for a disaggregation of Other.

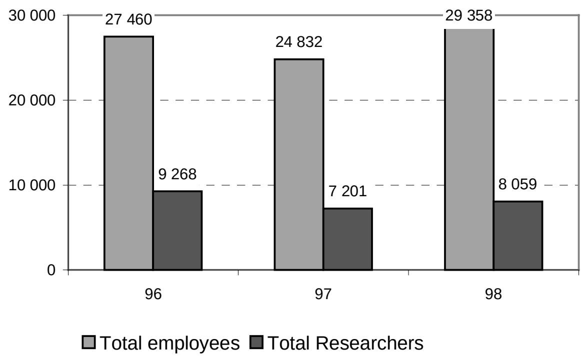
What technologies are they using?
Major technologies used, 1999



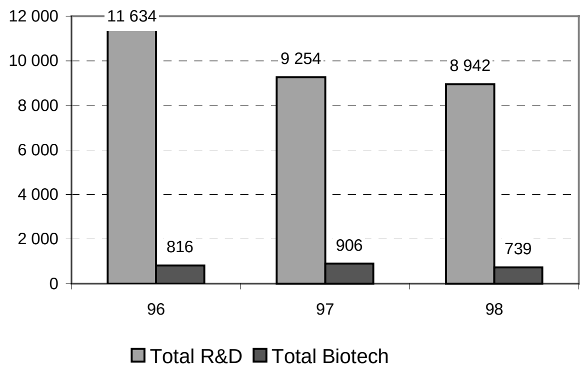
Biotech companies by size class, 1999
Determined by the number of employees



Who’s doing the biotech work?



How much are the biotech companies spending on R&D?
Millions PPP$



Note: The survey response rates were 64% in 1996/97 and refers to Financial Year 1996, 48% in 1997/98 and refers to Financial Year 1997, and 53% in 1998/99 and refers to Financial Year 1998.

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

BIOTECHNOLOGY IN JAPAN

Methodological note: The biotechnology targeted in this survey includes not only the new biotechnology such as recombinant DNA technology, cell fusion, and cell culture of plant and animal cells, but also the conventional technology used in fermentation and brewing, culturing, and mutagenesis technologies. For more information on the JBA survey and the definition of biotechnology refer to the Web site:

http://www.oecd.org/dsti/sti/s_t/biotech/stats/Inventory/japan.htm#JBA

- 24% of Japanese biotech firms are active in Food or Drink manufacturing, followed by Chemicals (16%) and Pharmaceuticals (11%). The large "Other category" (44%) is explained by the wide range of sectors included in the survey (*cf.* Table 1)
- Production dominated by the Food and drinks sector (70%), followed by Pharmaceuticals (16%) and Chemicals (7%).
- Although 44% of firms are active in the "Other category" they account for only 5% of production
- Conventional fermentation culture is the predominant technology used (87%) (*cf.* Methodological note)
- Companies tend to be large – over 40% have between 300 and 5 000 employees. However, this is most likely due to the survey methodology and the definition of biotechnology.
- On average over the three-year period, 30% of all employees are researchers who use 8.4% of total R&D funding for biotechnology.

BIOTECHNOLOGY IN JAPAN

Table 1. **Industry classification of companies (Survey 1999)**

Industry classification of company	Number	Percent
Agriculture	10	4.8%
Forestry	0	0.0%
Fisheries	0	0.0%
Mining	0	0.0%
Construction	8	3.8%
Chemical industry	34	16.2%
Pharmaceutical manufacture	23	11.0%
Food or drink manufacture	51	24.3%
Fibre, pulp, paper processing, mfg.	6	2.9%
Petroleum product, coal processing, mfg.	3	1.4%
Steel, non-ferrous metals mfg	1	0.5%
Machinery industry (incl. plant waste treatment equip.)	15	7.1%
Electric, electronic industry	6	2.9%
Precision machinery industry	1	0.5%
Other manufacturing industry	15	7.1%
Electric power, gas, heat, water	2	1.0%
Shipping communications industry	0	0.0%
Retail, wholesale, restaurant, business	10	4.8%
Finance, insurance industry	1	0.5%
Real estate	1	0.5%
Service industry	9	4.3%
Others	8	3.8%
No reply	6	2.9%
Total	210	100.0%

Table 2. **Japanese biotech firms by size-class (Survey 1999)**

Size class determined by the number of employees

Employees	Number of companies	Percent
A. < 50 employees	31	14.8%
B. 50 - 99	12	5.7%
C. 100 –299	36	17.1%
D. 300 – 999	41	19.5%
E. 1000 - 4999	51	24.3%
F. > 5000	39	18.6%
Total	210	100%

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

BIOTECHNOLOGY IN JAPAN

Table 3. **Annual domestic production of Japanese biotech firms, financial year 1998**

Product classification	Million PPP$	Percent
Foods	21 490	72.6%
Other foods	189	0.6%
Agriculture related	33	0.1%
Livestock and fisheries related	86	0.3%
Pharmaceuticals, diagnostic reagents and medical instruments	4 591	15.5%
Research samples and reagents	25	0.1%
Fiber and fiber processing	6	0.0%
Chemical products	2 092	7.1%
Bioelectronics	0	0.0%
Environment-related equipment and facilities	876	3.0%
Equipment and facilities for research and production	137	0.5%
Other products	15	0.1%
Data processing	41	0.1%
Services (including technical support)	40	0.1%
Total	29 620	100.0%

Table 4. **Annual domestic production of Japanese biotech firms, financial year 1998**

	Million PPP$	Number of companies
FY 1996	32 529	275
FY 1997	25 385	192
FY 1998	29 620	210

Table 5. **Estimated annual domestic production in FY 2003 compared with FY 1998**

Estimated production	Number of companies	Percent
A. Will increase (increase of 50% or more)	103	21.5%
B. Will increase slightly (increase between 11 and 49%)	160	33.5%
C. No change (±10%)	173	36.0%
D. Will decrease slightly (decrease between 11 and 49%)	27	5.6%
E. Will decrease (decrease of 50% or more)	17	3.5%
Total	480	100

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

BIOTECHNOLOGY IN JAPAN

Table 6. **Major technologies used, FY 1998**

Major technologies used	Production	
	Million PPP$	Percent
A. Conventional fermentation, culture and mutation processing technologies, etc.	25 803	87.3%
B. Cell fusion, cell culture, chromosome manipulation, tissue culture, and animal clone technologies	1 374	4.6%
C. Recombinant DNA technology	911	3.1%
D. Special culture technology such as immobilisation (bioreactor, etc)	238	0.8%
E. Conventional environment pollution treatment techniques using microorganisms (activated sludge processing methane fermentation composting, etc.)	700	2.4%
F. Bio-mimetic technologies (bio material, etc.), utilisation of electronic equipment (sensors, etc.), analysers, and software using the biological knowledge	538	1.8%
Total	29 564	100

Table 7. **Categories of major products, FY 1998**

Categories of major products	Production	
	Million PPP$	Percent
A. Products that are produced using processes employing biotechnology at your firm.	26 852	90.8%
B. Products that although are not produced using processes employing biotechnology at your firm but are using materials that have been manufactured through biotechnology.	825	2.8%
C. Products that are not produced using processes employing biotechnology but are using biotechnology as the main technology in the research and development stages.	486	1.6%
D. Products purchased and sold that are produced using biotechnology.	441	1.5%
E. Instruments, machines, facilities, or plants involved in production processes using biotechnology or biotechnology related research and development.	905	3.1%
F. Service providers of analysis testing software etc. which employ biotechnology.	70	0.2%
Total	29 578	100

Table 8. **Total number of employees in biotechnology-related work**

	Number of employees	Number of companies
FY 1996	27 460	275
FY 1997	24 832	192
FY 1998	29 358	210

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

BIOTECHNOLOGY IN JAPAN

Table 9. **Total number of researchers in biotechnology-related work**

	Number of researchers	Number of companies
FY 1996	9 268	275
FY 1997	7 201	192
FY 1998	8 059	210

Table 10. **Total research and development expenses**

	Million PPP$	Number of companies
FY 1996	11 673	275
FY 1997	9 330	192
FY 1998	9 153	210

Table 11. **Total biotechnology-related R&D expenses**

	Million PPP$	Number of companies
FY 1996	819	275
FY 1997	914	192
FY 1998	757	210

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

Table 12. **Japanese biotech firms by capital, 1999**

Capital of company in million PPP$	Number of companies	Percent	Capital of company in JPY million
A. <.19 million PPP$	17	8.1%	A. Less than JPY 30 million
B. .19 - .31	14	6.7%	B. Exceeding JPY 30, less than JPY 50
C. .31 - .63	19	9.0%	C. Exceeding JPY 50, less than JPY 100
D. .63 - 3.13	30	14.3%	D. Exceeding JPY 100, less than JPY 500
E. 3.13 -6.25	13	6.2%	E. Exceeding JPY 500, less than JPY 1 000
F. 6.25 -31.3	18	8.6%	F. Exceeding JPY 1 000, less than JPY 000
G. 31.3 -62.5	13	6.2%	G. Exceeding JPY 5 000, less than JPY 10 000
H. >62.5	84	40.0%	H. Exceeding JPY 10 000
I. No reply	2	1.0%	I. No reply
Total	210	100	

Source: Based on data from the Japan Bioindustry Association. (http://www.jba.or.jp)

BIOTECHNOLOGY IN THE NETHERLANDS

Methodological note: The Netherlands includes “older/traditional” biotechnology.

Table 1. **R&D full-time-equivalents employees in biotechnology and total**

	Total		Biotechnology		Biotech share in total sector R&D	Biotech share in total Biotech R&D
					Percent	
	1995	1997	1995	1997	1995	1997
Manufacturing	29 980	30 243	..	562	1.9	34.8
food products ; beverages	2 654	2 626	443	180	6.8	11.1
textiles and leather	182	213	..	2	0.9	0.1
paper	182	194	1	2	1.3	0.2
basic chemicals	6 412	2 311	72	x	..	..
pharmaceuticals, medicinal	2 253	2 966	89	x	..	..
other chemical products	..	2 659	..	27	1.0	1.7
rubber and plastic products	469	657	2	x	..	..
machinery and equipment	2 857	3 027	4	6	0.2	0.4
Services	..	9 808	..	553	5.6	34.3
Remaining sectors	..	2 358	..	359	15.2	22.2
agriculture, forestry and fishing	619	638	258	x	..	..
Research institutions (B-sciences)[2]	15 070	14 311	120	141	1.0	8.7
Total business enterprises	37 116	42 409	1 344	1 474	3.5	91.3
Total	52 186	56 720	1 464	1 615	2.8	100.0

x = confidential.

1) These firms are operating in several two digit NACE groups. The common denominator of these firms is that they operate on behalf of private enterprises.

2) B-sciences stands for agricultural sciences, natural sciences, engineering and medical sciences (NSE).

Source: Based on data from Statistics Netherlands (CBS). (http://www.cbs.nl/)

Methodological note: This is the only data collected by Statistics Netherlands on biotechnology, based on a classification of Field of Research and Technology developed by CBS: Research on genetic modification, cell fusion/biology, fermentation, development of proteins/enzymes, neuro biology, botanical improvement, bio catalysts. For more information on the CBS survey and the definition of biotechnology refer to the Web site http://www.oecd.org/dsti/sti/s_t/biotech/stats/Inventory/netherlands.htm.

- During the 1995-97 period, the number of researchers in biotechnology as a percentage of total researchers has remained constant (2.8%).

- Ninety percent of all biotechnology R&D researchers are in the business enterprise sector.

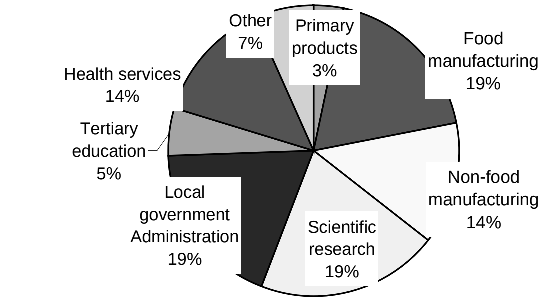
- There is little difference between the percentage of biotechnology researchers in manufacturing (34.8%) and services (34.3%).

- In manufacturing, the Food products and beverages sector has the largest share of biotechnology R&D researchers. This is probably due to the fact that the definition includes “older/traditional” biotechnology.

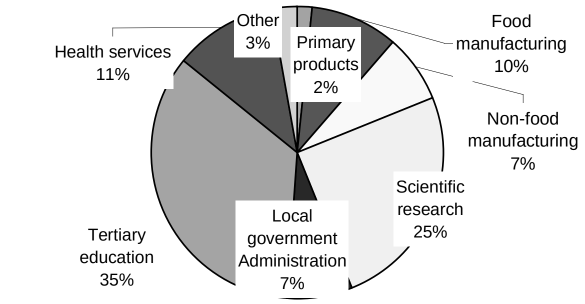
BIOTECHNOLOGY IN NEW ZEALAND

(Based on 180 enterprises which use at least one form of modern biotechnology process – total population)

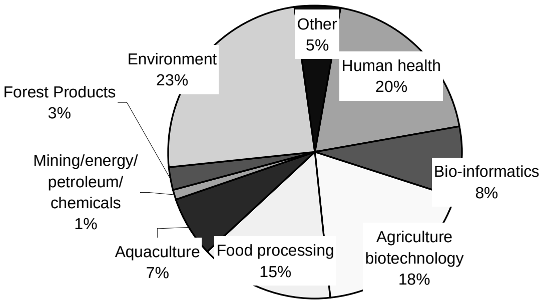
Where are the New Zealand biotech companies?
Industrial breakdown, 1998/99



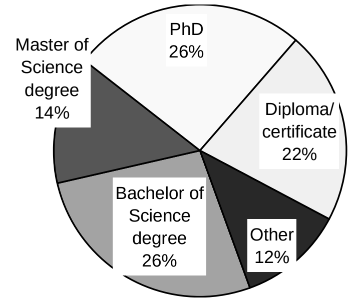
Which sectors are using the most processes?
Distribution of 2 088 processes, 1998/99



Distribution of activities that use biotechnology products and services



Distribution of human resources supporting biotechnology activity by qualification
Distribution of 2 727 employees (head count), 1998/99



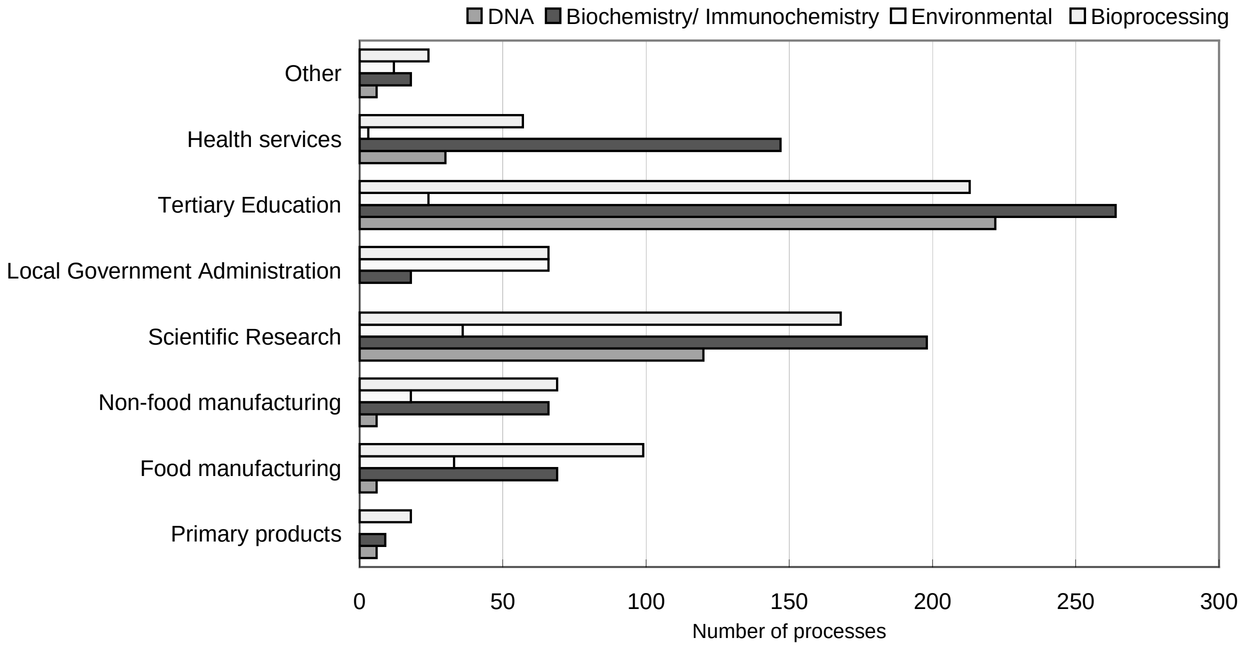
Source: Based on data from Statistics New Zealand.

Methodological note: In 2000, Statistics New Zealand, with the funding of the Ministry of Research, Science and Technology, launched its first Biotech firm survey (1998/99 Biotechnology Survey). The following data and analysis present the first set of official statistics on modern biotechnology in New Zealand and are extracted from the report "Modern Biotechnology in New Zealand" available at http://www.stats.govt.nz/domino/external/web/Aboutsnz.nsf/htmldocs/Paper+-+Biotechnology.

- The Food Manufacturing, Scientific Research and Local Government Administration industrial groupings reported the largest number of enterprises involved in biotechnology. However, enterprises in the scientific research and tertiary education industrial groupings reported using the largest number of processes.
- For 1989/99, income associated with modern biotechnology is an estimated PPP$ 325 million, broken down as PPP$ 223 million for the private sector and PPP$ 102 million for the public sector.
- For the same period estimated expenditure is PPP$ 277 million, PPP$ 189 million for the private sector and PPP$ 88 million for the public sector.
- Biotechnology processes are most frequently used at the research and development stage.
- Employment in the biotechnology activity represents 0.2% of the total employment. Forty percent of employees involved in modern biotechnology hold a post-graduate degree.

BIOTECHNOLOGY IN NEW ZEALAND

Distribution of utilisation of biotechnology processes by industrial grouping



Source: Based on data from Statistics New Zealand.

- Thirty eight percent of respondents indicated they had implemented a new biotechnology process in the last three years.

- Biochemistry/immunochemistry based technology processes attracted the largest number of responses. The largest number of the responses were sourced from enterprises in the scientific research and tertiary education groupings.

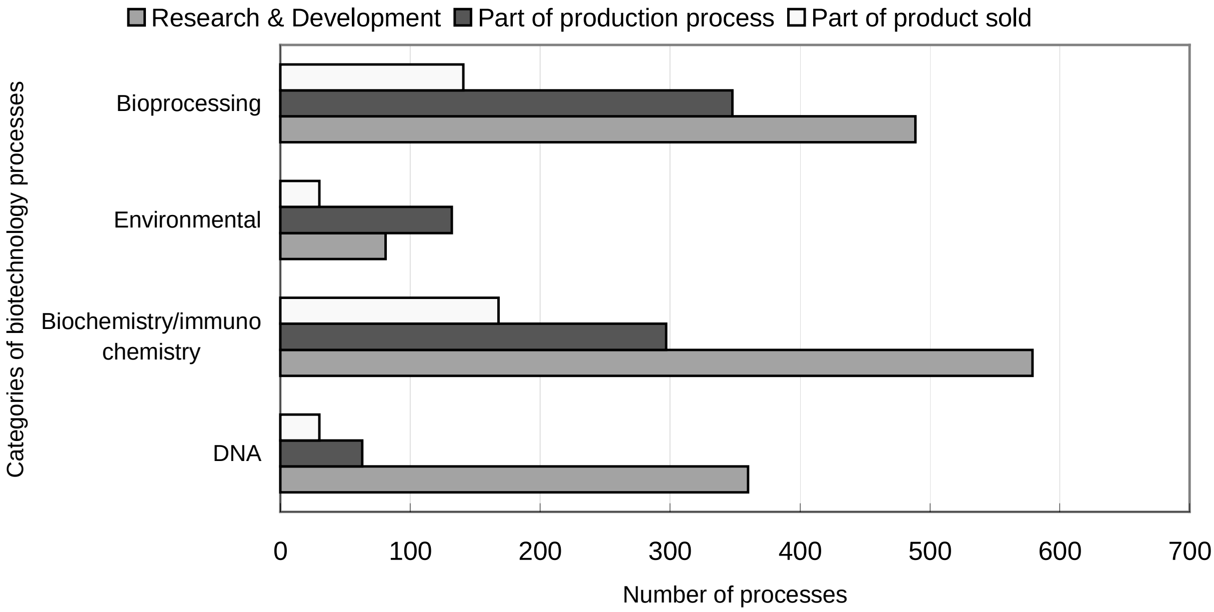
- Utilisation of bioprocessing-based technologies is spread across a wide range of industrial groupings. This is a result of the applicability of bioprocessing-based technologies to a wide range of productive activities.

- Environmental technologies are mainly used by the local government and food and non-food manufacturing industrial groupings.

- Enterprises in the scientific research and tertiary education industrial groupings indicated they used the largest number of biotechnology processes, and between them accounted for 60% of all processes used. This result is consistent with the hypothesis that the adoption of modern biotechnology into New Zealand is at an early stage.

BIOTECHNOLOGY IN NEW ZEALAND

Distribution of biotechnology processes by stage of utilisation

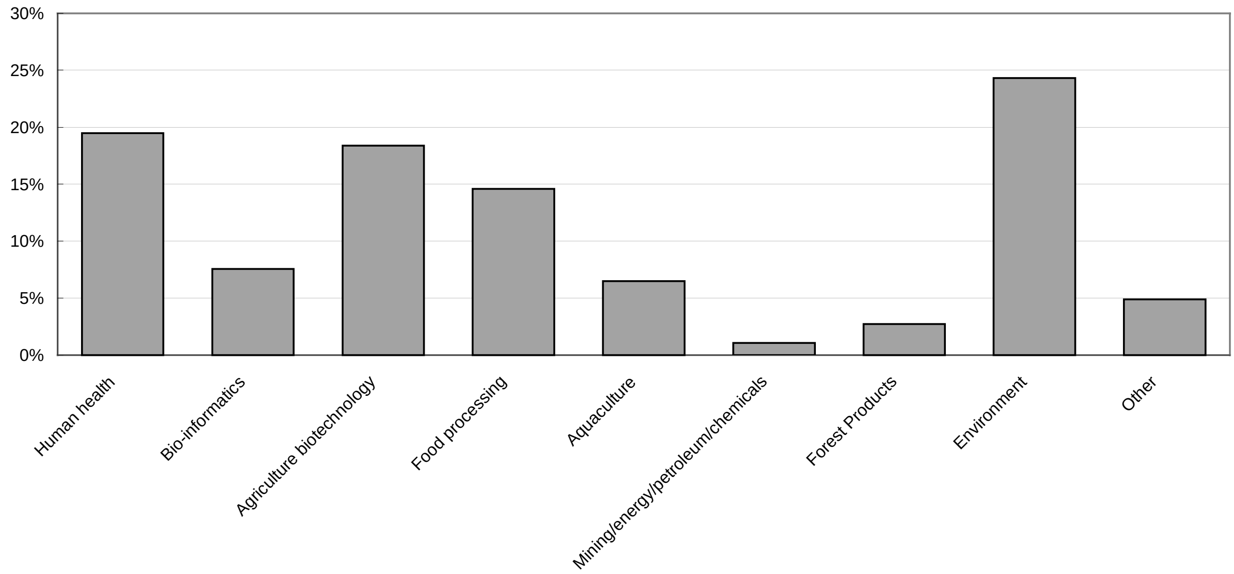


Source: Based on data from Statistics New Zealand.

- Utilisation of biotechnology processes as part of research and product process development attracted the largest number of responses.

BIOTECHNOLOGY IN NEW ZEALAND

Distribution of activities which use biotechnology products and services



Source: Based on data from Statistics New Zealand.

- Environmental activity attracted the largest number of responses. Enterprises in the scientific research, tertiary education and local authority administration industrial groupings provided the largest number of outputs to this category. The enterprises in the local authority administration industrial group use these processes in their treatment of sewage and wastewater.

- Human health biotechnology activity mainly utilised processes associated with diagnostic testing and the development of new treatment techniques in research facilities such as universities and crown research institutes. Agriculture biotechnology activity will be utilising biotechnology processes in areas such as the treatment of disease and the production of new and improved products.

- Food processing activity utilises biotechnology processes in areas such as testing to ensure that their output meets quality standards for domestic and foreign markets.

- Enterprises in the tertiary education and scientific research industrial groups are most active in human health and agricultural biotechnology activities.

BIOTECHNOLOGY IN NORWAY

Table 1. **Where are the Norwegian biotech companies?**

Number of companies that are active in biotechnology, 1999/2000

Companies	Established	Employees	Turnover [1] (1000 PPP$)	Business Focus
NycomedAmersham ASA	1997	8500	1,732,415.8	Multinational pharmaceutical company
Alpharma AS	1994	540	92,556.7	Pharmaceuticals, fine chemicals and feed
Axis-Shield ASA	1984	390	5,481.3	Medical diagnostic products
FMC Biopolymer	1999	250	22,464.8	Producer of alginate
Dynal Biotech ASA	1986	121	18,304.4	Biomagnetic separation
Medi-Cult	1987	59	6,144.5	Media for assisted reproduction
Biotec ASA	1990	25	52.4	Develop and produce biochemical substances
PhotoCure ASA	1993	22	113.9	Photodynamic technology for diagnosis and therapy
Nutri Pharma ASA	1993	21	363.3	Functional food
Biosentrum AS	1997	20	1,790.4	Large scale production of recombinant proteins
GenoMar AS	1996	19	40.0	Genomics and bioinformatics applied onaquaculture
Genovision AS	1998	19	50.1	Manual and automated DNA sample preparation
Intervet Norbio AS	1985	19	4,589.4	Fish vaccines
Pronova Biomedical AS	1998	15	611.0	Biopolymers for clinical applications
Colifast Nye ASA	1999	12	..	Rapid detection of pathological bacterias
Complete Genomics	2000	11	..	Proprietary method for DNA-sequencing
Biosense Laboratories AS	1996	10	182.6	Toxicological testing in food and wild life
Affitech AS	1996	9	304.6	Human recombinant antibodies
Bionor AS	1985	9	286.9	Diagnostic and therapeutic products for HIV/AIDS
MedProbe A/S	1986	8	1,717.2	Research reagents
Genpoin AS	1998	7	113.8	DNA-based tests for food and water quality
Natural ASA	1988	7	802.0	Functional food
Optomed AS	1998	7	29.3	Fiberoptic microsensors for medical applications
Diatec AS	1988	6	230.5	Custom production of monoclonal antibodies
Mison AS	1998	6	113.3	Ultrasound-guided surgery
Nor Chip AS	1998	6	15.6	Electronic microsystems applied on biological systems
DiaGenic AS	1998	5	..	Cancer diagnosis
Optoflow AS	1993	5	408.8	Instruments and reagents for detection of bacteria
AntiCancer Terapeutics AS	1997	3	22.9	Anticancer drugs based on radiolabeled antibodies
A-viral	1986	3	..	HIV-therapy
ChemTAG AS	1994	3	33.9	DNA as identification tags
Neorad AS	1998	3	..	Medical instruments
Vitas AS	1994	3	326.2	Analytical services within nutrition and health
Drug Discovery Laboratories	1995	2	93.0	Contract research in chemical engineering
Electrofect	2000	2	..	Method to introduce DNA into cells
Lauras AS	1998	2	20.8	Immune modulating HIV/AIDS-therapy
Plasmacute AS	1996	2	78.1	Human diagnostics of infectious diseases
CompChrom	1999	2	..	Purification and production of modified polymers
Gentian AS	1998	1	..	Photodynamic technology
GeNova AS	1997	..	0.3	
MicroTag AS	1998	..	41.7	Microbiological tests for food quality
Procaryo AS	1998	..	..	Quick test for mastitisd etection in dairy cows
Thia-Medica AS	1997	..	..	Lipid-based prophylactic food additive
Trans-Herba AS	1998	..	10.4	Transgenic plants as bioreactors
Total (44 Companies)		10,154	1,889,758	

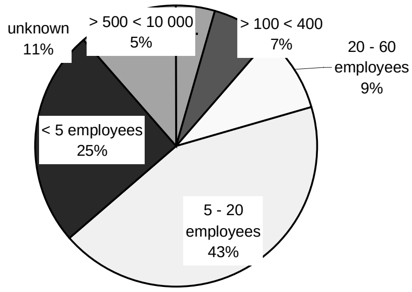
1) Information provided by CreditSafe, date 31.12.99.

Source: Based on data from The Norwegian Biotechnology Advisory Board. (http://www.bion.no/)

BIOTECHNOLOGY IN NORWAY

Biotech companies by size class, 1999

Determined by total number of employees



Source: Based on data from The Norwegian Biotechnology Advisory Board (BIOTEKNOLOGINEMNDA). (http://www.bion.no/)

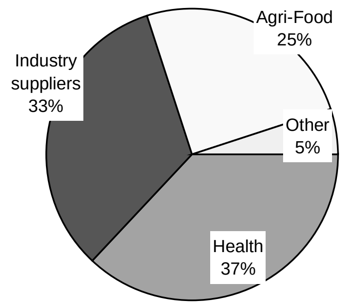
Methodological note: All of the following Norwegian companies are based in Norway, except for NycomedAmersham ASA and Medi-Cult, based in the United Kingdom and Denmark, respectively. The number of employees listed refers to all employees, not just those employed in biotech activities.

- Most firms were established in the 1990s.
- Most firms have between 5 to 20 employees (43%).

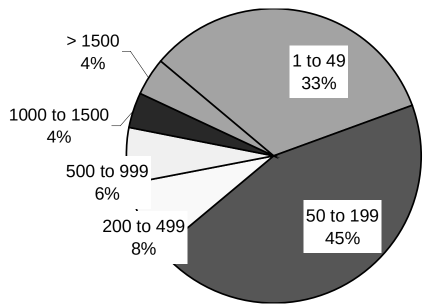
BIOTECHNOLOGY IN SPAIN

(Based on 149 companies)

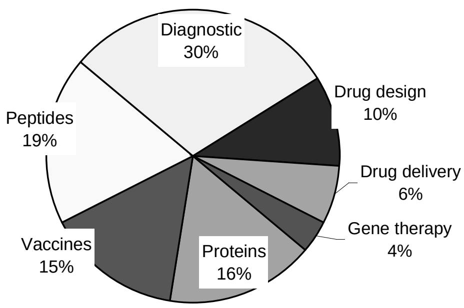
Main sector of activity covered by the Spanish biotech companies
Industrial breakdown, 1997



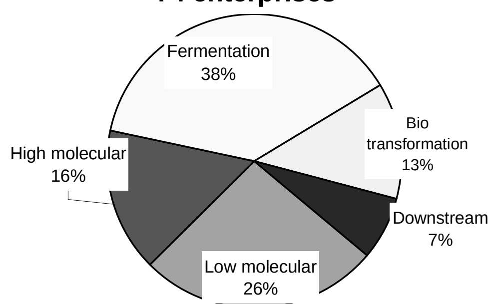
Spanish biotech companies by size class



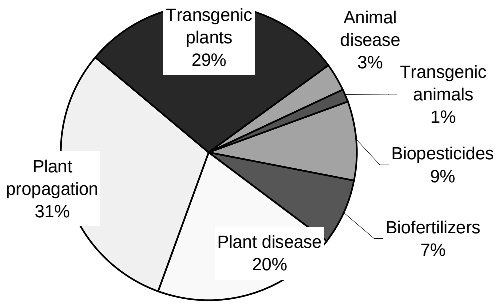
Health care: distribution of 43 enterprises[1]



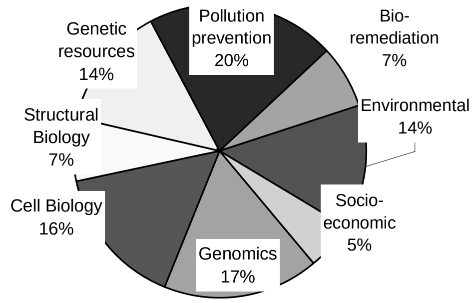
Industry suppliers: distribution of 74 enterprises[1]



Agri-food: distribution of 52 enterprises[1]



Other sectors: distribution of 39 enterprises[1]



1) Some companies appear in more than one category.

Source: CINDOC-CSIC (Consejo Superior de Investigaciones Cientificas Centro de Informacion y Documentacion cientifica). (http://www.cindoc.csic.es/)

Methodological note: CINDOC-CSIC (Consejo Superior de Investigaciones Cientificas Centro de Informacion y Documentacion CIENTIFICA) published a catalogue of Spanish Research Groups and Enterprises Working in Biotechnology in 1997; released as a book and CD-ROM, the catalogue includes information on the technologies used by 766 groups and approximately 150 enterprises.

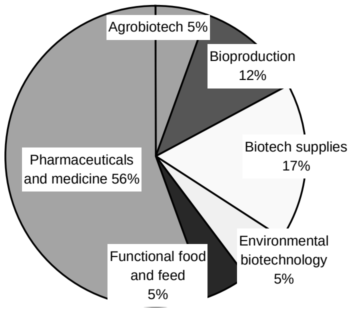
- Most firms involved in biotechnology are in the health care sector (37%) followed by the Industry supplier sector (33%).

- Most firms have between 50 to 199 employees (45%), followed by firms with 1 to 49 employees category (33%); combined they cover 78% of all enterprises working in biotechnology.

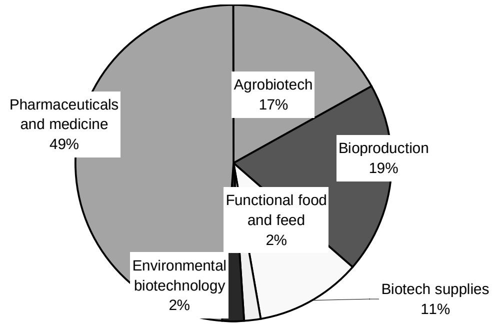
BIOTECHNOLOGY IN SWEDEN

(Based on 144 companies - total population)

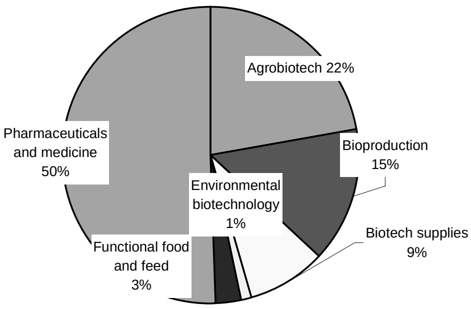
Where are the Swedish biotech companies?
Industrial breakdown, 1999



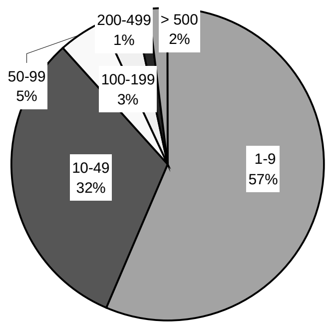
What are the Swedish biotech companies producing?
Distribution of 1999 turnover of PPP$ 366 million
(excludes large companies)



Where are biotech personnel working?
Distribution of 2 998 employees, 1999
(excludes large companies)



Biotech companies by size class, 1999
Determined by the number of employees



Source: Based on data from NUTEK Sweden (based on Svenska Market Management AB).

Methodological note: The definition includes both classical and modern biotechnology, but the focus is on modern biotechnology and innovative uses of classical biotechnology. These companies were identified as having activities according to the chosen definition of biotechnology and having employees. The results are based on responses to a survey from 62% of the population of firms active in biotechnology. Information on the number of employees and turnover refers to all employees and total turnover, not just that related to the biotech sector. For the detailed methodology used, refer to "The Swedish Biotechnology Innovation System" available at http://www.vinnova.se/publ/pdf/vf-01-02.pdf

- Pharmaceuticals and medicines account for 49% of the total revenues of biotech SMEs. This sector also has the most firms (56%) and the highest employment share (50%). Drug discovery and development is the largest sub-sector (53%) in this category.
- Bioproduction is the second largest revenue-generating sector (19%) and the third largest employer (15%).
- Agrobiotechnology is the second largest employer (22%) but ranks third in turnover (17%). Between 1997 and 1999, agrobiotechnology is the only sector to have seen a fall in turnover (-6%).
- The majority of firms have less than 50 employees (88%) and 57% of all firms have fewer than nine employees.

BIOTECHNOLOGY IN SWEDEN

Table 1. **Biotechnology companies by sector and size class: distribution in 1999**

Class[1] /Category	Micro	Small			Medium	Large	Total
	A	B	C	D	E	F	
Agrobiotechnology	4 (4)	2			2		8
Bioproduction	8 (8)	7	1	1			17
Biotech supplies	19(17)	4		1		1	25
Environmental biotechnology	7 (6)	1					8
Functional food and feed	3 (3)	4					7
Pharmaceuticals and medicine[2]	40(33)	28	6	3		2	81(33)
-Diagnostics	8 (5)	11	2				21
-Drug delivery	3 (3)	2	1	1			7
-Drug discovery and development	26(23)	12	1	2		2	43
-Medical technology	3 (2)	3	2				8
Total number of companies	81(71)	46	7	5	2	3	144
Per cent (%)	56.2(49.3)	31.9	4.9	3.5	1.4	2.1	

1) Classes according to the number of employees in each company: A: 1-9 (and in parentheses: 1-5); B: 10-49; C: 50-99; D: 100-199; E: 200-499; F: >500.
2) Included in the pharmaceuticals and medicine category are diagnostics, drug delivery, drug discovery and development, and medical technology.

Source: Based on data from NUTEK Sweden and Svenska Market Management AB. (http://www.nutek.se/)

BIOTECHNOLOGY IN SWEDEN

Table 2. **Employment by sector**

Category	**1997**	**1999**	Change (%)
The biotech industry in total[1]	2 312	2 998	29.7%
Agrobiotechnology	660	665	0.8%
Bioproduction	345	444	28.7%
Biotech supplies	172	259	50.6%
Environmental biotechnology	29	33	13.8%
Functional food and feed	70	81	15.7%
Pharmaceuticals and medicine[2]	1 036	1 516	46.3%
-Diagnostics	354	387	9.3%
-Drug delivery	158	213	34.8%
-Drug discovery and development	401	730	82.0%
-Medical technology	123	186	51.2%
AstraZeneca	7 310	8 547	16.9%
Pharmacia & Upjohn[3]	5 249	5 114	-2.6%
Amersham Pharmacia Biotech	1 060	1 130	6.6%

1) The "biotech industry in total" results includes all micro-, small and medium-sized companies in all categories, but excludes the results for the three large companies: AstraZeneca, Pharmacia & Upjohn, and Amersham Pharmacia Biotech.
2) Included in the pharmaceuticals and medicine category are diagnostics, drug delivery, drug discovery and development, and medical technology.
3) Currently Pharmacia Corporation. The economic data in Table 2 refers to conditions before Pharmacia merged with Monsanto.

Source: Based on data from NUTEK Sweden and Svenska Market Management AB. (http://www.nutek.se/)

BIOTECHNOLOGY IN SWEDEN

Table 3. **Turnover by sector**

Million PPP$

Category	**1997**	**1999**	Change (%)
Biotech industry in total[1]	274.5	365.6	33.2%
Agrobiotechnology	65.9	62.2	-5.7%
Bioproduction	40.9	71.3	74.5%
Biotech supplies	25.2	39.1	54.9%
Environmental biotechnology	3.4	6.4	86.3%
Functional food and feed	6.7	7.8	16.8%
Pharmaceuticals and medicine[2]	132.3	178.8	35.1%
Diagnostics	37.6	40.6	8.1%
Drug delivery	19.4	24.4	25.5%
Drug discovery and development	63.9	90.6	41.7%
Medical technology	11.4	23.2	103.2%
AstraZeneca	1 768.3	2 646.1	49.6%
Pharmacia & Upjohn[3]	..	..	
Amersham Pharmacia Biotech	170.9	265.0	55.0%

1) The “biotech industry in total” results includes all micro-, small and medium-sized companies in all categories, but excludes the results for the three large companies: AstraZeneca, Pharmacia & Upjohn, and Amersham Pharmacia Biotech.
2) Included in the pharmaceuticals and medicine category are diagnostics, drug delivery, drug discovery and development, and medical technology.
3) Currently Pharmacia Corporation. The economic data in Table 2 refers to conditions before Pharmacia merged with Monsanto.

Source: Based on data from NUTEK Sweden (http://www.nutek.se/) and Svenska Market Management ABA database from the Swedish company Svenska Market Management AB was used for the economic and employment data for each company. The data are based on the Annual Reports that companies send in to the Swedish Patent and Registration Office. Data from the last three available years were extracted, which can either mean that the last year was the whole year of 1999 or the split financial year 1998/99, depending on how the data was sent in to the Swedish Patent and Registration Office by the company.

BIOTECHNOLOGY IN SWEDEN

The following tables and accompanying analysis were extracted from a study undertaken by NUTEK Sweden (now a part of VINNOVA).[11] For the detailed methodology used in this study, refer to the paper available at http://www.nutek.se/analys/teknik/bibliometri.pdf.

Table 4. **Publication volume and mean impact factors for Swedish papers published in the selected journal categories between 1986-97**
Limited to articles with an impact factor > 5[12]

Science classes (ISI)	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	Total
Biochemistry & molecular biology	609	717	762	631	751	818	769	1023	884	852	926	874	9 616
Immunology	401	510	439	423	578	403	456	455	476	480	500	456	5 577
Neuroscience	389	348	407	372	465	429	479	548	541	564	495	479	5 516
Cell biology	184	193	172	167	193	194	200	284	294	330	268	221	2 700
Biophysics	177	177	173	155	189	191	194	303	158	150	170	163	2 200
Microbiology	162	169	153	159	188	156	199	215	168	174	168	188	2 099
Biotechnology & applied microbiology	56	56	58	64	67	84	72	82	94	96	94	89	912
Virology	53	61	49	42	53	73	71	39	60	64	65	58	688
Chemistry, medical	42	39	27	39	36	26	34	45	23	35	25	34	405
Material science, biomaterials	6	6	8	6	6	3	6	29	19	16	23	22	150
Mathematical meth., biology & medicine	2	3	2	5	2		2	6	8	2	4	7	43
Total number of articles	1 741	1 947	1 911	1 737	2 112	1 970	2 092	2 463	2 322	2 321	2 264	2 165	25 045
Mean impact factor	16.5	15.9	16.9	16.8	16.8	17.7	16.9	17.1	17.3	17.0	18.1	17.3	17.1

Source: Based on data from NUTEK Sweden. (http://www.nutek.se/)

- This table shows the distribution of the 25 045 articles with an impact factor over 5 in the selected journal categories and the mean impact factor, from JPIOD,[13] for the journals. The subject field with the largest publication volume is Biochemistry & Molecular biology with more than 38% of the publications and 22% were published in Immunology and Neuroscience each.

- The number of publications in the journal categories Biochemistry and Molecular biology, Biomaterials and Cell biology have increased notably between the 1980s and 1990s.

- None of the selected journal categories show a clear decrease in publication volume. The mean impact factors have increased slightly during the nineties compared to the eighties.

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11. See Anna Nilsson, Ingrid Pettersson, Anna Sandström, "A Study of the Swedish Biotechnology Innovation System using Bibliometry", NUTEK Working Paper, January 2000.

12. Note that the total number of entries exceed the total number of articles since a journal can be classified as belonging to more than one journal category. These impact factors are based on the mean number of citations received by a journal between 1981-96. Those with an impact value of less than five were not included in order to reduce the amount of marginal journals in terms of impact.

13. Journal Performance Indicators Diskette.

BIOTECHNOLOGY IN SWEDEN

Table 5. **The share of articles in biotechnology-related sciences by publication year and affiliation of the Swedish authors[1]**

Organisation	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean
Universities and university hospitals	92.3	93.6	93.8	94.4	95.1	95.1	95.5	96.4	95.5	95.6	95.2	95.4	94.9
Firms	9.0	7.1	8.1	8.7	7.8	7.8	5.8	5.9	6.0	6.2	6.1	6.4	7.0
Hospitals and animal hospitals	4.1	4.0	3.8	4.3	3.2	3.0	3.1	3.3	3.1	3.3	2.0	2.5	3.3
Other public organisations	4.9	4.1	4.8	5.9	4.2	5.2	5.8	4.0	4.7	3.4	3.7	3.9	4.5
Defence units	0.3	0.6	0.6	0.5	0.7	0.5	0.6	0.3	0.5	0.7	0.7	0.7	0.6
Industrial research institutes	0.2	0.2	0.6	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.2
Other	0.2	0.3	0.3	0.5	0.1	0.1	0.0	0.1	0.1	0.3	0.3	0.1	0.2

1) Since the authors can come from different organisations, the sums of the shares exceed 100%.

Source: Based on data from NUTEK Sweden. (http://www.nutek.se/)

- All Swedish affiliations have been standardised by main organisational type. The results for university hospitals and universities are combined, since they are in practice inseparable when it comes to research activities.

- As expected, 95% of all articles include at least one author from a university or a university hospital. Only 7% of the articles include an author affiliated to a firm, and this rate has been declining over time.

BIOTECHNOLOGY IN SWEDEN

Table 6. **International co-authorship publication rates in biotechnology for Swedish organisations**

Limited to Swedish organisations with more than 500 biotechnology publications between1986 and1997[14]

Country/ Organisation	US %	GB %	DE[15] %	FR %	DK %	FI %	IT %	NO %	NL %	JP %	CA %	CH %	BE %	Total number of international co-authorships[16]	Swedish only (% of total number of articles)[17]
Karolinska Inst.	31	9	10	6	4	6	10	4	6	4	4	4	3	3 778	61
Lund Univ.	30	13	13	6	10	4	2	2	3	5	5	4	1	1 682	62
Uppsala Univ.	30	10	12	7	6	7	3	6	4	6	4	3	2	1 463	65
Gothenburg Univ.	31	11	6	8	8	3	3	7	4	4	4	3	8	1 267	65
Stockholm Univ.	36	9	11	9	5	4	8	3	7	3	3	3	1	670	60
Umea Univ.	33	15	7	9	6	6	2	4	4	4	6	1	2	648	65
Slu	32	15	11	8	6	6	3	6	4	2	2	2	2	403	59
SMI	24	10	13	9	6	9	7	4	7	3	2	5	2	333	53
Linkoping Univ.	33	8	6	5	14	5	4	7	2	2	5	6	3	294	74
Pharmacia	22	13	7	9	10	8	4	6	4	2	7	7	1	272	63
Astra	26	15	3	3	7	6	7	7	8	3	6	7	3	195	70

Source: Based on data from NUTEK Sweden. (http://www.nutek.se/)

- All organisations have their largest share of international co-authorships with the United States. Great Britain and Germany are often in second or third place, but the pattern varies by the type of organisation. For example, Linköping University, Lund University and Pharmacia have above average collaboration rates with Denmark, and Karolinska Institutet has an above average collaboration rate with Italy.

- The share of internationally co-authored articles in relation to the total publication volume varies between different organisations. SMI has the highest share at 47% and Linköping University and Astra have the lowest shares at 26% and 30% respectively. The share of internationally co-authored articles for the other organisations ranges between 35% and 41%.

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14. The table includes the 13 countries with which Swedish organisations have the most co-authorships. International collaboration also occurs with other countries, although these are not included due to small numbers.

15. Note that for Germany (DE) the publications by authors from the Federal Republic of Germany and the German Democratic Republic, 1986-89, have been added to the number of articles by authors from Germany after 1989.

16. The total number of international articles only includes the 13 countries in the table.

17. Number of publications with only Swedish authors divided by the total number of publications for the organisation.

BIOTECHNOLOGY IN SWEDEN

Table 7. **The share of biotechnology articles that are internationally co-authored with 13 countries**[1]

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean
Belgium	0.9	0.9	1.2	1.3	0.7	0.9	1.1	1.4	1.1	1.0	1.7	1.7	1.2
Canada	1.6	1.6	1.7	1.2	1.0	1.5	0.9	2.0	1.6	1.7	1.5	2.4	1.6
Denmark	2.7	2.1	2.4	2.7	2.8	2.6	2.8	2.4	2.8	2.8	3.0	2.6	2.6
Finland	1.5	1.8	1.6	1.2	1.9	1.3	2.0	2.5	2.5	2.8	3.4	3.0	2.2
France	2.5	2.6	2.8	2.6	2.2	3.0	2.6	3.2	3.3	3.1	4.0	3.4	3.0
Germany	2.6	3.2	3.2	2.7	3.2	3.4	4.1	5.0	5.1	4.3	5.4	5.3	4.0
Italy	1.8	1.7	2.1	2.0	1.9	2.3	1.6	2.6	2.2	2.3	3.4	3.0	2.3
Japan	0.6	0.9	1.0	0.9	1.4	1.4	2.1	2.1	1.9	1.7	2.7	2.3	1.6
Netherlands	0.9	1.3	1.4	1.7	2.0	1.1	1.8	2.1	2.4	2.1	2.6	2.5	1.9
Norway	1.7	2.3	1.4	1.5	2.0	1.7	2.3	1.0	1.6	1.4	2.1	1.9	1.7
Spain	0.4	0.4	0.5	0.5	0.7	1.0	1.4	1.3	1.5	1.1	1.9	1.0	1.0
Switzerland	1.6	2.0	1.9	1.0	1.1	1.3	1.1	1.3	1.4	1.1	2.0	1.3	1.4
United Kingdom	4.0	3.2	4.7	4.1	4.2	4.0	4.3	3.8	4.5	4.0	6.2	5.1	4.3
United States	10.7	11.6	12.8	11.9	10.3	13.8	12.9	12.3	12.2	12.5	14.0	12.7	12.3
Total number of articles with countries above	578	695	738	615	750	774	860	1 059	1 029	972	1 218	1 046	10 319

1) The table includes the 13 countries with which Swedish organisations have most co-authorships. International collaboration with other countries is not included.

Source: Based on data from NUTEK Sweden. (http://www.nutek.se/)

- For all scientific fields, the share of all articles that include co-authorship with the United States has decreased (results not shown). In contrast, Table 7 shows that the rate of collaboration with the United States in biotechnology has remained stable between 1986 and 1997. The shares of co-authorships with Japan, Germany and Finland in biotechnology related science are, however, increasing.

BIOTECHNOLOGY IN SWITZERLAND

(Based on a directory which lists 233 companies – of which 117 are "dedicated" biotechnology companies – in 1999)

Table 1. **Where are the Swiss biotech companies[1]?**

Number of "dedicated" biotech companies in 1999

Sector	Number of companies
Lab. equipment	59
Bioreactors/Equipment/Engineering	31
Reagents/Biochemicals	29
Pharmaceuticals/Therapeutics/Vaccines	26
Diagnostics	25
Consulting	17
Platform technologies	16
Contract R&D	15
Bioseparations/Downstream processing	13
Cell culture	10
AnalyticalServices/QualityControl	9
Bioelectronics/Bio-informatics	9
Environmental treatment/Waste disposal	9
Food	9
Chemicals	8
Agriculture	6
Fermentation/Production	4
Medical devices	4
Biomaterials	3
Cosmetics/Health	2
Veterinary	2
Toxicology	1
Total	117

1) Some companies appear in more than one type. There are 117 "dedicated" biotech companies and 116 other companies where biotech only represents one segment of their activities.

Source: Based on data from SPP BioTech Programme Direction and Unitectra (http://www.unitectra.ch)

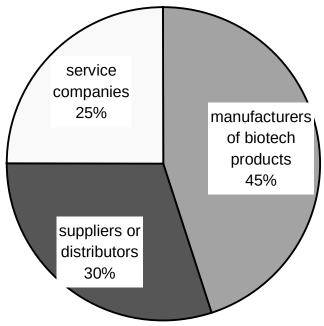
- Only 50% or 117 of the firms active in biotechnology are entirely "dedicated" to biotechnology. The remainder are "extended core" companies where biotechnology represents only one segment of their activities.

- The largest number of firms is concentrated in the Laboratory equipment sector (50%). 22% of the dedicated biotechnology firms are active in pharmaceuticals.

BIOTECHNOLOGY IN SWITZERLAND

Biotech companies by type of activity, 1999

Based on 233 companies



Source: Based on data from SPP BioTech Programme Direction and Unitectra (http://www.unitectra.ch)

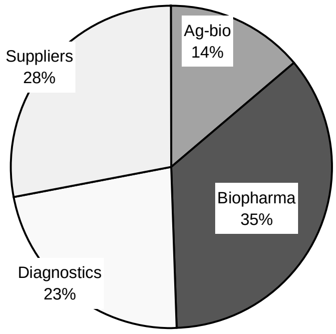
- Of all – “dedicated” and “extended core” – companies 45% are manufacturers of biotechnology goods and 30% are suppliers.

BIOTECHNOLOGY IN THE UNITED KINGDOM

(Based on 221 companies identified by a survey as representing the UK biotechnology sector in 1997)

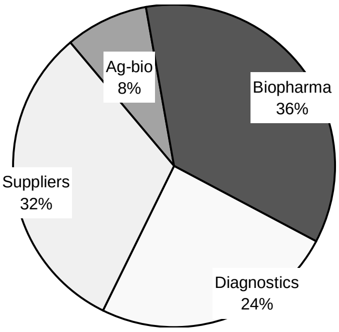
Where are the UK biotech companies?

Industrial breakdown, 1995/96



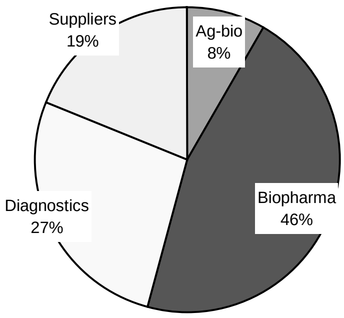
UK biotech companies revenue by source

Distribution of 1995/96 revenues of PPP$ 1 090 million and 221 companies



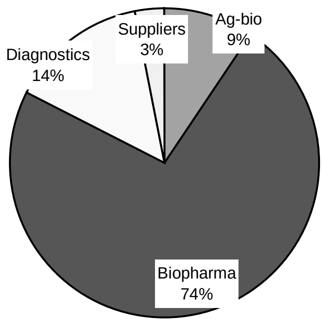
Who's doing the biotech work?

Distribution of 10 590 employees in 1995/96



Biotech R&D distribution by sector, 1995/96

Distribution of 1995/96 expenditure of PPP$ 295 million



Source: Based on data from Arthur Andersen, *UK Biotech1997 – Making the Right Moves*. 1997 (http://www.arthurandersen.com/)

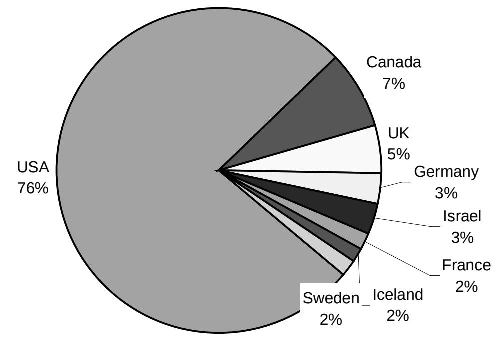
- Almost half of all biotechnology employment is in Biopharmaceuticals (46%); it is the largest revenue-generating sector (36%) and has the greatest number of firms (35%). It is also the sector that is the most R&D intensive (74%).

- The biotechnology Suppliers sector is the second largest sector in terms of the number firms (28%) and revenues (32%).

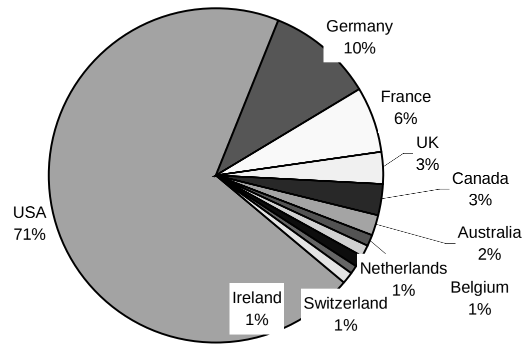
- Diagnostics is the third largest sector in terms of the number of companies (23%) and revenue (24%), and second in terms of R&D (14%).

BIOTECHNOLOGY IN THE UNITED STATES

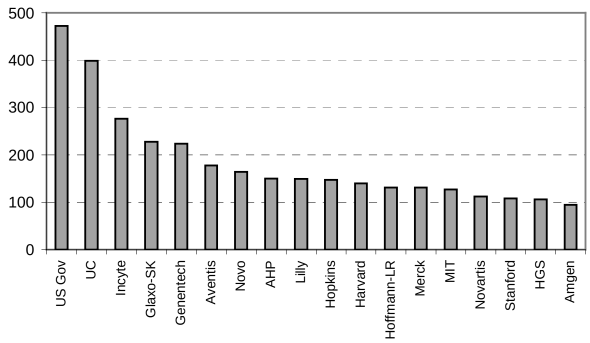
Genomics firms with publicly traded stock
64 firms, September 2000



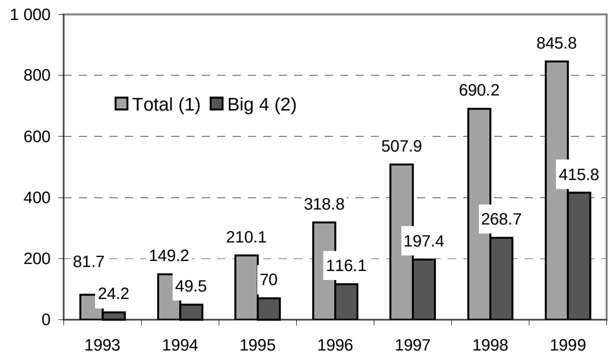
Genomics firms: privately held firms
97 firms, September 2000



Patents in DNA Patent Database[1]
Patents granted by the USPTO between 1980-99

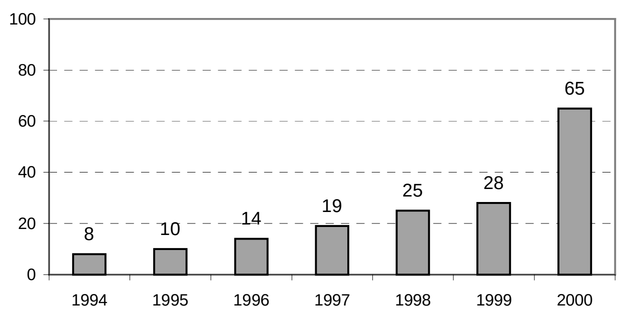


R&D of publicly traded genomics firms
Million PPP$

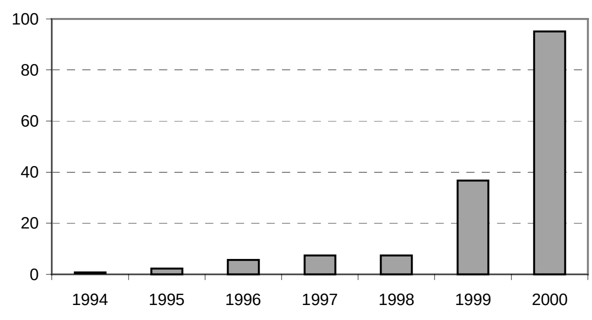


1) Based on data from DPD Database (www.genomic.org).

Number of publicly traded genomics firms



Total market capitalisation for publicly traded genomics firms
Billion PPP$



1) R&D figures reported to the Securities and Exchange Commission (or in annual reports) for Abgenix, Aclara, Affymetrix, Aurora Biosciences, Axys, Biacore, Corixa, CuraGen, Diversa, Gene Logic, Genome Therapeutics, Genomic Solutions, Genset, Hyseq, Invitrogen, Lexicon Genetics, Life Technologies, LJL Biosystems, Lynx, Magainin, Maxygen, Myriad Genetics, Pathogenesis, Protein Design Labs, and Sequenom Inc.

2) Celera, Human Genome Sciences, Incyte, and Millennium.

Source: Based on data from Stanford-in-Washington Program and Burroughs Wellcome Fund, unless otherwise specified. (http://www.stanford.edu/class/siw198q/websites/genomics/entry.htm)

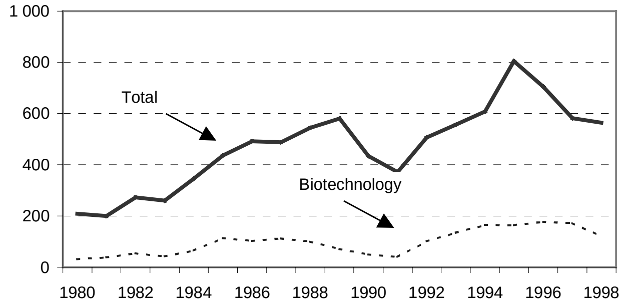
BIOTECHNOLOGY IN THE UNITED STATES

Methodological note: These data are extracted from the “World Survey of Funding for Genomics Research” report, prepared for the Global Forum for Health Research and the World Health Organization by Robert Cook-Deegan, Carmie Chan and Amber Johnson in September 2000. Genomics is a subset of biotechnology.

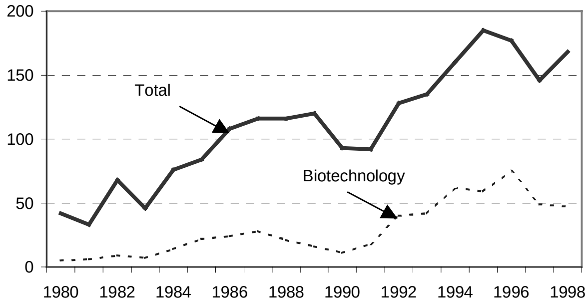
- The United States has the largest number of publicly traded (76%) and privately owned (71%) genomics firms in the world.
- 42% of DNA patents are held by private firms. The US Government possesses the largest absolute number of DNA patents (472) but only 28% of the total. The Higher education sector accounts for 30% of DNA patents. These figures could be an indication of which sectors are most focused on R&D.
- Over the 1993-99 period, the total R&D expenditure of publicly traded genomics firms grew 48% per annum. R&D expenditure of the Big 4 grew even faster, at a rate of almost 60% per annum.
- The number of publicly traded genomics firms grew from eight in 1994 to 65 in 2000.
- Total market capitalisation for publicly traded genomics firms grew rapidly between 1994 and 2000: On average a firm in 1994 had a market capitalisation value of PPP$ 0.10 billion and in 2000 approximately PPP$ 1.5 billion.

BIOTECHNOLOGY IN THE UNITED STATES

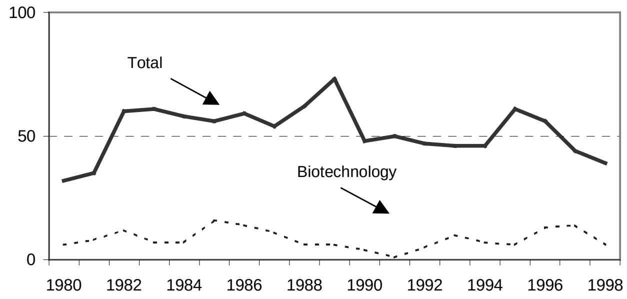
Total international strategic technology alliances



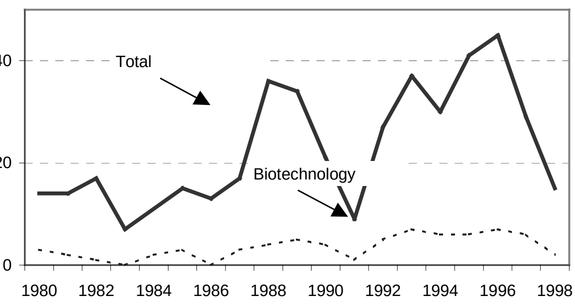
International strategic technology alliances
US–Europe



International strategic technology alliances
US–Japan



International strategic technology alliances
US–Others



Source: NSF: Special tabulations of the CATI database at MERIT, 1999 (http://www.nsf.gov/). Data used in this section has been reproduced in Annex 3 of this document.

- The international strategic technology alliances data that cover the 1980-98 period show that the total number of alliances grew at a steady rate (5.7% per annum). The number of biotechnology alliances over the same period grew at a faster rate (7.8%).

- Europe is the United States' first choice for international alliances and the total number of alliances is increasing 8% per year. In the biotechnology field, the number of alliances is increasing more rapidly at 13.3% per year.

- The number of alliances with Japan is also growing but at a much slower rate (1.11%) and the number of biotechnology related alliances is stable (0% annual growth).

BIOTECHNOLOGY ANNEXES

ANNEX 1

METHODOLOGY USED FOR THE SWEDISH BIBLIOMETRIC DATA

The following methodology was extracted from a study undertaken by NUTEK Sweden (now a part of VINNOVA).[18]

For the international comparison of Swedish publication volumes and relative impact factors in life science fields relevant to biotechnology, the National Science Indicators on Diskette (NSIOD) from the Institute for Scientific Information (ISI) were used. The relative impact is the number of citations per paper received divided by the average number of citations per paper for the whole world.

For all other analyses, a bibliometric data set was constructed by downloading all papers with the word “Sweden” in the address field from the CD-ROM version of the Science Citation Index (SCI). SCI includes the most important ten to fifteen percent of all scientific journals in medicine, natural sciences and engineering, but is believed to provide better coverage of the Life Sciences than engineering. All the Swedish addresses have been standardised by main organisation. The data set covers the period 1986-97 and during that period Swedish authors published 135 000 papers. The CD-ROM for a certain year does not contain the complete publication volume of that year since the articles published towards the end of the year appear in the next year’s CD-ROM edition. Therefore the publication volume in 1997 in the analysis is underestimated by about 10% and the corresponding decrease for 1997 may be found in the tables and figures. The articles published in 1985 and included in the 1986 CD-ROM were excluded in the analysis.

In order to define articles relevant to biotechnology, the journal subject categories as defined by ISI were used. The life science subject journal categories include: Biochemistry & Molecular biology (CQ), Biophysics (DA), Biotechnology & Applied microbiology (DB), Cell biology (DR), Chemistry, medical (DX), Mathematical methods, biology & medicine (MB), Immunology (NI), Materials science, biomaterials (QE), Microbiology (QU), Neuroscience (RU), Virology (ZE).

All in all, 28 418 Swedish papers were identified published in journals covered by SCI and classified with the selected codes in 1986-97. Only journals listed in Journal Performance Indicators Diskette (JPIOD) were included which means that the journals must have received at least 100 citations during 1981-96.

The journal coverage of SCI can be said to encircle basic research quite well. However, their set of journals includes some journals with rather low impact factors, meaning that they are cited infrequently. Of the papers, 218 were excluded since the journals they were published in had no impact factor listed and in order to reduce the amount of marginal journals in terms of impact, we also limited our analysis to journals that had reached an impact factor of at least five.

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18. See Anna Nilsson, Ingrid Pettersson, Anna Sandström, “A Study of the Swedish Biotechnology Innovation System using Bibliometry”, NUTEK Working Paper, January 2000.

The impact factors were taken from JPIOD produced by ISI. These impact factors are based on the mean number of citings a journal has received for its articles between 1981-96. This lead to a total number of 25 045 articles, *i.e.* 12% of the articles were not included in the following analysis due to no impact factor listed or an impact factor less than five. The rationale for applying these criteria is that the SCI coverage is quite good when it comes to influential core journals, but that the coverage of less significant journals is more arbitrary. The method however, has the drawback that journals focusing on narrow fields risk not being included, due to an impact factor of <5, even though they may be of good quality. The articles in journals with an impact factor less than five that were excluded were however screened for information on firms and firm collaborations. No additional firms or firm collaborations that are not identified in the already analysed data set were found.

ANNEX 2

METHODOLOGY USED FOR THE TRADE DATA

Harmonised System categories of biotechnology commodities (10-digits)

Definition of biotechnology provided by the USITC site

HS – Revision 1996

IMPORTS	
1.	2933.29.4500 Drugs, excluding aromatic or modified aromatic, containing an unfused imidazole ring (whether or not hydrogenated) in the structure
2.	2937.10.0000 Pituitary (anterior) or similar hormones and their derivatives
3.	
4.	2937.92.1010 Estrogens of animal or vegetable origin
5.	2937.92.1050 Other progestins of animal or vegetable origin
6.	2937.92.5010 Estrogens not derived from animal or vegetable materials
7.	2937.92.5020 Progestrerone not derived from animal or vegetable materials
8.	2937.92.5050 Other progestins not of animal or vegetable origin
9.	2937.99.9550 Other hormones and derivatives, other steroids, etc.
10.	2940.00.2000 D-Arabinose
11.	2940.00.6000 Other sugars, not elsewhere specified or included, excluding D-Arabinose
12.	
13.	
14.	3002.20.0000 Vaccines for human medicine
15.	3002.30.0000 Vaccines for veterinary medicine
16.	
17.	3002.90.5050 Toxins, cultures of micro-organisms and similar products

Harmonised System categories of biotechnology commodities (10-digits)

Definition of biotechnology provided by the USITC site

HS – Revision 1996

EXPORTS		
1.		
2.	2937.10.0000	Pituitary (anterior) or similar hormones and their derivatives
3.	2937.92.0000	Estrogens and progestins
4.		
5.		
6.		
7.		
8.		
9.		
10.	2940.00.2000	D-Arabinose
11.	2940.00.6000	Other sugars, not elsewhere specified or included, excluding D-Arabinose
12.	3002.10.0040	Foetal bovine serum (FBS)
13.	3002.10.0060	Other blood fractions not elsewhere specified or included
14.	3002.20.0000	Vaccines for human medicine
15.	3002.30.0000	Vaccines for veterinary medicine
16.	3002.90.5020	Antiallergenic preparations
17.	3002.90.5050	Toxins, cultures of micro-organisms and similar products

ANNEX 3
INTERNATIONAL STRATEGIC ALLIANCES DATA

Appendix table 2-67.
International Strategic Technology Alliances: 1980–98
(counts)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
TOTAL	209	200	272	260	345	437	491	488	544	580	434	371	507	556	609	805	704	582	564
Information technology	49	60	96	107	157	164	189	177	200	197	219	203	237	220	253	338	298	227	272
Biotechnology	31	38	54	42	65	113	103	112	100	71	50	40	101	134	165	164	177	172	120
All other, of which	129	102	122	111	123	160	199	199	244	312	165	128	169	202	191	303	229	183	172
New materials	9	23	27	35	28	58	87	65	60	47	35	21	38	59	33	46	36	27	37
Aerospace & defense	22	8	11	11	30	14	27	25	26	45	54	41	56	37	37	52	45	23	19
Automotive	19	7	9	8	8	20	26	22	45	56	12	3	4	15	26	32	37	44	17
Chemicals (non–biotech.)	40	26	30	29	25	32	19	38	58	84	47	40	39	68	52	60	28	42	53
Other	39	38	45	28	32	36	40	49	55	80	17	23	32	23	43	113	83	47	46
USA	139	126	200	177	234	235	292	318	367	357	312	287	394	444	497	639	578	497	477
Information technology	31	39	76	76	105	87	118	133	145	139	174	163	194	196	229	298	262	194	236
Biotechnology	24	28	45	27	51	68	77	78	67	50	32	36	83	116	133	131	148	162	108
All other	84	59	79	74	78	80	97	107	155	168	106	88	117	132	135	210	168	141	133
Europe	102	94	127	111	166	240	242	236	266	320	203	166	233	235	257	330	281	224	245
Information technology	20	28	48	34	75	96	105	84	91	96	81	73	92	67	60	85	75	81	87
Biotechnology	11	14	15	20	24	59	35	51	50	37	28	21	58	59	93	89	102	59	59
All other	71	52	64	57	67	85	102	101	125	187	94	72	83	109	104	156	104	84	99
Japan	53	68	89	97	100	137	160	130	113	126	85	79	79	78	84	111	103	60	70
Information technology	15	18	35	44	55	40	53	31	33	35	46	50	40	40	46	51	47	28	40
Biotechnology	7	11	17	11	11	31	30	26	11	12	9	2	8	15	14	15	21	15	8
All other	31	39	37	42	34	66	77	73	69	79	30	27	31	23	24	45	35	17	22
Across regions	107	114	171	138	179	213	233	242	280	338	210	178	245	273	285	352	332	252	257
Information technology	18	29	71	53	87	69	94	81	91	103	100	88	103	100	99	130	123	101	109
Biotechnology	14	19	26	16	24	52	41	50	37	36	28	22	58	66	87	81	110	73	58
All other, of which	75	66	74	69	68	92	98	111	152	199	82	68	84	107	99	141	99	78	90
New materials	4	15	16	20	15	26	33	30	32	23	24	9	18	31	12	25	11	11	23
Aerospace & defense	12	4	5	6	9	6	7	6	8	20	17	21	28	27	20	25	17	10	9
Automotive	10	3	5	6	5	14	17	17	34	43	3	1	0	7	14	14	16	16	5
Chemicals (non–biotech.)	26	22	22	19	17	24	11	29	45	62	29	26	22	32	31	35	18	21	30
Other	23	22	26	18	22	22	30	29	33	51	9	11	16	10	22	42	37	20	23
USA–Europe	42	33	68	46	76	84	108	116	116	120	93	92	128	135	160	185	177	146	168
Information technology	7	11	31	13	32	27	45	48	41	41	42	38	53	47	45	52	46	53	58
Biotechnology	5	6	9	7	14	22	24	28	21	16	11	18	40	42	62	59	75	49	47
All other	30	16	28	26	30	35	39	40	54	63	40	36	35	46	53	74	56	44	63

Appendix table 2-67.
International Strategic Technology Alliances: 1980–98
(counts)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
USA–Japan	32	35	60	61	58	56	59	54	62	73	48	50	47	46	46	61	56	44	39
Information technology	6	7	26	28	35	20	25	18	19	25	32	34	26	30	29	35	31	19	23
Biotechnology	6	8	12	7	7	16	14	11	6	6	4	1	5	10	7	6	13	14	6
All other	20	20	22	26	16	20	20	25	37	42	12	15	16	6	10	20	12	11	10
USA–Others	14	14	17	7	11	15	13	17	36	34	21	9	27	37	30	41	45	29	15
Information technology	0	1	5	3	2	5	2	5	11	10	10	3	9	10	12	22	22	15	10
Biotechnology	3	2	1	0	2	3	0	3	4	5	4	1	5	7	6	6	7	6	2
All other	11	11	11	4	7	7	11	9	21	19	7	5	13	20	12	13	16	8	3
Europe–Japan	11	20	16	18	21	35	36	26	24	30	25	19	24	20	23	29	25	9	21
Information technology	4	7	6	6	11	12	17	5	9	7	8	11	10	6	8	9	9	4	10
Biotechnology	0	1	2	2	0	7	1	4	1	6	4	0	3	4	6	6	6	1	2
All other	7	12	8	10	10	16	18	17	14	17	13	8	11	10	9	14	10	4	9
Europe–Others	5	10	7	6	10	20	12	21	36	61	22	5	17	31	20	28	20	20	11
Information technology	0	2	2	3	6	5	4	5	10	18	7	1	4	5	1	8	11	7	6
Biotechnology	0	2	1	0	0	3	1	1	4	3	5	1	5	3	6	2	7	3	1
All other	5	6	4	3	4	12	7	15	22	40	10	3	8	23	13	18	2	10	4
Japan–Others	3	2	3	0	3	3	5	8	6	20	1	3	2	4	6	8	9	4	3
Information technology	1	1	1	0	1	0	1	0	1	2	1	1	1	2	4	4	4	3	2
Biotechnology	0	0	1	0	1	1	1	3	1	0	0	1	0	0	0	2	2	0	0
All other	2	1	1	0	1	2	3	5	4	18	0	1	1	2	2	2	3	1	1
Within Regions	102	86	101	122	166	224	258	246	264	242	224	193	262	283	324	453	372	330	307
Information technology	31	31	25	54	70	95	95	96	109	94	119	115	134	120	154	208	175	126	163
Biotechnology	17	19	28	26	41	61	62	62	63	35	22	18	43	68	78	83	67	99	62
All other, of which	54	36	48	42	55	68	101	88	92	113	83	60	85	95	92	162	130	105	82
New materials	5	8	11	15	13	32	54	35	28	24	11	12	20	28	21	21	25	16	14
Aerospace & defense	10	4	6	5	21	8	20	19	18	25	37	20	28	10	17	27	28	13	10
Automotive	9	4	4	2	3	6	9	5	11	13	9	2	4	8	12	18	21	28	12
Chemicals (non–biotech.)	14	4	8	10	8	8	8	9	13	22	18	14	17	36	21	25	10	21	23
Other	16	16	19	10	10	14	10	20	22	29	8	12	16	13	21	71	46	27	23
Intra–USA	51	44	55	63	89	80	112	131	153	130	150	136	192	226	261	352	300	278	255
Information technology	18	20	14	32	36	35	46	62	74	63	90	88	106	109	143	189	163	107	145
Biotechnology	10	12	23	13	28	27	39	36	36	23	13	16	33	57	58	60	53	93	53
All other	23	12	18	18	25	18	27	33	43	44	47	32	53	60	60	103	84	78	57

Appendix table 2-67.
International Strategic Technology Alliances: 1980–98
(counts)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Intra–Europe	44	31	36	41	59	101	86	73	90	109	63	50	64	49	54	88	59	49	45
Information technology	9	8	9	12	26	52	39	26	31	30	24	23	25	9	6	16	9	17	13
Biotechnology	6	5	3	11	10	27	9	18	24	12	8	2	10	10	19	22	14	6	9
All other	29	18	24	18	23	22	38	29	35	67	31	25	29	30	29	50	36	26	23
Intra–Japan	7	11	10	18	18	43	60	42	21	3	11	7	6	8	9	13	13	3	7
Information technology	4	3	2	10	8	8	10	8	4	1	5	4	3	2	5	3	3	2	5
Biotechnology	1	2	2	2	3	7	14	8	3	0	1	0	0	1	1	1	0	0	0
All other	2	6	6	6	7	28	36	26	14	2	5	3	3	5	3	9	10	1	2
Data Addenda[a]																			
USA–Interregion	88	82	145	114	145	155	180	187	214	227	162	151	202	218	236	287	278	219	222
Information technology	13	19	62	44	69	52	72	71	71	76	84	75	88	87	86	109	99	87	91
Biotechnology	14	16	22	14	23	41	38	42	31	27	19	20	50	59	75	71	95	69	55
All other	61	47	61	56	53	62	70	74	112	124	59	56	64	72	75	107	84	63	76
Europe–Interregion	58	63	91	70	107	139	156	163	176	211	140	116	169	186	203	242	222	175	200
Information technology	11	20	39	22	49	44	66	58	60	66	57	50	67	58	54	69	66	64	74
Biotechnology	5	9	12	9	14	32	26	33	26	25	20	19	48	49	74	67	88	53	50
All other	42	34	40	39	44	63	64	72	90	120	63	47	54	79	75	106	68	58	76
Japan–Interregion	46	57	79	79	82	94	100	88	92	123	74	72	73	70	75	98	90	57	63
Information technology	11	15	33	34	47	32	43	23	29	34	41	46	37	38	41	48	44	26	35
Biotechnology	6	9	15	9	8	24	16	18	8	12	8	2	8	14	13	14	21	15	8
All other	29	33	31	36	27	38	41	47	55	77	25	24	28	18	21	36	25	16	20

[a]Counts of these inter–regional strategic technology alliances are included in the totals for across regions listed above. For example, the USA–Interregion totals are the sum of USA–Europe plus USA–Japan plus USA–Others. Total USA alliances are the sum of Intra-USA plus USA-Interregion.

SOURCE: J. Hagedoorn, Maastricht Economic Research Institute on Innovation and Technology (MERIT), Cooperative Agreements and Technology Indicators (CATI) database, unpublished tabulations.

See figure 2-36 and text table 2-18 in Volume I.

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