New Economy Observatory

2001 Cluster Studies

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Introduction

At the dawn of the 21st Century, Metropolitan Portland has emerged as one of the most innovative metropolitan regions in the United States. The region continues to witness ongoing economic change, and is part of a world-wide transition to an increasingly knowledge-based economy.

For the past several years the Institute has engaged in an analysis of the performance of the Portland-Vancouver metropolitan area economy, and the major industrial clusters within the 6 counties. Our work to date (http://www.upa.pdx.edu/IMS/NEO/NEO.html) has provided a unique and strategic overview of economic performance in and the traded sector industrial clusters in the economy of metropolitan Portland.

That work has revealed several clear messages for policy makers about the future of our economy:

- Intellectual capital is key to our present prosperity and future success. We succeed today because of the talents of our people, not simply the cost of our water, electricity, or land.

- The environment for creative accomplishment and entrepreneurship should be a critical public concern. High quality neighborhoods, great schools, environmental quality, the availability of venture capital, and building and sustaining the Portland “brand” are inter-related issues that need to be addressed with a coordinated strategy.

- The industries of the future will extend and modify current local strengths. The seeds of what we will become are already planted here.

- Our most important industries are not here by chance. Contrary to popular belief, they are not “footloose.” Place matters, and the relationships that make key firms successful here are not easily transported.

Nonetheless, our work also points out forcefully that this is a time of transition and unprecedented economic change. Our desires for a more diverse economy have been met, but the result is fast becoming a new economic mix that has implications for much more than simply the economic life of the city and its region. Rapidly changing technology and shifting markets make this an exciting and challenging time to achieve and maintain prosperity.

Although easily taken for granted, the region’s economic prosperity is no accident. Other metropolitan areas have waited for a downturn to catalyze serious interest in understanding the forces that shape their economic destinies. This metropolitan area, we think, is more inclined to make conscious choices about how to shape its future.

In response to the dynamic nature of the economy in our region, and in light of our findings, the Institute of Portland Metropolitan Studies has created the "New Economy Observatory." The mission of the New Economy Observatory (NEO) is to provide economic development professionals and local decisionmakers with strategic information regarding the:

- performance of the region's economy, both in absolute terms and relative to other competitor metropolitan regions;
- nature and formation of new businesses, the cutting edge of change in the new economy;
- institutions, actors, and processes that support or impede the creation of new knowledge-based businesses in the region; and
- inter-relationships between the region's quality of life and distinctive character, and the number and kind of new businesses being created.

We have consciously chosen the term "observatory" to name this initiative. By definition, an observatory is intended to provide both descriptive information and analysis useful for explaining the dynamics of the system under study. There is currently no central clearinghouse for monitoring and analyzing the emerging knowledge-based economy in this region. We believe that NEO is critically needed both to help inform local economic development efforts and to benchmark this region against others attempting to make the same kind of economic transition.

NEO has continued the work begun in the Institute's Regional Connections project through studies of the industry clusters whose success seems to be driving regional economic growth. The region's economy can be best understood as a collection of industry clusters—businesses with similar markets and technologies, and their suppliers—which derive advantage from being located in close proximity to one another. The rapid growth of the region's high tech cluster was a major factor in our growth during the 1990s.

In this report, sponsored by and prepared for the City of Portland's Portland Development Commission, we present work done this year on three clusters:

> --In the creative services cluster—advertising, public relations, film and video and the multimedia/web segment of software—we have updated our analysis of the region's employment. This cluster continued to grow robustly through 1999.
>
> --We are developing a comparative analysis of the biotechnology industry in Portland and leading biotechnology centers around the nation to better quantify the factors that lead to the growth of biotech industry clusters.
>
> --We are also studying the wood products industry, historically a mainstay of the Oregon economy, which includes a number of wholesale

distribution and equipment supplier firms, as well as manufacturers, in the Portland area.
Finally, we would like to acknowledge the fine work done by the New Economy Observatory team this year. Joe Cortright and Ethan Seltzer were the principle managers and designers of the New Economy Observatory effort. Joe Cortright, of Impresa Consulting, was the primary author of this document. Ethan Seltzer, Carlos Vilalta, Heike Mayer, John Provo, Lisa Selman, and Diane Sullivan all made contributions to the form and content. Ethan Seltzer and Emily Renfrow provided the final edit and format.

Robin Roberts, Economic Development Manager of the Portland Development Commission was the inspiration for this report and key contact between project staff at the Institute and others at the Portland Development Commission. This report would not have been possible without the support, financial and otherwise, of Robin, Abe Farkas, and other members of the Portland Development Commission staff and management.

Analysis of Metro Portland's Industry Clusters

This region, like others, has specific competencies reflected in the clusters of related firms that make up its traded sector. For example, we are good at semiconductors in this region, but relatively weak in telecommunications. These competencies and core clusters are not random, and they have roots in the economic history of this region.

The Institute began its investigation of clusters through its Regional Connections project (for access to reports on the region's economy produced by Regional Connections, please visit our web site: www.upa.pdx.edu/IMS/). Through that work, we determined that the core clusters for this region included semiconductors and electronic equipment; metals, machinery, and transportation equipment; creative services; lumber and wood products; nursery products; and specialty foods. Other clusters were suggestive, but we have not, as yet, been able to fully evaluate them.

As part of the ongoing work of the New Economy Observatory, we will be analyzing and reporting on the core industrial clusters in this region. In previous years, the Institute has undertaken several cluster studies of the regional economy for high technology, nursery products, and metals. In this report, we add to our knowledge of two clusters. Lumber and wood products is an important employer and a link to the rest of the state, but it is a declining cluster.

In contrast, creative services is a growing cluster, and is the newest cluster to emerge in the region during the decade of the 1990's. Finally, we also present initial work on biotechnology. There is intense interest in "growing" the biotechnology industry in this region and in almost every other metropolitan area in America. This work is a first step towards describing the role that the Portland region might play in biotechnology in the years ahead.

Wood Products

While most frequently associated with rural Oregon or the metro area's distant economic past, wood products manufacturing continues to be an industry sector for which the Portland metro area exhibits some signs of specialization.

Historical Perspective on Portland's Forest Product's Industry

While Oregon's economy has long been identified closely with the forest products industry, Portland's manufacturing base was actually substantially diversified into other industries more than a century ago. As Table 1 indicates, in 1904, only about 1 in 4 Portland manufacturing jobs was in the lumber and wood products industry. That proportion stayed relatively constant through the eve of the Second World War.

Table 1: Lumber and Wood Products Employment and Total Manufacturing Employment, Portland, Selected Years 1904 to 1939

Year	Lumber & Wood Products	All Manufacturing	Portland Share
1904	2,072	8,171	25%
1914	3,669	12,214	30%
1929	6,716	26,066	26%
1939	4,465	18,977	24%

Source: Census of Manufacturing, various years

Portland's relative importance as a center for wood products manufacturing in Oregon declined substantially throughout the first half of the twentieth century, as new mills were built outside the metropolitan area. Portland accounted for roughly a third of the state's wood products employment prior to the First World War. It's share steadily declined in subsequent years. By 1939, only about 1 in eight Oregon wood products jobs were in Portland.

Table 2: Lumber and Wood Products Employment, Portland and Oregon Selected Years, 1914 to 1939

Year	Portland	Oregon	Portland Share
1904	2,072	6,486	32%
1914	3,669	11,397	32%
1929	6,716	33,777	20%
1939	4,465	36,270	12%

Source: Census of Manufacturing, various years

Dimensions of the Cluster

The state's lumber and wood products industry includes a variety of major employment segments. These including actual logging, sawmills and planning mills, production of millwork and cabinets, hardwood and softwood veneer, and of mobile homes.

An important source of employment growth in recent years has been the cross-cutting category of Secondary Wood Products Industries. These "value-added" producers became a focus of policy in response to declining timber harvests in the late 1980's. The state defines them to include millwork and cabinets as well as some furniture and fixture makers, elements of SIC 24 and 25 describes below.

In describing the dimensions of the cluster we draw on Michael Porter's ideas about the role of specialized supplier networks in the development of competitive industrial clusters. Thus the list by Standard Industrial Code (SIC) that follows includes not only primary and secondary industries, but several leading specialized producers of machinery and wholesaling services that interact with firms in the cluster.

Forestry (SIC 8) includes establishments operating timber tracts, tree farms, forest nurseries or those that gathering other forest products. Currently the smallest segment in the cluster, it saw employment decline by almost one third, from 1,251 in 1992 to 875 in 1999.

Lumber and wood products (SIC 24) includes establishments engaged in cutting timber and pulpwood as well as mills engaged in producing basic lumber and wood materials like millwork, veneer and plywood. This category also includes firms involved in manufacturing certain finished articles such as wood containers, mobile homes, or prefabricated building components. Employment in this category grew between 1992 and 1999 from 6,973 workers to 7,344.

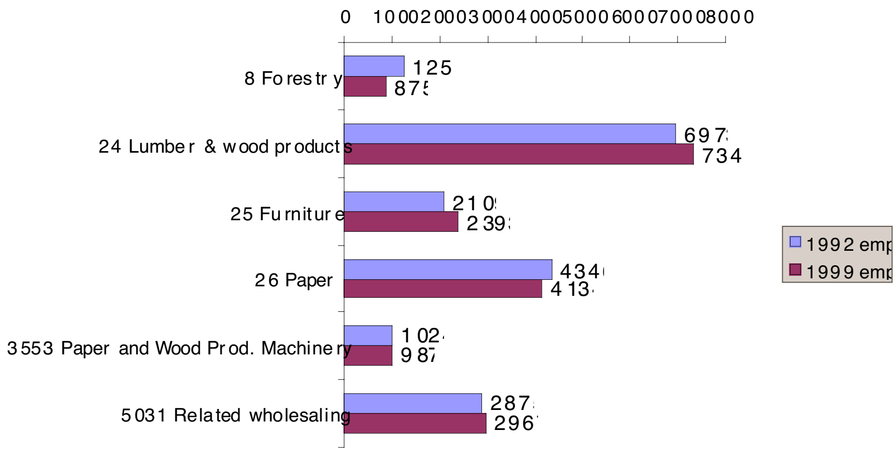
Furniture and fixtures (SIC 25) includes firms involved in the manufacture of household, office, and building furniture, as well as office and store fixtures. This category had the largest growth in the region, climbing by a thirteen percent from 2,109 in 1992 to 2,393 workers in 1999.

Paper and Allied Products (SIC 26) includes establishments involved in the manufacture of pulps from wood or other cellulose fibers, the manufacture of paper and paperboard, and the manufacture of paper or paper board into converted products such as paper bags, boxes, and envelopes. Employment in this industry declined by 212 jobs between 1992 and 1999, dropping from 4,346 to a total of 4,134 workers.

Woodworking machinery (SIC 3553) includes firms involved in manufacturing machinery for sawmills , for making particleboard and for otherwise producing wood products. Similarly, Paper Industries Machinery (SIC 3554) includes establishments involved in making machinery for industries producing paper and allied products. Employment in these industries, among the smallest in the cluster, declined from 1,024 workers in 1992 to 987 workers in 1999.

Wholesaling lumber and other construction materials (SIC 5031) includes establishments engaged in the wholesale distribution of rough, dressed, and finished lumber, plywood, reconstituted wood fiber products, doors and window frames, wood fencing. Employment in this segment grew from 2,875 workers in 1992 to 2,967 in 1999.

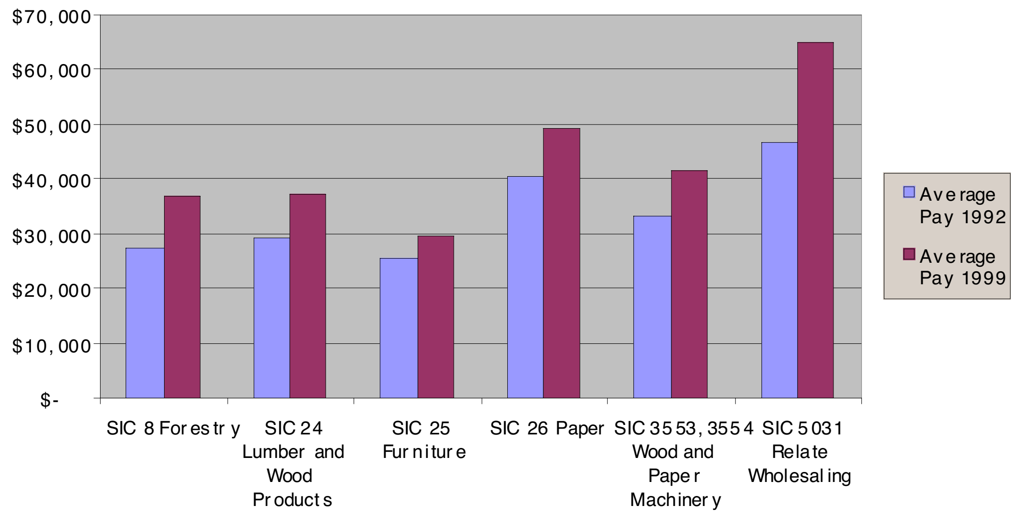
Figure 1: Metropolitan Portland Cluster Employment 1992 and 1999



Source: Oregon Employment Department, 1992 and 1999 Employment Data, Does Not Include Clark County, WA

Figure 2, below, summarizes average pay by industry for 1992 and 1999. These were very diverse, ranging from a highs in Related Wholesaling (SIC 5031), to a low in Lumber and Wood Products (SIC 24). The strongest growth over the decade came in Forestry (SIC 8) and Related Wholesaling (SIC 5031), which grew at annualized averages of four and five percent respectively between 1992 and 1999. Forestry pay grew from $27,387 in 1992 to $36,686 in 1999. Average pay in Related Wholesaling increased from $46,762 to $64,877. It should also be noted that the industry experiencing the greatest employment growth between 1992 and 1999, Furniture (SIC 25), was also the lowest paying industry in the cluster paying $24,551 in 1992 and $29,589 in 1999.

Figure 2: Metropolitan Portland, Average Pay by Industry 1992 and 1999



Source: Oregon Employment Department, 1992 and 1999 Employment Data, Does Not Include Clark County, WA

Portland's Role Today

Comparing Table 3 to the historical data described earlier we find that not surprisingly, Portland's share of the state's manufacturing employment has grown significantly. At the same time, Portland's share of lumber and wood products employment has actually increased, from 12 percent in 1939 to 17 percent in 1997.

Table 3: Total Employment 1997, Manufacturing, Lumber and Wood Products, Portland and Oregon

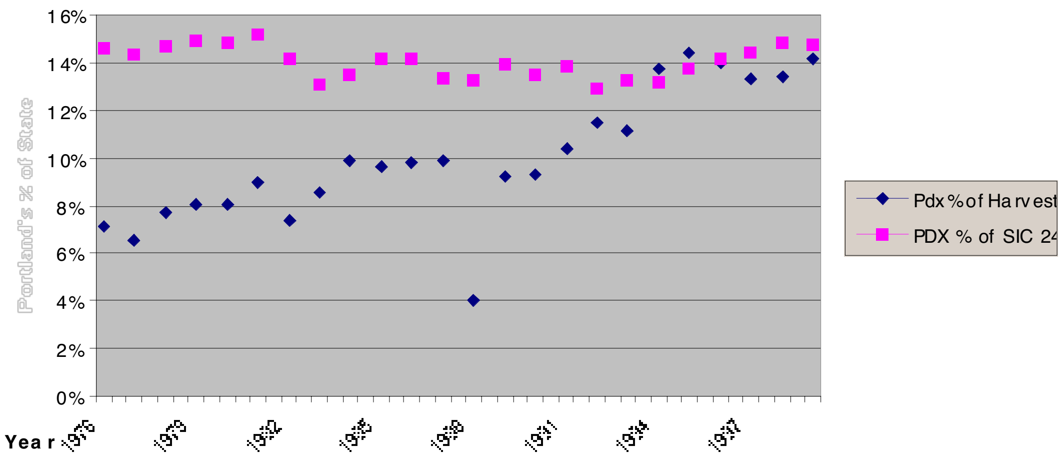
	Total Manufacturing	Lumber and Wood Products
Oregon	253,700	51,800
Metropolitan Portland	147,500	8,900
Metro as a percent of state		58%

Source: Oregon Employment Department, 1997 Current Employment Statistics

A closer look at recent employment history and timber harvests for both the state and Metropolitan Portland indicates that while both have experienced a range of highs and lows, the region's share of both employment and harvests has generally been on the rise.

Since the mid 1970's the state's employment in lumber and wood products has fluctuated dramatically, ranging from 81,376 in 1978 to a low of 49,648 in 1999. Similarly during the same period the Portland region has seen a high of 12,114 workers in 1979 to a low of 7,118 in 1993. State timber harvests have gone from a high of 8.6 billion board feet in 1988 to a low of 3.4 billion in 1999. At the same time timber harvests in Metropolitan Portland have ranged from 860 million board feet in 1986 to a low of 347 million board feet in 1988. While the range is the same, it may be worth observing that not only do the peaks and valleys between these statistics differ as noted above, but in Figure Three below, the share of employment and harvest occurring in the Metropolitan Region has generally risen in recent years.

Figure 3: Portland's Share of State Harvest and Employment in SIC 24



This study will continue in 2001-02 with a review of industry data as well as focus group sessions with industry leaders. The final results of the study will focus on not only how Portland's the lumber and wood products cluster functions but how it differs from the rest of the state, and the prospects for the industry in the future.

Creative Services

The region's creative services industry–composed of firms in advertising and public relations, film and video production, and multimedia software, and related businesses–has been a rapidly growing component of the regional economy. In an earlier project, NEO researchers prepared a detailed study of the region's creative services industry cluster.

NEO has updated its analysis of the growth of the creative services industry through the year 1999. They are drawn from the Employment Department's ES-202 file. The methodology for computing cluster employment and the industry sub-categories are the same as those we used in the creative services industry cluster study (*Designing Portland's Future: The Role of the Creative Services Industry*, June, 1999).

Table 4: Creative Services Industry Cluster Employment, 1992, 1998 and 1999, Portland Metropolitan Area

	Employment			Annual Growth Rate	
Cluster Segment	**1992**	**1998**	**1999**	**1992-98**	**1998-99**
Advertising Agencies and Services	1,626	2,312	2,365	5.9%	2.3%
Advertising, Commercial Photo, Graphic Design	919	1,183	1,301	4.2%	10.0%
Computer Software, Integration and Data Processing	4,436	8,241	9,501	10.3%	15.3%
Motion Pictures	747	1,243	1,332	8.5%	7.2%
Theatrical Producers and Services	311	682	676	13.1%	-0.9%
Public Relations Services	173	575	582	20.0%	1.2%
Total	8,212	14,236	15,757	9.2%	10.7%

Source: Author's calculations from Employment Department data.
Note: Data are average annual covered employment. The Portland Metropolitan Area is the five Oregon counties of the Portland MSA.

In addition, employment data enable us to examine the industry structure of various aspects of the creative services industry. Table 5 shows the distribution of employment by firm size in 1999 for metro area creative services firms. Table 13 shows the number of firms in each size category.

About 27 creative services firms with more than 100 employees account for a majority of all of the region's creative services employment.

Most creative services firms are quite small: roughly 650 of the region's 850 firms have fewer than ten employees (and these counts do not include many self-employed individuals not subject to the unemployment insurance laws, and therefore not included in these statistics).

Table 5 shows the distribution of employment by firm size in 1999 for metro area creative services firms. Table 5 shows the number of firms in each size category.

Table 5: Creative Services Industry Cluster Employment, 1999
By Firm Size, Portland Metropolitan Area

Firm Size	Ad/PR	Film/Video	Software	All Segments
Over 100	1,230	747	5,651	7,628
50-99	371	175	1,109	1,655
20-49	893	147	1,182	2,222
10-19	581	27	525	1,133
5-9	363	69	298	730
1-4	548	115	293	956
All Firms	3,986	1,280	9,058	14,324

Source: Author's calculations from Employment Department data.
Note: Data are average annual covered employment. The Portland Metropolitan Area is the five Oregon counties of the Portland MSA.

Table 6: Creative Services Industry Cluster Firms, 1999
By Firm Size, Portland Metropolitan Area

Firm Size	Ad/PR	Film/Video	Software	All Segments
Over 100	6	4	17	27
50-99	6	3	17	26
20-49	30	5	37	72
10-19	41	2	39	82
5-9	55	10	47	112
1-4	294	68	177	539
All Firms	432	92	334	858

Source: Author's calculations from Employment Department data.
Note: Data are average annual covered employment. The Portland Metropolitan Area is the five Oregon counties of the Portland MSA.

These data are not directly comparable to the employment totals for the region because they are calculated on a firm ownership basis, not an establishment basis. A firm can have several establishments (different locations) each with their own SIC code. Published data are aggregated by establishment SIC code. These data are aggregated by the firm's SIC code. Some employment in creative service establishments is grouped with firms in other SIC codes (not part of creative services, because their parent firm is in a different SIC code).

A Survey of the Biotech Industry

Technological change, particularly in the electronics industry, has played a key role in reshaping the metropolitan Portland economy in the past decade. It is only logical then, that many would speculate on the extent to which future technologies might trigger new development opportunities. Recent well-publicized advances in cataloging the human genome, and a local breakthrough in cancer therapy (exemplified by the local development of the drug Gleevek), have prompted considerable interest in pursuing biotechnology as a potential development strategy for metro Portland. The newly renamed Oregon Health and Sciences University (resulting from the merger of Oregon Health Science University and the Oregon Graduate Institute) has announced its own plans for "The Oregon Opportunity," a proposed $500 million program to expand the region's medical research capability in hopes of encouraging biotech related development.

In order to contribute to better regional understanding of the opportunities for biotechnology growth, the New Economy Observatory is undertaking a comparative analysis of the biotech industry in a number of different metropolitan areas in the United States. Studying and learning from the success stories of the nation's established biotechnology centers should provide useful insights to those seeking to promote biotech as a cornerstone of the region's 21st-century economy.

If there are fashions in economic development, biotechnology is clearly a highly fashionable industry. A survey of 77 local and 36 state economic development agencies reported that 83 percent have listed biotechnology as one of their top two targets for industry recruiting).[1] Clearly, the competition to be a biotech center will be keen.

Biotech is widely perceived to be the next great frontier of scientific advancement that will bring with it whole new industries. Places that failed to become the next Silicon Valley in the era of electronics, computers and the Internet, seem to believe they can become the technological and economic leaders in this new field.

What factors are responsible for the growth of biotechnology? What will cause biotech to flourish in some places (and not in others)? What opportunities do states and communities have to make themselves the hubs of a new biotech industry?

Defining Biotechnology

The term "biotechnology" is often used loosely to include any of a number of firms engaged in activities related to health care and medicine. Analyses of local industry clusters often refer to the bioscience or biomedical or medical technology industry clusters.

Biotechnology has potential applications in a wide variety of industries. Already, it is in use in agriculture (genetic engineering of plants and animals for food and fiber), in manufacturing process (food processing and chemical engineering) and even possibly in computing (bio-computers). While these are important applications, they are often more closely related to non-medical uses of biotechnology. The largest category of biotechnology applications is in health and medicine: diagnosing, treating and in some cases preventing disease.

[1] Velislava Grudkova, KPMG, May 30, 2001, Presentation to the EDA National Forum, Washington DC. "The Technology Economy: Why do Tech Companies Go Where they Go?"

Because this is the largest segment of the biotech industry we will focus on these therapeutic and diagnostic applications of biotechnology.

It is important to note the biotechnology is not synonymous with medical technology or even high-tech medicine. There are a number of medical technologies and disciplines that are unconnected to genetic and cellular manipulation. There is a wide variety of medical device manufacturers, producing everything from diagnostic instruments to surgical tools to physical prostheses. We do not include these firms in biotechnology. Nor do we include firms developing software or information technology for medical records, epidemiology and other purposes. While these are important technologies they are generally distinct from the genetic and cellular techniques that are the hallmark of biotechnology. (An important exception is software and tools for gene sequencing and analysis.)

Standard Industrial Classification Code

The standard industrial classification code doesn't have any single or exclusive category for biotechnology firms. Most biotechnology firms seem to be concentrated in two sets of SIC code categories. SIC 283 includes all manufacturers of pharmaceuticals, including firms making therapeutic and diagnostic substances, vitamins, drugs and similar products. Because many biotech firms research their products, but don't manufacture them (either because they aren't yet ready for manufacture, or because manufacturing is undertaken by some other firm, typically under license) many biotech firms are not classified as manufacturers. SIC 873 includes firms engaged in commercial and non-commercial research.

SIC 283: Pharmaceuticals
SIC 8734: Non-Commercial Physical Research (part)
SIC 8731: Commercial Physical and Biological Research

North American Industry Classification System

The NAICS which is gradually succeeding the SIC as the system for classifying business activity makes many changes to better address rapidly changing technology. In the area of biotech, however, NAICS essentially replicates the SIC framework. Most of SIC 283 carries over into NAICS 3254 (pharmaceutical and medicine manufacturing). Research activities formerly in SIC 873 are almost all included in the new NAICS category 54171 research and development in the physical, engineering and life sciences.

NAICS 3254 Pharmaceutical and Medicine Manufacturing
NAICS 5417102 Research and Development in the Life Sciences

Industry Characteristics

The biotech and pharmaceutical industries have a number of important characteristics that distinguish them from other industries (and from each other).

Here we briefly overview the history and development of the industry, the current structure of the industry, and some of the important aspects of the regulatory and competitive environment that affect firms in the industry.

The 1997 Economic Census provides data on the number of firms, employment, and sales of firms in the pharmaceutical and related industries. As noted in our analysis of industry definitions, these categories include a broader of activities that simply biotechnology. Overall, the industry has total sales of more than $93 billion. Nearly 1,500 firms employed nearly 200,000 employees in these industry segments.

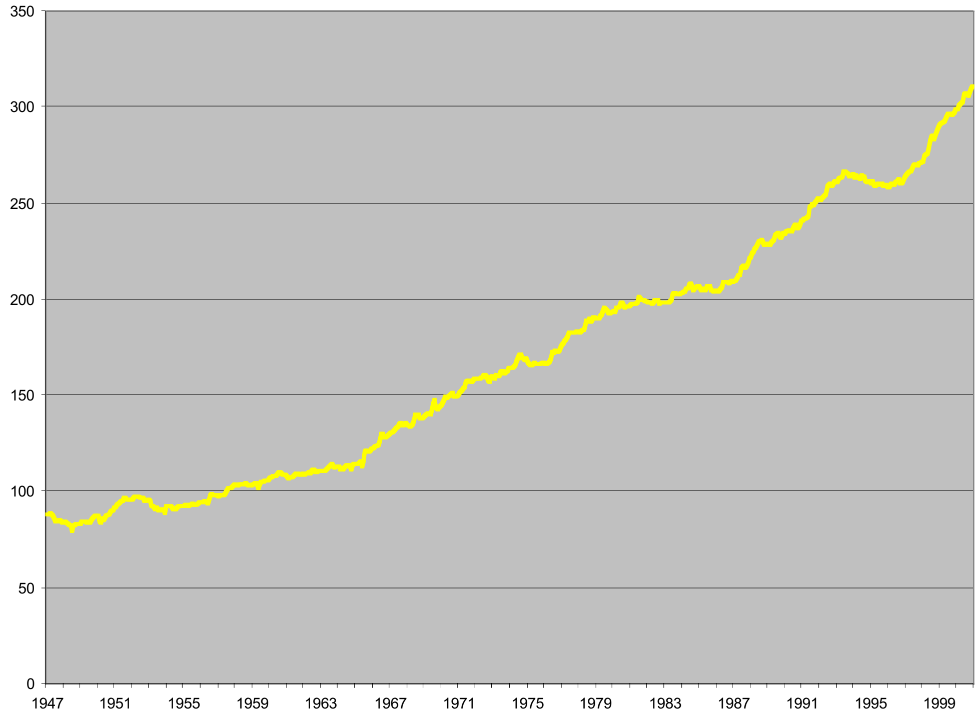
Table 7: Pharmaceutical and Biological Industry Employment and Sales, U.S., 1997

NAICS	Industry	Companies	Employment	Sales
325411	Medicinals/Botanicals	312	23,378	11,920,571
325412	Pharmaceuticals	710	115,781	67,520,044
325413	Diagnostic Substances	202	36,502	8,145,884
325414	Biological Products, except Diagnostic	268	23,285	5,685,943
5417102	Research & Development in the Life Sciences	4,044	98,279	11,722,721
Total		**5,536**	**297,225**	**104,995,163**

Source: Census Bureau, 1997 Economic Census

The pharmaceutical industry as a whole employs about 300,000 persons in the US. The industry has added about 100,000 jobs in the last 15 years. Year to year growth has been uneven; employment declined in the mid-1990s but rebounded and grew rapidly in the final years of the decade. (Census data organized by NAICS code are available only for 1997, so to illustrate the time trade, we have used data from the older SIC classification as reported by BLS for the period 1947 through 2000.

Figure 4: Employment in Pharmaceutical and Related Firms, 1947-2000



Source: Bureau of Labor Statistics

Within the field of biotechnology, there are two broad categories of firms. One set of firms was founded for the purpose of exploring and developing new technology. The other set is established firms applying biotechnology to their current businesses. In medical biotechnology, there are two principal types of firms: biotechnology research firms and pharmaceutical firms. Biotechnology research firms tend to be small, fairly recently established, and devote most of their resources to research and development. Pharmaceutical firms are much larger, much older, and have large, well-developed manufacturing and marketing operations, often world-wide in scale. The industry is led by US-based giants like Merck and Bristol-Myers-Squibb and European-based firms like Bayer and Novartis.

Firms tend not to move between these categories—small biotech firms, even extraordinarily successful ones—do not grow into large pharmaceutical firms. Instead, biotech research firms tend to sell, license, or joint-venture their technologies or sell their entire companies to larger pharmaceutical firms. The high cost of scaling up to global scale manufacturing and distribution and the profoundly different business skills required discourage small research firms from growing internally.

The result is huge differences in the apparent optimal scale of biotech research firms and pharmaceutical firms. Dibner (2000) calls them "Davids" and

"Goliaths." A study by Ernst and Young estimated that the typical pharmaceutical corporation is four decades older, and a hundred times larger (measured by employment or sales) than the typical biotech research firms.

Judged by annual revenues, pharmaceutical firms are much larger than their biotech brethren. According to rankings of revenue of publicly-traded U.S.-based firms, Biogen, the largest U.S. biotech company, would be smaller than each of the ten largest pharmaceutical firms. The tenth largest U.S. pharmaceutical firm has sales ($7.25 billion) in excess of the combined sales of the ten largest biotech firms ($6.99 billion). While the U.S. has the largest concentration of small biotechnology research firms, many of the world's largest biotech firms are located in other nations, particularly in Europe. Global leaders in pharmaceuticals include Novartis (Switzerland), Hoffman-LaRoche (Switzerland), Glaxo-Wellcome (Great Britain) and Bayer (Germany). These firms not only sell their products in the US, but many have US subsidiaries, or joint ventures with US firms. (OHSU's research on Gleevec was done for Novartis, which owns the patent on the drug).

Table 8: Sales and Sales Rank of Ten Largest U.S. Biotech Companies, 1999

Rank	Biotech Company	Sales ($)
1	Amgen Inc.	3,340,100,000
2	Biogen Inc.	794,435,000
3	Genzyme Corp	772,288,000
4	Immunex Corp	541,718,000
5	Life Technologies Inc.	409,609,000
6	Medimmune Inc.	383,375,000
7	Nabi	233,603,000
8	Charles River Laboratories Inc.	219,276,000
9	Gilead Sciences Inc.	168,979,000
10	Serologicals Corp	129,744,000
	Total	6,993,127,000

Source: PriceWaterhouseCoopers Edgarscan (2001)

Table 9: Sales and Sales Rank of Ten Largest US Pharmaceutical Companies, 1999

Rank	Pharmaceutical Company	Sales ($)
1	Merck & Co., Inc..	32,714,000,000
2	Bristol-Myers-Squibb Co.	20,222,000,000
3	Columbia Laboratories Inc..	18,921,074,000
4	Pfizer Inc.	16,204,000,000
5	American Home Products Corp.	13,550,176,000
6	Abbott Laboratories	13,177,625,000
7	Warner Lambert Co.	12,928,900,000
8	Eli Lilly & Co.	10,002,900,000
9	Schering Plough Corp.	9,176,000,000
10	Pharmacia & Upjohn Inc.	7,253,000,000

Source: PriceWaterhouseCoopers Edgarscan (2001)

The geography of the pharmaceutical and biotech firms tends to differ as well. Seven of the nation's ten largest pharmaceutical firms are headquartered in the New York-Philadelphia corridor. None of the ten largest biotech firms is found in this area. (PriceWaterhouseCoopers Edgarscan data, based on 1999 sales).

There is also a huge difference in profitability between biotech research firms and pharmaceutical firms. Most small biotech firms are losing money. According to Ernst and Young, the typical biotech firm spent $8.4 million on research and development and earned revenues of $2.5 million in 1998. In contrast, pharmaceutical firms tend to be extremely profitable. Merck & Company, one of the largest pharmaceutical houses, had net income of $4.6 billion an amount greater than the collective $3.4 billion loss of all of the biotech research firms combined.

Differences in size produce differences in volatility. Biotech research firms regularly rise and fall, according to industry observers. Dibner estimates that half of the biotech firms formed since the 1970s had folded, or been merged into other companies (2000). Pharmaceutical firms, as noted, tend to be much more long-lived, although recently there has been a wave of mergers among the industry leaders, producing even larger firms.

The pharmaceutical and biotech industries are also characterized by very widespread ties between firms. These ties take the form of cross-ownership, licensing, joint ventures and research agreements. Large pharmaceutical firms often invest in promising research at smaller biotech firms. Small firms obtain access to regulatory expertise, manufacturing and marketing capability. Firms frequently share technology: Recombinant Capital, a research firm specializing in the biotechnology industry reports more than 10,000 industry alliances over the past decade (www.recap.com).

Regulatory/Market Issues

In many respects, biotechnology is the quintessential knowledge based-industry. Genetic material is analogous to encoded information. Many of the advances in biotechnology stem from developing a better understanding of how genetic processes work and what genes are responsible for which traits and diseases.

It is no surprise then, that intellectual property is a defining feature of the biotechnology industry. Biotechnology involves the creation of new ideas through research, the development of new products and processes embodying these ideas, the testing of the efficacy of these products and the communication of this information to physicians and patients.

Government policy plays important roles in almost every stage of the biotechnology industry. Government support for basic and applied research provides much of the knowledge on which new products are based. The government heavily subsidizes the training of medical researchers. Patents on drugs, diagnostic products and most recently gene sequences, codify the ownership of particular kinds of knowledge. Patent policy is set by Congress and administered by the US Patent and Trademark Office. Most biotechnology products cannot be offered for sale unless their safety and efficacy has been approved by the Food and Drug Administration.

The FDA also regulates the conditions for manufacturing pharmaceuticals and their advertising to consumers. Finally, government policy on health care, particularly the decision of whether to include coverage for particular drugs or therapies in national health care programs like Medicare and Medicaid influence the demand for drugs. It is difficult to understate the importance of these governmental decisions to the performance of this industry. Everything from fundamental questions of policy—can a gene sequence be patented?—to mundane administrative trivia has a profound effect on industry development. For example, at one point the patent office had accumulated a backlog of more than 11,000 biotechnology-related patent applications, producing enormous uncertainty over property rights and product development (Dibner, 2000).

Regional Analysis

Economists and regional scientists have increasingly come to agree that industries frequently tend to cluster in relatively small geographic areas. The advantages of agglomeration, including a wide and deep talent pool, a market for specialized suppliers and the easy flow of information give such places critical mass. Clustering seems to be particularly important for knowledge-based industries, like electronics, where Silicon Valley continually generates new technologies, new products and new companies.

A variety of indicators illustrate the variations in the concentration of biotechnology activity among metropolitan areas. A preliminary examination of data on employment, patents, research funding, venture capital and the population of scientists and technicians helps us to identify those places that appear to have the strongest concentrations of biotechnology related activity in the US.

Employment

Biotech industry employment is clustered in a few metropolitan areas in the United States. In order to gain a broad overview of the spatial distribution of biotech employment, we examined the rankings of the top biotech employment centers on two levels of spatial analysis: first, primary metropolitan statistical areas (PMSAs) and second, consolidated metropolitan statistical areas (CMSAs) which are groups of adjacent primary metropolitan statistical areas. Both analyses show that biotech is concentrated in a few metropolitan areas in the US. The New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSAs is the leader in employment in the pharmaceutical and medicine manufacturing sector (NAICS 3254) as well as in the segment of research and development in the life sciences (NAICS 5417102).

Table 10: Top 20 CMSAs in NAICS 3254: Pharmaceutical and medicine manufacturing

	Geography	Est.	Sales	Annual payroll ($1,000)	Employees
1	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSA	130	13,022,476	1,218,607	22,578
2	Chicago-Gary-Kenosha, IL-IN-WI CMSA	37	4,020,908	1,008,278	18,753
3	Los Angeles-Riverside-Orange County, CA CMSA	134	4,873,133	475,380	11,885
4	San Francisco-Oakland-San Jose, CA CMSA	77	2,094,597	637,334	11,302
5	Philadelphia, PA--NJ PMSA	54	9,362,871	527,975	8,961
6	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	67	951,387	137,235	6,945
7	St. Louis, MO--IL MSA	35	1,316,859	182,056	4,581
8	Fort Worth--Arlington, TX PMSA	13	D	D	3,750
9	Indianapolis, IN MSA	10	D	D	3,750
10	New London--Norwich, CT--RI MSA	2	D	D	3,750
11	Raleigh--Durham--Chapel Hill, NC MSA	19	6,057,670	164,571	3,679
12	San Diego, CA MSA	58	578,091	153,056	3,547
13	Grand Rapids--Muskegon--Holland, MI MSA	8	725,239	124,705	3,019
14	Kalamazoo--Battle Creek, MI MSA	7	585,259	148,441	2,816
15	Kansas City, MO--KS MSA	24	2,180,531	101,052	2,477
16	Memphis, TN--AR--MS MSA	9	704,628	78,262	2,240
17	Denver-Boulder-Greeley, CO CMSA	34	D	D	2,125
18	Washington, DC--MD--VA--WV PMSA	25	308,412	90,703	1,750
19	Greenville, NC MSA	3	D	D	1,750
20	Greenville--Spartanburg--Anderson, SC MSA	6	D	D	1,750

Source: Economic Census 1997

The pattern of geographic concentration of employment is also apparent when we analyze the industry on the PMSA level. Here, the primary metropolitan statistical areas of Chicago, Newark, Philadelphia, Middlesex-Sommerset-Hunterdon, and Los Angeles are the areas with at least 5,000 employees (Table 11).

Table 11: Top 20 PMSAs in NAICS 3254: Pharmaceutical and medicine manufacturing

	Geography	Est.	Sales	Annual payroll ($1,000)	Employees
1	Chicago, IL PMSA	34	4,020,908	1,008,278	17,003
2	Newark, NJ PMSA	44	8,476,047	729,625	10,996
3	Philadelphia, PA--NJ PMSA	54	9,362,871	527,975	8,961
4	Middlesex--Somerset--Hunterdon, NJ PMSA	35	3,065,702	455,442	7,229
5	Los Angeles--Long Beach, CA PMSA	70	2,327,351	245,530	5,775
6	Orange County, CA PMSA	52	2,345,800	205,847	4,743
7	St. Louis, MO--IL MSA	35	1,316,859	182,056	4,581
8	Oakland, CA PMSA	25	692,924	266,555	4,163
9	San Francisco, CA PMSA	29	942,411	256,326	3,846
10	Fort Worth--Arlington, TX PMSA	13	D	D	3,750
11	Indianapolis, IN MSA	10	D	D	3,750
12	New London--Norwich, CT--RI MSA	2	D	D	3,750
13	Raleigh--Durham--Chapel Hill, NC MSA	19	6,057,670	164,571	3,679
14	San Diego, CA MSA	58	578,091	153,056	3,547
15	Boston, MA--NH PMSA	49	912,350	128,336	3,360
16	Grand Rapids--Muskegon--Holland, MI MSA	8	725,239	124,705	3,019
17	Kalamazoo--Battle Creek, MI MSA	7	585,259	148,441	2,816
18	Kansas City, MO--KS MSA	24	2,180,531	101,052	2,477
19	Memphis, TN--AR--MS MSA	9	704,628	78,262	2,240
20	Monmouth--Ocean, NJ PMSA	8	239,718	33,540	1,869

Source: Economic Census 1997
(D- Suppressed to prevent disclosure of firm level data.)

The consolidated metropolitan statistical areas centered on New York, Boston, San Francisco and Washington play an important role in the clustering of research and development activity in the life sciences. Life science research activity, in general, tends to cluster in urban agglomerations on the East and West Coasts.

Table 12: Top 20 CMSAs in NAICS 5417102: Research and development in the life sciences

	Geography	Est.	Sales ($1,000)	Annual payroll ($1,000)	Employees
1	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSA	382	753,582	352,113	14,328
2	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	284	D	D	11,249
3	San Francisco-Oakland-San Jose, CA CMSA	353	1,444,906	631,508	9,674
4	Washington-Baltimore, DC-MD-VA-WV CMSA	284	D	D	7,499
5	San Diego, CA MSA	181	951,602	421,086	7,487
6	Seattle-Tacoma-Bremerton, WA CMSA	102	D	D	5,499
7	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD CMSA	129	534,007	169,692	4,539
8	Los Angeles-Riverside-Orange County, CA CMSA	204	495,670	181,809	4,522
9	Raleigh-Durham-Chapel Hill, NC MSA	90	155,676	69,491	3,356
10	Albany-Schenectady-Troy, NY MSA	17	D	D	2,124
11	Denver-Boulder-Greeley, CO CMSA	81	121,932	76,440	1,501
12	Chicago-Gary-Kenosha, IL-IN-WI CMSA	91	D	D	1,499
13	San Antonio, TX MSA	34	D	D	1,124
14	Houston-Galveston-Brazoria, TX CMSA	56	66,735	29,173	943
15	Minneapolis-St. Paul, MN-WI MSA	70	59,856	26,318	930
16	Madison, WI MSA	24	D	D	924
17	Austin-San Marcos, TX MSA	20	81,851	55,394	890
18	Buffalo-Niagara Falls, NY MSA	14	D	D	750
19	Indianapolis, IN MSA	16	D	D	750
20	Wilmington, NC MSA	6	D	D	750

Source: Economic Census 1997

(D- Suppressed to prevent disclosure of firm level data.)

Table 13: Top 20 PMSAs in NAICS 5417102: Research and development in the life sciences

	Geography	Est.	Sales ($1,000)	Annual payroll ($1,000)	Employees
1	Boston, MA--NH PMSA	239	853,652	371,169	8,629
2	New York, NY PMSA	147	734,836	280,140	8,269
3	San Diego, CA MSA	181	951,602	421,086	7,487
4	Washington, DC--MD--VA--WV PMSA	223	994,616	345,626	6,973
5	Seattle--Bellevue--Everett, WA PMSA	91	D	D	5,499
6	Philadelphia, PA--NJ PMSA	119	530,924	168,576	4,506
7	San Jose, CA PMSA	134	731,872	273,366	4,347
8	San Francisco, CA PMSA	118	350,124	184,837	3,379
9	Raleigh--Durham--Chapel Hill, NC MSA	90	155,676	69,491	3,356
10	Los Angeles--Long Beach, CA PMSA	119	310,181	116,175	3,343
11	Newark, NJ PMSA	29	172,696	111,216	2,596
12	Albany--Schenectady--Troy, NY MSA	17	D	D	2,124
13	Middlesex--Somerset--Hunterdon, NJ PMSA	53	D	D	1,924
14	Boulder--Longmont, CO PMSA	17	D	D	1,750
15	Oakland, CA PMSA	84	172,229	89,168	1,658
16	Chicago, IL PMSA	90	D	D	1,499
17	Houston, TX PMSA	52	D	D	1,124
18	Nassau--Suffolk, NY PMSA	39	D	D	1,124
19	San Antonio, TX MSA	34	D	D	1,124
20	Baltimore, MD PMSA	61	D	D	1,124

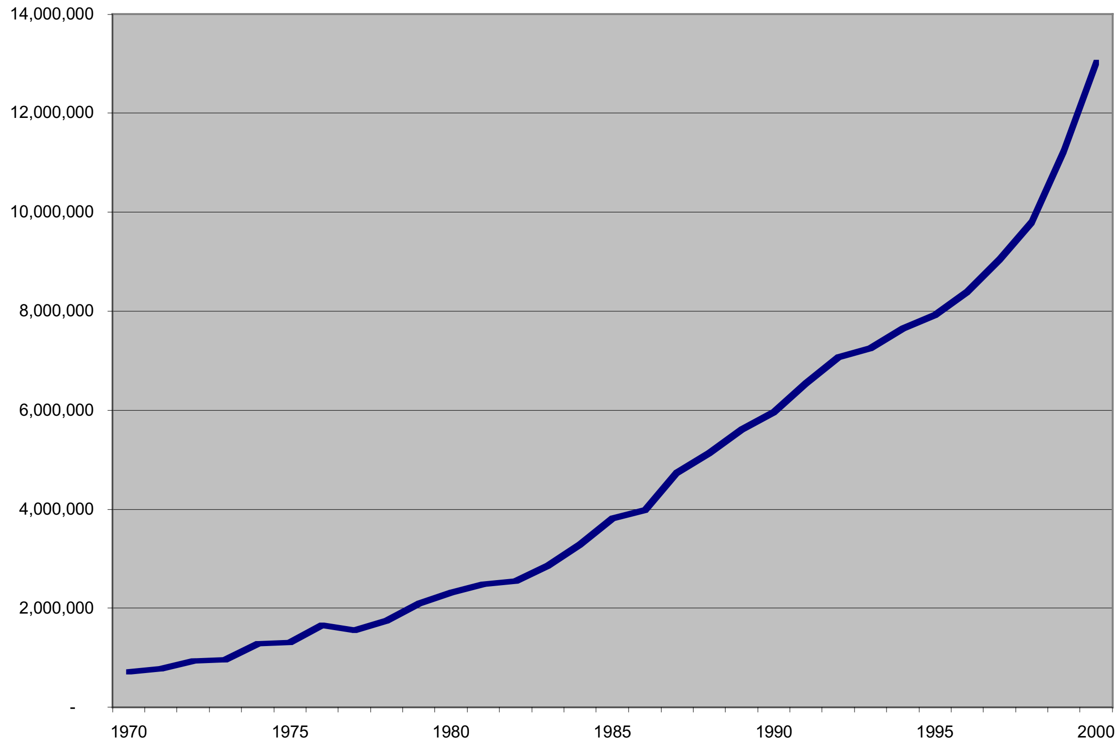
Source: Economic Census 1997
(D- Suppressed to prevent disclosure of firm level data.)

Research and Development Activity

Scientific advance is the driving force behind the growth of the biotechnology industry. The federal government's generous and growing support for medical and biological research helps seed the creation of new ideas and not incidentally supports the education and training of new research scientists.

While a wide variety of federal agencies providing funding for research and training related to medicine, health, biotechnology and to related fields like agriculture, the largest single funder of such research is the National Institutes of Health. Over the past decade the growth rate of spending for NIH extramural research has been 7.8 percent annually. Total NIH spending for research has more than doubled from about $6.5 billion in 1991 to more than $13 billion in 2000.

Figure 5: NIH Funding for Research and Training



Source: National Institutes of Health

Through the National Institutes of Health (NIH) the government provides funding for research activities of universities, medical schools, research institutions, and in some cases, private firms. In 1999, the NIH disbursed a total of $10.3 billion for research activities (National Institutes of Health 2000). Public support for biomedical research is large relative to the scale of the biotech industry. In 1998, the total research and development budgets of biopharmaceutical firms were $6.6 billion (Dibner, 1999).

Funding is disbursed to research programs throughout the nation, but goes disproportionately to areas with a large, well-established research infrastructure. Table 14 illustrates the distribution of NIH research funding by metropolitan area for 1999.

Table 14: NIH Research Funding, Selected Metropolitan Areas, 1999

Metropolitan Area	Research Funding ($)
Boston	1,247,698,372
New York	859,592,052
San Francisco	609,931,748
San Diego	577,369,565
Philadelphia	509,828,141
Raleigh Durham	488,277,716
Baltimore	479,981,425
Seattle	460,078,331
Washington	361,257,225
Los Angeles	359,626,035

Source: National Institutes of Health, 2001

Patents

Patent data provide an illuminating view of the biotech industry for a variety of reasons. Because the industry is predicated on knowledge creation and intellectual property, firms and researchers generally seek to patent new products and processes. This is particularly important in the structure of the industry as small firms develop their intellectual property and sell it to larger firms for manufacture and distribution.

Patent data are classified according to product or technology characteristics. While many patent classifications overlap with the biotechnology industry, including a variety of instruments used in medical and genetic research, and database technologies for epidemiological research and genetic studies, most biotechnology patents fall into relatively few categories. Four categories account for more than 27,000 patents issued between 1995 and 1999, and represent three (Class 424, 435 and 514) of the five patent classes with the most patents issued over this time period.

Table 15: Number of Patents in the Principal Biotechnology/Pharmaceutical Patent Classifications in the US, 1995-1999

Patent Classification	Description	Patents Issued 1995-1999
Class 424	Drug, Bio-Affecting and Body Treating Compositions	6,962
Class 435	Chemistry: Molecular Biology and Microbiology	9,777
Class 514	Drug, Bio-Affecting and Body Treating Compositions	9,546
Class 800	Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes	1,246
Total Biotech Patenting in the U.S.		**27,531**

Source: U.S. Patent and Trademark Office,

These patent classifications represent a large and growing fraction of all of the patents issued in the U.S. Between 1995 and 1999 these categories represented 8 percent of all of the patents issued in the United States. In 1995, these biotech-related categories represented about 5.6 percent of the patents issued in the U.S., by 1999, they were 8.8 percent of all the patents issued in the U.S. Even while these four patent categories are not an exhaustive list of all of the possible categories into which biotech-related innovations might fall, they are likely to encompass most of the patented biotechnology innovation, and therefore serve as a representative indicator of regional variations in biotech activity.

Tables 16 through 19 show the number of patents issued to the ten leading patentees in each of our four biotechnology-related patent classifications. “Individually owned patents” are patents owned by an individual rather than assigned to a corporation or other entity. Most patents are held by corporations, universities or government agencies which finance the research that leads to the patentable idea. Most patents are owned by private firms. Because they sponsor a considerable amount of research, universities and government agencies are large patent owners. The nation’s leading pharmaceutical and biotechnology companies appear frequently in the list of the most prolific biotech patentees, but none accounts for more than a small share of all patents. Procter and Gamble, for example, the largest drug patent holder (class 424) accounted for less than 5 percent of the patents issued in that category. (Although Pioneer Hi-Bred, a seed producer, accounts for about one-sixth of patents issued in the new class 800).

Table 16: Patents by organization for patent class 424: Drug, Bio-Affecting and Body Treating Compositions

	Company Name	1995	1996	1997	1998	1999	total
1	Individually Owned Patent	103	126	170	216	240	855
2	Procter & Gamble Company	31	31	73	61	109	305
3	United State of America, Health and Human Services	9	10	19	35	29	102
4	University of California	11	20	16	31	23	101
5	Alza Corporation	9	14	25	16	33	97
6	Colgate-Palmolive Company	8	15	21	26	27	97
7	Chesebrough-Pond's USA Co., Division of Conoco, Inc..	10	16	15	25	15	81
8	Genentech, Inc..	3	7	17	25	9	61
9	University of Texas	11	8	14	9	15	57
10	United States of America, Department of Agriculture	9	6	9	17	15	56

Table 17: Patenting by organization by patenting class 435: Chemistry: Molecular Biology and Microbiology

	Company Name	1995	1996	1997	1998	1999	total
1	Individually Owned Patent	76	84	123	144	161	588
2	Incyte Pharmaceuticals, Inc..		2	12	81	188	283
3	University of California	24	45	57	82	67	275
4	United State of America, Health and Human Services	28	44	44	57	48	221
5	Becton, Dickinson and Company	13	31	47	48	25	164
6	Genentech, Inc..	13	16	34	59	17	139
7	Smithkline Beecham Corporation	1	1	6	29	97	134
8	Abbott Laboratories	6	13	31	33	34	117
9	John Hopkins University	8	8	11	39	41	107
10	University of Texas	13	17	20	34	22	106

Table 18: Patenting by organization for patent class 514: Drug, Bio-Affecting and Body Treating Compositions

	Company Name	1995	1996	1997	1998	1999	total
1	Individually Owned Patent	97	131	150	173	186	737
2	Eli Lilly and Company	77	135	134	112	103	561
3	Merck +Co., Inc..	58	78	90	98	128	452
4	G.D. Searle & Co.	78	33	47	38	43	239
5	Pfizer Inc..	30	34	47	58	50	219
6	American Home Products Corporation	45	80	20	29	26	200
7	Bristol-Myers Squibb Company	42	38	48	35	31	194
8	Warner-Lambert Company	37	30	42	25	46	180
9	Abbott Laboratories	24	44	39	31	30	168
10	United State of America, Health and Human Services	17	22	42	39	24	144

Table 19: Patenting by organization for patent class 800: Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes

	Company Name	1995	1996	1997	1998	1999	total
1	Pioneer Hi-Bred International, Inc..	13	40	20	80	75	228
2	Asgrow Seed Company	-	5	30	29	12	76
3	DeKalb Genetics Corporation	3	11	-	7	46	67
4	Individually Owned Patent	2	2	5	18	19	46
5	Monsanto Company Inc..	3	12	11	8	11	45
6	Monsanto Corporation	-	-	-	1	42	43
7	Holden's Foundation Seeds, Inc..	7	6	7	9	12	41
8	University of California	1	5	7	8	16	37
9	E.I. Du Pont de Nemours and Company	2	4	4	8	7	25
10	Iowa State University Research Foundation	-	5	5	11	4	25

The amount of biotech patenting varies substantially across regions. With more than 2,000 biotech related patents, Boston clearly being the center for biotechnology innovation in the period between 1995 and 1999. San Diego, Washington D.C. and San Francisco each accounted for more than 1,000 biotech related patents in this five year period.

Table 20: Biotech Patenting by Region, 1995-1999

	Class 424: Drug, Bio-Affecting and Body Treating Compositions	Class 435: Chemistry: Molecular Biology and Microbiology	Class 514: Drug, Bio-Affecting and Body Treating Compositions	Class 800: Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes	Total Biotech Patents, 1995-1999
Boston	565	988	576	23	2,152
San Diego	643	384	187	28	1,242
Washington D.C.	321	508	287	22	1,138
San Francisco	200	622	283	27	1,132
San Jose	205	551	209	15	980
New York	251	345	344	14	954
Chicago	175	254	391	15	835
Oakland	135	352	163	24	674
Raleigh Durham	103	245	173	44	565
Seattle	111	274	139	-	524
Los Angeles	165	215	121	11	512
Baltimore	80	210	131	20	441
Minneapolis	132	107	56	20	315
Atlanta	72	71	62	-	205
Salt Lake	65	69	46	2	182
Denver	33	62	41	1	137
Portland	9	50	19	8	86
Austin	13	32	19	1	65
Phoenix	24	10	26	2	62
Sacramento	3	9	9	-	21

Source: Department of Commerce, Patent Office

Capital

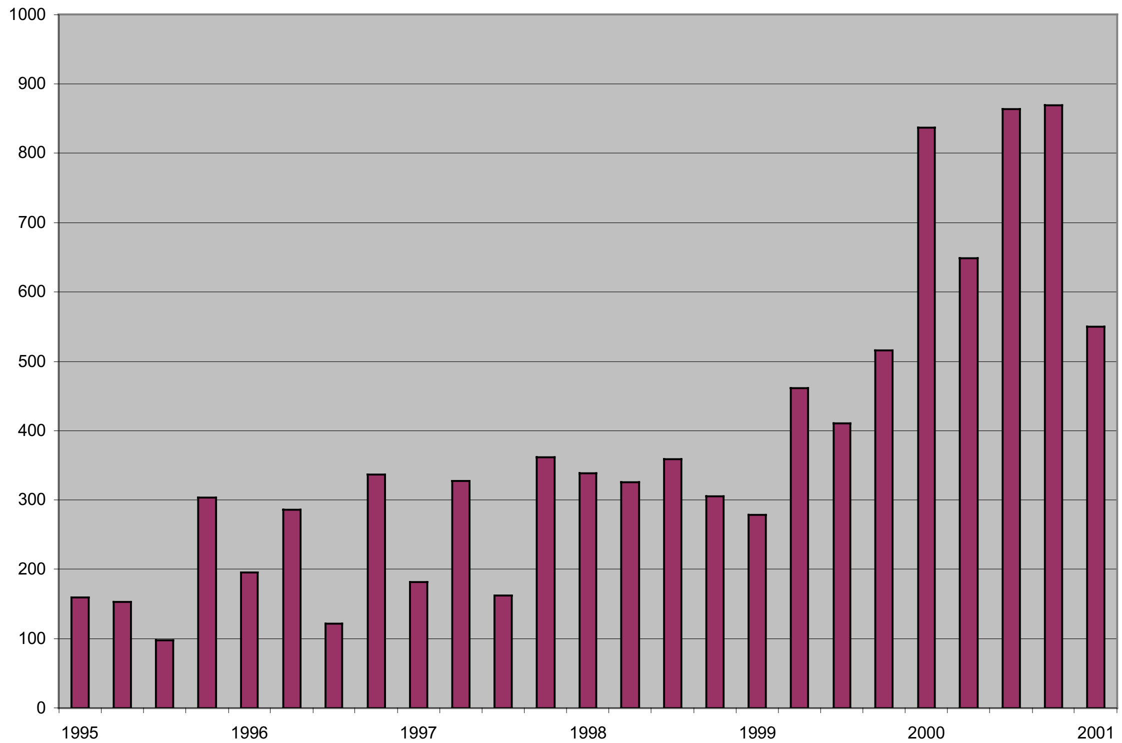
The availability of capital plays an important role in the development of the biotech industry. Not only does biotechnology require expensive and time-consuming research, but once developed, promising diagnostics and therapeutics must undergo a long testing and regulatory approval process. Much research and many promising products often fail to produce revenue. Consequently, large amounts of patient capital are required to develop and sustain the biotech industry. We trace out three measures of capital flows to the biotech industry, each reflecting different phases in the life cycle of firms and the development of products.

As noted previously, pre-venture financing for the creation of new biotech knowledge comes substantially from the federal government through its support of health related research. In addition there is a small role for self-financed firms and so-called angel investment (individual private investors underwriting the finances of start-up firms). But by far the most important source of start-up capital for the biotech industry is organized venture capital: private investments made by professional fund managers, typically specializing in a related set of technologies. Venture capital funds firms at their inception and usually funds research and product development needed to prove the potential of a research idea. A firm may get one or several rounds of venture capital financing as it develops its products. Because of the considerable expense and long lead times associated with developing and proving novel diagnostic and therapeutic products, patient venture capital is essential to the start-up of firms which may go several years before generating revenues.

Once developed, venture capitalists and other early stage investors seek to recoup their investment (or a portion of it) by having the firm issue stock to the public in an "initial public offering" or IPO. IPO financing is shaped both by the maturity of the firm and its product and the general state of the capital markets (enthusiasm for IPOs waxes and wanes with fluctuations in the overall stock market). Once in the public stock market, we can assess the relative flow of capital to biotech firms by examining their market capitalization - i.e. the value of the company's stock at its current market price.

Venture capital is a good leading indicator of the development of ideas into potential businesses. In 2000, during the midst of a capital market boom, biotech firms attracted more than $3 billion in venture capital investments. Biotech investments, which averaged less than $300 million per quarter between 1995 and 1998 were over $800 million per quarter in 2000. Still, biotech was not as popular as other investments: Biotech accounted for about 10 percent of all venture capital invested in 1995, and about 5 percent in 2000.

Figure 6: Venture Capital Investments in Biotechnology, 1995-2001 (millions)



Source: PriceWaterhouseCoopers MoneyTree 2001

Venture capital investments tend to be highly concentrated in relatively few metropolitan areas. This seems especially true for venture capital invested in biotechnology, as illustrated in Table 28.

Table 21: Biotechnology Venture Capital Investments, Ten Leading Metropolitan Areas, Fourth Quarter 1999 to Third Quarter 2000

Metropolitan Area	Venture Capital ($)
San Francisco-Oakland-San Jose, CA	724,247,748
San Diego, CA	278,420,000
Boston-Lawrence-Salem-Lowell-Brockton, MA	246,317,000
NY, Northern NJ, Long Island, NY-NJ-CT	141,400,000
Seattle-Tacoma, WA	127,656,000
Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD	88,397,009
New Haven-Waterbury-Meriden, CT	83,700,000
Raleigh-Durham, NC	65,100,000
Madison, WI	48,000,000
Denver-Boulder, CO	46,390,976

Source: Price Waterhouse Coopers Moneytree

Biological Scientists and Technicians

As a knowledge-based industry, biotechnology is highly dependent on the availability of specially trained professionals, particularly research scientists and technicians. One survey of biotech firms indicates that a majority of their activities involve research and development, making access to highly skilled personnel a critical location factor (Dibner, 2000). These persons tend to be heavily concentrated in a relatively few metropolitan areas.

Occupational data compiled by the US Bureau of Labor Statistics illustrate the patterns of concentrations of life scientists. (These data are not strictly comparable across metropolitan areas because data for some occupational categories is suppressed for particular metropolitan areas, either because there are so few persons in those occupations, or because a large fraction of such persons work for a single firm).

Table 22: Estimated Employment in Life Sciences Occupations, 1998

Metropolitan Area	Employment
New York, NY CMSA	11,730
Boston, MA-NH CMSA	9,740
Washington, DC-MD-VA-WV PMSA	9,500
San Francisco, CA CMSA	5,760
Los Angeles-Long Beach, CA CMSA	5,210
San Diego, CA MSA	4,080
Philadelphia, PA-NJ PMSA	3,530
Seattle-Bellevue-Everett, WA PMSA	3,040
Minneapolis-St. Paul, MN-WI MSA	2,740
Baltimore, MD PMSA	1,770

Note: Contains occupations such as biological scientists, medical scientists, all other life scientists, biological, agricultural, and food technicians and technologists, except health
Source: Bureau of Labor Statistics

Next Steps: Understanding the Biotech Industry

This preliminary analysis illustrates the major characteristics of the biotechnology industry and identifies the chief concentrations of biotechnology activity in the US. In the next phase of our research we will look in depth at the processes of development of biotech activity in different metropolitan areas.

- **Data Analysis**

Using the data on employment, patents, investment, and trained professionals, we will quantify the relative size of biotechnology complexes in different metropolitan areas. We will use these data to examine the relationships between research spending and the successful development of the biotech industry.

- **Metropolitan Profiles**

For each of the leading biotechnology complexes identified in our data analysis, we will construct a profile of that area's biotech industry, identifying principal firms and research institutes, examining technological specializations, and assembling information from case studies of the development of biotech in each area.

- **Sub-Regional Analysis**

Finally, we will use Geographic Information Systems to map the metropolitan location patterns of biotech industries. To what extent are they proximate to research institutions, located in central cities, clustered near one another, etc?

- **Tentative Metropolitan Areas Included**

Based on our preliminary analysis, the Portland metro area and six other metro areas are our highest priorities for inclusion in the study.

- Portland-Vancouver OR-WA, MSA
- Boston, MA MSA
- Washington, DC-MD-VA MSA
- Raleigh-Durham, NC, MSA
- Seattle-Everett, WA MSA
- San Francisco, Oakland, San Jose, CA CMSA
- San Diego, CA MSA

Table 23 provides an illustration about the employment patterns in these metro areas.

Table 23: Total Biotech Employment in Selected Metro Regions, 1997

Metropolitan Area	**NAICS 3254:** Pharmaceutical and medicine manufacturing	**NAICS 5417102:** Research and development in the life sciences	**Total Biotech Employment**
San Francisco-Oakland-San Jose, CA CMSA	11,302	9,674	**20,976**
Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	6,945	11,249	**18,194**
Washington--Baltimore, DC--MD--VA--WV CMSA	6,945	7,499	**14,444**
San Diego, CA MSA	3,547	7,487	**11,034**
Washington, DC--MD--VA--WV PMSA	1,750	6,973	**8,723**
Raleigh--Durham--Chapel Hill, NC MSA	3,679	3,356	**7,035**
Seattle--Bellevue--Everett, WA PMSA	758	5,499	**6,257**
Portland--Vancouver, OR--WA PMSA	703	583	**1,286**

Source: Economic Census 1997

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