Science-Metrix

Genomics in France

February 2003

Overview of Research in Genomics in France and Prospects for Scientific Cooperation with Canada

Prepared for
Genome Canada

Science-Metrix

Genomics in France

Overview of Research in Genomics in France and Prospects for Scientific Cooperation with Canada

February 2002

Prepared for
Genome Canada

Science-Metrix specializes in the measurement and evaluation of science, technology and innovation. Our data collection and assessment methods include bibliometrics, scientometrics, technometrics, surveys and interviews, environmental scans, monitoring and intelligence gathering. We perform program and policy evaluations, benchmarking and sector analyses, market studies and strategic planning.

514.495.6505 ▪ 4572 avenue de Lorimier ▪ Montréal ▪ Québec ▪ Canada ▪ H2H 2B5
info@science-metrix.com ▪ www.science-metrix.com

Executive Summary

This report on genome research in France uses public information sources available on the Internet, such as the Medline database, together with data from the Science Citation Index and the United States Patent and Trademark Office.

Section I presents an overview of genomic research programmes. Like Canada, France invested in a national effort in the field of genomics. The French government has made genomics a priority and its investments not only come in the form of money dedicated to research and development, but also in the form of infrastructures. These investments play a determining role in the structuring of genome research in France. Section I also presents data from the Internet on French institutions that are active in the field.

Section II compares France's position in genomics to that of Canada and other leading countries. A series of scientometric and technometric indicators shows that, given their converging strengths, Canada and France can enter mutually beneficial collaborative activities in a number of scientific specialties, particularly within the field of biomedical research, clinical medicine and mathematics.

Drawing from the Medline database, Section III examines the distribution of papers in genomics by sector, institution, city and researcher. The distribution of research in genomics in France is highly concentrated in Paris:

- Its output of papers is unmatched; it hosts all of the most important leading institutions in the different fields. More specifically, it hosts the two most productive government institutions, three of the five leading universities, more than half of the leading hospitals, the most prolific companies and 60% of the leading scientists.
- Moreover, nearly half of the companies active in the field of genomics present on the Internet are located in the Paris region. This reinforces the importance of Paris as a vital centre for genomics in France.

Other French urban centres with significant output are Strasbourg, Lyon, Marseille and Montpellier.

The views presented in this report are those of Science-Metrix and do not necessarily reflect the opinions of Genome Canada.

I. An Overview of Genomics in France

France, a leading nation within the European Union, is one of the most modern countries in the world. Through its alliance with Germany, France was instrumental in the economic integration of Europe, especially with the introduction of the euro which replaced the French Franc (FRF) in 1999 for institutions and 2002 for individuals (1€= 6.56FRF= 0.98$US= 1.54$C). France is in the midst of a transition from an economy that featured extensive government ownership and intervention to one that relies more on market mechanisms. Nonetheless, France's leaders remain committed to a capitalism in which they maintain social equity by means of laws, tax policies and social spending that reduce income disparity and the impact of free markets on public health and welfare. France's industrial activity is predominantly centered on machinery, chemicals, automobiles, metallurgy and aircraft. It ranks second worldwide in agricultural exports, next to the U.S. (CIA. 2002. The World Factbook 2002). France's population is about twice that of Canada and its labor force counts for about 45% of the population which is slightly less than Canada. Both countries' GDP per capita are in the same range (Table 1).

Table 1 Basic Socio-Economic Statistics

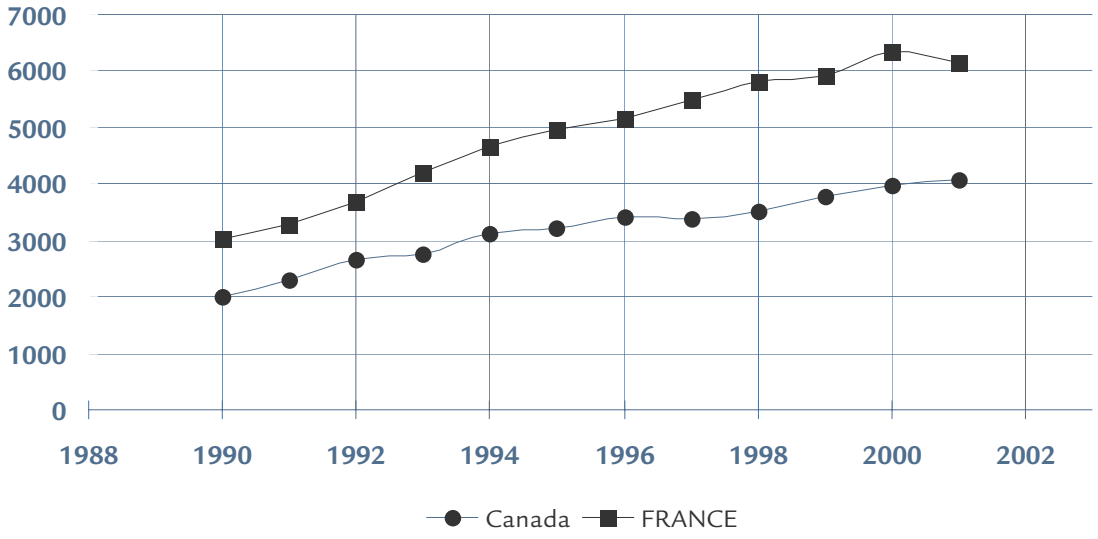
	France	Canada
Area (sq km)	547,030	9,976,140
Population (July 2001 est.)	59,769,983	31,902,268
Labour force (2000)	26,600,000 (45% of pop.)	16,400,000 (51%)
GDP*	U.S. $1.51 trillion	U.S. $875 billion
GDP per capita*	U.S. $25,400	U.S. $27,700
Government type	Republic	Parliamentary democracy

* Purchasing power parity – 2001 est.
Source: CIA. 2002. *The World Factbook 2002*.

From 1990 to 2001, France published around 58,768 papers in genomics that were indexed by Medline (measured by first author of paper and French affiliation). This is a little less than twice the amount of the 38,250 papers published by Canadian authors during the same period.

Figure 1 reveals that published papers in genomics by France grew at a comparable speed than those by Canada during the 1990s – with a 6.8% average annual growth in France compared to 6.7 % in Canada.

Figure 1 Papers in Genomics by France and by Canada, 1990-2001



Source: Science-Metrix (Medline)

National Research Programmes in Genomics

Genomic research in France is highly organized by the government. The *budget civil de recherche et développement* (BCRD, national budget of research and development) for 2002 presented by the *Ministère délégué à la Recherche et aux Nouvelles Technologies* (Ministry of Research and New Technologies), clearly identified the life sciences as its highest priority according them funding of 14.6 billion FRF, which is about a quarter of the total funds of 57,2 billion FRF. These funds are used to maintain and improve research infrastructures, pay existing researchers, and hire new ones, give research grants to doctoral students and so forth. In short, it is the main source of funding for the French research system.

A part of this budget is dedicated to the *Fonds National de la Science* (FNS, National Science Funds) which aims to finance specific research initiatives targeted by the government. Within the field of life sciences, genomics and post-genomics are the most important targets set by the FNS. The ministry of research and technology decided to maintain its funding through an *Action concertée incitative* (ACI, Concerted Incentive Action) at the level of previous years, which was around 75% of the budget allocated for life sciences (376M FRF out of 496M FRF on average for 1999, 2000, 2001).

Initiatives included in Genomic ACI and financed by the FNS for this period were:

- The *Genoscope* (CNS, National Sequencing Centre): Its mission is to produce large amounts of high quality genomic sequence data on different organisms (microbes, plants, animals and humans) that show scientific, medical or economic value.
- The *Centre National de Génotypage* (CNG, National Genotyping Centre): Its objective is to answer to the needs of the scientific and medical community for the identification of the genes leading to genetic diseases, notably the most frequent polygenic diseases (obesity, hypertension, asthma, etc.).
- The *Infobiogen* resource centre*:* This national resource centre's aim is to foster cooperative research in genomic, genetic and molecular biology informatics.
- The *Genoplante* network: Its objective is to analyse the genome of the five European agriculture flagship species (corn, wheat, rape seed, sunflower and pea) with the aim of developing new and more efficient varieties. It is also mandated to perform studies on the identification, evaluation and risk management of GMOs in the agricultural domain.
- The *Génopole* network: It consists of a network of campuses dedicated to the advancement of genomic research. Each *génopole* is a training centre (through a higher learning facility), a research centre (through private and public laboratories) and a genomic business hatchery (through structures that finance and counsel starting businesses).
- The *Genhomme* network: Created to ease the coordination between academic laboratories, NGOs and the private sector working in the field of human genomic and post-genomic research.

Genome Research in French Universities

Whereas Section III measures the scientific output of organizations, this section presents a summary of the data available on the Internet. The inherent nature of the French research system makes it difficult to be represented accurately on the Internet. The fact that the French government directly finances research by "leasing" researchers to universities for periods of at least four years makes it difficult to see what the affiliations of the different research teams are. Despite this situation, it is still possible to identify a numbers of university-level research hubs on the Internet.

Predictably, Parisian research communities are the most present on the Internet. Out of the multitude of Parisian universities, the communities of *Université Paris-Sud (Paris XI)* and of *Université Pierre et Marie Curie (Paris VI)* and *Université Denis Diderot (Paris VII)* are the most visible. Research at the *Université Paris XI* is exceptionally diverse, with research ranging from microbiology to the effect of electromagnetic radiation carried out in molecular biophysics and plant genetics laboratories. As for the *Université Paris VI-VII,* it has merged all its genomic research groups in one large division that

covers genomics, cell communication and new therapeutic approaches. The type of research that is carried out at *Paris VI* is also very diverse, covering disciplines from bioinformatics to muscle research. Both universities lack specialization in one or a few research domains.

Montpellier's universities I (health) and II (science) are also visible in the field of genomics. The *Institut de biotechnologie et pharmacologie (*IGMM*)* and the *Institut de génétique humaine (*IGH*)* are affiliated to these institutions; both host teachers from these Montpellier universities. The IGH is home to research groups in developmental biology, genetic pathology, gene mapping and sequencing and chromatin structure. It also has a strong bioinformatics unit. The IGMM has research groups working on signal transduction, retroviruses and biotherapy, oncogenesis and cellular cycles, biological development and differentiation, RNA function and vectorisation.

The *Université Joseph-Fournier (Grenoble III)* is also present in genomic research on the Internet. It hosts the TIMC laboratory *(Technique de l'Imagerie, de la Modélisation et de la Cognition)*, which works on the biological and medical applications of mathematics and informatics. The TIMC Genome group works on the elaboration of an integrated communication and storage system dedicated to medical genetics. *Grenoble III* also hosts the *Groupe de recherche en virologie structurale et moléculaire*, which works on the structure and molecular aspects of viruses such as adenoviruses, Epstein-Barr, Hepatitis C and negative RNA viruses. Finally, *Grenoble III* also hosts the Plant Cellular Physiology Laboratory, which works on the structure and function of the different organites and on the cellular impact of environmental stress. Again, the absence of specialization in a specific domain of genomics is obvious.

The above universities are the most visible ones on the Internet. Most of the other French universities active in the fields of health or science do produce some research in genomics but most of them do not advertise it clearly on the Internet.

French universities with significant visibility on the Internet in genomics are presented in Annex IA.

Genome Research in the Health Sector

The characteristics of the French research system makes it difficult to observe genomic research in the health sector on the Internet. Since the researchers are affiliated with one or more government-financed research groups, which are then "leased" to universities, each laboratory is affiliated to a governmental organisation and, most of the time, to a university but rarely, if ever, to a hospital. This probably explains the fact that only four organizations in the health sector seem to be active in the field of genomics as revealed by the Internet. This situation is very different from the actual distribution of scientific publications (22% of genomic publications come from the health sector); the Internet is therefore an incomplete indicator of the French health sector output.

The Curie Institute (http://www.curie.net/) is primarily a cancer research institute but it is also a cancer treatment centre. Its research covers the whole spectrum of cancer research from fundamental cell physiology to the radiological and chemical treatment of cancer. This institute carries out a sizeable amount of research in genomics (genetic recombination, gene therapy, structural genetics, cancerous gene identification, etc.).

The *Institut Pasteur* (Pasteur Institute) is primarily a research institution, hosting many research groups operating in the vast field of genomics with research that spans from the genome structure to microbial pathogenesis. It offers a small number of health services like immunization, consultation on tropical diseases and anti-rabies services. It has two campuses, Paris being the most important, and Lille the second most important.

Finally, the *CHU Pitié-Salpétrière* is a university hospital mainly affiliated with *Université Paris VI*. It hosts many IFRs (*Instituts fédératifs de recherche,* Federative research institutes) that are interested in genomics (mainly IFR 14: *Coeur muscle vaisseaux,* Heart muscles blood vessels). These IFRs pooled their equipment and technical knowledge to create a genomic platform giving each of them access to a greater variety of equipment and techniques.

French health sector organizations with significant visibility on the Internet in genomics are presented in Annex IB.

Genome Research in Governmental and Non-Governmental Organizations

Governmental research occupies a significant proportion of the French genomic research landscape. Most research groups are primarily financed by governmental organizations and can therefore be considered as extensions of them. In addition, some of the important governmental research organizations possess multiple research centers that host a plethora of researchers.

The *Institut National de la Recherche Agronomique* (National Institute of Agronomic Research, INRA) owns 21 regional centers with over 200 sites. A significant proportion of these research unit work on genomic-related subject.

The *Centre National pour la Recherche Scientifique* (National Center for Scientific Research, CNRS) finances around 100 research groups in genomics or genomic related fields. Unlike the INRA it does not possess its own research facilities; it only finances research groups that are housed by universities and other research facilities.

The *Institut National de la Santé et de la Recherche Médicale* (National Institute for Health and Medical Research, INSERM), like the CNRS, does not posses its own research facilities but finances most of the genomic research undertaken in hospitals. It finances around 500 genomic or genomic related research groups.

The *Commission de l'Énergie Atomique* (Atomic Energy Commission, CEA) is the governmental organization that deals with research on atomic energy and its development and exploitation of on French territory. Its research division is very active in the field of radiobiology and specifically on the effect of radiation on genetic material.

As mentioned before, the government also funds research centers like the *Genoscope*, the *Centre national de génotypage, Infobiogen,*etc.

As for NGOs, the *Genethon* is a research laboratory nearly totally financed by the *Association française contre les myopathies* (French Association against Myopathy, AFM). It specializes in research on gene and cell therapy and their applications to rare diseases.

French governmental and non-governmental organizations with significant visibility on the Internet in genomics are presented in Annex IC.

Genome Research in the Private Sector

Private genomic research in France is highly concentrated in health sciences. Most of the companies present on the Internet perform research in gene therapy, pharmaceutics and tools for bioinformatics and gene sequencing and identification.

In addition to multinational enterprises with headquarters in France (e.g. Avantis and Genset), many large corporations have a subsidiary in France (Monsanto, Novartis, Genaxis, Gen-IT, etc.). Moreover, due to the multiple governmental programs financing genomic research, an impressive number of small start-ups and university spin-offs are present on the Internet. Most of them are located in a *Génopole* or near the university from which they originated. Nearly half of the companies active in genomics and present on the Internet are located in the Paris region. Another important urban centre for companies active in genomic is Lille.

The address of firms located in France that perform research in genomics can be found in Annex II.

* * *

As mentioned before, genomic research in France is tightly controlled by the government. Like Canada, France has invested in genomic research but on a far more important scale. This has strong repercussions in every layer of French genomic research from public to private. The objective set by the government will likely be met since it has such a strong influence on the financing of research, but this will probably be done at the detriment of "fringe" research domains that are left out of the financing structure. Nonetheless, France successfully installed a system that facilitates the passage from theoretical research to commercial exploitation, especially through its *Génopole* network.

II. Strengths of France and Canada in Genomics

This section compares Canadian and French scientific output and the level of protection of their intellectual property. The analysis uses data from the Science Citation Index (SCI) and the United States Patent and Trademark Office (USPTO). The aim is to identify fields where Canada and France can cooperate in a mutually beneficial manner.

Global Position in Genomic Science and Technology

The global position of France and Canada (Table 4) is quite comparable; they are respectively placed 5th and 6th in a multicriteria ranking (global rank). However, their performances vary for each of the different indicators used here.

Table 2 shows that France occupies a similar rank to that of Canada in terms of scientific papers between 1990 and 1998, with both countries respectively standing 5th and 6th in a multicriteria ranking. Their performance, however, varies when it comes to specific indicators: France is slightly ahead of Canada in terms of number of papers, but Canada has more papers per inhabitants. Also, France specializes more than Canada in genomic research (index of specialization), but Canadian papers have a higher propensity of being published in journals that are cited more often (impact factor).

Table 2 Rank of Leading Countries in Genomics by Publication of Scientific Papers, 1990-1998

Rank	Number of papers	Papers per inhabitants	Index of specialization	Relative impact factor	Global rank
1	U.S.A.	Switzerland	U.S.A.	U.S.A.	U.S.A.
2	Japan	Sweden	Switzerland	Switzerland	Switzerland
3	U.K.	Netherlands	France	Canada	U.K.
4	Germany	U.S.A.	Sweden	Netherlands	Netherlands
5	France	U.K.	Japan	U.K.	France
6	Canada	Canada	Netherlands	France	Canada
7	Italy	Australia	U.K.	Germany	Sweden
8	Netherlands	France	Australia	Sweden	Japan
9	Australia	Germany	Canada	Australia	Germany
10	Sweden	Japan	Germany	Spain	Australia
11	Switzerland	Italy	Italy	Italy	Italy
12	Spain	Spain	Spain	Japan	Spain
13	USSR/Russia	USSR/Russia	USSR/Russia	USSR/Russia	USSR/Russia

Source: Science Citation Index and United Nations Statistics Division

The pattern for patents obtained in the world's largest market, the United States (Table 3), is somewhat different to that observed for publications. Globally, France ranks 5th, while Canada shines in the second rank. As with publications, Canada comes just below France in terms of absolute number of U.S.-granted patents (respectively 5th and 4th), but it has, again, more U.S. patents per inhabitant. Contrary to what was observed in table 4, Canada specializes more than France as far as patenting activities in genomic are concerned. However, both countries have a comparable patent growth rate, but Canada grows slightly faster than France.

Table 3 Ranking of Leading Countries in Genomics by Patenting Activities in the USA, 1990-1999

Rank	Number of patents in USA	USA patents per inhabitants	Index of specialization	Growth	Global rank
1	USA	USA	Australia	Switzerland	USA
2	Japan	Netherlands	Netherlands	Australia	Canada
3	Germany	Switzerland	Canada	Canada	Australia
4	France	Canada	USA	France	Netherlands
5	Canada	Sweden	USSR/Russia	USA	France
6	Netherlands	Japan	UK	Germany	Switzerland
7	UK	Australia	Spain	Sweden	Germany
8	Australia	France	France	Netherlands	Sweden
9	Switzerland	Germany	Sweden	UK	Japan
10	Sweden	UK	Germany	Italy	UK
11	Italy	Italy	Switzerland	Japan	Spain
12	Spain	Spain	Italy	Spain	Italy
13	USSR/Russia	USSR/Russia	Japan	USSR/Russia	USSR/Russia

Source: U.S.A. Trademark and Patent Office and United Nations Statistics Division

Positioning Canada and France for Cooperation

The strengths of Canadian and French genomic science vary considerably between scientific fields (Table 4). For instance, Canada is very strong in Biology, ranking 1st, while France ranks 8th. In biomedical research, that is the core field of genomics in terms of papers published, Canada and France rank about the same (respectively 5th and 4th, the latter being France' highest rank). It is thus possibly the most promising field for collaboration between the two countries. Chemistry and Clinical Medicine are fields where Canada ranks lowest (7th), while France occupies respectively the 5th and 9th rank. Similar to Biology, those two fields might not be the most promising ones for mutually beneficial collaboration.

Table 4 Global Rank of Leading Countries in Genomics by Scientific Field, 1990-1998

Rank	Biology	Biomedical Research	Chemistry	Clinical Medicine
1	Canada	USA	Switzerland	USA
2	Australia	UK	USA	UK
3	UK	Switzerland	Sweden	Netherlands
4	USA	France	Germany	Sweden
5	Japan	Canada	France	Switzerland
6	Netherlands	Germany	Japan	Japan
7	Germany	Netherlands	Canada	Canada
8	France	USSR/Russia	UK	Italy
9	Spain	Australia	USSR/Russia	France
10	Switzerland	Sweden	Spain	Australia
11	Sweden	Japan	Netherlands	Germany
12	Italy	Spain	Australia	Spain
13	USSR/Russia	Italy	Italy	USSR/Russia
Papers (%)	21,343 (6%)	205,864 (58%)	7,240 (2%)	117,948 (33%)

Source: Science Citation Index and United Nations Statistics Division

A number of scientific specialties also present great potential for mutually beneficial collaboration between France and Canada (Table 5). First, in the field of Biology, the Miscellaneous Zoology subfield could be of interest with France ranking 1st and Canada 2nd. In Biomedical Research, a field where both countries perform well, some specialties might provide great opportunities. These are Biochemistry & Molecular Biology, Biophysics, Cellular Biology, Cytology & Histology, General Biomedical Research and Microbiology. In the field of Clinical Medicine, the subfields of Anaesthesiology, Endocrinology and Geriatrics are three specialties where both countries could develop fruitful collaborations. Finally, in the field of Mathematics, the Probability & Statistics subfield also presents some potential for collaboration.

Table 5 Global Rank of Leading Countries in Genomics by Field and Sub-Field, 1990-1998

Field	1	2	3	4	5	6	7
Biology							
Botany	Australia	UK	Netherlands	Germany	Canada	United States	France
Dairy & Animal Science	Canada	Netherlands	United States	Australia	UK	Germany	France
Botany	Australia	Canada	United States	France	UK	Sweden	Netherlands
General Biology	United States	Australia	Germany	Switzerland	Canada	UK	France
Miscellaneous Zoology	France	Canada	United States	Australia	Germany	UK	Italy
Biomedical Research	United States	UK	Switzerland	France	Canada	Germany	Netherlands
Biochemistry & Molecular Biology	United States	Switzerland	Germany	France	Canada	UK	Japan
Biophysics	United States	Sweden	France	Canada	Germany	USSR/Russia	Spain
Cellular Biology Cytology & Histology	Switzerland	United States	France	Germany	Canada	Italy	Netherlands
Embryology	UK	Switzerland	United States	Germany	France	Canada	Spain
General Biomedical Research	United States	UK	Switzerland	France	Canada	Germany	Netherlands
Genetics & Heredity	UK	Netherlands	Canada	United States	Australia	Switzerland	France
Microbiology	Netherlands	United States	Switzerland	France	Canada	UK	Germany
Physiology	United States	Switzerland	UK	Germany	Canada	France	Sweden
Chemistry	United States	Switzerland	Sweden	Germany	France	Japan	Canada
Physical Chemistry	Sweden	France	United States	Germany	UK	Canada	Switzerland
Polymers	France	Japan	United States	Germany	Netherlands	Sweden	Canada
Clinical Medicine							
Anesthesiology	United States	Germany	Canada	France	Switzerland	UK	Japan
Endocrinology	United States	Canada	Sweden	France	Switzerland	Australia	UK
General & Internal Medicine	UK	United States	Sweden	Canada	Netherlands	Switzerland	France
Geriatrics	United States	Japan	Italy	Canada	France	Germany	Sweden
Miscellaneous Clinical Medicine	UK	France	United States	Japan	Switzerland	Netherlands	Canada
Neurology & Neurosurgery	United States	Switzerland	Canada	Sweden	UK	Germany	France
Pharmacology	United States	UK	Switzerland	Sweden	Canada	Japan	France
Psychiatry	UK	United States	Sweden	Canada	Australia	Germany	France
Respiratory System	UK	Canada	Switzerland	Japan	France	United States	Italy
Earth and Space	Canada	United States	Australia	Netherlands	Germany	France	Japan
Environmental Science	Canada	United States	Australia	Netherlands	Germany	Japan	France
Mathematics	UK	United States	France	Canada	Germany	Japan	Netherlands
Applied Mathematics	United States	UK	Netherlands	Canada	Italy	France	Spain
Probability & Statistics	UK	United States	Australia	Canada	France	Spain	Switzerland
Physics							
Optics	United States	Germany	Switzerland	Sweden	Canada	France	Japan
Psychology							
Behav. Sc. & Compl. Psycho.	Canada	United States	Switzerland	UK	Germany	France	Netherlands

Source: Observatoire des sciences et des technologies (SCI and United Nations Statistics Division)

* * *

The above analysis is a cumulative evaluation of French and Canadian scientific performance in genomic research. The fact that the scientific fields listed present opportunities for *planned* collaborative research does not mean that mutually beneficial collaboration could not be performed at an individual level between leading researchers in other areas.

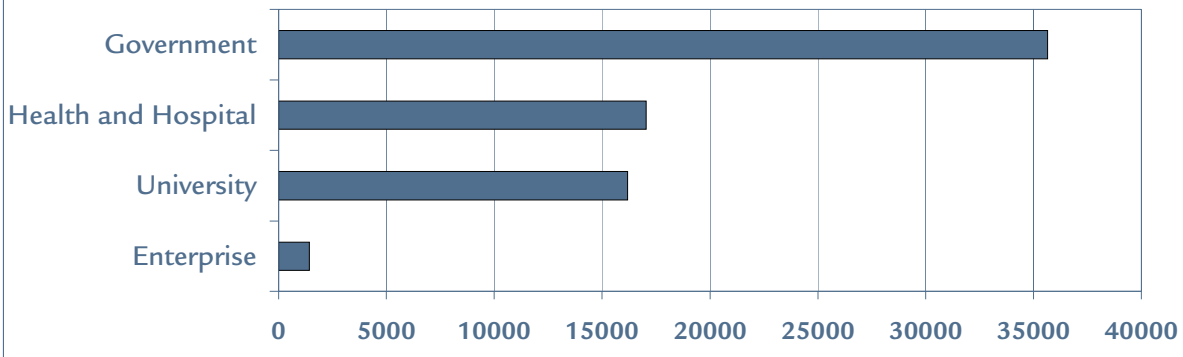
III. Leadership Structure of Genomics Research in France

This section examines the distribution of papers in genomics by sector, institution, city and researcher. The Medline database is used here because more than 91% of papers in genomics are published in journals classified in the fields of Biomedical Research and Clinical Medicine. From 1990 to 2001, France published around 58,800 papers in genomics that were indexed by Medline (measured by first author of paper and French affiliation).

Distribution of Papers in Genomic Science by Sectors

In France, 45% of papers in genomics are authored by researchers affiliated with governmental facilities (Figure 2). The health sector plays an important role in the development of research in genomics, since 22% of papers are authored by researchers affiliated with a health centre, a medical clinic, or a hospital (this includes university hospitals). Universities authored 21% of papers, while private enterprises authored 2%. Again, this distribution is caused by the unique structure of the French research financing system.

Figure 2 Papers in Genomics by Sector by France, 1990-2001



Source: Science-Metrix (Medline)

Figure 3 lists the most active institutions in the government sector. The two most important governmental research organizations are the CNRS (49% of sector production) and INSERM (37%). The other organizations present are the INRA (7%) and the CEA (3%). All these institutions are nationwide organizations with branches in different cities, as shown in Table 6.

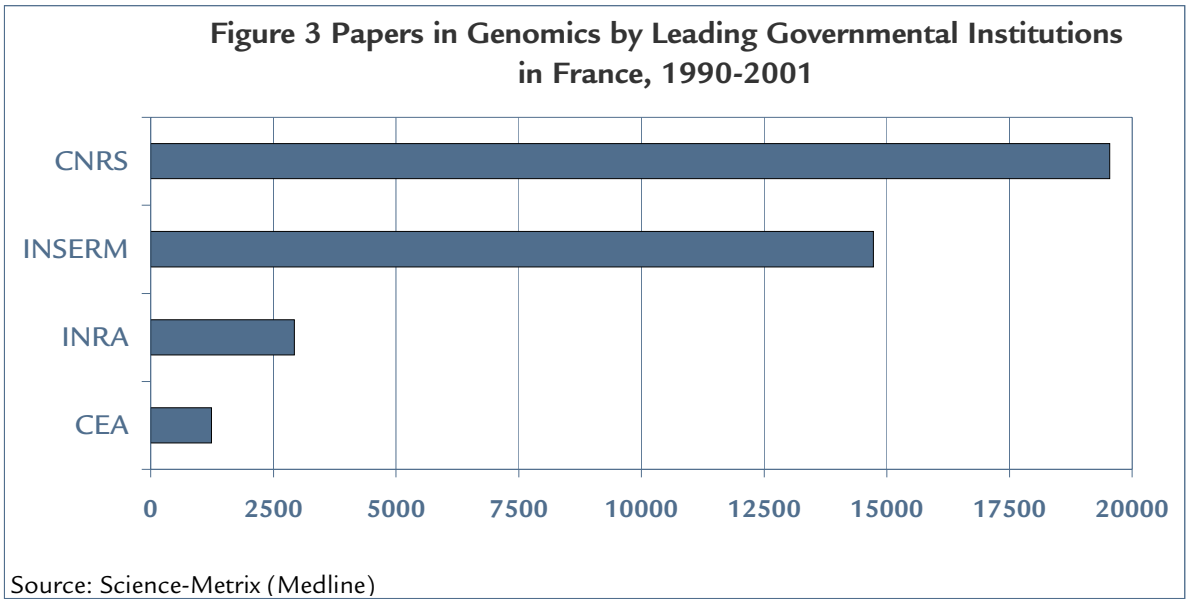


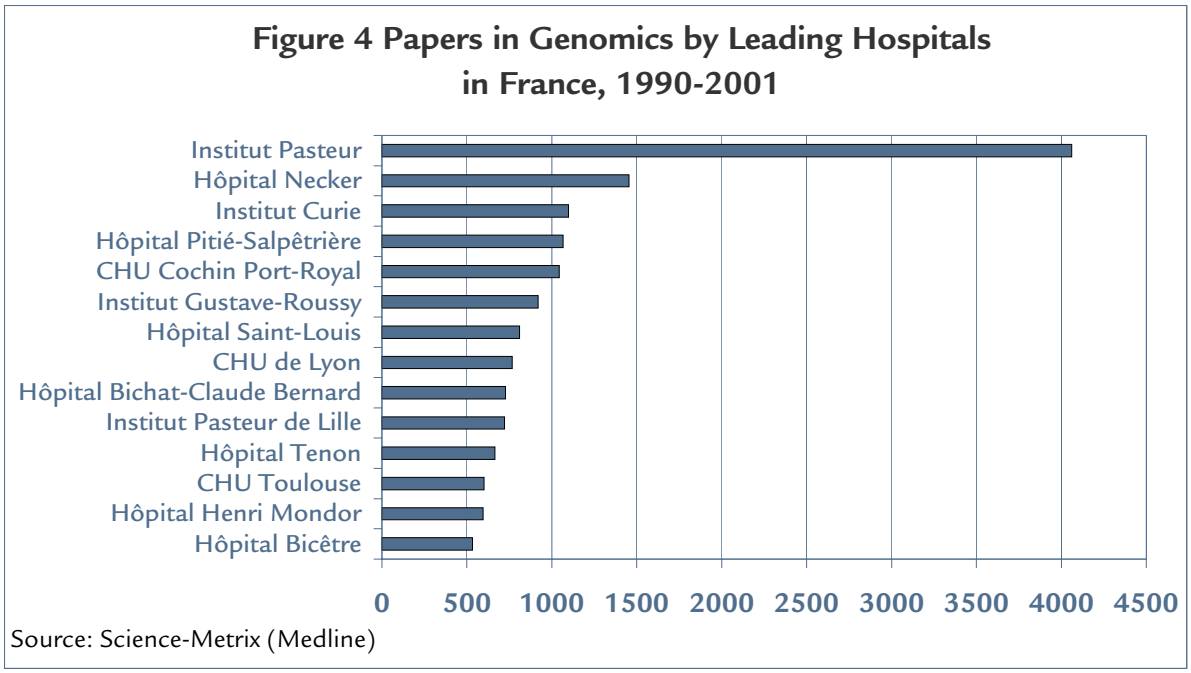
Table 6 shows the importance of Paris in this sector of genomic production. This is easily explained by the fact that all the important national research institutes have their headquarters in Paris. Strasbourg and Montpellier are second and third, which shows the importance of these cities in terms of governmental research.

Table 6 Ranking of Leading Governmental Institutions in Genomics in France. Number of Papers by City, 1990-2001

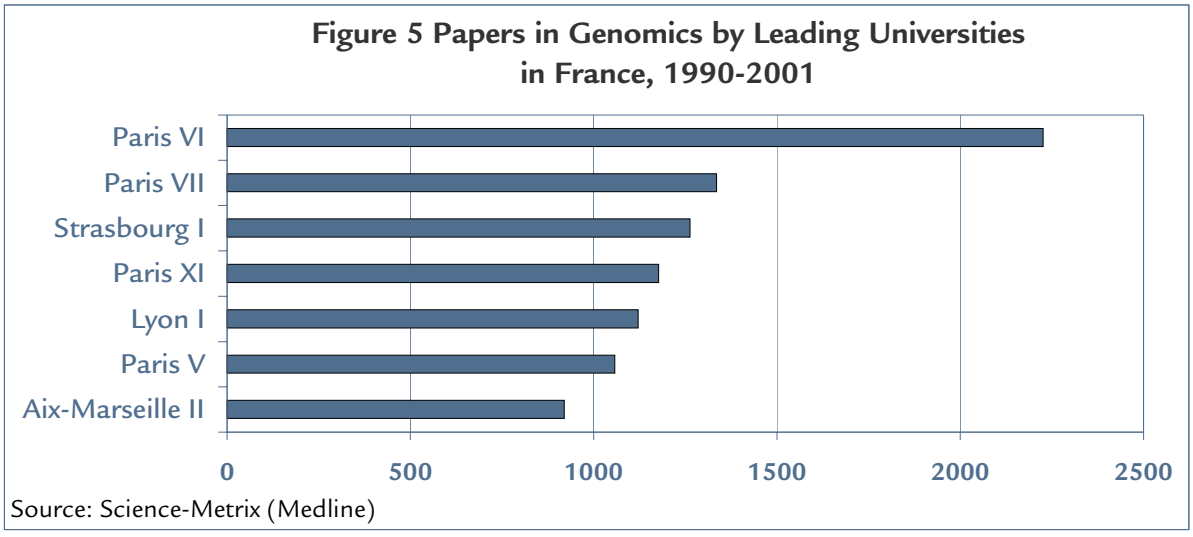
Rank	Institutions	Paris	Strasbourg	Montpellier	Lyon	Marseille	Toulouse	Lille	Grenoble	Others	Total
1	CNRS	11,369	2,553	1,512	1,093	1,245	1,080	516	629	2,029	19,541
2	INSERM	7,919	1,187	1,013	876	949	414	811	255	1,327	14,727
3	INRA	1,229		220	7	2	324	7		1,139	2,927
4	CEA	598							642		1,240
5	Others	925		249	28			25	49	63	1,331
Total		20,661	2,887	2,350	1,921	1,853	1,660	1,271	1,121	4,518	35,657

Source: Science-Metrix (Medline)

Figure 4 lists the most active institutions in the health and hospital sector. The *Institut Pasteur* is primarily a research institute but it offers some health services (mainly immunization). With 4,061 papers, it represents close to 19% of the sector's output. The following institutions, the *Hôpital Necker* (7%), *Institut Curie* (5%), *Hôpital Pitié-Salpétrière* (5%) and the *CHU Cochin Port-Royale* (5%), are all located in Paris and have produced over a thousand papers each. The *Institut Curie* is also a research center but its role as a healthcare provider is much bigger than the *Institut Pasteur*'s since it has an extensive oncology unit open to the public. The *Institut Gustave Roussy* is a non-profit private institution, exclusively devoted to oncology and it is included in the French public hospital system.



As shown in Figure 5, the leading university-level institution in France clearly is *Université Paris VI*. With 2,226 papers, it is responsible for more than 13% of papers produced by the university sector. This does not come as a surprise since the institution strongly invested in the field of genomics and made it one of its four research foci. The second most important university is *Université Paris VII* with a little more than 8% of papers by French universities. Following closely is *Université de Strasbourg I* with 7.5% of papers by universities. *Paris XI* (7%), *Lyon I* (6.7%) and *Paris V* (6%) are next in line with each more than 1,000 papers each. The importance of *Strasbourg I* and *Paris XI* for genomic research is evident since two important *Génopole* where founded in their vicinities (*Génopole de Strasbourg* and the most important *Génopole* : *Génopole d'Évry*).



Publications by private firms in France more than in other countries constitute a small part (2%) of the published scientific output in the field of genomics. Only 17 companies seem to have published in France (as shown in table 7). Aventis, located in Paris, published 44% of private sector papers whereas Sanofi-Synthélabo, also located in Paris, produced 16% of papers in this sector. Laboratoires Pierre Fabre, Transgene and Schering-Plough each published between 100 and 126 articles (8 to 9% each). Other firms published less than 100 articles each. The majority of these companies work in the health and pharmaceutical fields with the exception of L'Oréal which work in the field of cosmetics. The French private sector is clearly a negligible part of the scientific publishing landscape in the field of genomics. It would nonetheless be a mistake to think that no research is done by French companies. Like most private firms, they are very active but do not to publish their results.

Table 7 Ranking of Leading Enterprises in Genomics in France.
Number of Papers by City, 1990-2001

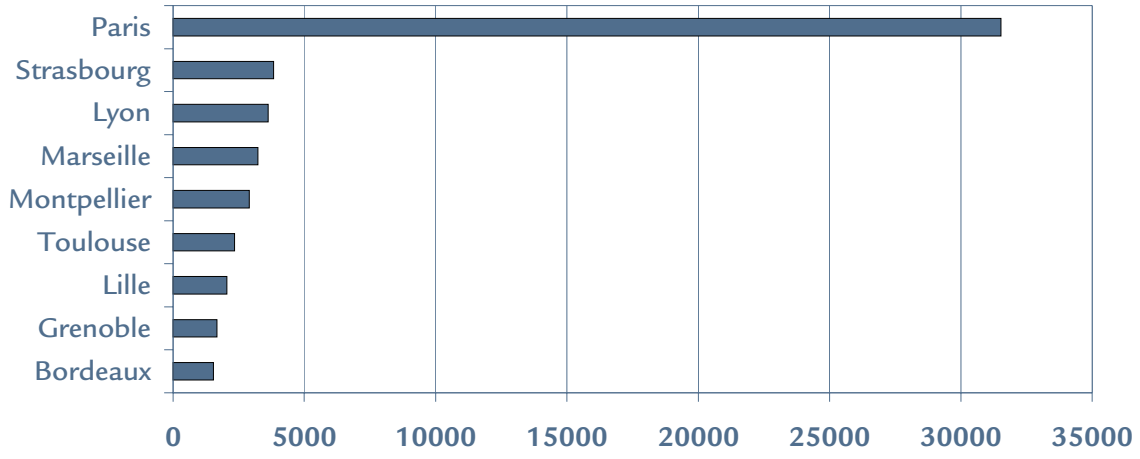
Rank	Enterprise	Headquarters Location	Paris	Lyon	Strasbourg	Toulouse	Castres	Dardilly	Montpellier	Saint Julien en Genevois	Marseille	Others	Total
1	Aventis	Paris	224	283	151								618
2	Sanofi-Synthélabo	Paris	35			207			53				230
3	Laboratoires Pierre Fabre	Castres					83			43			126
4	Transgene	Strasbourg			126								126
5	Schering-Plough	Kenilworth, NJ (USA)						108					108
6	Laboratoires Servier	Paris	77										77
7	Beaufour-IPSEN	Paris	39										39
8	Genset (Serono)	Paris	20										20
9	Immunotech	Fullerton, CA (USA)									20		20
10	L'Oreal	Paris	18										18
11	Hybrigenics	Paris	12										12
12	Laboratoire Alphabio	Marseille									11		11
	Others (n=5)		8		2	4							14
Total			433	283	279	211	83	108	53	43	31		1,417

Source: Science-Metrix (Medline)

Position of French Cities in Genomic Science

Figure 6 shows that Paris is the absolute capital of genomics in France producing 52% of the country's output by city. The city hosts most of the leading institutions active in the field of genomics: the INSERM and CNRS headquarters, most of the universities (including three of the five leaders), most of the hospitals (the five leading institutions) and seven of the leading enterprises. The city of Strasbourg ranks second with 6.3% of France scientific output, while Lyon ranks third with 5.9%.

Figure 6 Papers in Genomics by Leading Cities in France, 1990-2001

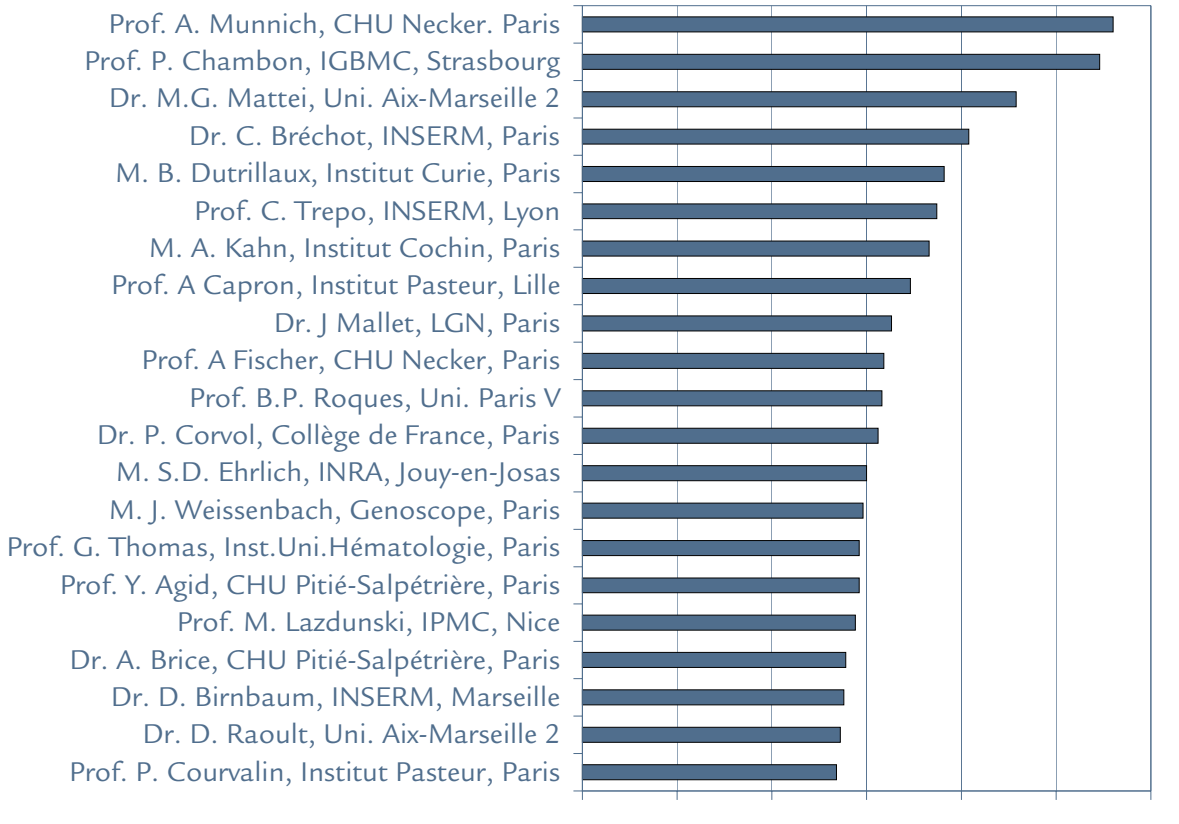


Source: Science-Metrix (Medline)

Leading French Researchers in Genomic Science

Figure 7 shows that 61.5% of the leading researchers are located in Paris. Three of the five most productive researchers are located in Paris. This is consistent with the distribution of papers by cities shown above. Due to the abundance of research institutions, there is no important concentration of leading researchers in one specific institution. However, the *CHU Necker* in Paris, shows a small, but noticeable, concentration. The *CHU Necker* houses the most prolific researcher and two other leading researchers. The *CHU Pitié-Salpétrière*, Paris, the *Institut Pasteur*, Paris, and the *Université Aix-Marseille II* each house two of the leading researcher and with *Aix-Marseille II* housing the third most prolific author. This comes as a surprise since *Université Aix-Marseille II* comes only 7th in terms of output in genomics in French universities and Marseille only comes 4th in terms of output by French cities. Other than this small exception, there are no surprises here since most of these highly productive researchers come from the hospitals, universities and urban centres with the largest scientific output.

Figure 7 Papers in Genomics by Leading Researchers in France, 1990-2001



Source: Science-Metrix (Medline)

* * *

The distribution of research in genomics in France is highly concentrated in the city of Paris. In second and third place, Strasbourg and Lyon come far behind Paris. CNRS Paris is the French institution with the largest output (11,369 papers); INSERM Paris comes second (7,919 papers); *Institut Pasteur* Paris, ranks third (4,061 papers) and *Université Paris VI* (2,226 papers) is fourth. Although Paris is the absolute leader in terms of output, Part I showed that organizations like the *Génopole* network are vigorously promoting research in genomics throughout the large urban centers in France, the most important *Génopole* being located in Évry in the Paris suburbs. It is also worth mentioning the importance of the INRA in Jouy-en-Josas in the agricultural and plant genomic engineering domain.

Annex IA – French Universities Performing Research in Genomics

University	Department
École Normale Supérieure (ENS)	Centre d'Études des Système Complexe et de la Cognition (CENECC) http://www.cenecc.ens.fr/
École Sup. de Physique et de Chimie Industrielles de la Ville de Paris (ESPCI)	Neurobiologie et Diversité Cellulaire http://www.bio.espci.fr/
Institut National Polytechnique (INP) de Toulouse	Laboratoire de Biotechnologie et Amélioration des Plantes (BAP) http://www.inp-toulouse.fr/recherche/laboratoires/bap/bap.shtml
Université Claude Bernard Lyon I	Laboratoire de Biométrie, Biologie Évolutive http://biomserv.univ-lyon1.fr/
Université d'Évry	Laboratoire Statistique et Génome http://stat.genopole.cnrs.fr/
Université de Marne-la-Vallée	Institut Gaspard-Monge (IGM) http://www.impg.prd.fr/Equipes/IGM.html
Université de Nice Sophia Antipolis	Laboratoire de Physiologie Cellulaire et Moléculaire, Génomique Fonctionelle du Muscle Squelettique http://www.unice.fr/LPCM/genomuscle-fr.html
Université de Rennes I	Institut de Recherche en Informatique et Système Aléatoire (IRISA), projet SYMBIOSE http://www.irisa.fr/symbiose/ Groupe d'Étude de la Reproduction chez le Mâle http://www.germ.univ-rennes1.fr/
Université de Versailles-Saint-Quentin-en-Yvelines	Laboratoire de Génétique et Biologie Cellulaire http://www.genetique.uvsq.fr/index.html
Université Joseph Fourrier Grenoble III	Laboratoire TIMC (UMR-CNRS 5525), équipe GENOME http://www-timc.imag.fr/genome/index.html Laboratoire de Physiologie Cellulaire Végétale (Interactions Plastes-Cytoplasme-Mitochondries) - (UMR 5019) http://awash.ujf-grenoble.fr/ujf/fr/recherche/labujf/dbpcv.phtml Virologie Structurale et Moléculaire (GDR 2372) http://www2.ujf-grenoble.fr/pharmacie/gdrviro/index.html
Université Montpellier I	Centre de Biochimie Structurale http://www.cbs.cnrs.fr/welcome.html
Université Montpellier II	Laboratoire Génome Interaction Population http://www.univ-montp2.fr/~genetix/
Université Paris VI-VII	Équipe de Bioinformatique et Génomique Moléculaire http://condor.urbb.jussieu.fr/ Laboratoire de Dynamique du Génome et Évolution http://dynagen.ijm.jussieu.fr/

Université Paris-Sud XI	Laboratoire d'Enzymologie et Biochimie Structurale http://www.lebs.cnrs-gif.fr/ Institut de Biochimie et de Biophysique Moléculaire et Cellulaire http://h0.web.u-psud.fr/ibbmc/ Institut de Génétique et Microbiologie http://www.igmors.u-psud.fr/
Université Paul Sabatier Toulouse III	Centre de Biologie du Développement http://www-cbd.ups-tlse.fr/cbd/index.html
Université Victor Segalen Bordeaux II	Laboratoire des Interaction Plantes-Pathogènes http://www.bordeaux.inra.fr/ipp/

Source: Science-Metrix (Internet)

Annex IB: French Health Organizations in Genomics

Hospital	**Department**
CHU Pitié-Salpétrière	IFR 14, Coeur Muscle Vaisseaux http://www.chups.jussieu.fr/ext/IFR14/index.htm Plateforme Post-Génomique Pitié-Salpétrière (P3S) http://www.ifrns.chups.jussieu.fr/platef-genom/index.html
Institut Curie	Recombination and Genomic Instability http://www.curie.fr/sr/cdrom/equipes/dutxe.htm
Institut Pasteur, Paris	Génétique des déficits sensoriels http://www.pasteur.fr/recherche/RAR/RAR2001/Gds.html Laboratoire de Génomique des Microbe Pathogènes (GMP) http://www.pasteur.fr/recherche/unites/gmp/
Institut Pasteur, Lille	Laboratoire d'Analyse Génomique http://www.pasteur-lille.fr/france/recherche/lag_2000.htm

Source: Science-Metrix (Internet)

Annex IC – French Governmental and Non-Governmental Organizations Performing Research in Genomics

Institution	**Department or Web address**
Centre National de Génotypage (CNG)	http://www.cng.fr/f/index.html
CNRS (Centre National pour la Recherche Scientifique)	Centre de Génétique Moléculaire (CGM) http://www.cgm.cnrs-gif.fr/ Institut de Génétique Humaine (IGH) http://www.igh.cnrs.fr/ Institut de Génétique Moléculaire de Montpellier http://www.igm.cnrs-mop.fr/accueil_+_menus.htm Institut Fédératif de Recherche IFR40 Pôle de Biotechnologie Végétale http://ifr40.smcv.ups-tlse.fr/index.html

CNRS, Marseille	Information Génétique et Structurale http://igs-server.cnrs-mrs.fr/ Génomique de *Bacillus Subtilis* http://ir2lcb.cnrs-mrs.fr/denizot.html
Centre de Ressource Infobiogen (CRI)	http://www.infobiogen.fr/presentation/infobiogen.html
Commission de l'Énergie Atomique (CEA)	Service de Génomique Fonctionelle (SGF) http://www-dsv.cea.fr/content/cea/d_dep/d_drr/d_sgf/
Coopération internationale en recherche agronomique pour le développement (CIRAD)	http://www.cirad.fr/
INSERM (Institut National de la Santé et de la Recherche Médicale)	UMR 554, Protéomique et Génomique Structurale http://www.montp.inserm.fr/unit554/U554equipe5.htm
Génoplante	http://www.genoplante.org Projet FST (Flanking Sequence Test) http://genoplante.evry.inra.fr/projects/fst/DocsIntro/Page_accueil.html
Génopole	General http://www.genopole.org/ Génopole Toulouse-Midi-Pyrénées http://genopole.toulouse.inra.fr/ Génopole Marseille http://www.genopole.univ-mrs.fr/
Genoscope	http://www.genoscope.cns.fr/externe/
Généthon	http://www.genethon.fr/php/index.php
INRA (Institut National de Recherche Agronomique)	Département de Génétique et d'Amélioration des Plantes http://www.inra.fr/gap/ UR 102 - Génétique et Amélioration des Plantes http://medicago.toulouse.inra.fr/ATS/gapdijon.html Laboratoire de Génétique Cellulaire http://www.toulouse.inra.fr/lgc/lgc.htm
INRA, Évry	Unité de Recherche en Génomique Végétale – URGV http://www.evry.inra.fr/public/index.html
INRA, Versaille	Station de Génétique Végétale du Moulon http://moulon.inra.fr/welcome.html Étude du Génome des Plantes, des Microorganismes et des Insectes en vue d'Application Agronomique http://www.versailles.inra.fr/laboratoires/genome.htm
INRA, Antibes	Unité Interaction Plantes-Microorganismes et Santé Végétale (I.P.M.S.V.) http://www.antibes.inra.fr/ipmsv/index.fr.html
INRIA (Institut National de Recherche en Informatique et en Automate)	Projet Helix http://www.inrialpes.fr/helix.html
Institut de Recherche pour le Développement (IRD)	Rice Genomic Group http://www.mpl.ird.fr/rice/

Source: Science-Metrix (Internet)

Annex II Companies Active in the Fields of Genomics, Proteomics and Bioinformatics in France

This annex comprises enterprises that were active in genomics between 1990 and 2002 or that acquired firms active in genomics during those years.

Avidis S.A.
Biopôle Clermont-Limagne
63360 Saint-Beauzire
France
Email: contact@avidis.fr
Internet: www.avidis.fr

Groupe Beaufour-Ipsen
42, Rue du Docteur Blanche
75016 Paris
France
Tel: +33 1 44 30 43 43
Fax: +33 1 44 30 43 21
Email: contact.web@beaufour-ipsen.com
Internet: www.beaufour-ipsen.com

BMD
BP 103
Actipole N°25 Boulevard de Beaubourg
77423 Marne la Vallée cedex 2
France
Tel: +33 1 64 62 10 12
Fax: +33 1 64 62 09 66
Email: bmd@bmd-net.com
Internet: www.bmd-net.com

Biométhode
Genopole Industries
4, rue Pierre Fontaine
91000 Evry
France
Tel: +33 1 60 87 89 44
Fax: +33 1 60 87 89 99
Email: info@biomethodes.com
Internet: www.biomethodes.com

Bio-Xtal
4, route de la Noue
91190 Gif-sur-Yvette
France
Tel: +33 1 69 18 90 50
Fax: +33 1 69 07 89 40
Email: management@bioxtal.com
Internet: www.bioxtal.com

Cellectis SA
28, rue du Docteur Roux
F-75724, Paris Cedex 15
France
Tel: +33 1 40 61 34 18
Fax: +33 1 45 68 84 53
Email: mail@cellectis.com
Internet: www.cellectis.com

E.S.G.S. Groupe Cybergène
Allée Christophe Colomb
91035 Evry
France
Tel: +33 1 60 878 200
Fax: +33 1 60 878 201
Email: esgs@eurosequence.com
Internet: www.eurosequence.com

ExonHit Therapeutics SA
26 rue Brunel
F-75017 Paris
France
Tel: +33 1 58 05 47 00
Fax: +33 1 58 05 47 19
Email: exonhit@exonhit.com
Internet: www.exonhit.com

GenOdyssee S.A.
Parc d'Affaires Technopolis
3, Avenue du Canada
Bat Alpha, BP 810
Les Ulis 91974 Courtabœuf cedex
France
Tel: +33 1 69 29 80 55
Fax: +33 1 69 29 80 79
Email: escary@genodyssee.com
Internet: www.genodyssee.com

Genome express
11 Chemin des Prés
38944 Meylan
France
Tel: +33 4 56 38 11 11
Fax: +33 4 56 38 11 00
Email: gexinfo@genomex
Internet: www.genomex.com

Genfit
Parc Eurasanté - Lille Métropole
885, rue Eugène Avinée
59120 Loos
France
Tel: +33 3 20 16 40 00
Fax: +33 3 20 16 40 01
Email: contact@genfit.com
Internet: www.genfit.com

Genset SA
24, Rue Royale
75008 Paris
France
Tel: +33 1 55 04 59 00
Fax: +33 1 55 04 59 29
Email: Investor.Relations@genset.fr
Internet: www.genset.fr

GenoScreen
Parc Eurasanté
180, avenue Eugène Avinée
59120 LOOS
France
Tel: +33 3 20 87 71 53
Fax: +33 3 20 87 72 64
Email: contact@genoscreen.fr
Internet: genoscreen.chez.tiscali.fr

GENAXIS France
Espace Innovation 2
Parc Scientifique Georges Besse
110 Allée Charles Babbage
F-30000 NIMES
France
Tel: +33 4 66 04 75 85
Fax: +33 4 66 84 74 70
Email: genaxis@aol.com
Internet: www.genaxis.com

Gen-IT SA Europe
147, Avenue Paul Doumer
92500 Rueil Malmaison
France
Tel: +33 1 41 96 80 30
Fax: +33 1 41 96 80 31
Email: contact@gene-it.com
Internet: www.gene-it.com

GenOway
46 allée d'Italie
69007 Lyon
France
Tel: +33 4 72 72 96 17
Fax: +33 4 72 72 96 19
Email: info@genOway.com
Internet: www.genoway.com

Groupe l'Oréal
41, rue Martre
92117 Clichy
France
Tel: +33 1 47 56 82 65
Fax: +33 1 47 56 86 42
Email: info@loreal-finance.com
Internet: www.loreal.com

Hybrigenics
3-5 impasse Reille
75014 Paris
France
Tel: +33 1 58 10 38 00
Fax: +33 1 58 10 38 49
Email: science@hybrigenics.fr
Internet: www.hybrigenics.fr

Integragen
4 rue Pierre Fontaine
91000 Evry
France
Email: contact@integragen.com
Internet: www.integragen.com

It.Omics
Parc Eurasanté
310 avenue Eugène Avinée
59120 LOOS
France
Tel: +33 3 20 16 40 50
Fax: +33 3 20 16 40 01
Email: contact@it-omics.com
Internet: it-omics.com

Laboratoire Alphabio
23, Rue de Friedland (Angle Rue d'Iéna)
13006 Marseille
France
Tel: +33 4.91.25.41.00
Fax: +33 4.91.78.14.75
Email: info@alphabio.fr
Internet: www.alphabio.fr

Laboratoire Aventis (Headquarter)
42-50 quai de la Rapée
F-75012 Paris
France
Tel: +33 1 55 71 55 71
Fax: +33 1 55 71 55 55
Email: aventispharma.fr@aventis.com
Internet: www.aventispharma.fr

Laboratoires Pierre Fabre SA
Le Carla Burlats
81106 Castres Cedex
France
Tel: +33 5 63 62 38 50
Email: contact.pf@pierre-fabre.com
Internet: www.pierre-fabre.com

Merck-Lipha S.A.
37, rue Saint Romain
69379 Lyon cedex 08
France
Tel: +33 4 72 78 25 25
Fax: +33 4 78 75 39 05
Email: contact@lipha.fr
Internet: www.lipha.fr

Neurolab
53, Bd du Général Martial Valin
75015 Paris
France
Tel: +33 1 45 57 20 80
Fax: +33 1 45 57 20 72
Email: contact@neurolab.fr
Internet: www.neurolab.fr

Neurotech S.A.
Bâtiment Génopole-Industries
4, rue Pierre Fontaine
91000 EVRY
France
Tel: +33 1 60 87 89 13
Fax: +33 1 60 87 89 50
Email: t.shepherd@neurotech.fr
Internet: www.neurotech.fr/societe/index.htm

Novartis Pharma S.A.
2 et 4 rue Lionel Terray
BP 308
92506 Rueil Malmaison Cedex
France
Tel: +33 1 55 47 60 00
Fax: +33 1 55 47 60 50
Email: communication.phfrru@pharma.novartis.com
Internet: www.pharma.novartis.fr

Nucleis
3, allée Pierre de Coubertin
69007 Lyon
France
Tel: +33 4 78 72 79 40
Fax: +33 4 37 37 45 39
Email: nucleis.grave@wanadoo.fr
Internet: www.nucleis.com

Proteaxis
191 rue Nicolas Appert
59650 Villeneuve d'Ascq
France
Tel: +33 3 20 19 06 19
Fax: +33 3 20 19 06 18
Email: Contact@proteaxis.fr
Internet: www.proteaxis.fr

Proteigene
B.P. 2223
7 rue Leo Lagrange
27950 Saint Marcel
France
Tel: +33 2 32 64 45 45
Fax: +33 2 32 64 30 72
Email: infos@proteomicsolutions.fr
Internet: www.proteomicsolutions.fr

Qiagen S.A.
3 avenue du Canada
LP 809
91974 Courtaboeuf Cedex
France
Tel: +33 1 60 92 09 30
Fax: +33 1 60 920 9 25
Internet: www.qiagen.com

Sanofi-Synthélabo
174, av. de France
75013 Paris
France
Tel: +33 1 53 77 40 00
Internet: www.sanofi-synthelabo.com

Servier
22 rue Garnier
92578 Neuilly-sur-Seine CEDEX
France
Tel: +33 1 55 72 60 00
Internet: www.servier.fr

Skuldtech
88, cours des Camisards
34080 Montpellier
France
Tel: +33 4 67 52 63 96
Fax: +33 4 67 52 63 96
Email: info@skuldtech.com
Internet: www.skuldtech.com

Transgene S.A.
11 rue de Molsheim
67082 Strasbourg Cedex
France
Tel: +33 3 88 27 91 00
Fax: +33 3 88 27 91 11
Email: communication@transgene.fr
Internet: www.transgene.fr

Urogene S.A.
4, rue Pierre Fontaine
Genopole
91058 Evry cedex
France
Tel: +33 1 60 87 89 80
Fax: +33 1 60 87 89 89
Email: info@urogene.com
Internet: www.urogene.com