Milken Institute

The Greater Philadelphia Life Sciences Cluster

An Economic and Comparative Assessment

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Executive Summary

The life sciences industry is an emerging powerhouse for U.S. global economic competitiveness in the 21st century. Encompassing biotechnology, pharmaceuticals, medical devices, associated research and development activities and life sciences support infrastructure—including research universities, teaching hospitals, medical laboratories, venture capital firms and many other related sectors—it is one of the most knowledge-intensive and research-rich sectors of the U.S. economy. It directly and indirectly supports millions of jobs and pays above-average wages to life science industry workers. Life sciences' economic and scientific contributions propel many regions. The end result of consuming its products—better health—has immeasurable value for the national economy as well.

Key Findings

- **The Greater Philadelphia area had more than 53,000 workers in the core life sciences industry in 2003, second only to Greater New York.**
- **In 2003, the life sciences supporting industries in Greater Philadelphia employed 310,200 people.**
- **Greater Philadelphia ranked 1st on the Current Impact Index.**
- **Greater Philadelphia's life sciences industry is responsible for 276,000 total jobs (including ripple effects), or 11.4 percent of all employment and $13.7 billion, or 12.8 percent of total earnings in the region.**
- **Greater Philadelphia placed 3rd on the Innovation Pipeline Index.**
- **On the overall Life Sciences Composite Index, which merges the current impact assessment and innovation pipeline results, Philadelphia was 3rd, just behind first-place Boston and second-place Greater San Francisco.**

In the Greater Philadelphia region, the life sciences industry is a clear potential source of comparative advantage for the region's economy over the long term and it ranks among the largest clusters in the country. Close to 400 companies are engaged in core life science activities in the Greater Philadelphia region. Large multinational pharmaceutical firms such as GlaxoSmithKline, Merck, Wyeth, Johnson & Johnson and AstraZeneca have major operations in the region and serve as important anchors for the broader cluster. Many of these firms trace their regional roots back to the 19th century.

Medical device firms vary from those with foreign roots such as Synthes and affiliated companies (Switzerland), which manufacture orthopedic instruments and implants at their Paoli and West Chester, PA locations, to startups such as the Kensey Nash Corporation, recognized by *Fortune* as one of the fastest-growing publicly held small companies in America. Biotechnology firms such as monoclonal-antibodies pioneer Centocor, now a subsidiary of Johnson & Johnson, and Cephalon are important newer cluster members.

Major centers of research and human capital production include institutions from within Philadelphia proper—the University of Pennsylvania, Thomas Jefferson University, Temple University, Drexel University and University of the Sciences in Philadelphia, for example—as well as those in the region's wider catchment area—Swarthmore College, Princeton University and the University of Delaware, among others. The University of Pennsylvania's medical school, the first in the country, was the region's largest recipient of National Institutes of Health (NIH) funding to medical schools. The hospital of the University of Pennsylvania, offering a full range of diagnostic and therapeutic services, is a major teaching and clinical research institution. With respect to independent hospitals, Children's Hospital of Philadelphia was the leading recipient of NIH funding in the region. Medical research institutes include Philadelphia's Fox Chase Cancer Center and The Wistar Institute, the region's leading recipients of NIH funding to research institutes.

In this study, we benchmark and assess the current position of the Greater Philadelphia life sciences relative to 10 other leading centers, estimate the total impact on the region's economy by calculating the multiple ripple effects, evaluate how it is positioned for future growth by investigating its ongoing ability to innovate, and formulate an overall composite for the life sciences. Lastly, we offer observations and suggestions on how the region might improve upon areas where it does not hold a competitive advantage.

Since clusters rarely conform to official Metropolitan Statistical Area definitions, our study defines life science regions by combining a few MSAs and adding or removing some counties. If an MSA had a high degree of life science linkages and interaction with another adjacent MSA, essentially operating as one cluster, we combined the two metropolitan statistical areas and referred to the new geographic area as "Greater." For example, we include Mercer County, NJ (Trenton, NJ MSA) into the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA reflecting the strong linkages of Mercer County's life science companies and institutions with those of Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA. This extends the cluster to include Princeton, NJ.

We benchmarked Greater Philadelphia against these 10 metropolitan areas—Greater New York, Boston, Greater Raleigh Durham, Minneapolis, Chicago, Dallas, Greater San Francisco, Seattle, Greater Los Angeles and San Diego—based on the high concentrations of life science and related industries present in those regions. To compare the relative strengths of each life science cluster, we scaled out each component by the region's population, employment, businesses, or relevant economic output measures such as gross metro product (GMP). After conducting these scaling calculations to provide a common basis for comparisons, we combined absolute and relative performance to generate comparable scores that allowed us to provide a meaningful evaluation of Greater Philadelphia's performance to the other leading regions. This approach brings out a more true-to-life representation of the richness and national importance of the clusters.

Current Impact Assessment

The current impact assessment gauges the relative economic outcome of the life sciences industry on the regions studied by measuring employment size and growth then assessing its absolute and relative importance to the region. By measuring economic outcomes, we can gauge the effectiveness of policymakers, participants and other stakeholders in transforming life science innovations into an economic growth engine for Greater Philadelphia's residents.

The core life sciences industry definition used in this study encompasses the following four industries:

- pharmaceuticals
- biotechnology
- medical devices
- R&D in the life sciences

Besides the core life sciences industry, we also measured the overall employment contribution and concentration of 26 life sciences supporting industries since the growth of a life science cluster is fueled by its interaction with a metro's hospitals, medical practitioners, and other fast growing, knowledge-intensive life sciences related industries.

The results for the core life sciences were recorded on the life sciences current impact index, comprised of the following seven components:

- employment level in 2003,
- location quotient (LQ)[1] in terms of employment in 2003,
- relative employment growth from 1997-2003,
- number of establishments in 2003,
- number of life science industries with location quotients greater than 2.0,
- number of life science industries with location quotients less than 0.5, and finally,
- number of life science industries growing faster than the U.S. from 1997-2003.

The first four components focus on industry size and performance, while the latter three measure diversity. The core life sciences current impact composite index provides a multi-dimensional perspective of each region's current economic impact.

In 2003, Greater Philadelphia had almost 53,500 workers employed in the life sciences industry. Only Greater New York ranked higher with over 74,500 jobs in 2003. Equally important, Greater Philadelphia's concentration of core life sciences employment was nearly three times the national average, registering an LQ of 2.81 in 2003. In the composite index of the current impact measures, Greater Philadelphia ranked third in terms of core life sciences, with only Greater San Francisco and San Diego scoring higher overall.

Of seven core life science current impact measures, Greater Philadelphia was strongest in the following four: absolute employment level (second after Greater New York), employment concentration (second after Greater Raleigh Durham), relative employment growth (second after Greater Raleigh Durham), and tied for first with three other metros in the number of life science industries growing faster than the nation as a whole.

Greater Philadelphia's overall position on the life sciences current impact index is heavily contingent upon the pharmaceutical industry, a powerful regional economic force. The region's pharmaceutical firms employed over 30,000 people in 2003, representing 56 percent of core life sciences employment, and had the highest employment LQ at 7.4. Greater Philadelphia ranked first on the pharmaceuticals composite index, scoring 100 in employment concentration. Additionally, Greater Philadelphia scored 93.1 for absolute pharmaceutical employment.

In the areas of medical devices and biotechnology, primarily manufacturing, Greater Philadelphia was positioned less favorably at eighth. However, in R&D in the life sciences, primarily biotechnology-related R&D, Greater Philadelphia ranked fourth overall. The region was first in R&D in life sciences employment growth between 1997 and 2003. This R&D activity was 3.5 times higher in Greater Philadelphia than for the nation overall.

Greater Philadelphia's support infrastructure is another essential ingredient of its life sciences sector. In 2003, Greater Philadelphia employed 310,200 people in the life sciences supporting industries, which accounted for 12.8 percent of the region's total employment. Greater Philadelphia is second on the current impact index for supporting life science industries, after Greater New York and just ahead of Boston. Although not the largest in absolute terms for supporting life science industries, Greater Philadelphia scored well in areas of concentration and diversity, solidifying its overall position; only five out of the 26 supporting industries had LQs less than 0.75. However, more than 60 percent of its supporting industries had an employment concentration above the national average in 2003.

The total current impact composite index is comprised of the sum of the weighted current impact composite index for the core life sciences industry and the life sciences supporting industries. As the table reveals, Greater Philadelphia is first (score = 100) on the total current impact composite index, followed closely by Greater New York and Greater San Francisco. Greater Philadelphia edged out Greater New York by virtue of its nearly 10-point higher score on core life sciences, pulled ahead of Greater San Francisco due to the latter's relative weakness in the supporting industries, and bested Boston with modestly higher scores in both categories.

Total Life Sciences Current Impact

LIFE SCIENCES		Core Life Sciences	Life Sciences Supporting Industries	Total Current Impact
Rank	MSA	Composite Index 2003	Composite Index 2003	Composite Index 2003
1	Greater Philadelphia	93.6	78.0	100.0
2	Greater New York	83.9	100.0	99.7
3	Greater San Francisco	100.0	57.2	98.0
4	Boston	87.7	76.5	94.9
5	Greater Los Angeles	90.4	64.4	92.8
6	Greater Raleigh Durham	92.7	56.1	91.9
7	San Diego	96.4	45.4	91.2
8	Minneapolis	72.3	53.0	74.8
9	Chicago	63.6	70.0	73.7
10	Seattle	62.7	49.6	66.0
11	Dallas	40.5	48.4	48.2

Multiplier Impacts

The importance of the life science industry to the Greater Philadelphia region is assessed by its impact on the overall economy. Multiplicative values known as "multipliers" allow us to do this by quantifying how employment, earnings and output in life sciences ripple through other regional economic sectors. In addition to providing numerical data on an industry's regional impact, economic multipliers also bring to light region-wide interdependencies and inter-industry relationships.

Three key forces are at play when measuring multiplier impacts. Beyond the **direct impact** of industry employment, earnings and output, the life sciences industry impacts many supplier industries such as inorganic chemicals, specialized manufacturing equipment, and legal, financial and consulting services. The **indirect impact** represents the number of jobs, earnings or value of output generated from all supplier industries necessary to support employment, earnings and output in life sciences.

The higher employment and wages in life sciences and these supplier industries ripple throughout the local economy leading to higher purchases of goods and services, in turn, making more income available to be spent in the local economy. This is known as the **induced impact**. By aggregating these impacts, we arrive at the **total impact** that the life sciences contribute to Greater Philadelphia's economy.

Altogether, Greater Philadelphia's core life science industry is responsible for 276,000 jobs (total impact), or 11.4 percent of all employment in the region. Of those, 53,500 are accounted for directly, while 131,500 and 91,000 are generated through the indirect and induced effects, respectively. For every job within the life sciences in Greater Philadelphia, an additional 4.2 jobs are created in all other sectors.

Similarly, the life science industry in Greater Philadelphia is responsible for $13.7 billion, or 12.8 percent of total earnings in the region. $4.6 billion is registered directly, while $5.4 billion and $3.7 billion are generated through the indirect and induced impacts, respectively. For each dollar in earnings produced in the life sciences sector, an additional $2.0 in earnings is generated beyond it.

Additionally, the life science industry in Greater Philadelphia is responsible for $15.5 billion, or 7.1 percent of gross metro product in the region. $6.9 billion is generated directly, while an incremental $4.8 billion and $3.8 billion are generated through the indirect and induced impacts, respectively. Since output multipliers are based on a final-demand concept, they usually result in lower coefficients than for employment and earnings. For each dollar of output produced in the life sciences sector, an additional $1.20 in output is generated beyond it.

The pharmaceutical industry's relative contribution to Greater Philadelphia's economy is attributable to its size and high multipliers. Each incremental job created in the industry generated an additional 5.8 jobs in other sectors. The pharmaceutical sector alone was responsible for 203,700 jobs, $10.1 billion in total earnings, and $10.8 billion of output, or nearly three-fourths of life sciences' total impact.

Innovation Pipeline Index

A region's life science innovation pipeline is an important socio-economic asset that plays a pivotal role in the birth, development and long-term growth of a region's life science industry. The innovation pipeline is made up of five subject areas: research and development (R&D), risk capital and entrepreneurial infrastructure, human capital, workforce, and innovation output.

The R&D findings are derived from input indicators on various types of funding and monetary awards given to life science research activities. Of the 11 R&D components, Greater Philadelphia performed best in terms of industry R&D to the life sciences. The region received an estimated $2.6 billion in industry R&D funding in 2002, and its per capita funding level was $433, the highest among its peer group. Greater Philadelphia registered its second best performance in R&D (2nd) for NIH funding to independent hospitals. Its composite life sciences R&D score was 86.3 ranking the region fifth, but not that far from top-scoring Boston, which earned a baseline score of 100, placing it first.

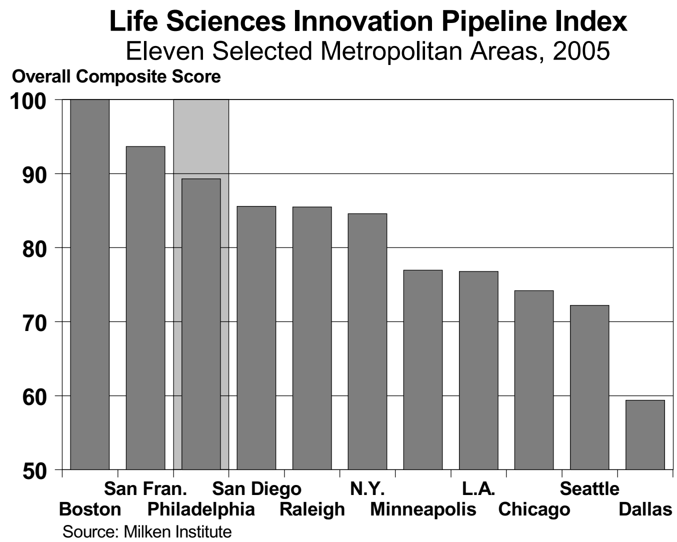
Risk capital and entrepreneurial infrastructure is an indicator of how new ventures in life science are being funded and their entrepreneurs supported. Risk capital investment amounts and growth are the economic life blood of new, pioneering firms. Entrepreneurial infrastructure relates to how conducive a region is to fostering firm formation and development. Of the seven risk capital and entrepreneurial infrastructure components, Greater Philadelphia performed exceptionally well in the area of life science VC investment growth (1st), academic degrees awarded in entrepreneurship (1st) and Technology Fast 500 companies. Overall the Greater Philadelphia region scored 81.5, ranking it fourth behind top-scoring Greater San Francisco.

Human capital hones in on the specialized training and education people receive for careers in life sciences. Our human capital review involved an extensive analysis of bachelor, master and Ph.D. degrees granted in more than 20 disciplines that prepare people for knowledge-intensive work in life science fields. Greater Philadelphia's best ranking was in its number of life science Ph.D.-granting institutions, where it placed second only to Boston. Other high rankings for Greater Philadelphia were bachelor's degrees awarded in life sciences over the most recent 10 years on record, and aggregated measures such as total number of life science bachelor's degrees awarded, population of life science graduate students, and number of life science master's degrees awarded. In all four of these components, the region ranked third. The region placed third on the human capital composite index, with a composite score of 90.0. The only metropolitan regions ahead of Greater Philadelphia were Boston and Greater Raleigh Durham.

Human capital serves as the "raw material" for the "finished product" of a skilled workforce. To realize the full potential of a region's innovation pipeline requires maximizing its human capital capacity to generate an economically productive workforce. Of the 13 workforce components, Greater Philadelphia's performance is notable in the areas of intensity of medical and health services managers (2nd), intensity of chemists (3rd), and intensity of chemical technicians (2nd). On the overall workforce composite index, Greater Philadelphia earned a score of 88.2 and ranked fifth. Boston, Greater San Francisco, San Diego and Greater Raleigh Durham occupied the top four positions.

Innovation output in the life sciences is highly dependent upon regulatory forces. Our analysis models and interprets a variety of both FDA and patent-related data to appreciate the breadth of indicators that reveal the output performance of a metro region's life science innovation pipeline. For innovation output based upon 13 component measures, Greater Philadelphia stands out in the following three areas: FDA new drug approvals (2nd), clinical trials-Phase I (3nd), and percent of life science patents in the area (2nd). On the innovation output composite index, the Greater Philadelphia region scored a high 96.7 index points and was third among leading regions. The first-place performer on the composite was Boston, whose compostie score was 100, closely followed by Greater San Francisco (99.2).

The Greater Philadelphia region placed third with a score of 89.3 on our innovation pipeline index. This is an outstanding performance considering the well-known innovation strengths of many of the regions to which Greater Philadelphia was compared. Ahead of Greater Philadelphia on the index was Boston, whose top performance earned it a benchmark score of 100 index points, followed by Greater San Francisco. San Diego and Greater Raleigh Durham ranked fourth and fifth. Greater Philadelphia's third-place showing was based upon consistently strong results in the five areas. In all five categories the region outperformed the average of the top clusters in the country.



Overall Composite Index

Greater Philadelphia's position among the country's top life science centers is formulated by combining the current impact assessment measures with the innovation pipeline analysis to arrive at an overall composite index score. The current impact assessment tells us where Greater Philadelphia currently stands in relation to other leading life science clusters, while the innovation pipeline evaluates how it is positioned for the future.

The first four innovation pipeline categories measure how well equipped Greater Philadelphia is for growth in life sciences relative to other leading centers studied in terms of R&D, risk capital and entrepreneurial infrastructure, human capital and workforce. The last measure of the region's innovation pipeline examines output. In arriving at an overall composite for this study, we assigned equal weights of 50 percent on the current impact assessment and innovation pipeline.

Greater Philadelphia's score of 97.1 ranked it third on the overall composite index. This is attributable to its first-place finish on the total current impact index and its third-place position on the innovation pipeline index, contributing to its solid overall position. Greater Philadelphia is just 2.0 index points above Greater San Francisco on the total current impact index while it is 10.7 and 4.4 index points behind Boston and Greater San Francisco on the innovation pipeline, respectively. This pulled them ahead of Greater Philadelphia on the overall composite index for life sciences.

Overall Composite Index for Life Sciences				
MSA	Innovation Pipeline	Total Current Impact	Overall Composite Index	Rank
Boston	100.0	94.9	100.0	1
Greater San Francisco	93.7	98.0	98.4	2
Greater Philadelphia	89.3	100.0	97.1	3
Greater New York	84.6	99.7	94.6	4
Greater Raleigh Durham	85.5	91.9	91.1	5
San Diego	85.6	91.2	90.7	6
Greater Los Angeles	76.8	92.8	87.0	7
Minneapolis	77.0	74.8	77.9	8
Chicago	74.2	73.7	75.9	9
Seattle	72.2	66.0	70.9	10
Dallas	59.4	48.2	55.2	11
Weights	0.50	0.50		

Greater San Francisco edged out Boston on the current impact assessment; however, since the spread between their scores is slightly greater on the innovation pipeline, Boston slipped ahead to number one on the overall composite index. Greater New York ranked fourth on the overall composite index, coming in second on the total current impact assessment just behind Greater Philadelphia and is positioned sixth on the innovation pipeline. Perhaps Greater New York's most significant asset is its support infrastructure built around its life science cluster.

Conclusions

The Greater Philadelphia life sciences cluster ranks among the elite centers in the country. While rankings from any quantitative evaluation system are sensitive to the criteria chosen and the weights assigned to them, the depth and breadth of our life sciences benchmarking system displays Greater Philadelphia's considerable strengths.

The Greater Philadelphia region is well-positioned for future growth in the life sciences. The region has many comparative advantages, but it could ensure its elevated position by improving areas where it does not hold a competitive advantage. Retention of locally developed human capital would provide a deeper pool of workforce talent. Another area of focus should be on life sciences startup firms and the associated risk capital, from pre-seed, seed to venture finance support that these fledging firms require, along with a strong network of institutions and other support infrastructure.

Avenues of investigation on human capital/workforce include:

- *Find ways to close human capital/workforce gaps.*
- *Evaluate why other regions perform better in workforce intensity in key fields.*
- *Obtain an in-depth understanding of how local institutions prepare students.*
- *Analyze how local university-industry connections function.*
- *Determine what access Greater Philadelphia's human capital has to regional risk capital and entrepreneurship infrastructure.*

The foregoing list is not exhaustive, yet it does illustrate aspects to consider in ascertaining the ultimate source or sources of imbalance that characterize the human capital/workforce dimensions of Greater Philadelphia's future growth. Greater Philadelphia organizations are aware of these issues. Governor Rendell announced a new state grant in May 2005 being managed by the Life Sciences Career Alliance which will provide for job training in the biotechnology and life sciences industries in the Philadelphia area.

Boston and Greater San Francisco hold the top two positions in part due to greater venture capital availability and the superb commercialization networks that have developed. Analysis of and action on the following issues would prove beneficial:

- *Alter cultural barriers to university commercialization and firm spin-offs.*
- *Assist in applying for federal development awards (STTRs and SBIRs).*
- *Develop innovative programs to aid access to pre-seed and seed funding.*
- *Foster interaction between new biotechnology and pharmaceutical firms.*
- *Increase state and local funding into privately managed venture capital pools.*
- *Encourage pharmaceutical firms to increase affiliated venture capital funds' investments.*
- *Build regional collaborations among the various public, private and philanthropic organizations.*

The stakeholders of the region are aware of many issues related to new-firm birth and growth. A thorough investigation with a stated goal of developing programs to address deficiencies in promoting start-up formation and improving access to capital throughout the development cycle should be pursued.

Greater Philadelphia has regional assets that other regions can only aspire to develop. These observations on workforce and entrepreneurial/risk capital support are offered in the context of the region being a premier life sciences center. Maintaining or improving upon its existing strengths and viewing other areas as opportunities will only enhance its position in the future.

[1] The Location Quotient (LQ) equals % employment in metro divided by % employment in the U.S. If LQ>1.0, the industry is more concentrated in the metro area than in the U.S. average.

Introduction

The life sciences industry is an emerging powerhouse for U.S. global economic competitiveness in the 21st century. Encompassing biotechnology, pharmaceuticals, medical devices, associated research and development activities and life sciences support infrastructure—including research universities, teaching hospitals, medical laboratories, venture capital firms and many other related sectors—it is one of the most knowledge-intensive and research-rich sectors in the U.S. economy. It directly and indirectly supports millions of jobs and pays above-average wages to life-science industry workers. Life sciences' economic and scientific contributions propel many regions. The end result of consuming its products—better health—has immeasurable value for the national economy as well.

The biotechnology industry is on the verge of significant breakthroughs in the treatment of cancer, heart disease and brain disorders such as Alzheimer's and Parkinson's disease. Biotechnology companies are making tremendous progress in decoding genetic structures and in their understanding of cellular processes that aid diagnosis and the development of drugs and vaccines for a wide array of diseases and ailments. Numerous proteins are already used as therapeutics, the result of recombinant DNA technology. Biotechnology companies have, through their partnership with pharmaceutical firms, improved the quality of human life and extended the life span of many individuals.

The biotech industry is perhaps the most research-intensive sector in the economy. For example, the top five biotechnology firms invest an average of $120,000 per employee on research and development (R&D). This pool of highly paid, equity-owning knowledge workers and the supplier infrastructure that develops around them, promise significant wealth and job creation for the winning regions.

The pharmaceutical industry, too, is among the most research-intensive sectors in the economy, seeding future discoveries by investing $30.6 billion in research and development in 2004. Pharmaceutical firms invested over $40,000 per employee on R&D, ranking the industry among the leaders in the U.S.

Pharmaceuticals are an immense, truly global industry, yet the supply and demand of its output is ultimately determined by local conditions. The characteristics of the industry are important to understand, especially in regions such as Greater Philadelphia where a critical mass of pharmaceutical and related industrial activities has taken root.

The medical device industry is a significant contributor to the life science sector as well, as a complement to biotech and pharmaceutical manufacturing and related R&D activities. The advancement of medical devices coupled with breakthroughs in genetics and information systems lead to new treatments, machinery, drug delivery vehicles and diagnostic treatment efficacy. With production estimated at $77 billion, the U.S. is the largest producer of medical technology, while seeding its future discoveries by investing 11.4 percent of sales in research and development in 2002. Venture capital financing in the medical device industry accounted for more than $1.6 billion in 2003.

The life sciences supporting industries are the interconnected institutions, service-provider firms and other downstream and upstream activities that enhance the innovative capabilities of the core life science member firms. It represents the entire value chain of a life sciences cluster from suppliers to end products and health services, including its related suppliers and specialized infrastructure. Such a cluster of interdependent, linked firms and institutions represents a collaborative organization form that offers its members advantages in efficiency, effectiveness and flexibility.

In the Greater Philadelphia region, the life sciences industry is a clear potential source of comparative advantage for the region's economy over the long term. The Greater Philadelphia area serves as corporate headquarters for some of the nation's top pharmaceutical, biotechnology and medical device firms. It also has major research and development operations of many large domestic and international firms. Several of the region's universities are among the premier life science research centers in the world. Additionally, Greater Philadelphia has many important teaching and research hospitals. The economic benefits for those locales in which life science clusters have already formed will likely be immense.

Greater Philadelphia is well positioned to be one of the primary clusters of life science activities, yet very little systematic comparison information has been compiled to aid in evaluating its current position and prospects for the future. We hope this study fills that information void. We believe this study to be a comprehensive and thorough assessment of the Greater Philadelphia life sciences cluster relative to other leading regions.

This report benchmarks and assesses the current position of the Greater Philadelphia life sciences cluster relative to 10 other leading life science centers (Greater New York, Boston, Greater Raleigh Durham, Minneapolis, Chicago, Dallas, Greater San Francisco, Seattle, Greater Los Angeles and San Diego), estimates its total impact on the region's economy by calculating the multiple ripple effects, evaluates how it is positioned for future growth by investigating its ongoing ability to innovate, and formulates an overall composite for the life sciences. Lastly, we offer observations and suggestions on how the region might address some of its comparative disadvantages.

Since clusters rarely conform to the offical MSA definitions, our study defined life science regions by combining a few MSAs and adding or removing some counties. If an MSA had a high degree of life science linkages and interaction with another adjacent MSA, essentially operating as one cluster, we combined the two metropolitan statistical areas and referred to the new geographic area as "Greater." For example, we include Mercer County, NJ (Trenton, NJ MSA) into the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA reflecting the strong linkages of Mercer County's life sciences companies and institutions. This extends the cluster to include Princeton, NJ (please see *Metroplitian Statistical Area Changes* in the Current Impact Assessment section.)

To compare the relative strengths of each life science cluster, we scaled out each component by the region's population, employment, businesses, or relevant economic output measures such as gross metro product (GMP). After conducting these scaling calculations to provide a common basis for comparison, we combined absolute and relative performance to generate comparable scores that allowed us to provide a meaningful evaluation of Greater Philadelphia's performance relative to the other leading regions. This approach brings out a more true-to-life representation of the richness and national importance of the clusters.

The first section, **The Greater Philadelphia Story: A Brief History and Overview**, provides the historical evolution of the life science industries in Greater Philadelphia. It discusses the antecedents that led to the formation of key firms and presents a timeline of the sector's evolution. That section summarizes developments in pharmaceuticals, medical devices and biotechnology including major products developed, among them diagnostic tests and devices, and the diseases and illnesses that they treat or cure. This provides a more nuanced and qualitative assessment about the Greater Philadelphia life science cluster that helps differentiate it from other clusters.

The **Current Impact Assessment** section discusses the relative economic outcome of the life sciences industry. The current impact measure assesses the absolute and relative importance of employment size and growth of life sciences to the region. By measuring economic outcomes, we can gauge the effectiveness of policymakers, participants and other stakeholders in transforming life sciences' innovative assets into an economic growth engine for Greater Philadelphia's residents. We created a unique regional life sciences data set that provides employment estimates through 2003. Other researchers are using data through 1997, which is ancient history in the life sciences area.

The **Multiplier Impacts** section assesses the ripple effects of the life sciences industry on Greater Philadelphia's economy. In addition to the direct impact of industry employment, earnings and output, the industry impacts many supplier industries such as inorganic chemical compounds, financial and advertising services and specialized machinery manufacturing. The indirect impact is another component of capturing the unique structure of the interwoven Philadelphia life science cluster by quantifying the linkages with its support sectors. The higher employment and wages in these supplier industries ripple throughout the local economy leading to more purchases of goods and services, which in turn, makes more capital available to be spent in the local economy (induced impact).

In the **Innovation Pipeline** section we cover the support infrastructure and outcome measures that reflect the ability of a region to capitalize on its strengths in knowledge and inventiveness. Five subject areas comprise the innovation pipeline: research and development (R&D), risk capital and entrepreneurial infrastructure, human capital, workforce, and innovation output. A rich innovation pipeline plays an important part in a region's life sciences industry competitiveness and ability to sustain long-term growth. It also constitutes an important asset in its own right for state, regional and national economies. We analyze the innovation pipelines of Greater Philadelphia with a view toward determining its capacities to generate and commercialize life sciences innovations relative to other leading centers.

The **Conclusions** section summarizes the findings and offers observations and suggestions on how the region might address some comparative disadvantages to improve Greater Philadelphia's position in the future.

The **Appendix** contains detailed information of many of the indicators used in this study.

The Greater Philadelphia Story: A Brief History and Overview

Close to 400 companies are engaged in life science activities in the Greater Philadelphia region. Their activities span a wide range of cutting-edge innovation in pharmaceuticals, biotechnology and medical devices. The firms themselves vary from companies such as Dittmar, Inc., which has contributed to West Chester, Pennsylvania's economy for 120 years by providing acute and primary care surgical instruments and medical equipment,[1] to start-ups such as the Kensey Nash Corporation, recognized by *Fortune* as one of the fastest-growing publicly held small companies in America. Firm size ranges from small companies such as these to vast multinational corporations employing thousands of workers generating billions of dollars in revenue. The vibrant life sciences industry in the Greater Philadelphia region creates and attracts talent, generates profits for reinvestment, advances innovation and contributes to the improved well-being of its constituents and many others around the globe.

To highlight the impact of the life sciences industry on the Greater Philadelphia region, the Milken Institute has ranked the top 20 area life science firms by employment. These 20 firms represent approximately 85 percent of the area's total life science employment. All are multinational enterprises or affiliated with global corporations; each has customer sales and/or growth aspirations that span the world in manufacturing as well as research and development.

Leading Life Science Companies

Top 20 by Employees in the Greater Philadelphia Area, 2004*

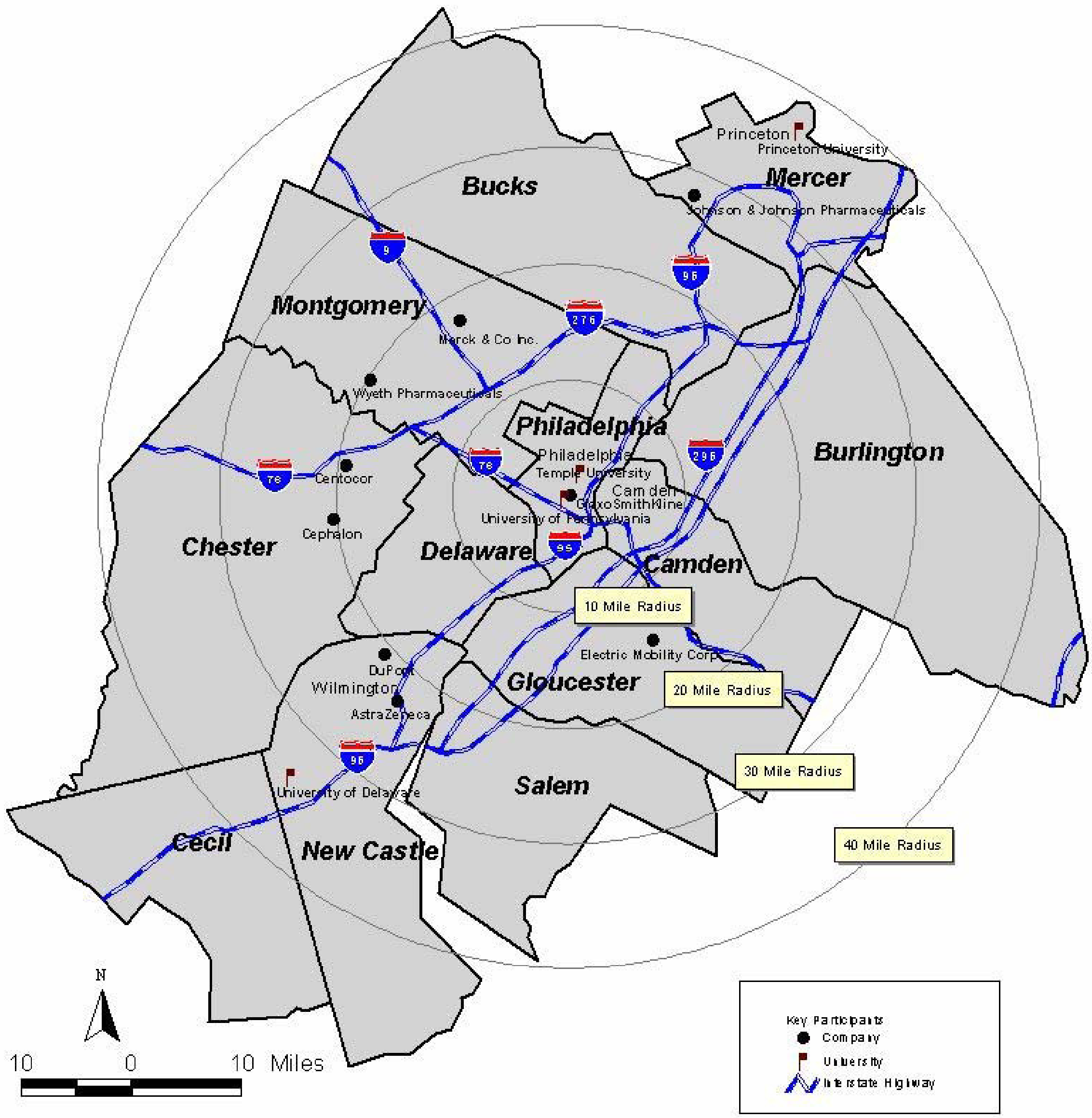
Rank	Company	Employees	Market Cap ($, Bill.)
1	Merck & Co., Inc.	11,475	71.30
2	Wyeth	7,335	55.05
3	GlaxoSmithKline	7,000	137.92
4	AstraZeneca	5,201	68.93
5	Bristol-Myers Squibb Company	1,803	49.38
6	McNeil Consumer Healthcare	1,200	N/A
7	Rohm and Haas Company	1,100	11.00
8	Covance, Inc.	1,100	2.90
9	Baxter Health Care Corporation	1,077	21.48
10	Centocor, Inc.	1,000	N/A
11	Dade Behring, Inc.	1,000	2.67
12	J&J Pharmaceutical Research	1,000	204.11
13	Johnson & Johnson Pharmacy	800	204.11
14	Sanofi-Synthelabo, Inc.	800	60.78
15	Cephalon, Inc.	706	2.77
16	Synthes	690	N/A
17	Pharmanet, Inc.	652	N/A
18	IMS America, Inc.	600	5.69
19	Research Pharmaceutical Search	582	Private
20	Electric Mobility Corporation	500	Private

Source: Harris InfoSource

*Note: J&J, with 4,160 employees, is the fifth largest life science employer in the Greater Philadelphia area. J&J affiliated companies include McNeil Consumer Healthcare, Centocor, Inc., J&J Pharmaceutical Research, Johnson & Johnson Pharmacy and Normaco Inc.

Greater Philadelphia Life Sciences Cluster

Key Participants



Sources: Harris InfoSource, Milken Institute

Established firms dominate the list of Greater Philadelphia's top 20 life science employers. The following pages describe the evolution and significance of the industry's long history in Greater Philadelphia and its environs.

Although this study is concerned with contemporary issues, in this section we provide a brief historical review of the evolution of the life sciences industry specific to Greater Philadelphia. Innovation, excellence and entrepreneurship characterize Greater Philadelphia's life sciences industry.[2]

Firm location strategies and government policy decisions flow from a number of relevant factors. History, it is argued, is one potentially relevant factor. This is what Krugman had in mind when he stated that "if there is one single area of economics where path dependence is unmistakable, it is in economic geography—the location of production in space."[3] This section views the spatial location of economic activity as process-dependent.[4] Just as the annual rings of an oak tree reveal its historical formation and growth, this section uncovers the industrial and technological development of Philadelphia's life sciences industry layer by layer from inherited, previous location formations.

No past experience, however rich, and no historical research, however thorough, can keep the present generation from the creative task of finding its own answers, making its own decisions and shaping its own future. The following highlights past relationships relevant to the current discussions, that assist in understanding the present situation and setting unique policy for advancing the life sciences industry in Greater Philadelphia.

Background

Philadelphia, the largest city in Pennsylvania and one of the oldest cities in the United States, has played a critical role in American history and the birth of American independence and democracy. As early as 1609, Dutch and Swedish colonists explored, farmed and traded in the Philadelphia area. In 1615, a navigator from the Netherlands viewed the land site that ultimately became Philadelphia. It is a planned city, founded and developed by William Penn, one of many Quakers from England who settled the area. Thomas Wynne, practicing in the 1680s, was the city's first doctor.

The sovereigns of the "old world" who had acquired possessions in the North American continent, gave large tracts of such land to certain of their wealthy subjects and to commercial groups who undertook to finance the migration of colonists. As the community developed, increasing numbers of German, Scottish and Irish immigrants arrived so that by 1700, Philadelphia had approximately 2,000 residents. For a time in the 18th century, Philadelphia was the largest city in the Americas north of Mexico City, second only to London in size in the British Empire.

University of Pennsylvania[5]

In 1749, Benjamin Franklin presented a pamphlet titled *Proposals for the Education of Youth in Pensilvania*. Unlike other American Colonial colleges, the focus was not on education for the clergy but rather the preparation of students for lives of business and public service – entrepreneurship and public policy. The first classes were held in 1751.

In 1755, the foundation for the establishment of life sciences in the region was strengthened when the University of Pennsylvania (originally called the College, Academy and Charitable School of Philadelphia) was given the power to grant college-level degrees. More than 250 years later, the University of Pennsylvania continues to offer Ivy-league education to some of the world's top students, serving as a model for research colleges and universities throughout the world. It is home to the nation's first medical school, which as early as 1874, added a university teaching hospital. The university is also the birthplace of technological invention. In 1946, U-Penn introduced ENIAC, the world's first electronic, large-scale, general-purpose digital computer enabling high tech advanced research in life sciences.

America's first hospital, the Pennsylvania Hospital, was founded in 1751 by Benjamin Franklin and Dr. Thomas Bond. The hospital, which began with the care of the "sick, poor and insane of Philadelphia, spawned the very early stages of applied medical research."[6] Philip Syng Physick (1768-1837), the "father of American surgery," was an American physician born in Philadelphia who took a position at Pennsylvania Hospital.

Modern Day Pennsylvania Hospital[7]

Today, Pennsylvania Hospital is a 515-bed acute-care facility that provides a full range of diagnostic and therapeutic medical services functioning as a major teaching and clinical research institution. The hospital is known for its general and specialty surgical services, including orthopedics, vascular medicine/surgery, neurosurgery, otorhinolaryngology (ENT), urology, obstetrics—especially high-risk maternal and fetal services—neonatology, neurosciences and behavioral health. Pennsylvania Hospital also has programs for cancer, cardiac care and bloodless medicine and surgery. The hospital has over 24,500 inpatient admissions, 201,000 outpatient visits and over 4,200 births, annually. Pennsylvania Hospital is part of the University of Pennsylvania Health System and is located at 8th and Spruce Streets in the historic Society Hill district of Philadelphia.

Philadelphia's large size and growing prosperity were success factors that led to the relocation in 1790 of the seat of the U.S. government from Federal Hall in New York to Congress Hall in Philly.[8] Industrialization grew swiftly as immigrants came to Philadelphia bringing with them skills and knowledge. Transportation, including the railway boom that began in 1849, navigable rivers and proximity to the eastern shore, also contributed to a rapid commercial, industrial and cultural growth.

Foreign direct investment (FDI) into Philadelphia is associated with a rising United States industry behind tariff walls, and the consequent reduction of European export markets. DuPont, one of the leading corporations in the U.S. today, was founded by foreign investors. At its origin, the DuPont Company utilized French management, capital, machinery and workmen (Wilkins, 1989).

DuPont[9]

In 1802, Eleuthère Irénée du Pont paid Wilmington, Delaware businessman Jacob Broom $6,740 for the initial site of the company that bears his name. One hundred years after first breaking ground, the explosives manufacturing firm had become a modern, science-based chemical company with research labs. DuPont established an experimental station in 1903 near Wilmington to conduct and promote scientific research as a major platform for industrial growth. The facility was DuPont's first general scientific laboratory and the site of many of the company's most spectacular research triumphs including neoprene, nylon and lycra.

DuPont was one of the first companies to hire a physician as an employee. In 1935, DuPont established one of the world's first industrial medicine facilities.

The acquisition of Endo Laboratories in 1969 provided DuPont with valuable experience in drug manufacturing and marketing, and paved the way for its future success in pharmaceuticals. In 1991, as part of an overall strategy to expand its Life Sciences Division, the DuPont Merck Pharmaceutical Company was formed to conduct research in cardiovascular, radiopharmaceutical and central nervous system products. The company's most successful products include: Sinemet to fight Parkinson's disease; Cardiolite cardiac imaging agents; Cozaar, a hypertension drug discovered by DuPont and marketed by Merck; and Sustiva to fight HIV infection.

Today's slogan, "the miracles of science" melds DuPont's traditional strengths in basic research with new disciplines such as agricultural biology and biotechnology.

In 1807, sudden temporary protection against British competition of a more complete nature than any tariffs could give, helped young industries in Pennsylvania. This came from the embargo, then evolved into the War of 1812. Those seven years of American trade restrictions and war radically curtailed the importation of English manufactures and at the same time stimulated the development of infant industries in Philadelphia, especially organic chemicals.

The first private psychiatric hospital, Friends Hospital, was founded in the region in 1813.[10] The first college of pharmacy in the U.S. was the Philadelphia College of Pharmacy.[11] Founded in 1821, the college trained pharmacists, inspected locally produced and imported drugs and helped launch the impressive and historic careers of the founders of six of the top 10 pharmaceutical companies in the world today. They are:

- Dr. Eli Lilly (class of 1907) and his father, Josiah K. Lilly (class of 1882), founder of Eli Lilly and Company;
- Gerald F. Rorer (class of 1931), founder of what is now part of Aventis Pharmaceuticals;
- William R. Warner (class of 1856), founder of Warner-Lambert Company, Inc.;
- Robert L. McNeil, Jr. (class of 1938) and his grandfather, Robert McNeil (class of 1876), founders of what is now McNeil Consumer Products;
- John Wyeth (class of 1854), founder of what is now part of Wyeth American Home Products; and
- Silas M. Burroughs (class of 1877); and Sir Henry S. Wellcome (class of 1874), founders in England of Burroughs Wellcome and Company, now part of GlaxoSmithKline

The American Pharmaceutical Association was founded in 1852 and served as a gatekeeper to the industry.[12] Shortly thereafter, in 1861, the Philadelphia Drug Exchange was created to market Philadelphia manufacturers' drug products, boosting the national image of both the industry and region. By the 1880s and 1890s, many of the Philadelphia drug manufacturers were mass producing drugs and distributing them throughout the United States.

During this period, Merck entered the United States. The late Dr. Maurice Hilleman, former director of the Merck Institute for Vaccinology, is credited with developing more vaccines than any person and is recognized for having changed the face of the world in providing a means to prevent and control a number of its most important diseases. Dr. Hilleman's accomplishments include vaccines against mumps, measles, rubella, chicken pox, bacterial meningitis and pneumonia, flu, hepatitis A, hepatitis B, and many more disease entities. As a result, entire generations of well-inoculated Americans escaped diseases that were once the scourge of childhood.[13] When Dr. Hilleman died on April 11, 2005, he was Adjunct Professor of Pediatrics, School of Medicine, University of Pennsylvania. Penn recently announced the establishment of The Maurice R. Hilleman Chair in Vaccinology.

Merck & Co., Inc.[14]

Merck, a global research-driven pharmaceutical company in the top 100 of the *Fortune 500*, was established as a small branch of a German fine chemical firm in New York City in 1891. Today, innovation at this American firm is carried out at Merck Research Labs, an integrated "global laboratory."

Merck Research Labs in the U.S. are located in Rahway, New Jersey; West Point, Pennsylvania; San Diego, California; and Boston, Massachusetts. At the West Point state-of-the-art research facility, scientists and engineers work on bioprocess R&D including fermentation, cell culture and downstream processing of vaccines, gene therapy products and therapeutic proteins. In addition, analysis and characterization of biological products is performed. Pharmaceutical R&D researchers at the West Point site work on interdisciplinary teams to maximize the potential success of new drug candidates, developing stable and bio-available formulations.

In 2004, Merck employed 11,475 workers at its three Pennsylvania sites: West Point, a pharmaceuticals research and development laboratory; North Wales, engaged in pharmaceuticals manufacturing; and Blue Bell, which provides research services for the pharmaceutical industry. More specifically, at the Blue Bell site, epidemiologists help define new drug clinical trial entry criteria, outcome measures and data for sample size calculations. Merck employees at these sites forge strong interactions with academic and private research institutions.

The market capitalization of this global firm exceeds $70 billion.

During the 19th century, Philadelphia began moving toward manufacturing for economic growth and despite recurring financial panics, crises and depressions, the city boomed between 1830 and 1860. The year 1830 saw the early establishment in Philadelphia of a key predecessor of the now successful global pharmaceutical firm GlaxoSmithKline (see inset below). By 1850 it was the world's largest manufacturer of pharmaceutical chemicals.

GlaxoSmithKline[15]

GlaxoSmithKline (GSK), formed in 2000, is an amalgamation of many successful mergers and acquisitions. The company traces its roots in the U.S. back to 1830, when John Smith opened his first drugstore in Philadelphia. In the 1980s, SmithKline conducted a series of key strategic acquisitions including, in 1989, Allergan (a leader in eye and skin care) and Beckman Instruments (one of American's premier diagnostic and measurement instrument companies). The company then merged with the Beecham Group to form SmithKline Beecham. Combining various strands of an Anglo-American corporate heritage, the company in its current form was created with the merger of GlaxoWellcome and SmithKline Beecham.

GSK has leadership in four major therapeutic areas: anti-infectives, central nervous system, respiratory and gastro-intestinal/metabolic. In addition, it is a leader in the important area of vaccines and has a growing portfolio of oncology products. The company also has a consumer health care portfolio comprising over-the-counter medicines, oral care products and nutritional health care drinks, all of which are among the market leaders.

With its corporate headquarters in London and operational headquarters located in Philadelphia, the company registers a market capitalization in excess of $138 billion. GSK employs some 7,000 people in Philadelphia, Collegeville, King of Prussia and Conshohocken, PA. Its research activities in the U.S. center around three GlaxoSmithKline laboratories in Pennsylvania and one in Research Triangle Park, North Carolina.

GSK's philanthropy includes efforts to improve public and science education. In 2004, a three year grant of $300,000 was awarded to the National Board for Professional Teaching Standards to increase the number of science teachers pursuing certification in North Carolina and Philadelphia. In 2004, the Philadelphia Education Fund received a grant of $129,000 from the company for the "Middle Grade Matters" campaign to improve middle-school education. "Science in the Summer," a free library-based science education program in the Philadelphia area, is sponsored by GSK. The program, which emphasizes the teaching of basic scientific concepts, received a grant of $365,000 in 2004. Throughout this program's 19 year history, GSK's continuing commitment to scientific education has encouraged the participation of and benefited more than 68,000 children.

In the late 18th century, Philadelphia suffered epidemics of yellow fever, cholera and typhoid that claimed the lives of many of its residents. The incidence of, and efforts to eradicate, these killer diseases spawned hospital establishments and spurred medical research in the area. For example, the Thomas Jefferson University began in 1824 (see insert below); 1847 saw the organization of the American Medical Association in Philadelphia, and the Medical College of Pennsylvania (originally called the Female Medical College) was founded in 1851. The first hospital for children, The Children's Hospital of Philadelphia, was founded in 1855[16].

Thomas Jefferson University[17]

Thomas Jefferson University, an academic health center, was founded in 1824 as Jefferson Medical College in Philadelphia. It was the city's second medical college. The college, which has awarded more than 26,000 medical degrees, opened an infirmary to treat the poor in 1825. By 1844, Jefferson was providing patient beds over a shop at 10th and Sansom Streets. A 125-bed hospital, one of the first in the nation affiliated with a medical school, opened in 1877, and a school for nurses began there in 1891.

As the university progressed, new structures were added to the 13-acre Philadelphia Center City campus: the Main Hospital Building (1907), Thompson Building (1924), Medical College and Curtis Buildings (1929 and 1931), Foerderer Pavilion (1954), Jefferson Alumni Hall (1968), Scott Memorial Library (1970), Edison Building (acquired 1973), Gibbon Building (1978), Bodine Center for Cancer Treatment (1986), Medical Office Building (1986), Clinical Office Building (1990) and Bluemle Life Sciences Building (1991). On July 1, 1969 the institution became Thomas Jefferson University, composed of Jefferson Medical College, Thomas Jefferson University Hospital, the College of Graduate Studies, and the College of Allied Health Sciences.

Today, this academic health center tests and treats 25,000 inpatients and more than 300,000 outpatients every year, and enrolls 2,600 future health care professionals. Public and private funding of Jefferson research exceeds $64 million annually. From its modest beginnings in George McClellan's office across from Philadelphia's Independence Hall, Thomas Jefferson University is today the largest free-standing academic health center in Philadelphia, and Jefferson Medical College is the largest private medical school in the United States.

The Wyeth brothers' firm, which began as a small Philadelphia drugstore in 1860, was also a research laboratory that transformed the way drugstores operated. Later known as Wyeth Laboratories, it became the first to "advance manufacture" frequently prescribed medicines in bulk.[18]

Wyeth[19]

John Wyeth and his younger brother, Frank, opened a retail drugstore with a small research laboratory in Philadelphia at 1411 Walnut Street in 1860. Both brothers had attended the Philadelphia College of Pharmacy. Since the Civil War era, the company has grown into a globally active and innovative firm with business activities in prescription pharmaceuticals, such as the contraceptive Ovral, over-the-counter consumer health products that include well-known Advil, Robitussin, Dristan, Chap Stick and Centrum, animal health products (Fel-O-Vax FV for the prevention of a serious immunodeficiency in cats), vaccines (e.g., Prevnar Pneumococcal 7-valent Conjugate Vacine) and biologicals. Among Wyeth's most successful pharmaceutical products are the antidepressant Effexor, the biopharmaceutical for rheumatoid arthritis Enbrel and Protonix, the proton pump inhibitor for the treatment of gastroesophageal reflux disease.

Wyeth has its headquarters in Collegeville, Pennsylvania. The company employs 7,335 people at its three Pennsylvania locations: West Chester, where the firm manufactures sterile bulk penicillin powders and pharmaceutical products; and two Philadelphia locations where it manufactures pharmaceuticals and is involved in pharmaceutical research laboratory services.

Wyeth is known for its generous philanthropy. In 1968, in order to facilitate the delivery of life-saving smallpox vaccinations to millions of people around the world, Wyeth waived patent royalties on its innovative bifurcated needle; in 1979 the company received recognition from the World Health Organization for its contribution to the eradication of this disease.

Philadelphia was the first large city north of the Mason-Dixon line to be involved in the Civil War. The Civil War, which began in 1861, quickly became one of the most devastating medical events of the 19th century. Smallpox vaccinations protected soldiers against at least one deadly disease, but there was no defense against dysentery, malaria, typhoid, yellow fever, venereal and many other diseases. Demand increased dramatically for painkillers, preservatives and disinfectants. Philadelphia received many of the returning wounded and the Union set up its first military hospital in the city. Eventually, this military hospital in Philadelphia had over 10,000 beds and cared for more than 150,000 soldiers and sailors during the war.[20]

Philadelphia's medical device industry flourished from the mid-1800s when doctors in Philadelphia treated many of the wounded returning from the American Civil War. As global conflicts continue, land mines and road-side bombs create a huge market for medical devices such as artificial limbs.

The late 1800s saw a flurry of medical and science establishments constructed in the city including:

- the formal opening of the new Philadelphia Orthopedic Hospital, on the corner of 17th and Summer Streets (February, 1872); and
- on October 5th of the same year, the formal possession by the managers of the German Hospital of their new hospital on the corner of Girard and Corinthian Avenues.

Cornerstones were laid:

- on Olney Road, near the York Pike, for the Jewish Hospital (October 9, 1872);
- on the southwest corner of 19th and Race Streets of the building of the Academy of Natural Sciences (October 30, 1872); and
- at the corner of 21st Street and College Avenue for the new building of the Women's Medical College (1875).

The new building of the Homeopathic Hospital for Children at 914 Broad Street, formally opened in March 1884. Four years later, in May 1888, St. Agnes' Hospital at Broad and Mifflin Streets was dedicated and formally opened.[21] The first independent medical research facility in the United States, the Wistar Institute, was founded in 1892.[22] In 1904, the first cancer hospital, the Hospital of the Fox Chase Cancer Center, opened.[23]

The development of the first ready-made, ready-to-use surgical dressings by Johnson & Johnson in the mid-1880s marked not only the birth of a company, but also the first practical application of the theory of antiseptic wound treatment. A new product, based on a new surgical concept, led to a dramatic reduction in the threat of infection and disease, which claimed an appalling number of postoperative victims.[24]

Johnson & Johnson

Johnson & Johnson's operations began in 1886 with 14 employees on the fourth floor of a small building that once was a wallpaper factory. Today, J&J employs approximately 109,000 people and is the world's most comprehensive and broadly based manufacturer of health care products, as well as a provider of related services, for the consumer, pharmaceutical, medical devices and diagnostics markets.

Johnson and Johnson Pharmacy, a J&J affiliate in the Greater Philadelphia region, has 800 employees operating in Montgomery, PA.

Johnson & Johnson Pharmaceutical Research & Development, LLC, a world leader in genomic based drug discovery, has two sites in Greater Philadelphia: the Spring House site, situated just outside the city of Philadelphia; and the expansive Titusville site, located in Mercer County, NJ. This affiliate's innovations in drug discovery and development, and advancements in biotechnology make it a significant contributor of new products to the treatment of human diseases. The company performs R&D for the pharmaceutical business units of Johnson & Johnson worldwide.

The late 1880s saw a continued emphasis on education. One evening in 1884, a young man went to see a Dr. Russell H. Conwell in his Philadelphia study, expressing his desire to prepare for the Christian ministry. Conwell's willingness to teach the youth led to the creation of a school appropriately called "Temple," which became chartered as Temple College in 1888 and incorporated as Temple University in 1907.

Temple University[25]

Temple University today is a comprehensive public research university with more than 34,000 students. It has a distinguished faculty in 17 schools and colleges, including the schools of law, medicine, pharmacy, podiatry and dentistry, and a renowned health sciences center.

Temple is one of Pennsylvania's three public research universities, along with the University of Pittsburgh and Penn State University. Based in Philadelphia, Temple has five regional campuses, including the flagship Main Campus, Health Sciences Campus and Center City Campus; a major suburban campus—Temple University at Ambler—and a suburban art campus in Elkins Park. The University has education centers in Harrisburg and Fort Washington and integrated international campuses in Tokyo, Japan and Rome, Italy. Temple also offers educational programs and information exchange opportunities in the People's Republic of China, Israel, Greece, Great Britain, France and other countries throughout the world.

AstraZeneca[26]

AstraZeneca, one of the world's leading pharmaceutical companies today, was formed on April 6, 1999 through the merger of Astra AB of Sweden and Zeneca Group PLC of the UK. Its U.S. headquarters are located in Wilmington, Delaware. Today, the company employs 5,201 workers at its two pharmaceutical manufacturing sites in the greater Philadelphia area: Wilmington and Newark, DE.

The history of AstraZeneca in the U.S. can be traced back to 1912 when the Atlas Powder Company was created in Wilmington, Delaware. In 1972, ICI acquired Atlas Chemical Industries and moved the U.S. headquarters of ICI America from Stamford to the Fairfax campus in Wilmington.

Astra AB, founded in 1913 and headquartered in Sweden, was an international pharmaceutical group engaged in the research, development, manufacture and marketing of pharmaceutical products, primarily for four main product groups: gastrointestinal, cardiovascular, respiratory and pain control. Astra also targeted some research effort toward the central nervous system and marketed a range of pharmaceutical products and operated Astra Tech, a medical devices group.

Headquartered in London, Zeneca was a major international bioscience firm engaged in the research, development, manufacture and marketing of pharmaceuticals (focusing on cancer, cardiovascular, central nervous system, respiratory and anesthesia), agricultural chemicals and specialty chemicals, and the provision of disease-specific health-care services. The company's businesses were research and technology intensive with extensive international development and marketing skills and a strong common science base.

The "roaring twenties" were a period of prosperity despite the trade protectionism that frequently curtailed overseas business. The increase in automobiles and other consumer goods in the U.S. provided a strong stimulus for new chemical products. Within the chemical industry, imports declined, new supply chains were established and manufacturing in Pennsylvania grew to surpass foreign means of serving the Philadelphia market. This was an antecedent to developing chemical compounds that later become critical as raw materials in producing pharmaceutical products.

Although not immune, the chemical industry was somewhat insulated and therefore fared relatively well during the depression. In the 1930s, a number of major products were invented whose full economic impact was reached after World War II. At the end of that war, Philadelphia chemical producers were in a powerful position. Many of their overseas competitors had been savaged, their credit weakened, plants bombed or taken over for military-related production, and distribution networks were disrupted. As a result, the U.S. emerged as the dominant chemical-producing nation at the end of the war.

The 1940s brought a vigorous return to globalization. Global trade and international currency fluctuations impacted business strategy. During the interwar years, Philadelphia's chemical industry grew in technological sophistication. The government of the United States provided some measure of tariff protection to this industry.

Medical devices, which encompasses everything from tongue depressors and crutches to prosthetics, is an entrepreneurial industry. The development of sophisticated and complex medical devices (such as MRIs, pacemakers, cardiac defibrillators, patient monitors, ultrasonic devices, biological sensors, in vitro diagnostics, etc.) are the result of high-rel scientific methods and analytical tools developed during the 1950s and 1960s.[27]

The Introduction of Biotechnology

Philadelphia's economic growth was slow compared to other cities in the U.S. during the 1950-1970 suburb explosion. However, in the 1970s, developments underway since WWII ushered in the biotechnology revolution. Biotechnology is an outgrowth of interdisciplinary research in molecular biology, immunology and biochemistry, aided by new techniques such as x-ray structural analysis and computer-assisted drug synthesis. Just as our understanding of chemistry in the 20th century revolutionized products and production processes in the dye industry, pharmaceuticals, agriculture and fuel, biotechnology redirected the focus from chemistry to molecular biology in applications across a variety of industries.[28] Biotechnology changed the face of pharmaceutical chemistry.[29]

The emergence of biotechnology on the West Coast posed a challenge to Philadelphia's traditional pharmaceutical firms and their core technology base in organic chemistry. Biotech's genetically engineered, targeted approach effectively superseded the typical approach to drug discovery and development. Startup firms founded on new technology outside the pharmaceutical industry with new sources of risk capital funding from venture capital markets, entered the field.

In 1979, researchers at a laboratory for molecular biology in Cambridge, U.K., formed Centocor. This biotechnology company's first product was a diagnostic test for the detection of the rabies virus.[30]

Centocor[31]

Centocor is a biotechnology company based in Horsham, Pennsylvania active in product-development focused on the newly discovered science of monoclonal antibodies (tailor-made antibodies derived from the clones of a single cell). In June 1982, Centocor consolidated operations in Malvern, Chester County, Pennsylvania. As a result of a 1999 merger, Centocor became a fully-owned subsidiary of Johnson & Johnson.

Centocor employs 1,000 workers in activities related to the manufacture of biotech products for therapeutic medicine. The company's research pipeline targets two main areas: immunologic disorders and cardiovascular disease. Its main products are Remicade (infliximab, the only monoclonal antibody approved for Crohn's disease and rheumatoid arthritis), ReoPro (abciximab, a first-in-class drug for coronary care) and Retavase (Reteplase recombinant, a novel treatment for heart attack).

Centocor works in collaboration with several pharmaceutical partners including Eli Lilly and Company, which holds worldwide marketing rights to ReoPro® (except in Japan where Fujisawa Pharmaceutical maintains market share), Schering-Plough, with international marketing rights to Remicade, except in Japan and parts of the Far East whose markets are served by the Tanabe Seiyaku Co.

Cephalon[32]

Cephalon, founded in 1987, is a fast-growing biopharmaceutical company that employs 706 workers specializing in neurological disorder pharmaceuticals R&D at its West Chester, Pennsylvania location. Key U.S. sites other than the company's corporate headquarters in West Chester, are manufacturing facilities in Salt Lake City, Utah and Eden Prairie, Minnesota. Key European sites include offices in Guildford, England; Martinsried, Germany; and Maisons-Alfort, France. Cephalon has a market capitalization of approximately $3 billion and total sales exceeded $700 million in 2004.

Cephalon reinvests approximately 28 percent of its sales revenue in R&D, specializing in drugs that treat neurological diseases and cancer. Research in the area of kinase inhibitors has been especially successful for the company—Cephalon has put four different kinase inhibitors into human clinical studies.

Over the past five years, Cephalon has been transformed into a biotech-based pharmaceutical company with a broad, international commercial presence. Cephalon currently markets more than 20 products internationally, including three proprietary products in the United States: PROVIGIL, the first in a new class of wake-promoting agents; ACTIQ, the only prescription medicine approved in the world for treatment of breakthrough pain in opiod-tolerant cancer patients; and GABITRIL, indicated throughout much of the world as adjunct therapy for treatment of partial seizures associated with epilepsy.

Medical Devices

Countering the excitement of emerging biotech was the increasing regulatory scrutiny of the life sciences industry especially in the field of medical devices. Medical devices, which came under official FDA control in 1976, presented unique regulatory challenges as compared to the pharmaceutical and biotech industries. FDA historian, Suzanne Junod, Ph.D. said, "the device industry is radically different from many other categories that fall under FDA jurisdiction. A lot of devices are really engineered products, so advances often come in engineering, not in safety and efficacy. At the end of WWII, there were all sorts of electronic components that the military had not used. They ... looked official. They looked like they should do something, but, of course, they didn't do anything. They were totally fraudulent."[33] Devices with little or no medical value flooded the marketplace.

The advent of implantables, such as heart valves and pacemakers, represented real progress in the use of modern technology for medical devices, but they also carried greater risks. "They were legitimate," said Junod, "but they were not always meeting quality standards from an engineering standpoint." For example, the Dalkon Shield, a birth-control device popular in the early 1970s, had several dangerous design flaws that resulted in serious physical repercussions to the patient and huge lawsuits against the corporation. Problems were also encountered with silicone implants.[34]

While the FDA emphasis on enforcement improved quality assurance for patients, it also caused delays, which, while not as long as those for pharmaceuticals, increased costs in the industry. The negative side effects were exacerbated by the enactment of restrictive device amendments to the Federal Food, Drug, and Cosmetic Act in 1990 and 1992. The situation choked many emerging new technologies and triggered an exodus of medical device companies from the United States.[35]

Dr. Neal Dunning, an expert and industry pioneer in the medical device and diagnostic industry, views these regulatory constraints as a boost to the medical device industry in America. ''Industrialists often rail against 'those bureaucrats that keep interfering with the progress of industry.' Sometimes they are correct. But I believe that the Medical Device Amendments, brilliantly envisioned by Peter B. Hutt and carefully implemented by the early members of the Bureau, helped form the foundation of this booming industry. Notably, it is now one of the few commercial sectors in which the United States has a strong positive balance of trade.''[36]

Manufacturing is paramount to this sector. A successful medical device company is Synthes, which from the 1970s to 1990s, expanded its distribution worldwide with sales subsidiaries in all important markets.

Synthes[37]

The history of Synthes can be traced back to 1920 Switzerland and the manufacture of high-quality watches. Innovative engineering and experimentation with new materials took the company beyond its renowned Rolex and into the field of medical devices.

After Synthes USA was founded in 1974, the Synthes Spine Company was formed in 1991 to serve the fast-growing market of degenerative spine disorders and trauma. In 1996, Stratec Holding went public with a substantial part of the share capital traded on the Swiss Exchange. Just three years later, Stratec Holding and Synthes (USA) merged, creating one of the world's leading osteosynthesis companies. With the acquisition of Norian, the Synthes-Stratec group gained access to a leading U.S.-based manufacturer of biocompatible bone substitute material.

Over the past five years Synthes-Stratec has grown by more than 100 percent and increased its net profits by 260 percent. The company employs over 3,500 people in North and Latin America as well as in Europe. In the Greater Philadelphia area, Synthes, Synthes-Stratec and Synthes USA, employ 690 people in the manufacturing of orthopedic instruments and implants at their Paoli and West Chester, PA locations.

Electric Mobility Corporation[38]

Electric Mobility was founded in 1974 by Francis Flowers, Sr. to produce and market PedalPower® electric motors for bicycles. Francis Flowers Sr. and his son Michael, now company CEO, developed specialized electric motors in response to the gas crisis. When the energy crisis abated, demand lagged. Company research revealed the needs of a previously undiscovered market—electric bikes were being used by older and mobility impaired people to get around their neighborhoods.

The company began concentrating on products for the mobility impaired. In 1981 they introduced the Cycle Chair, a battery powered tricycle that provided additional stability. It shortly became apparent that customers were not bothering to pedal their Cycle Chairs but were using the motors exclusively. In addition, further research revealed a need for mobility assistance indoors as well as outdoors. Thus, they began development of their landmark product, the compact Rascal® Scooter, designed exclusively for electric power.

Further product development continued with innovative features such as the "Take-Apart" Frame, which allows the scooter to break down into pieces for easier transport, and the patented "ConvertAble" option that changes the Rascal Scooter from a rugged outdoor 3- or 4-wheeler into an indoor powered wheelchair in seconds without tools. In 1998, the American Society for Aging awarded Electric Mobility's power chairs their Gold Award for Outstanding Product Design for Mature Consumers. The company's Fold & Go™ and AutoGo® models were introduced in 2003.

The Kensey Nash Corporation is an example of a small medical device manufacturing company that began operations in 1984 with just two employees and an innovative idea to remove atherosclerotic plaque from diseased arteries using a high-speed rotary catheter. While technological advances have eclipsed this device, the firm has evolved growing to almost 300 workers who generate revenues upwards of $58 million at its Exton, Pennsylvania location.

Advances in engineering and electronics led to the computer and information technology revolution in the second half of the 20th century.[39] The increasing sophistication of computer capabilities aided the research paradigm shift from pharmaceuticals to biotechnology. The use of software as a medical device component in drug delivery has grown as well. Computer-controlled devices now administer combination drug therapies and hone in on radiation treatment targets. Producers of chemicals, pharmaceuticals, biologicals and medical devices increasingly demand high-tech inputs to support their R&D. Advances in IT propelled productivity gains in manufacturing as route functions became increasingly automated.

U.S. regions, such as San Diego and the San Francisco Bay Area, captured significant market share in the indirect life science support industries due to their competitive advantages in computer electronics. Restructuring and the massive realignment of the sectors also changed the geography of the industry; outsourcing and offshoring were explored as a means to reduce costs.

Many firms keep the entire discovery and development process in-house, but usually, bringing a product to market is distributed among different sites around the world and even different firms. The degree of outsourcing or vertical disintegration is always tempered by extreme caution regarding proprietary product and process knowledge.[40] The level and extent of protectionism varies with each firm and drives outsourcing strategy.

Most of the world's leading traditional pharmaceutical firms have their world or U.S. headquarters, or in the case of foreign-based multinational enterprises, their foreign direct investment (FDI), in traditional, mature regions. These firms have generally located their principal research laboratories and product launching plants either on-site or in close proximity to their offices. As new products achieve commercial economies of scale and manufacturing production processes become increasingly routine, they are frequently outsourced to lower-wage regions, both inside the U.S. and to foreign nationals. Conversely, foreign firms are increasingly relocating their research and development operations to the United States.

Although less glamorous, downstream functions such as manufacturing and marketing contributed substantially to Philadelphia's economic well-being. This occurred through growth in regional incomes, maintenance of a relatively good income distribution and contribution to a quality-living environment.

Traditionally, life science manufacturing focused on providing sufficient capacity and developing better sourcing strategies. Some of them have now begun to upgrade their manufacturing functions, viewing manufacturing strategically as a mechanism for reducing production costs, and gaining and retaining competitive advantage. Rising manufacturing costs as a percentage of sales have led many firms to invest in reengineering their production processes.[41] Soaring manufacturing costs at GlaxoSmithKline motivated the firm to review continuous quality improvements in their manufacturing processes. Manufacturing, which had been low on the list of priority concerns for many firms for many years, is now a frontline issue for cost efficiencies and quality control.

Firms in the Philadelphia region retained much of the high-end manufacturing, especially advanced and pilot drug manufacturing. Pilot manufacturing, where drugs are produced in relatively large batches for the first time, is particularly significant in biotechnology since the newer, biotech-based drugs are increasingly complex, difficult to produce and require a set of highly skilled scientific and production workers.[42] In a study that contrasted the production processes of chemically-synthesized and biotech-based drugs, Gary Pisano[43] posited that profitable production of biotech-based drugs is harder to attain because the science underlying biotechnology is still so new and not yet fully understood. Economies of scale are difficult to achieve and are not yet a routine function for biotechnology-based products. This may help to explain why mature pharmaceutical regions such as the greater Philadelphia area, retain the bulk of pilot production.[44]

Consolidation and Clustering

Debates over national systems of health care in the early 1990s threatened pharmaceutical firm profits. They were further seriously endangered by the failure of high-profile products during the late stages of and after clinical trials. The industry responded by consolidating and restructuring. Mergers, acquisitions, partnerships, cooperative strategic alliances and licensing deals dominated the industry at this time. Traditional pharmaceutical firms looking to improve their product pipelines matched up with biotech companies seeking external resources, additional expertise and the ability to quickly scale-up production and global marketing capabilities. Life science firms sought gains in advanced products. A pattern of increasing interdependence emerged. Consolidation enabled firms to manage inter-brand competition effectively. Increases in the enormous R&D costs and time frames along with the fixed costs associated with larger production scales, further fueled the consolidation process. The biotech, medical device and pharmaceutical sectors seek shared risk and lower costs for research. The dependence on retained earnings for further investment has intensified consolidation tendencies.

Research shows that almost all creative centers are places with a high concentration of educated people and the ability to retain skilled workers.[45] Successful life science clusters are highly dependent upon the quality of medical and technological research, as well as the availability of specially trained research scientists and technicians. The universities therefore form the basic intellectual infrastructure that supports the continued success of the local scientific clusters.[46] Much of the research generated in the Greater Philadelphia area is performed at medical schools and other medical research institutions with substantial federal government R&D support, especially NIH funding. A university's ability to build intellectual capacity by recruiting and retaining world-class scientists lies at the core of this success. Such universities have been the hot bed of technological innovation and entrepreneurship. Most life science firms trace their intellectual roots and human capital back to these institutions.

Princeton University[47]

Princeton University: The First 250 Years, published in honor of its 250th anniversary in 1996, captures the rich history of this beautiful 500-acre campus. Today, there are approximately 4,600 undergraduate and 2,000 graduate students enrolled at Princeton from more than 60 countries around the world. Its 700 full-time faculty members and about 300 part-time and visiting faculty teach as well as engage in scholarly research. The graduate school, established in 1900, has students who win many awards including fellowships from the Department of Defense, Hertz, Mellon, National Science Foundation, U.S. Department of Education and Ford Predoctoral Fellowships for Minorities.

In May 2005, Philadelphia health commissioner John Domzalski announced that the Princeton University graduate students in the Woodrow Wilson School of Public and International Affairs, had developed a "practical and visionary" plan to provide universal health care for Philadelphia's residents.[48] The graduate students, including David Grande, a medical doctor and former intern at the Philadelphia Department of Public Health, examined how other American cities addressed the issue of the uninsured—especially cities such as Boston, Detroit, Milwaukee, San Diego and Tampa that, like Philadelphia, did not have a public hospital.

Princeton University, recognized globally for its academic excellence, offers life science Ph.D. studies in chemistry and chemical engineering, ecology and evolutionary biology, and molecular biology. It has demonstrated success in educating graduates for careers in academia, government, and the nonprofit and corporate sectors. The University, with 5,291 employees, is Mercer County's largest private employer and one of the largest in the region.

The strength of the Greater Philadelphia life science cluster is augmented by catalyst organizations, such as BioAdvance and Pennsylvania BIO, that work toward building collaborations among academic, entrepreneurial, corporate, financial and government partners. Consortiums, councils, venture capitalists and foundations within the greater Philadelphia area fund research centers of excellence and accelerate the transfer of technology from laboratories to startups and established companies. Over time, life science success in the Greater Philadelphia area can be traced back to dynamic individual competition, firm rivalry, research collaboration and increased interdisciplinary cooperation.

Summary

The extent to which established firms dominate Greater Philadelphia's life science industry is striking. GlaxoSmithKline traces its Philadelphia roots back to 1830; Wyeth was founded there in the 1860s and Merck began operations in 1891. AstraZeneca's activities in Pennsylvania began in 1912. Rhome & Haas has contributed to Philadelphia for more than 90 years. In 1931, Baxter was the first manufacturer of commercially prepared intravenous solutions there. Dade Behring has been a leader in clinical diagnostics for more than a century. And, the McNeil name has been associated with the manufacturing and sale of pharmaceutical products since 1879, when Robert McNeil opened his first retail drug outlet in Pennsylvania. Of our top 20 employment listing, Centocor is the only firm among the top 10 that was founded in the 20th century, though Centocor is now a subsidiary of Johnson & Johnson. The history of Synthes, one of America's modern 1970s medical-device success stories, can be traced back to a Swiss watch-making firm established in the 1920s. The long history of life sciences in the Greater Philadelphia area and its evolution are significant to the future success of the new, smaller entrepreneurial companies.

Over the years, urban sprawl has extended Philadelphia across southeastern Pennsylvania and into Delaware and New Jersey. The Greater Philadelphia metro area has expanded to the point that it merges with several nearby cities, forming a large urbanized area.[49] Philadelphia quickly established itself as a leading region for life sciences largely because it created the necessary institutional structure to support the industry.

In Greater Philadelphia, the life science industry's ability to evolve through its encouragement and accommodation of scientific breakthroughs, shifted the product focus from botanical products to alkaloids and biologicals, and finally, to synthetic chemicals. Similarly, production technology shifted competitive advantage from small-scale apothecary and medical device shops to large manufacturing plants and finally to integrated multinational R&D operations. Flexibility and timely adjustments to changing regulatory and market conditions define today's dynamic life sciences industry. Greater Philadelphia's continued evolutionary success in life sciences is connected to its ability to adjust quickly to changing conditions, such as stem cell research and generics, and upcoming changes in the Medicare drug benefits effective in 2006.

The number and complexity of scientific breakthroughs and medical technology advances require an increasing amount of sophistication from practitioners and technology managers in hospitals, industry and government. This need increases the demand for skilled personnel. All cities, regions and nations wishing to attract, retain and drive success in life sciences must ensure the availability of qualified human capital to meet this demand. Subsequent sections of this report, Current Impact Assessment and Innovation Pipeline, present a deeper understanding of Greater Philadelphia's inventory of assets that can be applied to this goal.

[1] Information obtained in a telephone interview 3.05 with Dittmar employee Deric Knight.

[2] The following four components comprise life sciences: pharmaceuticals, biotech, medical devices and life science R&D. For additional detail see: Current Impact Assessment, Methodology section later in this report.

[3] Krugman, Paul. 1991. "History and industry location: The case of the manufacturing belt," *The American Economic Review*, 81, page 80.

[4] Weber, Max. 1922/1978. *Economy and Society: An Outline of Interpretive Sociology*, Berkeley: University of California Press. Englander, O. 1926. Kritisches und Positives zu einer allgemeinen reinen Lere vom Standort, *Zeitschrift fur Volkswirtschaft und Sozialpolitik*, Neue Folge. Ritschl, H. 1927. "Reine und historische Dynamik des Standorte der Erzeugungszweige," *Schmollers Jahrbuch*, 51.

[5] See: http://www.upenn.edu/about/heritage.php/

[6] http://pennhealth.com/pahosp/about/

[7] http://pennhealth.com/pahosp/about/

[8] http://en.wikipedia.org/widi/History_of_Philadelphia#History/

[9] http://heritage.dupont.com/

[10] http://www.bioadvance.com/home/about_regional.asp

[11] The University currently ranks second in the United States in the percentage of graduates pursuing Ph.D. programs in the medical sciences. See: http://www.usip.edu/aboutUSP/

[12] Amatori, Franco and Geoffrey Jones. 2003. *Business History around the World*, Cambridge: Cambridge University Press.

[13] http://www.ihv.org/bios/hilleman.html

[14] Merck archives. 1992. *Merck Sharp & Dohme: A Brief History*, Rahway, New Jersey: Business History Group, http://www.merck.com/ and http://phx.corporate-ir.net/phoenix.zhtml?c=73184&p=irol-reportsannual, http://www.voicenet.com/~wordinfo/deutsch/commerce.htm

[15] http://www.gsk.com/index.htm, http://www.gsk.com/financial/financialreports.htm, Nobel Foundation , SG Cowen and About GlaxoSmithKline. 2004. "Our Heritage". www.gsk.com/about/background.htm

[16] http://www.bioadvance.com/home/about_regional.asp

[17] http://www.jefferson.edu/main/facts.cfm and http://www.jefferson.edu/main/about2.cfm

[18] http://www.wyeth.com/about/history.asp

[19] http://www.wyeth.com/about/timeline.asp

[20] http://mcmcweb.er.usgs.gov/phil/philhistory.html

[21] http://www.ushistory.org/philadelphia/timeline/1890.htm

[22] http://www.bioadvance.com/home/about_regional.asp

[23] http://www.bioadvance.com/home/about_regional.asp

[24] http://www.jnj.com/our_company/history/history_section_1.htm

[25] http://www.temple.edu/about.html

[26] www.astrazeneca.com/article/11163.aspx.

[27] Hans, Allen. 2004. See: http://www.devicelink.com/mddi/archive/04/08/004.html

[28] Feldman, Maryann. 2003. "The Locational Dynamics of the U.S. Biotech Industry: Knowledge Externalities and the Anchor Hypothesis," Working Paper, University of Toronto, Rotman School of Management.

[29] Peyer, Hans Conrad. 1996. *Roche: A Company History 1986-1996*, Basel, Switzerland: Editiones Roche.

[30] http://www.centocor.com/cgi-bin/site/about/whoweare_timeline.cgi#top

[31] http://www.centocor.com/cgi-bin/site/about/whoweare.cgi

[32] http://www.cephalon.com/business/index.html

[33] See interview with Heather Thompson: http://www.devicelink.com/mddi/archive/04/08/012.html

[34] See interview with Heather Thompson: http://www.devicelink.com/mddi/archive/04/08/012.html

[35] http://www.medicaldevices.org/public/about/regulation.asp

[36] Dunning, Neil. 2004. "Reflections, 25 Years of DSMA and FDA: Ah Yes, I Remember It Well!" *Medical Device & Diagnostic Industry*. See: http://www.devicelink.com/mddi/archive/04/08/005.html

[37] http://www.synthes.com/html/History.4302.0.html

[38] http://www.electricmobility.com/electric_mobility.html

[39] DeVol, Ross, Perry Wong, Junghoon Ki, Armen Bedroussian and Rob Koepp. 2004. *America's Biotech and Life Science Clusters: San Diego's Position and Economic Contributions*, Santa Monica: Milken Institute.

[40] Lee, K. and S. Burrill. 1995. *Biotech 96 Pursuing Sustainability: The Tenth Industry Annual Report*. Palo Alto: Ernst & Young.

[41] Hayes, R., G. Pisano and D. Upton. 1996. "Eli Lilly & Company, Manufacturing Process Technology Strategy," *Strategic Operations, Competing Through Capabilities*, New York: The Free Press.

[42] Pisano, G. 1997. *The Development Factory: Unlocking the Potential of Process Innovation*, Boston: Harvard Business School Press, Lee, K. and S. Burrill. 1995. *Biotech 96 Pursuing Sustainability: The Tenth Industry Annual Report*, Ernst & Young, Palo Alto and Gray, M. and E. Parker. 1998. "Industrial Change and Regional Development: The Case of the US Biotechnology and Pharmaceutical Industries," WP 95, ESRC Centre For Business Research, England: University of Cambridge.

[43] Pisano, G. 1997. *The Development Factory: Unlocking the Potential of Process Innovation*, Boston: Harvard Business School Press.

[44] Gray, M. and E. Parker. 1998. "Industrial Change and Regional Development: The Case of the US Biotechnology and Pharmaceutical Industries," WP 95, ESRC Centre For Business Research, England: University of Cambridge.

[45] Wu, 2005 points out that research shows that increasing the average level of education in a metropolitan area by one grade increases the total factor productivity by 2.8 percent (see: Appleseed Inc., 2003).

[46] Wu, Weiping. 2005. "Dynamic Cities and Creative Clusters," World Bank Policy Research Working Paper 3509, February.

[47] http://www.princeton.edu/main/about/

[48] http://www.princeton.edu/main/news/archive/S11/59/08C78/index.xml?section=topstories

[49] http://mcmcweb.er.usgs.gov/phil/philhistory.html

Current Impact Assessment

Background and Relevance

The purpose of this chapter is to examine the economic impact and growth of the life sciences industry throughout each metro studied, with the related goal of providing a comprehensive comparison of each metro's industry performance to other major life sciences clusters. A metro that has access to talented pools of researchers, innovators and professionals experienced in the life sciences industry and proximity to a number of major research universities, hospitals, and venture capital firms, is in a better position to capitalize on its human, physical and financial assets and to sustain long-term growth in the life sciences industry.

The core life sciences industry encompasses the following four industries:

- pharmaceutical industry
- R&D in the life sciences industry
- medical devices industry
- biotechnology industry

The core life sciences industry includes a total of 13 industries, 12 at the six-digit NAICS level and one at the seven-digit NAICS level (see the methodology discussion at the end of this section).

We also measured the overall employment contribution and concentration of life sciences supporting industries since the growth of a life sciences cluster is fueled by its interaction with a metro's hospitals, medical practitioners and other fast growing knowledge-intensive life sciences related industries. Health care related industries including HMO medical centers and nursing care facilities bolster the growth of a metro's life sciences cluster. Supporting industries encompass a total of 26 industries.

The current impact measures draw on the relative economic outcome of the life sciences industry. The analysis looks at the effects of a positive or negative change in economic activity. The current impact measure assesses the absolute and relative importance of employment size and growth that the life sciences industry offers.

The current impact index is comprised of the following seven components:

- employment level in 2003,
- location quotient[1] (LQ) in terms of employment in 2003,
- relative employment growth from 1997-2003,
- number of establishments in 2003,
- number of life science industries with location quotients greater than 2.0,
- number of life science industries with location quotients less than 0.5, and finally,
- number of life science industries growing faster than the U.S. from 1997-2003.

The first four components focus on the issues of size and performance, while the latter three measure diversity. The Current Impact Composite Index, comprised of these seven components, provides a relative snapshot of the current economic impact or outcome.

Size and Performance

The competitiveness of each metro's life sciences industry in terms of economic outcome, size and performance is measured by employment level, employment concentration as measured by location quotient, relative employment growth indexed to the U.S., and the number of life-science establishments per 10,000 establishments. The employment level is defined by employment size in 2003. The location quotient is an index for comparing a metro's share of employment in a particular industry relative to that of the national share. A metro with a location quotient greater than one means that it has a higher relative concentration of life sciences employment than the U.S. as a whole. A location quotient equal to one indicates that the metro has an industry employment share on par with the share of the nation. A metro with a location quotient less than one means that the area has a smaller share of industry employment than found nationally.

Relative employment growth for each metro was measured by the current level of employment in life sciences indexed to its base year, 1997, and then taken as a proportion of the indexed growth in the U.S. A metro's relative indexed growth of 120 indicates that compared to the U.S., the metro's life sciences industry grew 20 percent above the national average. Relative indexed growth of 80 implies that the metro grew 20 percent below the national average.

The number of life science establishments per 10,000 total establishments a metro has also affects the current impact assessment. For example, a particular metro with a total of 100,000 establishments of which 10 are engaged in core life sciences means that there is only one life sciences establishment for every 10,000 establishments in the metro.

Diversity

The following three indicators of diversity in the life sciences were measured for each metro. The diversity present in a given metro was then compared to the other metros studied. They were:

- the number of life science industries with employment location quotients greater than 2.0,
- the number of life science industries with employment LQs less than 0.5, and
- the number of life science industries whose employment grew faster than the national average.

The first diversity measure focused on metropolitan areas that have at least twice the employment concentration of the U.S in the life sciences industry. The second diversity measure listed above identifies metropolitan areas that are 50 percent or below the national average.

Based on this methodology, our diversity measures allowed us to rule out extremes. For instance, a metro with a very high employment location quotient due to a low overall employment base could result in distorted conclusions. The diversity measurements equalize the results by attributing the same amount of significance to any LQ above 2.0, whether it is 2.5 or 15; likewise for metros whose LQ is less than 0.5.

The third diversity measure is the number of core life sciences industries in a given metropolitan area whose employment grew faster than the U.S. between 1997 and 2003. This measure identified the metros that experienced strong relative growth in recent years versus those that did not. A metro with a high core life science employment base and a high core life sciences employment location quotient, may still have grown at a slower pace relative to other parts of the nation. A possible explanation for this phenomenon might be that the metropolitan area is losing some of its employment to other parts of the country, and/or not effectively capitalizing on its resources or inputs.

Since much of each metro's success in life sciences is owed to its supporting industries, the analysis also applied the following two diversity measures to the 26 life sciences supporting industries:

- the number of life sciences supporting industries with employment LQ's greater than 1.0, and
- the number of life sciences supporting industries with employment LQ's less than 0.75.

Current Impact Composite Index

The current impact composite index encompasses the seven components used in determining the current impact measures.

The composite index was calculated using the following methodology. For each component, each metro was benchmarked to the top metro in that category, creating a normalized scoring system that could be consistently compared across each measure. Doing this eliminates extreme bias. In the second step, unique weights were assigned to each of the seven components in order to arrive at the composite score. The weights are indicative of each measure's relative importance and contribution to the metro's overall performance. Since size and performance constitute a primary indicator when measuring economic outcome, we acknowledged this fact by assigning them greater weight in this analysis. Thus, if a metro ranked first in every category, that metro would earn a score of 100 and rank first in the overall composite. The last step in arriving at the total current impact composite index was to take the sum of the weighted composite index of the core life sciences and the life sciences supporting industries.

Metro Findings

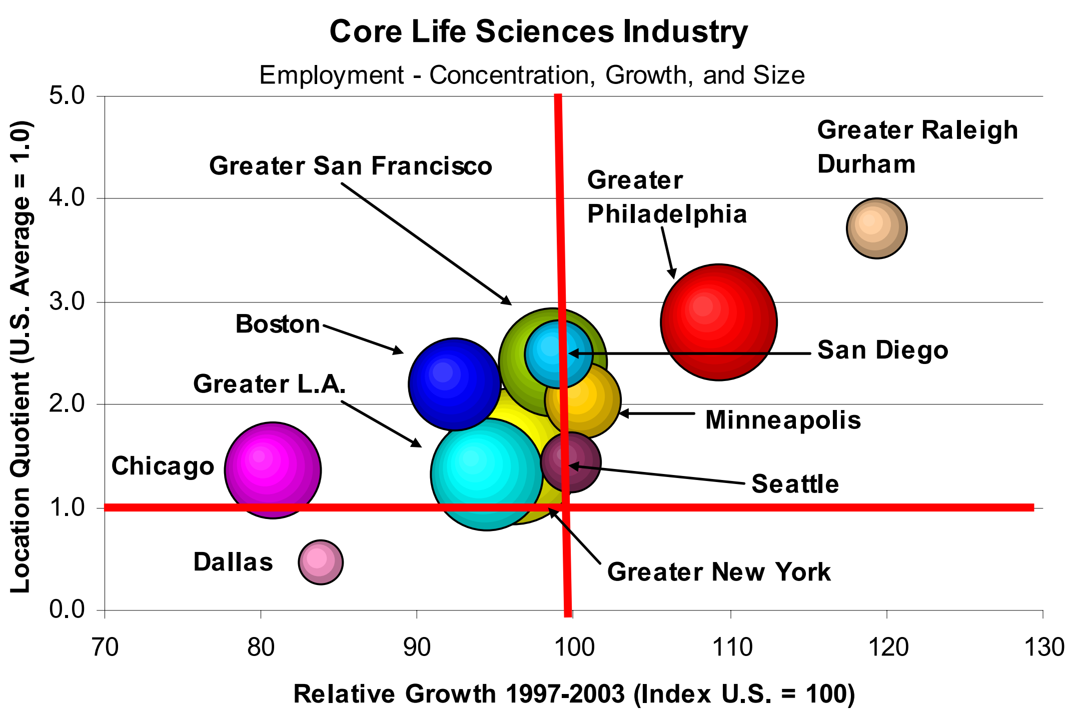
"The economic future of the Philadelphia metropolitan area depends on harnessing the life sciences for regional economic development."[2] Greater Philadelphia's life sciences industry is remarkably strong. It was second-highest in life science employment size, relative growth and employment concentration. In 2003, Greater Philadelphia had almost 53,500 workers employed in the life sciences industry. Only Greater New York ranked higher with over 74,500 jobs in 2003. As the county breakdown reveals Montgomery County registered more than 21,000 life science employees, representing almost 5 percent of the county's total employment in 2003. Merck & Co., Inc. as well as GlaxoSmithKline is one of Montgomery County's biggest life science employers.

Greater Philadelphia's concentration of life science employment was nearly three times the national average, registering an LQ of 2.81 in 2003. Greater Raleigh Durham ranked first for life science employment and relative employment growth.

Core Life Sciences
Greater Philadelphia, Ranked by Employment LQ, 2003

Rank	County	Life Sciences Employment	Total County Employment	% of Total Employment	Employment LQ
1	Montgomery, PA	21,390	440,420	4.9%	6.20
2	Mercer, NJ	6,246	152,743	4.1%	5.22
3	Chester, PA	7,528	196,335	3.8%	4.89
4	New Castle, DE	5,942	245,862	2.4%	3.08
5	Philadelphia, PA	6,874	533,881	1.3%	1.64
6	Delaware, PA	1,953	183,665	1.1%	1.36
7	Gloucester, NJ	759	79,418	1.0%	1.22
8	Bucks, PA	1,830	226,322	0.8%	1.03
9	Camden, NJ	874	169,279	0.5%	0.66
10	Burlington, NJ	83	164,575	0.1%	0.06
11	Cecil, MD	0	20,060	0.0%	0.00
12	Salem, NJ	0	18,404	0.0%	0.00
	Total	53,479	2,430,962	2.2%	2.81

The three-dimensional bubble chart below depicts each metro's particular strengths and weaknesses in life sciences employment concentration, growth and size. The vertical y-axis illustrates life sciences employment concentration in each metropolitan area. The horizontal x-axis relates to each metro's relative life science industry growth from 1997 to 2003. Finally, bubble size indicates each metro's life science industry employment size. Outstanding performance is represented by a large bubble in the upper-right quadrant of the graph.



Of the 11 metros analyzed only Greater Philadelphia and Greater Raleigh Durham show relative employment growth substantially to the right of the vertical line at 100. These two metros also place way above the horizontal line at 1.0, indicating strong employment concentration relative to the nation. Minneapolis, with an LQ of 2.04, relative employment growth of 100.6 and employment size of over 23,000, is also positioned to build on its strengths in life sciences. Of the 10 metros that have employment LQs above the national average, Greater San Francisco ranked fourth in terms of absolute employment and sixth in terms of relative employment growth. It is particularly interesting to see that Greater New York ranked first in terms of absolute employment, but seventh in terms of concentration and relative growth, while Greater Los Angeles ranked third in absolute employment but scored relatively low when looking at its LQ and relative growth.

Greater Philadelphia ranked third on the composite index of these current impact measures (CIM) for the core life sciences; only Greater San Francisco and San Diego scored higher overall. The following table gives the current impact measures for each metro and their ranks using a relative scoring system. Greater Philadelphia scored 100 for the diversity measure of number of industries growing faster than the U.S.

Current Impact Measures (CIM) - Scores for Core Life Sciences
Ranked by Composite Index

CORE LIFE SCIENCES		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater San Francisco	62	65	83	82	82	80	100	100
2	San Diego	27	67	83	100	100	100	83	96
3	Greater Philadelphia	72	75	92	46	55	57	100	94
4	Greater Raleigh Durham	21	100	100	77	82	40	100	93
5	Greater Los Angeles	69	36	79	43	100	100	92	90
6	Boston	47	59	77	72	82	67	92	88
7	Greater New York	100	40	81	31	36	57	67	84
8	Minneapolis	31	55	84	47	64	44	92	72
9	Chicago	52	36	68	29	45	50	58	64
10	Seattle	20	38	84	50	55	36	100	63
11	Dallas	11	12	70	24	45	29	67	40

The table below identifies the three diversity measures by metropolitan area for the core life sciences industry. As previously noted, the first diversity measure looked at the number of industries with a location quotient greater than two. According to the table, Greater Philadelphia has two industries among the core life sciences that have an LQ above 2.0. Three industries in Greater Philadelphia have an LQ of less than 0.5. Another positive impact of Greater Philadelphia's reputation as a cluster for life sciences is the high number of industries among the core life sciences that grew faster than the U.S. from 1997 to 2003.

Diversity Measures - Core Life Sciences
By MSA, 2003

MSA	# of Industries with LQ>2.0	# of Industries with LQ<0.5	# of Industries Growing>US
Boston	5	2	7
Chicago	1	4	3
Dallas	1	10	4
Greater Raleigh Durham	5	6	8
Greater Los Angeles	7	0	7
Minneapolis	3	5	7
Greater New York	0	3	4
Greater Philadelphia	2	3	8
San Diego	7	0	6
Greater San Francisco	5	1	8
Seattle	2	7	8

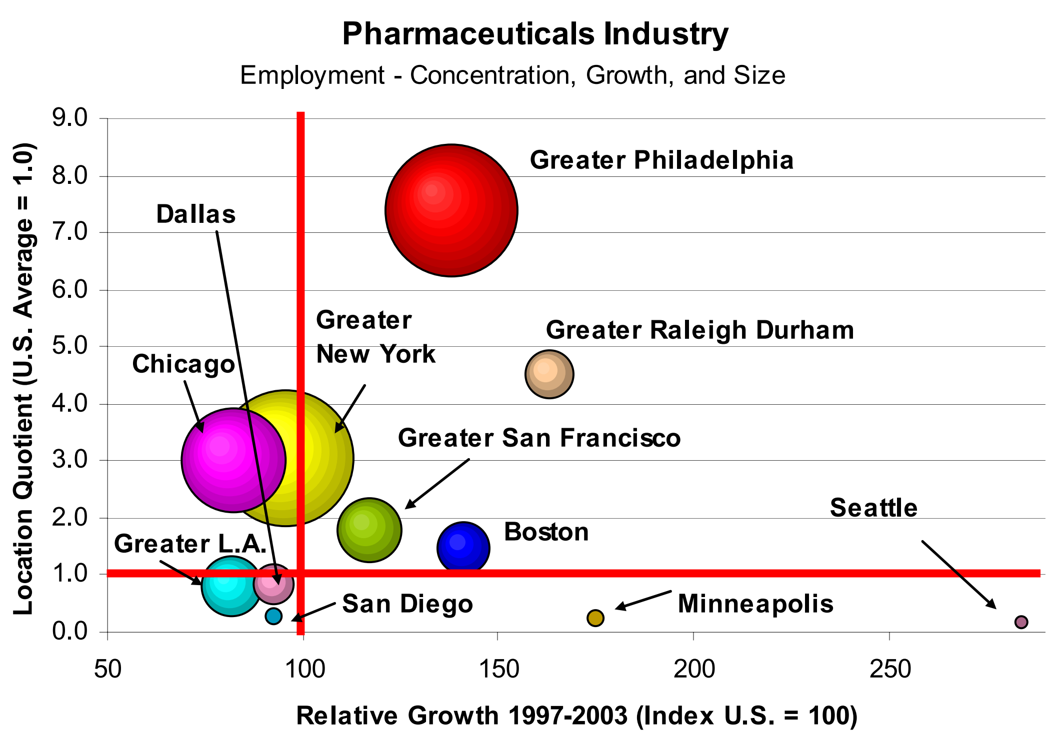
Core Life Science Industries

This section highlights the economic details of the life sciences industry in Greater Philadelphia and the comparable metros studied. As defined earlier, the core life sciences industry encompasses the following four industries:

- Pharmaceuticals Industry
- R&D in the Life sciences Industry
- Medical Devices Industry
- Biotechnology Industry

The core life sciences industry includes a total of 13 industries, 12 at the six-digit NAICS level and one at the seven-digit NAICS level.

The pharmaceutical industry is a powerful economic force in the Greater Philadelphia metro. The bubble chart below demonstrates Greater Philadelphia's outstanding strengths in the pharmaceutical industry. The metro's large presence of pharmaceutical firms such as Merck & Co., GlaxoSmithKline and AstraZeneca, created a large labor pool—more than 30,000 employees in 2003—that is a major driver of economic growth for the region. Notably, in Greater Philadelphia, 56 percent of core life sciences employment was in pharmaceuticals in 2003. Greater Philadelphia ranked first among the 11 metros for employment LQ.

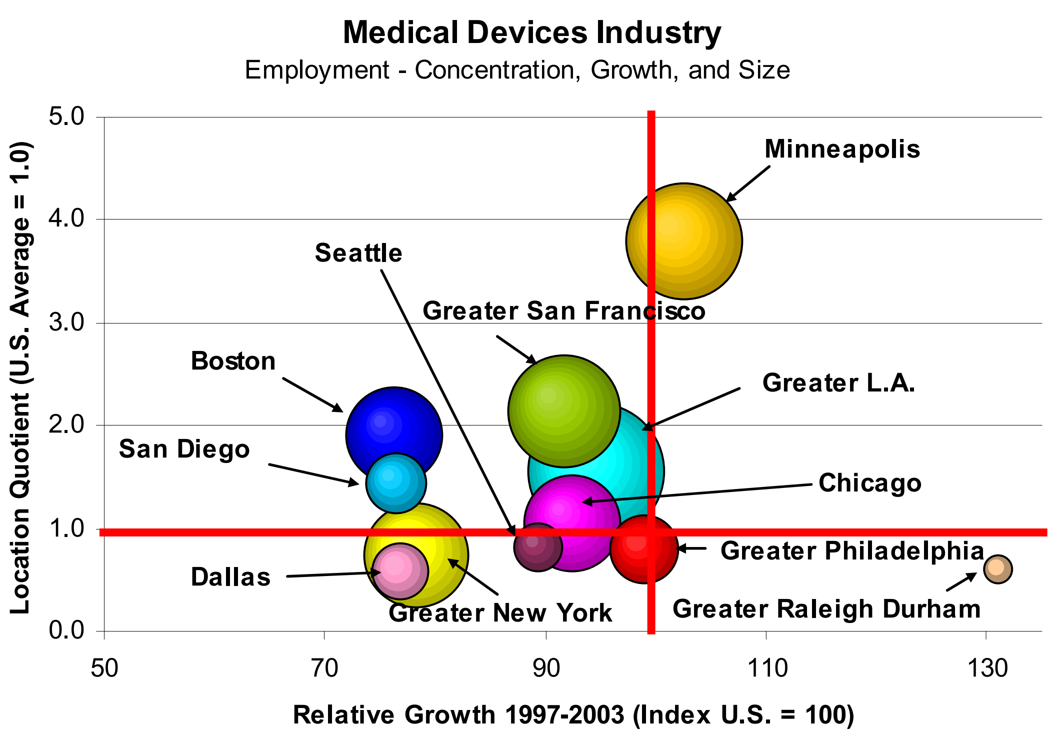


The table below confirms that Greater Philadelphia's prosperity is tied to the viability of its pharmaceuticals firms. Greater Philadelphia ranked first on the pharmaceuticals composite index, scoring 100 in employment concentration and number of industries growing faster than the U.S. Greater Philadelphia's score of 93.1 on the absolute employment measure is also an indicator of the pharmaceutical industry's importance of to the region.

Current Impact Measures (CIM) - Scores for Pharmaceuticals
Ranked by Composite Index

PHARMACEUTICALS		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater Philadelphia	93	100	49	84	50	50	100	100
2	Greater New York	100	41	34	81	50	50	50	81
3	Greater Raleigh Durham	13	61	57	100	50	50	100	69
4	Greater San Francisco	23	24	41	47	100	100	100	62
5	Chicago	57	41	29	24	50	50	50	55
6	Greater Los Angeles	21	11	29	54	100	100	50	54
7	San Diego	1	4	33	87	100	100	50	53
8	Boston	16	20	50	59	50	50	100	50
9	Seattle	1	2	100	29	50	50	100	45
10	Minneapolis	2	3	62	30	50	50	100	38
11	Dallas	10	11	33	32	50	50	50	34

Greater Philadelphia was third in terms of relative employment growth in the medical devices industry. However, Greater Philadelphia compared less favorably to other leading metros in that industry in terms of employment concentration and absolute employment size. Greater Los Angeles employed the highest number of people in medical devices with 26,818 people in 2003, while Minneapolis had the highest employment concentration at 3.8.



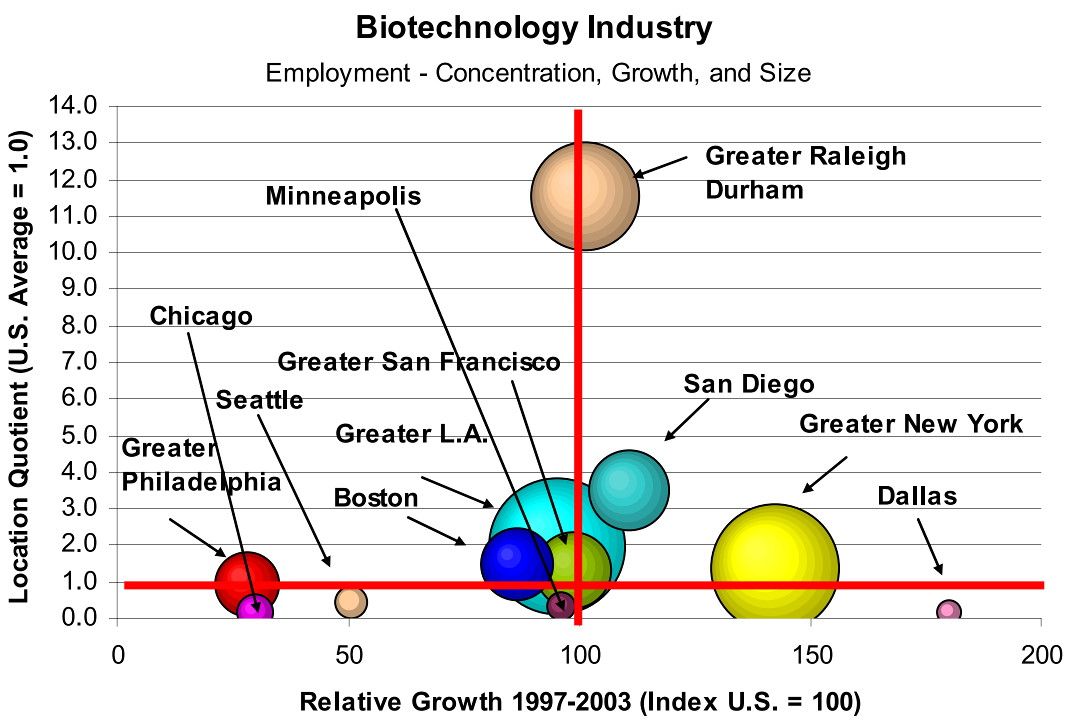
Minneapolis ranked first on the medical devices composite index, a reflection of its longstanding strength of companies in medical devices including 3M in Ramsey County and St. Jude Medical Co. in Hennepin.

Current Impact Measures (CIM) - Scores for Medical Devices
Ranked by Composite Index

MEDICAL DEVICES		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Minneapolis	71	100	78	100	80	50	86	100
2	Greater Los Angeles	100	41	72	79	100	100	100	99
3	Greater San Francisco	68	56	70	94	80	50	71	85
4	Boston	49	50	58	74	100	50	71	74
5	Chicago	50	28	70	63	40	100	43	66
6	San Diego	19	38	58	89	60	100	57	65
7	Greater New York	59	19	60	52	20	50	43	54
8	Greater Philadelphia	25	21	76	66	20	50	100	53
9	Seattle	13	21	68	84	40	20	86	50
10	Greater Raleigh Durham	4	16	100	57	40	17	86	46
11	Dallas	17	15	59	51	40	17	43	38

With respect to biotechnology, another key industry among the core life sciences, 2,400 people were employed in Greater Philadelphia in 2003, accounting for 5 percent of the metro's core life sciences industry. Among the large companies in Greater Philadelphia primarily engaged in biotechnology is Centocor, which became a fully-owned subsidiary of Johnson & Johnson in 1999.

The employment LQ of Greater Philadelphia is slightly below the national average, placing it seventh behind Boston. Greater Raleigh Durham's employment concentration was the highest of the 11 metros, registered at 11.5 in 2003.

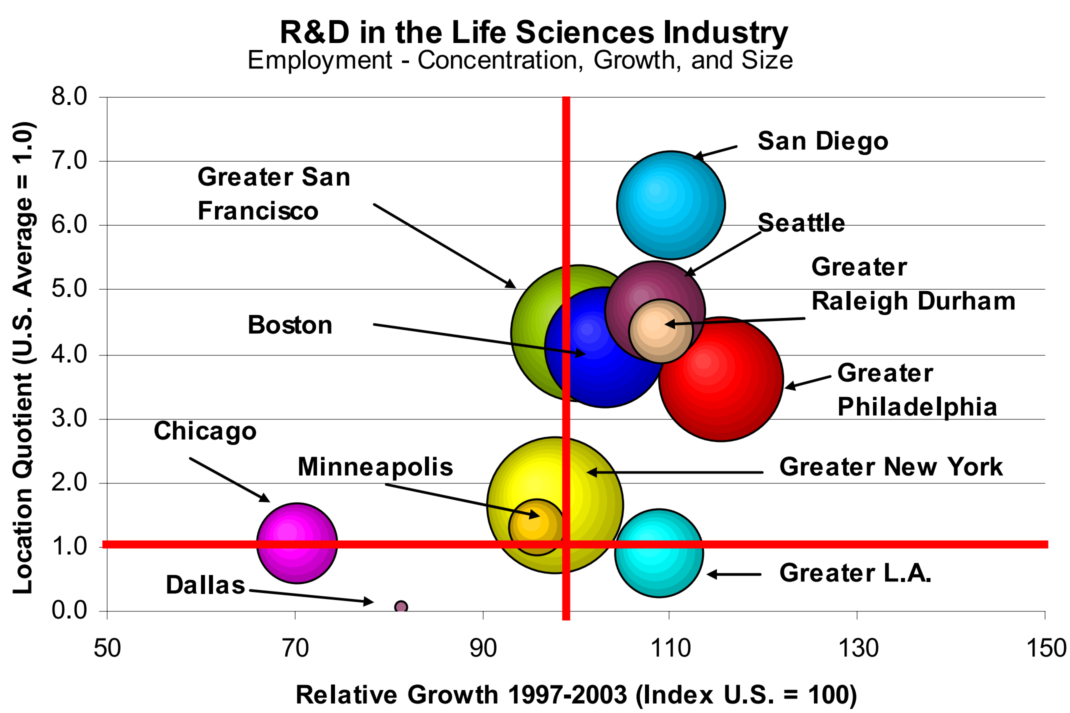


San Diego scored 100 in four categories in biotechnology, placing it second on the composite index behind Greater Raleigh Durham. Two out of the three industries that comprise biotech have been growing relatively faster in San Diego than in the United States, with all three industries having LQs greater than 2.0. Greater Philadelphia scored relatively low on the biotechnology composite index at 32.7. A significant reason for this is the fact that biotechnology R&D, an area in which Philadelphia is fairly strong, is classified under the general NAICS code for scientific services and thus does not appear in this chart.

Current Impact Measures (CIM) - Scores for Biotechnology
Ranked by Composite Index

BIOTECHNOLOGY		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater Raleigh Durham	64	100	56	50	100	100	67	100
2	San Diego	37	30	62	100	100	100	100	86
3	Greater Los Angeles	100	17	53	25	75	100	33	79
4	Greater New York	87	12	79	18	25	50	100	68
5	Greater San Francisco	33	12	55	37	25	100	100	56
6	Boston	28	12	48	45	25	100	67	52
7	Dallas	3	1	100	14	25	25	100	37
8	Greater Philadelphia	23	8	16	22	50	50	33	33
9	Minneapolis	5	3	53	37	25	25	67	31
10	Seattle	6	4	28	18	25	33	67	24
11	Chicago	7	2	17	9	25	25	67	19

Focusing on R&D in the life sciences industry reveals that Greater Philadelphia does relatively better than most of the metros in terms of absolute employment; 27 percent of Greater Philadelphia's core life sciences employment was in R&D. Greater Philadelphia's employment in this category between 1997 and 2003 also grew relatively faster than the U.S., placing the metro first in the employment growth category.



Greater Philadelphia scored 100 on four of the seven measures comprising the R&D in the Life Sciences composite, ranking the metro fourth in the overall composite index of current impact measures. Note that the bulk of R&D recorded in this category is devoted to biotechnology because firms not engaged in manufacturing are classified as scientific services in the NAICS classifications.

Current Impact Measures (CIM) - Scores for R&D in the Life Sciences

Ranked by Composite Index

LIFE SCIENCE R&D		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	San Diego	61	100	95	100	100	100	100	100
2	Greater San Francisco	100	69	87	79	100	100	100	99
3	Boston	78	65	89	71	100	100	100	91
4	Greater Philadelphia	82	57	100	35	100	100	100	86
5	Seattle	57	74	94	37	100	100	100	82
6	Greater Raleigh Durham	22	69	94	83	100	100	100	79
7	Greater New York	98	26	85	19	50	100	50	70
8	Greater Los Angeles	42	14	94	27	50	100	100	57
9	Minneapolis	18	21	83	24	50	100	50	47
10	Chicago	37	17	61	16	50	100	50	46
11	Dallas	1	1	70	13	50	50	50	28

In sum, 56 percent of Greater Philadelphia's core life sciences employment was in pharmaceuticals, 27 percent in R&D in the life sciences, 12 percent in medical devices and 5 percent in biotechnology in 2003.

Supporting Industries

The following table presents an overview of the economic contribution of the industries that support the life sciences. Those contributions were arrived at by examining absolute employment and employment concentration across the 11 metros.

Life Sciences Supporting Industries

Ranked by Employment LQ, 2003

Rank	MSA	Total Life Sciences Supporting Industries Employment	Total MSA Employment	Percent of Total Employment	Employment LQ
1	Greater New York	912,740	6,358,150	14.4%	1.25
2	Boston	262,990	2,020,989	13.0%	1.13
3	Greater Philadelphia	310,188	2,430,962	12.8%	1.11
4	Chicago	395,916	3,681,327	10.8%	0.94
5	Greater Raleigh Durham	57,426	545,582	10.5%	0.92
6	Minneapolis	153,309	1,458,790	10.5%	0.91
7	Greater San Francisco	249,902	2,465,561	10.1%	0.88
8	Seattle	127,723	1,297,310	9.8%	0.86
9	Greater Los Angeles	472,554	4,969,204	9.5%	0.83
10	Dallas	203,317	2,271,855	8.9%	0.78
11	San Diego	91,167	1,035,959	8.8%	0.77
	US	12,198,326	106,150,283	11.5%	1.00

In 2003, Greater Philadelphia employed 310,188 people in life sciences supporting industries, which accounted for 12.8 percent of the region's total employment. The aggregate employment LQ of 1.11 indicates that there is a higher concentration of life sciences supporting industries in Greater Philadelphia than the national average. We also found that Greater Philadelphia's employment concentration among the life sciences supporting industries is relatively high.

The data on Greater Philadelphia demonstrates that its general medical and surgical hospitals help promote the region's life sciences growth. That industry employed nearly 5 percent of Greater Philadelphia's total employment in 2003. The metro's employment concentration of druggists' goods merchant wholesalers was 3.21, indicating that Greater Philadelphia had more than three times the employment concentration in this industry than the U.S. average. This is primarily due to the area's large pool of major pharmaceutical companies. Montgomery County especially has a considerable amount of employees working in this industry group. Also noteworthy, Greater Philadelphia has over 47,000 employees in the offices of physicians category (except mental health), representing almost 2 percent of the metro's employment.

Life Sciences Supporting Industries

Greater Philadelphia, 2003

Industry	NAICS	Total Employment	% of Total Employment	Employment LQ
Optical Instrument & Lens Mfg	333314	336	0.0%	0.71
Medical Equip. & Merchant Wholesalers	423450	3,422	0.1%	1.26
Druggists' Goods Merchant Wholesalers	42421	7,797	0.3%	3.21
Ophthalmic Goods Merchant Wholesalers	42346	123	0.0%	0.71
Optical Goods Stores	44613	1,619	0.1%	0.97
Direct Health & Medical Insurance Carriers	524114	9,100	0.4%	1.24
Medical Laboratories	621511	3,161	0.1%	1.21
Offices of Physicians (exc Mental Health)	621111	47,103	1.9%	1.11
Offices of Dentists	62121	17,356	0.7%	1.01
Offices of Optometrists	62132	2,158	0.1%	0.99
Offices of all other misc Health Practitioners	621399	1,901	0.1%	1.55
Kidney Dialysis Centers	621492	1,484	0.1%	1.02
Nursing Care Facilities	62311	36,791	1.5%	1.00
Pharmacies & Drug Stores	44611	23,330	1.0%	1.39
Diagnostic Imaging Centers	621512	1,825	0.1%	1.19
Offices of Chiropractors	62131	2,516	0.1%	1.00
Offices of Podiatrists	621391	1,379	0.1%	1.81
HMO Medical Centers	621491	180	0.0%	0.16
Freestanding Emergency Medical Centers	621493	672	0.0%	0.52
Home Health Care Services	62161	16,300	0.7%	0.89
Blood & Organ Banks	621991	728	0.0%	0.61
General Medical & Surgical Hospitals	62211	118,516	4.9%	1.10
Other Specialty Hospitals	62231	7,212	0.3%	1.83
Testing Laboratories	541380	1,803	0.1%	0.78
All other Basic Inorganic Chemical Mfg	325188	1,454	0.1%	1.27
All other Basic Organic Chemical Mfg	325199	1,922	0.1%	1.14
Total Life Sciences Supporting Industries		310,188	12.8%	1.11

Greater Philadelphia ranked second on the life sciences supporting industries composite index.

Current Impact Measures (CIM) - Scores for Life Sciences Supporting Industries
Ranked by Composite Index

LIFE SCIENCES SUPPORTING INDUSTRIES		Size and Performance		Diversity		Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	# of Ind. LQ>1 2003	# of Ind. LQ<0.75 2003	Composite Index 2003
1	Greater New York	100	100	100	80	100
2	Greater Philadelphia	34	89	84	80	78
3	Boston	29	91	63	100	76
4	Chicago	43	75	53	100	70
5	Greater Los Angeles	52	66	68	57	64
6	Greater San Francisco	27	71	58	44	57
7	Greater Raleigh Durham	6	73	58	57	56
8	Minneapolis	17	73	53	31	53
9	Seattle	14	69	42	40	50
10	Dallas	22	62	42	40	48
11	San Diego	10	61	42	40	45

In Greater Philadelphia, only five out of the 26 supporting industries had LQs less than 0.75 and more than 60 percent had an employment concentration above the national average in 2003.

Diversity Measures - Life Sciences Supporting Industries
By MSA, 2003

MSA	# of Industries with LQ >1.0	# of Industries with LQ <0.75
Boston	12	4
Chicago	10	4
Dallas	8	10
Greater Raleigh Durham	11	7
Greater Los Angeles	13	7
Minneapolis	10	13
Greater New York	19	5
Greater Philadelphia	16	5
San Diego	8	10
Greater San Francisco	11	9
Seattle	8	10

The total current impact composite index is comprised of the sum of the weighted current impact of the core life sciences composite index and the life sciences supporting industries composite index. Greater Philadelphia ranked first on the total current impact composite index, followed closely by Greater New York and Greater San Francisco.

Total Life Sciences Current Impact

LIFE SCIENCES		Core Life Sciences	Life Sciences Supporting Industries	Total Current Impact
Rank	MSA	Composite Index 2003	Composite Index 2003	Composite Index 2003
1	Greater Philadelphia	93.6	78.0	100.0
2	Greater New York	83.9	100.0	99.7
3	Greater San Francisco	100.0	57.2	98.0
4	Boston	87.7	76.5	94.9
5	Greater Los Angeles	90.4	64.4	92.8
6	Greater Raleigh Durham	92.7	56.1	91.9
7	San Diego	96.4	45.4	91.2
8	Minneapolis	72.3	53.0	74.8
9	Chicago	63.6	70.0	73.7
10	Seattle	62.7	49.6	66.0
11	Dallas	40.5	48.4	48.2

Role of the Supporting Life Sciences Sector in the Greater Philadelphia Metro

The impact of Greater Philadelphia's life sciences supporting industries cannot simply be measured by levels of employment and LQ. Health care and related services has seen the largest increase in jobs both nationally and in Greater Philadelphia over the past several years. However, Greater Philadelphia's local economy far more effectively tied these resources into the greater life science economy, particularly in connection with the strong presence of the pharmaceutical industry in and around the city.

The most significant role among the life sciences supporting industries is that played by the region's highly prestigious general and specialty medical schools and research hospitals. Philadelphia's medical research centers not only provide a strong local impact through the relatively high wages and supporting jobs they provide, but also by serving as a focal point for grants and investment from both pharmaceutical companies and federal agencies such as the National Institute of Health. The prominence of these medical facilities also helps to account for the unusually low concentrations of HMO medical centers (LQ=0.16) and freestanding emergency medical centers (LQ=0.52) compared to the national average.

Medical schools and research hospitals

The University of Pennsylvania Medical School is one of the oldest and most prestigious in the country. Its network of leading hospitals, exceptional graduate medical programs and highly regarded dental and nursing schools, serve as the principal focal point for medical training and research in the Greater Philadelphia area. Penn is the largest recipient of research and development funding in the state, with the largest portion of its research spending directed to medicine and life sciences.[3]

The University of Pennsylvania Health System includes the Hospital of the University of Pennsylvania, Pennsylvania Hospital and Presbyterian Medical Center. While the former hospital serves as a center of teaching and research, Presbyterian is a leading center of cardiovascular care, and Pennsylvania Hospital has been named one of the leading hospitals in the country by both *U.S. News* and *World Report* and *Modern Maturity*. Founded in 1751, Pennsylvania Hospital is the oldest hospital in the U.S. It is nationally ranked in cardiac care, cardio-vascular surgeries, geriatrics, infectious care, orthopedics and pulmonary care. The University of Pennsylvania hospital is nationally ranked in fifteen categories, including cancer, digestive disorders, ear, nose and throat, geriatrics, gynecology, cardiology and heart surgery, hormonal disorders, kidney disease, neurology, neurosurgery, ophthalmology, psychiatry, rehabilitation, respiratory disorders, rheumatology and urology. The hospital has been ranked by *U.S. News and World Report* as one of its top tier of hospitals for eight straight years.[4]

Thomas Jefferson University is another prominent dedicated medical university in Greater Philadelphia, as well as being the second largest local employer, with over 22,000 employees in the university and its managed hospitals. Private funding of medical research at the university exceeds $64 million annually, making it one of the key centers for medical advancements in the metro. The graduate school at the university provides programs in numerous physical science disciplines such as biology, genetics and pharmacology that supplement the strong medical program. The university's highly regarded hospital[5] is one of the leading university affiliated hospitals, not only regionally, but nationally as well. Along with other university-affiliated hospitals such as those associated with the University of Pennsylvania, Temple University and Drexel University, Jefferson Hospital has continued to keep Philadelphia a leading center of research and advanced medical techniques. The hospital is nationally ranked in several fields, including rehabilitation, cardiology/cardiac surgery and orthopedics.

Temple University supplements the University of Pennsylvania in playing a significant role both in medical research and in the overall life science supporting industries. Four out of five of its graduate professional schools—medicine, dentistry, podiatry and pharmacy—are prominent life science professional schools that serve as key centers of medical training and research. The university is one of the chief recipients of private research funding in the region, and has established partnership programs with many of the leading life science companies in the region.

Temple University Hospital is a center of research in numerous fields, particularly pulmonology, cardiology, cardiothoracic surgery, gastroenterology, orthopedics and sports medicine.[6] Unlike many other research and specialty hospitals in the region, Temple University Hospital is a primary care facility with one of the busiest emergency departments in the region.

Temple University's School of Dentistry is the second oldest in the nation, founded in 1863. The school includes a department of dental informatics as well as several research laboratories, including those in applied periodontal and craniofacial research, oral biology and oral biomaterials.[7] The strong research presence at the school provides an economic benefit to its surrounding area not normally associated with the field.

The Temple University School of Podiatry is one of only seven programs in the country accredited to give a specialized doctorate in podiatry, and one of only two in the northeast U.S. Philadelphia has an unusually high concentration of podiatrists, with an LQ of 1.81, that can be directly related to the presence of the School of Podiatry and the high volume of urban dwellers who walk to work.

Drexel University's College of Medicine, in partnership with Tenet Healthcare, manages three of the leading hospitals in Greater Philadelphia. The university's partnership with Tenet stems from Drexel's acquisition of MCP Hahnemann University, run by Tenet following the latter's bankruptcy. Drexel's College of Medicine is one of the top 100 universities in the country in federal research expenditures.[8] The partnership with Tenet Healthcare allows the university to pool its resources with Tenet's teaching hospitals and attract research funding through managed health-care sources in addition to the pharmaceutical funding most prevalent in Greater Philadelphia.

Other key supporting industries

Two of the largest employers in the Greater Philadelphia metro are involved in general health management and long-term care services. Genesis HealthCare provides and operates facilities for long-term care and rehabilitation, and is the largest operator of nursing homes in Greater Philadelphia. Crozer-Keystone Health System has over 7,100 employees in the metro area and has consistently served as an innovator in children's and community health-care programs.[9]

Greater Philadelphia has a slightly higher concentration of medical laboratories and direct health and medical insurance carriers than the country as a whole with LQs of 1.21 and 1.24, respectively. This is consistent with the slightly higher LQs of virtually all of Greater Philadelphia's life science supporting industries. As noted in the following section, the clustering effect of the life sciences has played a significant role in the overall economic development of the metro. One supporting industry that has particularly benefited has been chemical manufacturing.

In the organic and inorganic chemical manufacturing industry, Greater Philadelphia has benefited from the presence of DuPont and the concentration of other chemical manufacturing companies in and around Wilmington that have significantly aided the manufacturing and preparation of pharmaceuticals in the region. Although Greater Philadelphia as a whole does not significantly outstrip the rest of the country in employment concentration in organic and inorganic chemical manufacturing, the industry is one of the few that has continued to thrive in the region and has managed to outperform the nation in employment as a whole.[10] In fact, chemical manufacturing is the only major manufacturing sector to increase employment in Greater Philadelphia between 1982 and 2002, while overall manufacturing employment in the metro declined by a dramatic 32 percent. A significant reason for this increase was the very high proportion of chemical industry employment directly related to pharmaceuticals, 44 percent, well above the national average of 25 percent. Chemical manufacturing jobs also have the advantage of being higher paying on average than most other manufacturing jobs in the region, and have contributed to the fact that Greater Philadelphia has retained a larger proportion of higher-wage manufacturing jobs even as large numbers of lower-end jobs have moved to locations with lower overall cost structures.

Clustering and the Spatial Dimension of Greater Philadelphia Metro

This section offers insight into industry clusters and the potential advantages that developed clusters provide to regional economies. Here we present the spatial distribution of life science establishments and employment in Greater Philadelphia and the economic payoff of the metro's life science cluster.

The key element to competitiveness in a global economy is a region's ability to support and enhance the growth of the interrelated industries in which that particular region specializes. This concentration of interrelated industries is often referred to as a cluster. "A **cluster** is a geographic concentration of competing, complementary or interdependent firms with a common need for talent, technology, infrastructure, etc. Cluster relationships are dynamic and evolve in reaction to market and other forces."[11] Clusters are a complex network of suppliers, services, support institutions and producers including governmental and nongovernmental entities such as universities, patent attorneys and venture capitalists located in a particular region that drives innovation and thus, the creation of new products, new companies and higher skilled/ higher wage jobs.[12] These agglomerations of interrelated industries foster wealth creation in a region, principally through the export of goods and services beyond its borders.[13]

Each industry cluster is unique due to differences in industry sector, number and sizes of establishments, purchase-sale linkages, and inter-firm cooperation and collaboration. "A common misperception of clusters is that they are based upon a single industry. One industry might be at the core of a cluster, but without its partners, it may not endure for long."[14]

Technology and knowledge-driven innovation are essential to wealth creation and overall economic vibrancy in the global economy. A region's future economic performance is linked to its ability to translate research into innovations that translate into new technology companies being established and grown. "Success in creating high-tech clusters is now the distinguishing determinant of regional vitality."[16]

Advances in life science research and development are changing the way we live and work. The knowledge-intensive life sciences industry is driven by the creation, accumulation and exploitation of knowledge. The life sciences industry will increase our understanding of diseases, and subsequent development of new effective drugs and vaccines, thereby providing careers in cutting-edge R&D, high-tech manufacturing and medical services. As economic activity is increasingly based more on intangible assets, those regions that experience rapid growth of life sciences clusters will be those with more innovations, less of which will escape to other regions, or at least, will do so at a slower rate.

Regional viability is linked to the ability to establish local technology and life sciences related clusters that are networked to the global business community. Communities retain local vitality, yet still link their business to the global economy by creating an environment that attracts and retains footloose companies.[17]

Industry clusters and the associated support infrastructures that affect their competitiveness among regions as well as across national borders are a region's best protection against being arbitraged in a global cost-minimization game. Competition in today's economy is highly dynamic. Companies can mitigate input-cost disadvantages through global sourcing, making old comparative advantages less important. Competitive advantages rest increasingly on making productive use of inputs that are based largely on innovation competencies.[18] Clusters linked to the outside world provide their regions access to the best practices and latest industry developments. Regions excel to the extent that the firms and talent within them can innovate successfully by being there, rather than somewhere else.[19]

Geographic clustering of technology clusters is critical to a region's economic growth. The role of locations, especially the immediate business environment surrounding companies is essential for innovation, competitive success and fostering sustained agglomeration processes. Spatial dimensions of economic activity are central to understanding how an economy works.[20] The fact that knowledge is generated and transmitted more efficiently in close proximity leads to the phenomenon that economic activity based on new knowledge has a high tendency to cluster in a geographic area. Agglomeration effects typically arise from three primary sources: labor-force pooling, supplier networks and technology spillovers.

The key to regional technology sustainability is based upon the diversity of its ecosystem. Clustering innovative activity is imperative. These newly established companies are able to assist regions in developing management capabilities that can be leveraged to quicken the pace of innovation for new entrants. Newly formed entrepreneurial firms strongly influence technology management capabilities resident in the region by rapidly exploiting emerging technology market opportunities. Several high-tech regions have developed capabilities for rapid design changes at dominant companies, and more importantly, integrating new regional knowledge into business startups.

The power of life sciences clusters in determining the relative economic growth of regions is high. Greater Philadelphia's strong research expertise in conjunction with industrial experience creates the right conditions for new life sciences establishments. The growth of Greater Philadelphia's life sciences cluster is primarily the result of its reputation as a world center for the U.S. pharmaceutical industry, its strong local research infrastructure including the region's many research-intensive academic establishments such as the University of Pennsylvania, and its breakthrough research. It is the eclectic mix of university research, technology spin-out companies from that work and startups working in a closely networked life sciences cluster that encourage companies to move to Greater Philadelphia. Underpinning the region's factors that are vital to cluster success is a mature support network for entrepreneurs, including venture capitalists, high-tech accommodation and professional services providers.

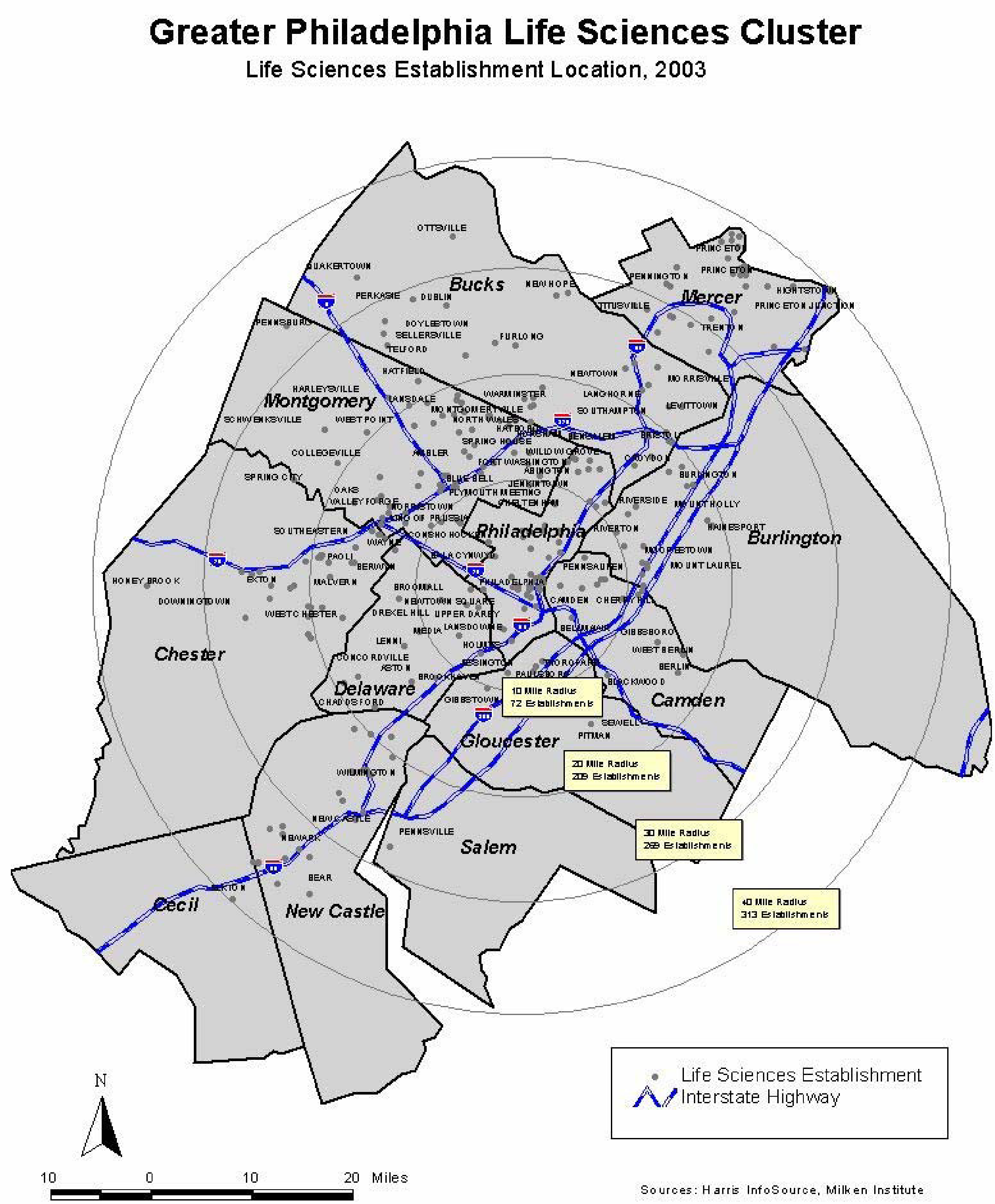
The map of Greater Philadelphia's life sciences firms by ZIP code in 2003 demonstrates its ability to create an environment of collaboration and the exploration of new ideas and its ability to attract new life sciences companies. Many of these life sciences companies are located near I-95.

Montgomery County represents the densest concentration of life sciences establishments in Greater Philadelphia. The life sciences industry emerged as a major driver of the county's economy with over 21,000 people employed in 73 life sciences establishments. The detailed breakdown of Montgomery County further reveals that Plymouth Meeting is home to nine life sciences establishments, while Horsham is supported by six life sciences companies. Norristown and King of Prussia are home to five life sciences companies.

The next largest concentration of companies is found in Philadelphia County. The City of Philadelphia is home to 51 life sciences firms. Among the leaders are Wyeth Pharmaceuticals Co., Inc. and GlaxoSmithKline.

In Mercer County, the life sciences industry is comprised of 34 establishments with Johnson & Johnson Pharmaceutical Research, Inc. and Bristol-Myers Squibb Co. as significant contributors to the county's economy. In Princeton alone, there are 14 companies engaged in the life sciences industry.

Wilmington and Newark in New Castle County have an established base of life sciences companies with a concentration of 13 and 11 firms, respectively. Malvern in Chester County with 10 firms is another key area of Greater Philadelphia's life sciences industry. It has the potential to add thousands of future life sciences companies and jobs to its local economy. West Chester in Chester County encompasses seven firms, among them, Cephalon, a fast-growing biopharmaceutical company.



The following map gives an overview of the spatial dimensions of the Greater Philadelphia life sciences cluster, showing the concentration of employment by area within a 10-mile radius. As evidenced by the map, Montgomery County and Philadelphia County have high concentrations of core life sciences employment. The firm-level breakdown[22] for

Philadelphia County reveals that GlaxoSmithKline employs more than 5,000 employees and Wyeth Pharmaceuticals Co. employs 7,000 people.

The impact of Greater Philadelphia's life sciences cluster in Montgomery County is evidenced by the more than 21,000 life sciences jobs provided by Merck & Co. and GlaxoSmithKline. Wyeth Pharmaceuticals Co. has its headquarters in Collegeville in Montgomery County.

AstraZeneca, a leading global pharmaceutical company, employs approximately 4,500 people at its site in Wilmington, New Castle County.

Mercer County reaps a substantial economic benefit from the presence of Bristol-Myers Squibb Co. in Pennington (1,800 employees) and Johnson & Johnson Pharmaceutical Research, Inc. (1,100 employees) located in Titusville.

Montgomery County has 73 life sciences companies with 21,390 employees (table below). The county's largest life sciences firm is Merck & Co. located in West Point. Philadelphia County employs nearly 7,000 people in 51 establishments in the core life sciences industry, while Chester County is home to 37 life sciences establishments. Among Camden County's 17 life sciences establishments is Baxter Health Care Cooperation that employs 1,000 people.

Greater Philadelphia Life Sciences Cluster

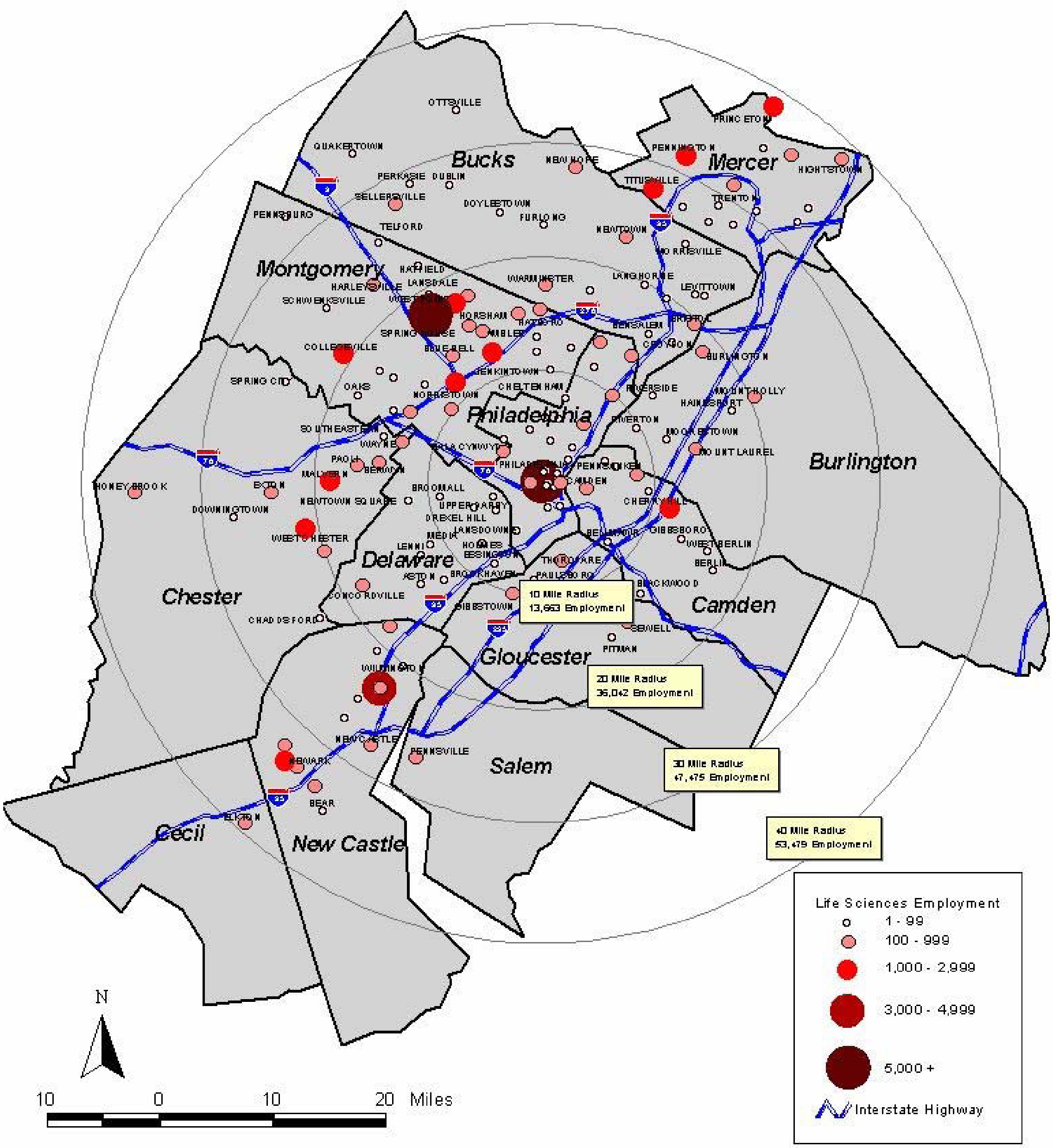
Core Life Sciences, Ranked by Employment, 2003

Rank	County	State	Establishment	Employment
1	Montgomery	Pennsylvania	73	21,390
2	Chester	Pennsylvania	37	7,528
3	Philadelphia	Pennsylvania	51	6,874
4	Mercer	New Jersey	34	6,246
5	New Castle	Delaware	28	5,942
6	Delaware	Pennsylvania	16	1,953
7	Bucks	Pennsylvania	33	1,830
8	Camden	New Jersey	17	874
9	Gloucester	New Jersey	7	759
10	Burlington	New Jersey	15	83
11	Cecil	Maryland	1	0
12	Salem	New Jersey	1	0
		Total	313	53,479

Sources: BLS (ES202), Census (CBP), Harris InfoSource, Milken Institute

Greater Philadelphia Life Sciences Cluster

Life Sciences Employment Centers by ZIP code, 2003



Sources: Harris InfoSource, Milken Institute

Methodology

This section defines the life sciences industry at a more detailed level and addresses the data sources and estimation techniques used to arrive at the current impact measures.

Defining the industries

The data for this analysis, based on the 2002 North American Classification System (NAICS) as defined by the Office of Management and Budget (OMB) of the federal government, was gathered from a series of government sources.

In measuring the current impact assessment, data was compiled for the core life sciences industries identified earlier as biotechnology, medical devices, pharmaceuticals and life sciences R&D. Special attention was also given to the life sciences supporting industries (see the appendix.)

The table below gives an overview of NAICS-based industry classifications that were used in defining the **biotechnology** industry.

Defining the Biotechnology Industry

NAICS	Biotechnology Industry
325411	Medicinal and botanical manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Other biological product manufacturing

Likewise, the **medical devices** industry is defined using the following NAICS-based industry classifications:

Defining the Medical Devices Industry

NAICS	Medical Devices Industry
339111	Laboratory apparatus and furniture mfg.
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
334510	Electromedical apparatus manufacturing
334517	Irradiation apparatus manufacturing

The **pharmaceutical industry** is defined as:

Defining the Pharmaceutical Industry

NAICS	Pharmaceutical Industry
325412	Pharmaceutical Preparation Manufacturing

Life sciences R&D is NAICS-based industry classification:

Defining the R&D in the Life Sciences Industry

NAICS	R&D in the Life Sciences Industry
5417102	R&D in Life Sciences

As is shown in the table below, the core **life sciences** industry group encompasses biotechnology, pharmaceuticals, medical devices and life sciences R&D.

Defining Core Life Sciences

NAICS	Life Science Industry Group
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-vitro Diagnostic Substance Manufacturing
325414	Other Biological Product Manufacturing
5417102	R&D in Life Sciences
339111	Laboratory Apparatus and Furniture Mfg.
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
339114	Dental Equipment and Supplies Manufacturing
339115	Ophthalmic Goods Manufacturing
339116	Dental Laboratories
334510	Electromedical Apparatus Manufacturing
334517	Irradiation Apparatus Manufacturing

The life sciences industry group rewards those metros that focus on more than just biotechnology. Cities like Boston that are known for manufacturing pharmaceutical products, score higher in the life sciences category.

In addition to collecting data on the core life sciences, this analysis was supplemented by data on the industries that support the life sciences. The industries included in the **life sciences supporting industries** are summarized in the table below.

Defining Life Sciences Supporting Industries

NAICS	Life Sciences Supporting Industry Group
333314	Optical Instrument & Lens Mfg
423450	Medical Equip. & Merchant Wholesalers
42421	Druggists' Goods Merchant Wholesalers
42346	Ophthalmic Goods Merchant Wholesalers
44613	Optical Goods Stores
524114	Direct Health & Medical Insurance Carriers
621511	Medical Laboratories
621111	Offices of Physicians (exc Mental Health)
62121	Offices of Dentists
62132	Offices of Optometrists
621399	Offices of all other misc Health Practitioners
621492	Kidney Dialysis Centers
62311	Nursing Care Facilities
44611	Pharmacies & Drug Stores
621512	Diagnostic Imaging Centers
62131	Offices of Chiropractors
621391	Offices of Podiatrists
621491	HMO Medical Centers
621493	Freestanding Emergency Medical Centers
62161	Home Health Care Services
621991	Blood & Organ Banks
62211	General Medical & Surgical Hospitals
62231	Other Specialty Hospitals
541380	Testing Laboratories
325188	All other Basic Inorganic Chemical Mfg
325199	All other Basic Organic Chemical Mfg

Data Estimation Techniques

There are limitations of the data associated with firm-level employment statistics to the extent that many companies in the life sciences industry are involved in different areas such as R&D in the life sciences, pharmaceuticals, biotechnology or medical devices industry that can result in different data sources classify companies in different industries. Given the differences in companies' databases, we overcome these measurement inconsistencies by taken various government data sources as well as taking the Harris Infosource database into account. In the case of AstraZeneca we did overcome data discrepancies between the Bureau of Labor Statistics and Harris InfoSource by reconciling the coding differences and adjusting the employment figures accordingly.

Six of the seven measures used in arriving at the current impact assessment are based on employment data, while one is based on the number of establishments. The employment data was derived using government released ES202 and County Business Pattern data. The ES202 reports payroll employment derived from the quarterly tax report submitted to state Employment Development Departments (EDDs) that are subject to unemployment insurance (UI) laws. County Business Pattern (CBP) data, available from 1998-2002, was used to calculate the shares of employment at a more detailed NAICS level, and then applied to the higher NAICS level from ES202 for those years. Since ES202 data at the 4-digit NAICS level is available for 2003, the employment shares from the 2002 CBP were then redistributed using the absolute change in ES202 employment from 2002 to 2003. Similarly, the 1998 CBP employment shares are applied to the 1998 ES202 and then carried back one year to 1997, thus maintaining a realm of consistency and producing detailed historical estimates through 1997.

For the R&D in the life sciences industry, represented by the 7-digit NAICS code 5417102, data is publicly available from the 1997 Economic Census. Employment shares from the 2002 CBP and historical trends from the ES202 data set were applied in obtaining more current estimates.

Finally, establishment data at the detailed 6-digit NAICS level was compiled from the County Business Patterns and then processed into the appropriate categories as described earlier in this section.

By applying these estimation techniques, detailed metro employment data up to the 6-digit NAICS level (and 7-digit for R&D in the life sciences) is compiled for 1997 to 2003.

Metropolitan Statistical Area Changes

The Office of Management and Budget (OMB) defines metropolitan statistical areas. Using the 2000 census data, the OMB has revised metropolitan statistical areas (MSAs) across the country. The current definition is as of November 2004. The general concept of MSAs is one of a large population nucleus, combined with adjacent territory that a high degree of economic and social integration with that nucleus as measured by community ties.

Along with these changes of the geographic definition of the MSAs, our study defined life science regions by combining some MSAs, eliminating or even adding some counties since clusters rarely conform to the offical MSA definition. If an MSA had a high degree of life science linkages and interaction with another MSA essentially operating as one cluster, we combined the two metropolitan statistical areas and referred to the new geographic area as "Greater."

Greater Los Angeles is a good example. Our study combined the two metropolitan statistical areas of Los Angeles-Long Beach-Santa Ana, CA MSA and Oxnard-Thousand Oaks-Ventura, CA MSA and defined the life sciences region as "Greater Los Angeles." Our definition takes into account that both MSAs form a geographic concentration of innterconnected companies and institutions in the life sciences industry. For example, companies like Amgen, one of the world largest biotechnology companies, is located in the Oxnard-Thousand-Oaks-Ventura, CA MSA, however the company has strong ties to suppliers of specialized inputs and governmental and other institutions in the Los Angeles-Long Beach-Santa Ana, CA MSA.

Likewise, removing Middlesex County, NJ from the New York-Northern New Jersey-Long Island, NY-NJ-PA MSA is intended to stress the fact that Middlesex County, NJ with its resources in life science research, development and large pool of life sciences-related venture capital funds, qualifies to be looked upon as a "small" life sciences cluster on its own. The life sciences cluster in Middlesex County, NJ benefits from its efficient infrastructure, strong base of supporting functions and institutions and a great supply of better trained employees. Neither New York or Philadelphia have strong enough gravitational pull and interconnections for Middlesex County to be considered part of their respective life sciences clusters.

Including Mercer County, NJ (Trenton, NJ MSA) in the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA reflects the strong linkages of Mercer County's life sciences companies to the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA. The presence of the metro's multiple suppliers and institutions that assist in knowledge creation as well as efficient access to specialized inputs, services and employees reflect the fundamental influence of externalities and linkages across firms and associated institutions in Greater Philadelphia's life sciences industry. This extends the cluster to include Princeton, NJ.

The table below provides the list of the 11 life science regions studied with their official OMB definition and detailed information on the counties they encompass.

Metropolitan Statistical Areas Defined

Life Science Region	Official Metro Name, defined by OMB	County		
Boston	Boston-Cambridge-Quincy MA-NH MSA	Norfolk, MA Plymouth, MA Suffolk, MA	Essex, MA Rockingham, NH Strafford, NH	Middlesex, MA
Chicago	Chicago-Naperville-Joliet, IL-IN-WI MSA	Cook, IL De Kalb, IL Du Page, IL Grundy, IL Kane, IL	Kendall, IL McHenry, IL Will, IL Jasper, IN Lake, IN	Newton, IN Porter, IN Lake, IL Kenosha, WI
Dallas	Dallas-Fort Worth-Arlington, TX MSA	Collin, TX Dallas, TX Delta, TX Denton, TX	Ellis, TX Hunt, TX Kaufman, TX Rockwall, TX	Johnson, TX Parker, TX Tarrant, TX Wise, TX
Greater Raleigh Durham	Raleigh-Cary, NC MSA Durham, NC MSA	Franklin, NC Johnston, NC Wake, NC	Chatham, NC Durham, NC Orange, NC Person, NC	
Greater Los Angeles	Los Angeles-Long Beach-Santa Ana, CA MSA Oxnard-Thousand Oaks-Ventura, CA, MSA	Los Angeles, CA Orange, CA	Ventura, CA	
Minneapolis	Minneapolis-St. Paul-Bloomington MN-WI MSA	Anoka, MN Carver, MN Chisago, MN Dakota, MN Hennepin, MN	Isanti, MN Ramsey, MN Scott, MN Sherburne, MN Washington, MN	Wright, MN Pierce, WI St. Croix, WI
Greater New York	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (excludes Middlesex, NJ)	Monmouth, NJ Ocean, NJ Somerset, NJ Nassau, NY Suffolk, NY Bergen, NJ Hudson, NJ	Passaic, NJ Bronx, NY Kings, NY New York, NY Putnam, NY Queens, NY Richmond, NY	Rockland, NY Westchester, NY Essex, NJ Hunterdon, NJ Morris, NJ Sussex, NJ Union, NJ Pike, PA
Greater Philadelphia	Philadelphia-Camden-Wilmington PA-NJ-DE-MD MSA Trenton, NJ MSA	Burlington, NJ Camden, NJ Gloucester, NJ Bucks, PA	Chester, PA Delaware, PA Montgomery, PA Philadelphia, PA	New Castle, DE Cecil, MD Salem, NJ Mercer, NJ
San Diego	San Diego-Carlsbad-San Marcos, CA MSA	San Diego, CA		
Greater San Francisco	San Francisco-Oakland-Fremont, CA, MSA San Jose-Sunnyvale-Santa Clara, CA, MSA	Alameda, CA Contra Costa, CA Marin, CA San Francisco, CA San Mateo, CA	San Benito, CA Santa Clara, CA	
Seattle	Seattle-Tacoma-Bellevue, WA MSA	King, WA Snohomish, WA Pierce, WA		

[1] The Location Quotient (LQ) equals % employment in metro divided by % employment in the U.S. If LQ>1.0, the industry's concentration is higher in that metro area than in the U.S. average.

[2] Andrew Wigglesworth in Linda Loyd. "Region faces shortage of science workers." *The Philadelphia Inquirer*. March 7, 2002. http://www.philly.com/mld/inquirer/2809727.htm

[3] Federal Reserve Bank of Philadelphia. 2002. *The Industrial Evolution: Two Decades of Change in the Philadelphia Metro Area's Economy*, Philadelphia: Federal Reserve Bank of Philadelphia, p.13

[4] http://www.uphs.upenn.edu/about_uphs/besthosp.html

[5] http://www.philadex.com/philadelphia/hospitals/jefferson.asp

[6] http://www.philadex.com/philadelphia/hospitals/temple.asp

[7] http://www.temple.edu/dentistry/about/history.htm

[8] http://www.drexel.edu/med/campus/history.asp

[9] http://www.crozer.org/Crozer/About+Us/default.htm

[10] Federal Reserve Bank of Philadelphia p.7

[11] Southern Minnesota Initiative Foundation. 2004. Cluster Study. Southern Minnesota Industry Inventory and Cluster Analysis Project. http://www.smifoundation.org/clustergeneralexecsumm04.pdf

[12] Porter, Michael E. 1998. "On Competition," *Harvard Business Review Book Series*, pp. 218-221.

[13] Kotkin, Joel and Ross C. DeVol. 2001. *Knowledge-Values Cities in the Digital Age*, Milken Institute Research Report, pp. 10-15.

[14] DeVol, Ross C. 2000. *Blueprint for a High Tech Cluster, The Case of the Microsystems Industry in the Southwest*, Milken Institute Policy Brief, pp. 1-6.

[15] Kotkin, Joel and Ross C. DeVol, "Knowledge-Values Cities in the Digital Age," Milken Institute Research Report, February, 2001, pp. 10-15

[16] DeVol, Ross C. 2000. *Blueprint for a High Tech Cluster, The Case of the Microsystems Industry in the Southwest*, Milken Institute Policy Brief, p. 9.

[17] Moss Kanter, Rosabeth. 2000. "Thriving Locally in the Global Economy," *World View: Global Strategies for the New Economy*, Jeffrey E. Garten, editor. 2000. Harvard Business School Publishing, pp. 227-243

[18] Porter, Michael E. 2000. "Clusters and the New Economics of Competition," *World View: Global Strategies for the New Economy*, Jeffrey E. Garten, editor. Harvard Business School Publishing, pp. 201-225.

[19] Coyle, Diane. 2001. Paradoxes of Prosperity: Why The New Capitalism Benefits All. New York, NY: TEXERE.

[20] Fujita, Mashisa, Paul Krugman, and Anthony J. Venables, *The Spatial Economy: Cities, Regions, and International Trade*, Cambridge, MA: The MIT Press.

[21] DeVol, Ross C. 2000. *Blueprint for a High Tech Cluster: The Case of the Microsystems Industry in the Southwest*, Milken Institute Policy Brief, August p. 4.

[22] BLS industry employment does not necessarily reflect firm-level employment given by Harris InfoSource.

Multiplier Impacts

Background and Relevance

The importance of the life science industry to the Greater Philadelphia region is significantly enhanced by its impact on the overall economy. Multiplicative values known as "multipliers" allow us to measure this impact quantifying how employment, earnings and output in the life science industry ripple through other regional economic sectors. In addition to providing statistical data on an industry's regional impact, economic multipliers also capture region-wide interdependencies and inter-industry relationships. These relationships directly influence how regional economies respond to changes in long-term industry structure and business cycles.

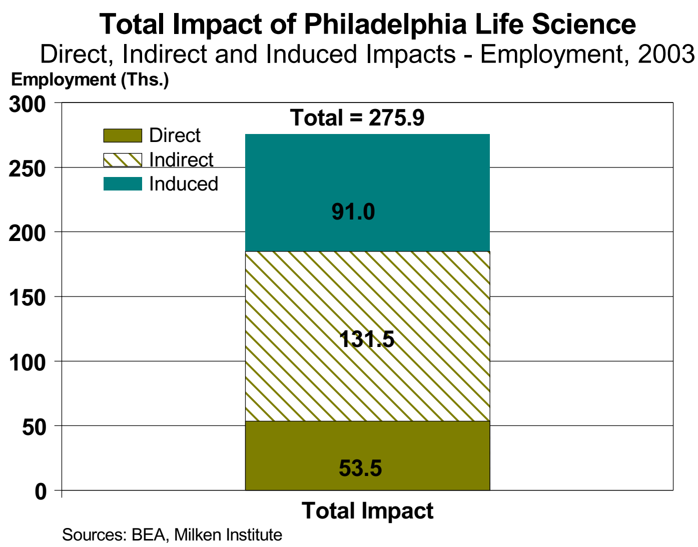
The multiplier impacts are characterized by four key components. The first is the industry's **direct impact**, that is, the number of jobs, amount of earnings or output directly generated by a given life science sector.

Economic effects, however, go beyond the industry in which the activity originated. Associated spillover economic activity in related industries is captured by the **indirect impacts**. Supplier industries that cater to the life science sector, for instance, generate a vast number of jobs within the wholesale and retail trade industries. These suppliers in turn utilize a network of suppliers to obtain goods and services. The cumulative employment, earnings and output generated by all of this tightly and extensively interconnected economic activity ripples throughout the regional economy. The wealth created leads to greater purchases of goods and services. This, in turn, produces still more income that becomes available to a region's residents who recycle their earnings back into their local economies.

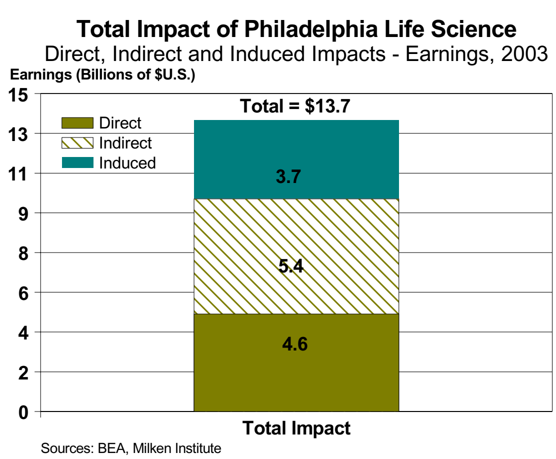
The net result of this latter process is known as **induced impact**. For example, in addition to the consumer spending by chemists, microbiologists, biotech researchers and pharmacists, spending by restaurant workers, retail clerks, real estate agents, contractors, and many others indirectly dependent upon the industry is also accounted for in this measure. It is through the aggregation of these impacts, also referred to as the **total impact**, that a given industry contributes to its local economy.

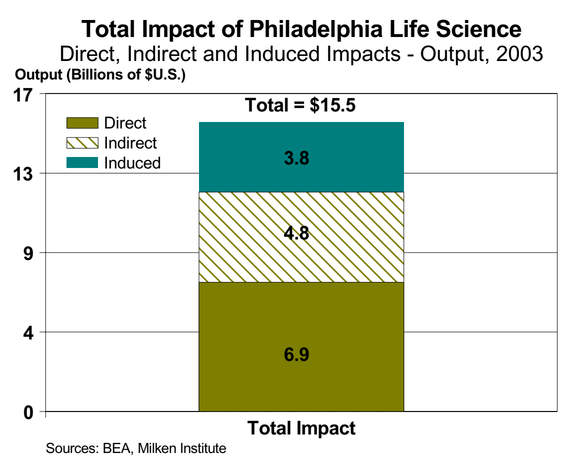
Metro Findings

In 2003, the life science industry in the Greater Philadelphia region employed nearly 53,500 workers, creating $4.6 billion in earnings and producing a gross metro product of $6.9 billion. These figures represent the direct impact of the life science sector on the regional economy. When the full extent of multiplicative dynamics are accounted for, life science is responsible for nearly 276,000 jobs (total impact), or 11.4 percent of all employment within the region. In addition, the industry's total impact accounts for 12.8 and 7.1 percent of the region's total earnings and output, respectively.



The additional 222,500 jobs, $9.1 billion in earnings, and $8.6 billion in output stem from the indirect and induced impacts that life science brings to the rest of the economy. Specifically, the indirect impact generates an additional 131,500 jobs, $5.4 billion in earnings and $4.8 billion of output, while the induced effect adds another 91,000 jobs, $3.7 billion and $3.8 billion worth of earnings and output, respectively. Together they contribute to the total impact that the life science sector brings to the region.





Accordingly, the total life science employment multiplier in Greater Philadelphia is 5.2 (276,000/53,500). In other words, each job in the region's life science sector produces an additional 4.2 jobs in other sectors. By the same token, since 2.2 percent of total employment in the region is in the life sciences, the industry ultimately accounts for 11.4 percent of total employment in Greater Philadelphia when including the multiplier effect (2.2 percent multiplied by 5.2).

Between 1997 and 2003, the life science industry accounted for 8.2 percent of total employment growth in Greater Philadelphia. When applying the employment multiplier, it suggests that 40.9 percent of total employment growth can be attributed to life sciences.

The following table provides a breakdown of the direct, indirect and induced impacts on employment in Greater Philadelphia by the following industry classifications: biotech, pharmaceuticals, medical devices, R&D in the life sciences and total life science.

Multiplier Impacts on Employment
Greater Philadelphia, 2003

Category	Direct-Effect Employment Multiplier	Total Impact (Thous.)	Direct Impact (Thous.)	Indirect + Induced (Thous.)	Induced Impact (Thous.)	Indirect Impact (Thous.)
Biotechnology	6.8	16.5	2.4	14.0	5.2	8.8
Pharmaceuticals	6.8	203.7	30.0	173.7	64.8	108.9
Medical Devices	2.6	17.7	6.7	11.0	5.4	5.6
R&D in the Life Sciences	2.7	38.1	14.3	23.8	15.5	8.2
Total Life Science	**5.2**	**275.9**	**53.5**	**222.4**	**91.0**	**131.5**

Sources: Milken Institute, BLS, BEA

Similarly, an earnings multiplier of 3.0 indicates that for each dollar of earnings produced in the life science sector, an additional $2 worth of earnings is generated beyond it. The table below summarizes Philadelphia's multiplier impacts on earnings with respect to life science.

Multiplier Impacts on Earnings
Greater Philadelphia, 2003

NAICS	Direct-Effect Earnings Multiplier	Total Impact (US$ Mill.)	Direct Impact (US$ Mill.)	Indirect + Induced (US$ Mill.)	Induced Impact (US$ Mill.)	Indirect Impact (US$ Mill.)
Biotechnology	3.5	832.1	237.7	594.4	221.7	372.8
Pharmaceuticals	3.5	10,121.9	2,891.2	7,230.7	2,696.3	4,534.4
Medical Devices	2.3	739.7	320.1	419.6	208.5	211.1
R&D in the Life Sciences	1.8	2,039.2	1,150.9	888.4	581.3	307.1
Total Life Science	**3.0**	**13,732.9**	**4,599.8**	**9,133.1**	**3,707.8**	**5,425.3**

Sources: Milken Institute, BLS, BEA

By the same token, an output multiplier of 2.2 indicates that for each dollar of output produced in the life science sector, an additional $1.20 of output is created in other sectors. Since output multipliers are based on a final-demand concept, they typically result in lower coefficients (see methodology). The table below summarizes Greater Philadelphia's multiplier impacts on output with respect to life science.

Multiplier Impacts on Output
Greater Philadelphia, 2003

	Total Output Multiplier	Total Impact (US$ Mill.)	Direct Impact (US$ Mill.)	Indirect + Induced (US$ Mill.)	Induced Impact (US$ Mill.)	Indirect Impact (US$ Mill.)
Biotechnology	2.2	553.3	247.9	305.4	113.9	191.5
Pharmaceuticals	2.2	10,847.6	4,860.7	5,986.9	2,232.5	3,754.4
Medical Devices	2.2	937.6	429.8	507.8	253.7	254.1
R&D in the Life Sciences	2.3	3,144.2	1,377.9	1,766.3	1,155.8	610.5
Total Life Science	**2.2**	**15,482.8**	**6,916.4**	**8,566.4**	**3,755.8**	**4,810.6**

Sources: Milken Institute, BLS, BEA

It is no surprise that among all life science components, Greater Philadelphia's greatest strength lies in pharmaceuticals. The industry's relative contribution to the metro's overall economy is apparent by its high multipliers, particularly with respect to employment and earnings. Each additional job created within the industry generates an additional 5.8 jobs in other sectors. The pharmaceuticals sector alone is responsible for 203,700 jobs, $10.1 billion in total earnings, and $10.8 billion of output, when accounting for the total impacts. In other words, pharmaceuticals constitute nearly three-fourths of all life science employment, earnings and output in the Greater Philadelphia region after adjusting for its ripple effects.

In absolute terms, the next biggest impact of the life sciences stems from research and development. While much of this impact is driven primarily through the presence of "Big Pharma," the emergence of independent firms specializing in R&D has grown in the region. The bulk of R&D recorded in this category is devoted to biotechnology since under the NAICS system, a firm not engaged in manufacturing a product, is classified as scientific services. Life science related R&D is responsible for 38,100 jobs (total impact), once multiplicative dynamics are taken into effect. The industry is also responsible for $2.0 and $3.1 billion in total earnings and output, respectively.

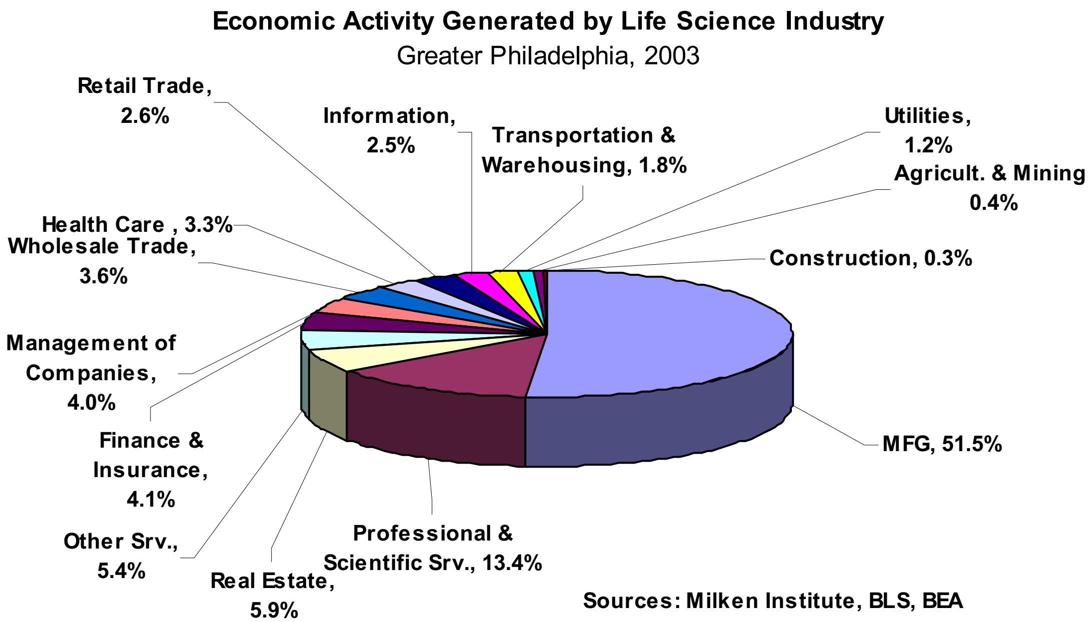
R&D multipliers tend to be smaller since its services do not spread as vastly across other sectors. During the R&D phase, drugs must go through several rounds of clinical trials and approvals before entering any form of large scale manufacturing. While the development phase may take several years, rising R&D costs absorb much of the revenue stream. Conversely, drug manufacturing at each stage of production is more likely to have an immediate impact in other sectors.

Each additional job created in the medical devices industry generates an additional 1.2 jobs elsewhere. As a result, medical devices' is responsible for an additional 11,000 jobs, accounting for 17,700 jobs in aggregate.

One might question why the multiplier for biotech is equivalent to that of pharmaceuticals. Given that the most detailed industry multipliers from the Bureau of Economic Analysis (BEA) available only at 4-digit industry classification level, we cannot obtain a unique set of multipliers for those two industries (namely, pharmaceuticals and biotech) since they both stem from the same NAICS code, 3245. At the detailed six-digit level, pharmaceuticals are classified by NAICS code 325412, while biotech is represented by NAICS codes 325411, 325413 and 325414. Since the bulk of Greater Philadelphia's life science employment stems from pharmaceuticals, it is safe to assume that the region's multiplier for NAICS 3254 is a better reflection of its pharmaceutical industry. Please refer to the methodology section in the Current Impact Assessment of this study for more details.

Assuming biotech's multiplier is equivalent to that for pharmaceuticals, the biotech industry would be responsible for 16,500 jobs when incorporating for its indirect and induced impacts. Since the BEA does not report a separate multiplier for life science, it must be derived implicitly. By combining the total impacts of pharmaceuticals, biotech, medical devices and life science R&D, one can arrive at an implicit life science multiplier with respect to employment, earnings and output. They are as follows: 5.2, 3.0, and 2.2, respectively.

While the bulk of direct and indirect impacts are captured by the manufacturing sector (51.5 percent) including pharmaceutical, biotech and medical devices manufacturing, other industries also benefit significantly, namely professional and scientific services (13.4 percent) and real estate (5.9 percent). Combined, wholesale and retail trade absorb 6.2 percent of all activity generated by the life sciences. Economic activity here is defined as the value of wealth created, and is measured specifically by output. The pie chart below illustrates how this wealth is distributed across all sectors.



Methodology

The Milken Institute utilized the Regional Input-Output Modeling System (RIMS II) developed by the Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce to conduct its systematic economic multiplier impact analysis. This methodology makes use of the input-output structure of U.S. industries to estimate the total impact that one industry has on the wider economy. Furthermore, these multipliers serve as useful tools in regional economic impact analysis.

The employment, earnings and output multipliers from RIMS are applied to the appropriate employment, earnings and output estimates (or direct impact) compiled from the Bureau of Labor Statistics (BLS). The input-output matrix from RIMS provides the necessary coefficients or multipliers needed to estimate the total number of jobs and value of wealth generated by the life science industry in other sectors of the economy. Thus, the total impact is calculated by applying the multiplier to the direct impact for employment, earnings and output. Further statistical estimation is conducted to derive the difference between the induced and indirect shares.

The employment and earnings multipliers are based on a direct-effect concept. In other words, these multipliers quantify how life science employment and earnings directly impact employment and earnings across all industries. More specifically, the direct-effect employment multiplier measures the change in the number of jobs in all industries that result from a change of one job in the life science industry. Similarly, the direct-effect earnings multiplier calculates the total dollar change in the earnings of households employed by all industries that results from a $1 change in earnings paid directly to households employed by the life science industry. Finally, the output multiplier is based on a final-demand concept. It measures the total dollar change in output in all industries that results from a $1 change in output delivered to final demand by the life science industry. The final demand concept excludes the impact of intermediate purchases of goods and services. In other words, it does not fully reflect the impact at each stage of production, thereby resulting in a lower coefficient (or multiplier) relative to employment and earnings.

BEA multipliers are based on 2001 regional data and are derived from 1997 U.S. annual I-O matrix. Industries for which multipliers are available are based on the 4-digit North American Industry Classification (NAICS) system as defined by the Office of Management and Budget. The industries for which multipliers were carried out included the following NAICS codes: 3254 (for pharmaceuticals and biotech), 3345 & 3391 (for medical devices), and 5417 (for R& D in the life sciences).

Innovation Pipeline Index

A region's life sciences innovation pipeline encompasses the economic inputs and outputs that underpin that area's life science related resources and creativity. A rich innovation pipeline plays a pivotal role in the birth, development and long-term growth of a region's life science industry. It also constitutes an important socio-economic asset to its regional and wider state and national economies.

This section of our report analyzes the innovation pipeline of Greater Philadelphia and 10 peer metropolitan regions. There are five subject areas of data gathering, modeling and analysis. They are R&D assets, risk capital and entrepreneurial infrastructure, human capital, workforce, and innovation output.

- **Research and development** (R&D) findings are derived from input indicators on various types of funding and monetary awards given to life science research activities. R&D is widely recognized to be the backbone of innovation in knowledge-intensive industries. A region with an advanced R&D infrastructure has a distinct advantage in building and sustaining an industry cluster for the life sciences.

- **Risk capital and entrepreneurial infrastructure** relates to how new ventures in life science are being funded and their entrepreneurs supported. Risk capital, analyzed using metrics such as venture capital investment amounts and growth, is the economic life blood of new, pioneering firms. Entrepreneurial infrastructure relates to how conducive a region is to fostering firm formation and development.

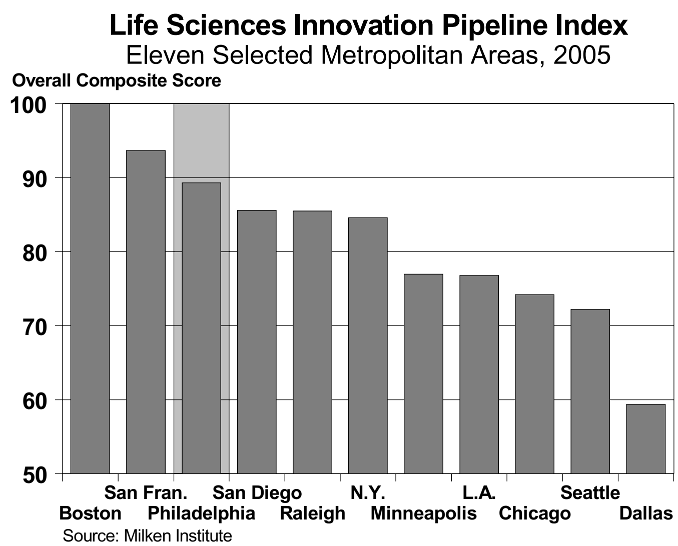
- **Human capital** centers on the specialized training and education people receive for careers in life sciences. Our measures for human capital provide a multi-dimensional perspective of the fundamental, as well as more nuanced, elements in the data available for understanding a region's human capital output and capacity. Human capital is both a reflection of an area's ability to generate talent and its potential for nurturing a highly skilled workforce.

- Evidence of a region's standing in terms of specialized life science **workforce** numbers is important at several levels. For one, it shows how well a metropolitan area is at attracting the highly skilled and mobile individuals who lie at the heart of creativity in the life sciences. This sort of information is additionally valuable as a source of comparative data because regions compete especially hard for skilled workers, the single most valuable asset in commercial innovation. Workforce data takes on additional shades of meaning when it is referenced back to applicable statistics on human capital. Human capital serves as the "raw material" for the "finished product" of a skilled workforce. To realize the full potential of a region's innovation pipeline requires maximizing its human capital capacity to generate an economically productive workforce.

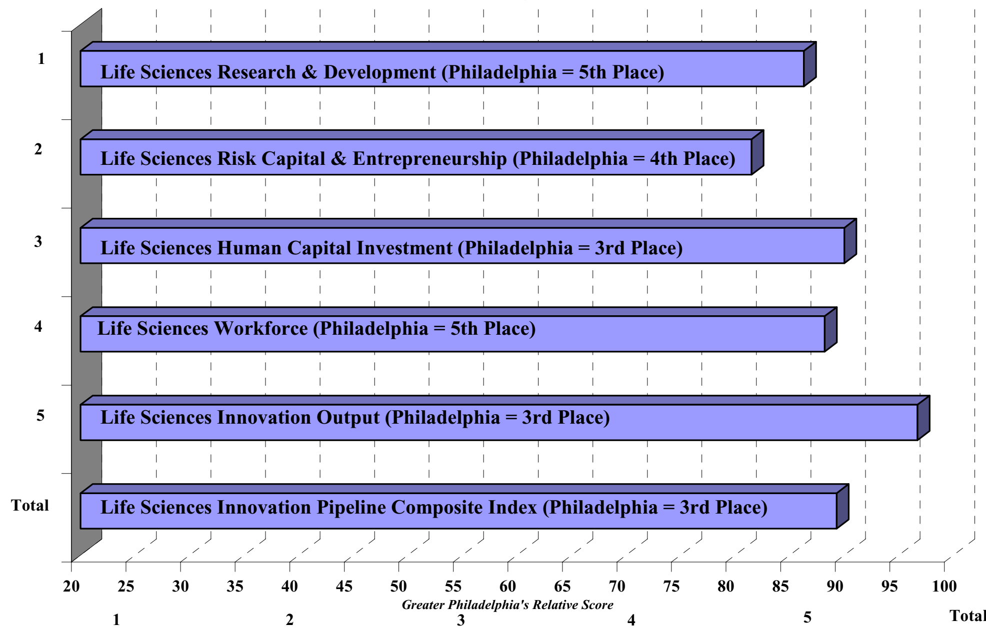
- **Innovation output** in the life sciences is demonstrated especially in the technologically oriented biopharmaceutical and medical device sectors. Before innovations from these sectors can be introduced to the market, they must be approved by the U.S. Food and Drug Administration (FDA). Valuable inventions also are patented to protect their intellectual property. Our analysis models and interprets a variety of both FDA and patent-related data to appreciate the breadth of indicators that reveal the output performance of a metro region's life science innovation pipeline.

Composite results from the above five research areas form the basis of the Milken Institute's Innovation Pipeline Index. The later pages of this section detail each of the five category's background and relevance, our major regional findings and the methodologies employed in deriving our data and rankings. Even with the study's focus on 11 key metro areas, all regions can benefit from the findings and insights generated by the Index and its constituent research subjects.

Looking first at what the overall composite findings reveal in terms of regional rankings, the Greater Philadelphia region placed third with a score of 89.3 on our Innovation Pipeline Index. This is outstanding performance considering the well-known innovation strengths of many of the regions to which Greater Philadelphia was compared. Ahead of Philadelphia on the index was Boston (whose top performance earned it a benchmark score of 100 index points) followed by Greater San Francisco. San Diego and Greater Raleigh Durham (virtually tied with 85.6 and 85.5 index points, respectively) ranked fourth and fifth. Greater New York ranked in the middle of the 11 metro regions with its sixth-place score of 84.6. The next four regions—Minneapolis, Greater Los Angeles, Chicago, and Seattle—all scored in the seventies. Eleventh-place Dallas scored close to 60 with 59.4 index points.



Life Sciences Innovation Pipeline Composite Index
Greater Philadelphia's Score



	1	2	3	4	5	Total
Philadelphia	86.3	81.5	90.0	88.2	96.7	89.3
11 Metro Avg.	81.3	70.1	80.5	86.5	86.5	81.7

Greater Philadelphia's third-place showing on the index was based on consistently strong results in the five subject areas that constitute the innovation pipeline. In all five categories the region outperformed the average for its peer grouping. In three out of five areas—risk capital and entrepreneurial infrastructure, human capital and innovation output—Greater Philadelphia exceeded the average by about 10 or more index points. The region was closest to the average in its performance in workforce measures. For the region to enhance its overall ranking within its comparative universe of peer metros, workforce indicators provide a rich source of information on possible areas for improvement. Considering the region's outstanding human capital base, it has the advantage of an already high-quality pool of human resource assets to use in this regard. At the same time, the region's single best showing was for innovation output, where its 96.7 index points put it very close to the benchmark top score of 100. This demonstrates that whatever categories of performance could be improved upon, in terms of bottom-line innovation outputs, Greater Philadelphia performed exceptionally well.

Research and Development

Background and Relevance

Research and development (R&D) assets are widely recognized as the pipeline of technological innovation, and levels of R&D expenditures are accepted as reliable indicators of innovation capacities.[1] A region with a better R&D infrastructure has a comparative advantage when it comes to building new industry clusters, and attracting tech-based firms and an educated workforce.

Measured against the rest of the world, the U.S. maintains an exceptional level of R&D expenditures. In 2000, U.S. spending surpassed that of all other G-7 countries, including Japan, Germany, France, United Kingdom, Canada and Italy. Despite the recent slowdown in industry-financed R&D, U.S. total R&D maintained positive growth rates in 2000 and 2001 with steadfast gains in federal R&D expenditures.[2]

Information technology sectors (telecommunications, computers and electronic products), which witnessed impressive increases in the late 1990s, experienced declines in R&D investment in 2001 and 2002. Meanwhile, industrial R&D expenditures in the life sciences increased throughout those periods. Just as R&D inputs played an essential role in creating and maintaining computer and telecommunication clusters, they now underpin the building up of new growth centers in commercial life science, especially biotech and medical device clusters.

R&D assets drive technological innovation and product creativity in the life sciences industry to a greater degree than in most others. Biopharmaceuticals and their means of delivery (be they through medical devices or hospital systems) are heavily dependent on basic research. This type of research takes place at strong academic research institutions and medical research facilities by scientists with the substantial support of public funding. Life science research universities and institutions are the melting pot that combines biological scientists, medical engineers, research funding and new ideas into biological inventions and products.

In the case of bringing pharmaceutical products to market, the industry's relationship with R&D assets continues well into the applied research and commercialization phases of product development. The drug approval process is both lengthy and costly. It takes, on average, 12-15 years to go from initial, or preclinical, development to commercial approval,[3] which requires substantial applied research feedback from institutions, their scientists and other specially trained workers. Appreciated from the dimension of new firm formation and industrial rejuvenation, it is also the case that new enterprises in the life sciences tend to situate where there are strong educational and R&D support structures. This particularly applies to the instance of biotechnology firm clustering.[4]

In this study, data and analysis was conducted on regional R&D assets as detailed in 11 component measures developed by the Milken Institute. These measures were chosen and weighted according to their relevance to innovation in the life science industry. The components included are:

- industry R&D in the life sciences;
- academic R&D in the life sciences;
- National Science Foundation (NSF) funding to the life sciences;

- amount of STTR awards to life science firms;
- the number of Small Business Technology Transfer (STTR) awards to life science firms;
- Small Business Innovation Research (SBIR) awards to life science firms;
- amount of SBIR awards to life science firms;
- the competitive NSF funding rate for life science related proposals;
- National Institutes of Health (NIH) funding to independent hospitals;
- NIH funding to medical schools; and
- NIH funding to research institutes.

These components are also compiled into an overall Life Sciences R&D Composite Index.

Industry expenditures constitute the largest financial support base for R&D in the life sciences. This category is thus a key element in the industry's innovative capacity and competitiveness. Industry R&D funding is dedicated to supporting scientific discovery and technological or product innovation for the purpose of marketplace success. Nevertheless, in the quest for commercial gain, crucial advances in the actual "science," not only the "business" of the life sciences, are often realized. In total, the 11 regions examined in this study received upwards of $16 billion in industry R&D funding.

Academic R&D is a measure of the importance of university research to the life sciences industry, as well as the R&D capacity of each region's university system. Academic R&D focuses on basic rather than applied research, thus it is particularly significant to life science industry sectors such as biotech, whose research activities tend to involve the early stages of biopharmaceutical commercialization. In total, the 11 regions examined in this study received $7.5 billion in academic R&D funding.

The National Science Foundation (NSF) is a key public investor in technological progress and intellectually creative people. With a $5.65 billion budget for FY 2004, the NSF received a record number of over 43,000 proposals and funded more than 10,000 new awards dispersed to nearly 2,000 universities and institutions. Excluding expenditures by the National Institutes of Health (NIH), the NSF provided 63 percent of total federal support to academic basic research in the biological fields.

The Small Business Technology Transfer (STTR) program is aimed at extending the participation of small businesses in federal R&D and encouraging private sector commercialization of technology with federal assistance. The STTR award program plays a pivotal role in supporting the operations of fledgling enterprises and research organizations in the life sciences while helping to strengthen their scientific and innovative capacities.

The Small Business Innovation Research (SBIR) award is a federal program designed to support private sector R&D through a set-aside program allocated for cutting-edge technology generated by small businesses that has not yet been commercially released. SBIR awards are granted based on need and new ideas that have commercialization potential. SBIR awards raise the level of entrepreneurial creativity among small life science firms and provide them with opportunities to commercialize new knowledge not yet viable.

The National Institutes of Health (NIH), part of the U.S. Department of Health and Human Services, is the largest single funding agency to the life sciences. The NIH invests more than $27 billion annually with more than 80 percent of its funding awarded through some 50,000 competitive grants to more than 212,000 researchers at over 2,800 universities, medical schools, and other research institutions. In this study, NIH funding is analyzed according to three component categories: funding to independent hospitals, funding to medical schools, and funding to research institutes. The combined funding in all three component categories for the 11 regions analyzed amounts to some $7.5 billion.

Regional Findings

Greater Philadelphia's best-performing R&D measure was for industry R&D to the life sciences, the first component measure in our analysis of regional R&D assets. The region received a total of $2.6 billion in industry R&D funding in 2002. Averaged out for Greater Philadelphia's population, the region's per capita funding level was $433, the highest among its peer group. Following Greater Philadelphia, the other top-five ranking peer regions were Greater New York, Boston, Minneapolis and Greater San Francisco. The Milken Institute has developed a unique estimate of metro-level industry R&D in the life sciences based upon state figures provided by the National Science Foundation (NSF). Our methodology provides an added dimension to place-based innovation in the life sciences (please see Methodology at the end of this section.)

Greater Philadelphia is home to some of the leading R&D-investing life science firms in the world. GlaxoSmithKline (GSK) invested $5.3 billion in R&D worldwide in 2004, representing 15.9 percent of sales. After GSK's formation, it introduced a flexible and innovative R&D structure by concentrating its resources to maximize drug discovery productivity. GSK reorganized its R&D function by creating Centers of Excellence for Drug Discovery which focus on a specific disease area. GSK has substantial R&D operations in the region. Wyeth spent $2.4 billion on R&D in 2004, focusing on pharmaceutical, vaccine and biotechnology treatments. Collegeville, PA has a large Wyeth biopharmaceuticals R&D unit. Merck, the largest life science employer in the Philadelphia region with major R&D facilities, invested $4.0 billion in R&D worldwide in 2004. Greater Philadelphia's leading biotechnology firms, among them Centocor and Cephalon, are also major investors in R&D.

Compared to its stellar performance in industry R&D funding, the Greater Philadelphia region scored less well, though still solidly, in academic R&D to the life sciences. The region received a total of $633 million in academic R&D funding in 2002. Averaged out for its population, the region's per capita funding level was $104, equivalent to approximately one-quarter of the level it received for industry R&D, ranking the region sixth among its peer group. Ahead of Greater Philadelphia, the top-five ranking peer regions in this component measure were Greater Raleigh Durham (which received $560 per capita), Greater San Francisco, Boston, Greater New York and Greater Los Angeles.

Greater Philadelphia scored ninth among its peer metro areas for NSF Research Funding to the Life Sciences. The region attracted a total of $9.3 million in NSF funding earmarked for life science research, actually higher than Seattle's $7.8 million and not far off from San Diego's $10.2 million. Yet, when averaged out per $100,000 of Gross Metro Product (GMP), Greater Philadelphia earned only $4.30 versus Seattle's $5.90 and San Diego's $8.60. The top five performers in this component measure were Greater Raleigh-Durham, Minneapolis, Boston, Greater San Francisco and San Diego.

A total of four Greater Philadelphia enterprises were recipients of STTR Awards to Life Science Firms in the latest year on record. On an absolute basis, this places the region fifth among its peer metros. Averaged out per 100,000 businesses, however, the region earned 2.6 awards. In our ranking system, which combines absolute and averaged figures, Greater Philadelphia placed eighth overall. The top five leading metros in the region's peer group for this measure were Boston, Greater Raleigh-Durham, Greater San Francisco, Greater Los Angeles and San Diego.

Viewed from the angle of STTR awards measured by dollar amounts granted to life science firms, Greater Philadelphia performed comparatively better. Receiving a total of $857,000 in 2002, this level of award money combined with its averaging per every million dollars of GMP placed the region sixth overall. Viewed in relation to its ranking for number of STTR Awards to life science firms, the region received more award money than its number of awards and business base would suggest. Immediately above Greater Philadelphia for the STTR award dollar amounts category were Greater Raleigh-Durham, Boston, Greater New York, San Diego and Chicago.

For the component that measured number of SBIR awards to life science firms, Greater Philadelphia received a total of 39 SBIR awards, averaging 25.2 awards per 100,000 businesses. Regional support groups such as Innovation Philadelphia offer proposal preparation assistance programs to firm's applying for these awards, and their efforts have recently aided companies like Advaxis, a Chester County biotechnology firm whose methods use genetically engineered bacteria to create vaccines for cancer and other diseases. In this comparative category, Greater Philadelphia placed sixth overall. The top five leading metros in its peer group were Boston, San Diego, Greater San Francisco, Greater Raleigh-Durham and Seattle.

For SBIR awards measured by dollar amounts granted to life science firms, Greater Philadelphia performed slightly below its performance level for number of awards granted. Receiving more than $12 million in 2002, this level of award money combined with its averaging per every $100,000 dollars of GMP placed the region seventh overall. The top five metros competing for SBIR award dollar amounts were Boston, San Diego, Greater Raleigh-Durham, Greater San Francisco and Seattle.

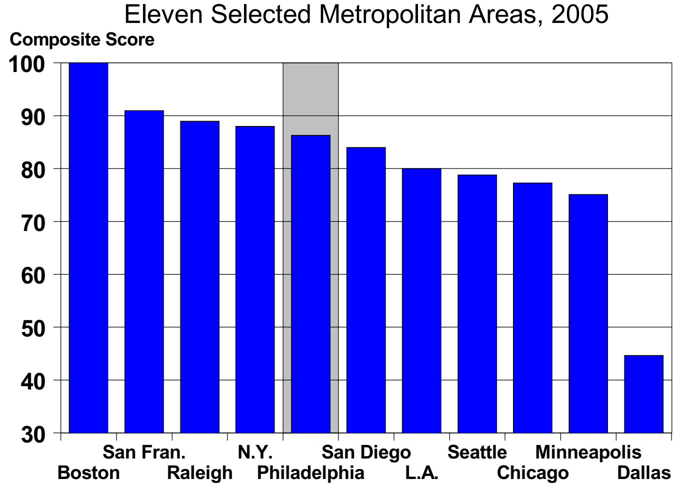
Greater Philadelphia life science researchers received 17 NSF grants in 2004. This was the result of an approximate 20 percent success rate in applications coming from the region. Although Greater Philadelphia placed eighth in its peer cohort, its comparative score of 80.5 (which is logarithmically adjusted to facilitate comparison) is only about 20 points behind the top-scoring metro region of Greater San Francisco. Following San Francisco, rounding out the top five regions were Greater New York, Greater Raleigh-Durham, Chicago and Seattle.

For the component that measured NIH Funding to Independent Hospitals, Philadelphia registered its best performance among the R&D asset measures except for industry R&D to the life sciences. With independent area hospitals receiving $77.3 million NIH funds in 2003, this amount averaged out to $12.6 per capita. The leading recipient of NIH funding to independent hospitals in the region was Children's Hospital of Philadelphia, the nation's first pediatric hospital and one among the leading pediatric hospitals and research centers in the world. The number one performing region for this measure was Boston. The three other peer metros among the top five performers were Greater New York, Greater Los Angeles and Greater San Francisco. Boston's performance in this category is remarkable, accounting for 77.9 percent of the 11 metro total.

With regard to NIH Funding to Medical Schools, Greater Philadelphia area institutions received $467.9 million in 2003, an average of $76.3 per capita, and ranked the region fifth among its peer metros. The University of Pennsylvania is the region's largest recipient of NIH funding to medical schools. Penn's School of Medicine received 938 NIH awards with a total value of nearly $360 million in fiscal 2003, placing it second and third in the nation in these regards respectively. The peer four regions scoring ahead of Greater Philadelphia in the top five of our component measure are Greater Raleigh-Durham, Greater San Francisco, Greater New York, and Boston.

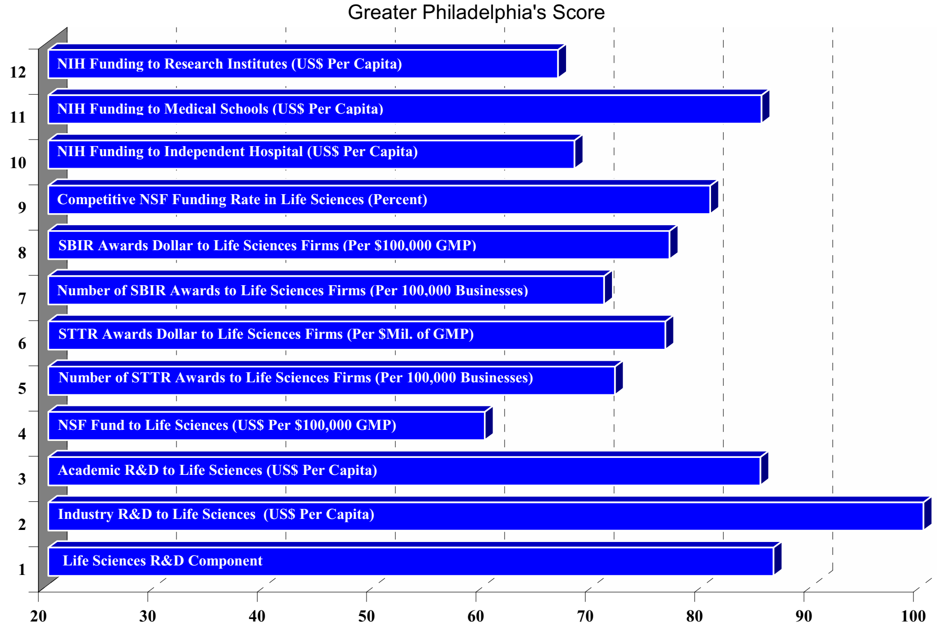
In the final component measure of NIH Funding to Research Institutes, Greater Philadelphia research centers received $87.3 million in 2003, an average of $14.2 per capita. This ranked the region eighth among its peer metros. Philadelphia's Fox Chase Cancer Center and the Wistar Institute are the region's leading recipients of NIH support, taking in a total of 126 grants and $57.5 million NIH research funding. Among the noted accomplishments of these local research bodies, the 2004 Nobel Prize in chemistry was awarded to Fox researcher Irwin Rose and two Israeli research colleagues for their groundbreaking studies on the breakdown of proteins within cells. The top five ranking peer regions for this component were San Diego, Seattle, Boston, Greater Raleigh-Durham and Greater New York.

Life Sciences Research and Development
Eleven Selected Metropolitan Areas, 2005



Source: Milken Institute

Life Sciences Research and Development
Greater Philadelphia's Score



	1	2	3	4	5	6	7	8	9	10	11	12
Philadelphia	86.3	433.1	103.7	4.3	2.6	4.0	25.2	5.6	19.8%	12.6	76.3	14.2
11 Metro Avg.	81.3	245.1	149.5	7.6	4.1	7.1	44.9	9.2	22.1%	21.6	95.8	35.4

The Greater Philadelphia region ranked fifth among its universe of peers on the composite life sciences R&D measure. The composite takes into account all 11 individual components. Based on regional performance across these metrics, Greater Philadelphia registered a composite score of 86.3. With the region's score in the high 80s, it is not that far off from the top-scoring metro, Boston, which earned a baseline score of 100 for its first-place showing. The three other regions placing in the top five were Greater San Francisco, Greater Raleigh-Durham and Greater New York. If the region is to advance its competitive standing in R&D assets, it should continue to build upon its greatest areas of strength—industry R&D and independent hospital research—while finding ways to bolster those areas with room for improvement—NSF research funding and awards to small businesses.

Methodology

In data collection and analysis, we focused on 11 metropolitan areas that showed the greatest specialization and concentration within the life science industry in the U.S. To compare the relative strengths of each metro region's life science research and development assets, we scaled out each component by the region's population, businesses, or relevant revenue indicators such as gross metro product (GMP), which in this particular series of measures guides our analysis of NSF research funding. After conducting these averaging calculations to provide a basis for like-to-like comparisons, we combined absolute and relative performance to generate comparable scores that allowed us to accurately rank individual performance within the peer universe of 11 regions.

Many previous studies based their findings upon absolute measures of indicators only, which can result in an unbalanced understanding of comparative performance.[5] To arrive at the Institute's component measurements, we take absolute data and filter it into relative measures. These are then related back to the figures of raw performance. This approach brings out a more true-to-life representation of the richness of the clusters. For an appropriate balancing of component measures, we also apply weightings in accordance with a component's impact on the whole spectrum of measures. In the case of R&D measures, industry R&D is accorded a 25 percent weighting; all others (which relate mainly to academic and government funding) are weighted 7.5 percent each. This prevents industry-based figures getting "washed out" in the larger volume of other statistics. It also recognizes the importance of commercial R&D support within the business of the life sciences.

The National Science Foundation (NSF), Small Business Administration (SBA) and National Institutes of Health (NIH) were three major sources of data used to compile and analyze the 11 components of this section. Industry R&D data came from the NSF. Because this category of data is only available at the state level and not broken out by metro region, we used a region's proportion of R&D-based employment to its state's overall R&D employment as a proxy. We applied this ratio to state industrial R&D spending in the life sciences to derive the equivalent metro spending amount. In the case of a metro such as Greater Philadelphia with counties in two or more states, the ratios were applied to the counties in each state and aggregated to the metro area total. Data for regional component measures on academic R&D, NSF funding and competitive NSF funding rates were collected directly from NSF data banks. STTR and SBIR statistics were obtained from the Office of Advocacy, a department of the Small Business Administration. National Institutes of Health's database was employed to obtain NIH funds to metros, institutes and research universities in the 11 selected metropolitan areas.

Risk Capital & Entrepreneurial Infrastructure

Background and Relevance

Entrepreneurial capacity and performance are major players in the current economic milieu in which creativity and innovative dynamics determine the competitive advantage of a firm and an industry. Risk capital and entrepreneurs are pivotal because new firms and spinoffs are the best breeding grounds for new ideas.

This study's section on risk capital and entrepreneurial infrastructure examines seven component measures, each portraying essential aspects of the business climate for life science startups and the entrepreneurial activities associated with new firm formation and growth. We evaluated the targeted 11 metros' entrepreneurial support base using data accumulation and analysis of key risk-finance measures—such as venture capital investment amounts and growth—and other indicators of a strongly supportive environment for entrepreneurship—such as the number of life science business starts—in the life science industry.

Venture capital (VC) investment targets young and fast-growing businesses that demonstrate potential for high return on investment. An important source of equity funding for startups, venture capital has a history of funding new technologies and innovations. These are the most risky investments, but can offer high returns. Venture capitalists supported fledgling semiconductor firms and personal computers, followed by the disk drive industry, biotechnology in the early 1990s, software in the mid-1990s and dotcoms at the end of the decade.[6] Leading biotech firms such as Genentech and Amgen are among those who benefited from early-stage VC investment.

Venture capital firms (VCs) are also key actors in the Greater Philadelphia life science industry providing early stage financing, managing and marketing support to the innovative firms started by resident scientists and entrepreneurs. The following table lists the top 10 venture capital investors in the Philadelphia metro region, ranked by investment from January 2004 through March 2005.[47]

Venture Capital Investing in Greater Philadelphia Life Sciences
Most Active Venture Ivestors Jan. 1, 2004 through Mar. 31, 2005

Rank	Firm	Companies	Deals	Investment (US$, Mill.)
1	Quaker BioVentures, Inc.	4	4	20.5
2	New Enterprise Associates	6	6	17.7
3	Atlas Venture, Ltd.	1	1	10.4
4	Liberty Partners	1	1	10.0
5	3i Group PLC	1	1	9.0
6	Carlyle Group, The	1	1	7.6
7	Burrill & Company	1	1	7.4
8	EGS Healthcare Capital Partner	1	1	6.5
9	Edison Venture Fund	2	2	5.8
10	Lazard Technology Partners	1	1	5.0
11	Morgenthaler Ventures	2	2	5.0
12	BioAdvance	11	11	4.7
13	TL Ventures	2	2	4.3
14	Birchmere Ventures	1	1	4.2
15	Reinvestment Fund , The (TRF)	2	2	3.7

We examined venture capital investment in the commercial life sciences according to four dimensions: average annual amount of VC investment in life science companies, life science VC investment growth, the number of companies receiving venture capital, and growth in life science companies receiving venture capital investment. All risk capital component measures constitute important indicators for gauging VC dynamism and trends in the regions we studied. Although venture capital funding declined since peaking during the technology-stock-driven market bubble of the late 1990s, risk capital remains a pivotal force in the support structure for new businesses, especially those that operate knowledge-intensive life science sectors such as biotech and medical devices.

Academic degrees in entrepreneurship are based on the number bachelor's degrees awarded by regional institutions in this specialized field of study. This component measured data over a 10-year period (1991-2001). Having captured this length of time, it offers not only an indication of present regional strengths in entrepreneurial talent, but also the momentum that has built up in cultivating entrepreneurial skills and management techniques. The largest grantor of entrepreneurship degrees in not only the Greater Philadelphia region, but among all metro regions studied, was the University of Pennsylvania with 913 degrees conferred over this time span.

Business starts are a clear indicator of the health of a metro region's entrepreneurial environment. Successful new-firm formation in knowledge-intensive industries also conveys the flow of a region's R&D assets to technology commercialization. To the wider population, new business creation moreover reflects an area's capacity to create jobs and rejuvenate its economy.

The Deloitte Technology Fast 500 list identifies North America's fastest-growing technology firms in terms of revenue growth over the course of five years, in this case 2000-2004. The companies on the list are innovative, rapidly expanding firms that promise long-term technological and economic impact. The Technology Fast 500 list also indicates the depth of managerial capabilities needed to maintain high rates of growth as firms mature. To be eligible for the Technology Fast 500, a firm must meet a combination of criteria such as revenue requirements.

Among all Technology Fast 500 firms in 2004, 108 (22 percent) hailed from the life sciences industry. This compares to 14 percent of Fast 500 firms that came from the Internet sector and 5 percent from the computers/peripherals sector. The large presence of life science companies in the Technology Fast 500 signals a continued increase from 2001, when life science companies made up 15 percent of the list, to 2002, when they made up 16 percent, and 2003 when they rose to 19 percent.

Regional Findings

In the component measure for venture capital investment in the life sciences, Greater Philadelphia attracted an annual average of $176 million in VC equity funding during 2002-2004. This is equivalent to slightly more than $81 per $100,000 of Gross Metro Product (GMP). The region's combined average annual level of investment and its average level per $100,000 of GMP ranked Greater Philadelphia eighth among its peer metro regions. The top five in this component measure were Greater San Francisco, San Diego, Boston, Greater Raleigh Durham and Seattle.

In the area of VC investment growth, Greater Philadelphia turned in one of two top performances among the component measures for risk capital and entrepreneurship. Growing in absolute numbers by some $220 million between 2002-2004, venture capital investment increased by a roaring 305 percent. This performance earned the region a number-one ranking in the measure and placed it more than two times ahead of the next leading regions: Greater San Francisco, Boston, San Diego and Greater New York. Although a remarkable accomplishment, high growth is often associated with starting from a low base (as it is in the case of Greater Philadelphia). Regional leaders should be satisfied with the gains being made. Yet they also should appreciate that long term, the key will be to find ways to maintain continual risk-capital investment in order to financially sustain the region's promising new life science businesses.

In the category of companies receiving life sciences VC investment, Greater Philadelphia registered an average annual number of 23 enterprises receiving risk capital during 2002-2004, equivalent to approximately 15 companies per 100,000 businesses in the region. The combined levels of attainment ranked Greater Philadelphia seventh among like regions. The top five ranking regions in this measure were Greater San Francisco, San Diego, Boston, Greater Raleigh Durham and Seattle.

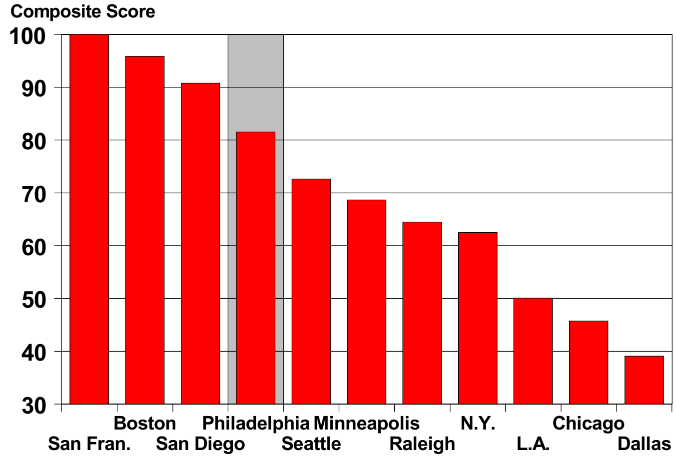
Providing an added angle to data on companies receiving risk capital finance is the measure for growth in the number of companies receiving life science VC investments. In this measure, Greater Philadelphia registered an absolute increase of 15 life science companies receiving VC financing between 2002 and 2004 demonstrating exceptionally strong growth of 175 percent. The combination of strong absolute and percentage growth provided Greater Philadelphia with a high score of 96.9, placing it third among its peer metro regions. Scoring only slightly above Greater Philadelphia were Greater San Francisco and Boston. Following behind it in the top five were San Diego and Seattle. The solid growth experienced by Greater Philadelphia and other leading regions in the top five contrasts with the negative growth experienced by the bottom five regions in this measure: Greater New York, Chicago, Greater Raleigh Durham, Dallas and Greater Los Angeles.

The measure of academic degrees awarded in entrepreneurship over the latest 10 years on record revealed that Greater Philadelphia universities graduated 921 entrepreneurship majors. This was by far the largest graduate pool of its kind in the comparison group, and more than double that of Chicago, the metro region with the next highest absolute number of graduates. Averaged per 100,000 people of the region's 25-34 age cohort, Greater Philadelphia had more than 114 graduates. The region's absolute and averaged figures ranked it firmly in first place. The other regions placing in the top five were Dallas, Chicago, Boston and Minneapolis. Greater Philadelphia's remarkable standing in this category is owed to Penn's Wharton School, whose entrepreneurial studies program is recognized as one of the best and largest of its kind, offering more than 20 courses to some 2,000 students and entrepreneurs.

In terms of business starts in the life sciences, Greater Philadelphia performed less well than in its other risk capital and entrepreneurial infrastructure measures. Based upon data from Harris InfoSource on new life science businesses created during the 2002-2004 time period, Greater Philadelphia's startup rate was one-fourth that of Boston, the leader in this category. Its combined performance placed Greater Philadelphia ninth. The top five metro regions in this measure were Boston, Minneapolis, Greater San Francisco, Greater Raleigh Durham and Greater Los Angeles. New life science firm creation is one of Greater Philadelphia's top challenges and opportunities, especially in the biotechnology area.

Nine of Greater Philadelphia's regional firms earned a place on the Technology Fast 500 list. This impressive accomplishment is equivalent to 5.81 Technology Fast 500 life science firms for every 100,000 business enterprises overall. The region earned a third place ranking among its peers, surpassed only by Greater San Francisco and San Diego. Boston and Greater Raleigh Durham were the other metros in the top five. Representative Fast 500 life science firms from the Greater Philadelphia area included King of Prussia's Octagon Research Solutions (number 57 on the Fast 500), which uses advanced techniques to help other life science firms with drug development and approval, and West Chester's Cephalon (number 150), a biopharmaceutical company that specializes in drugs to treat and manage neurological diseases, sleep disorders and cancer.

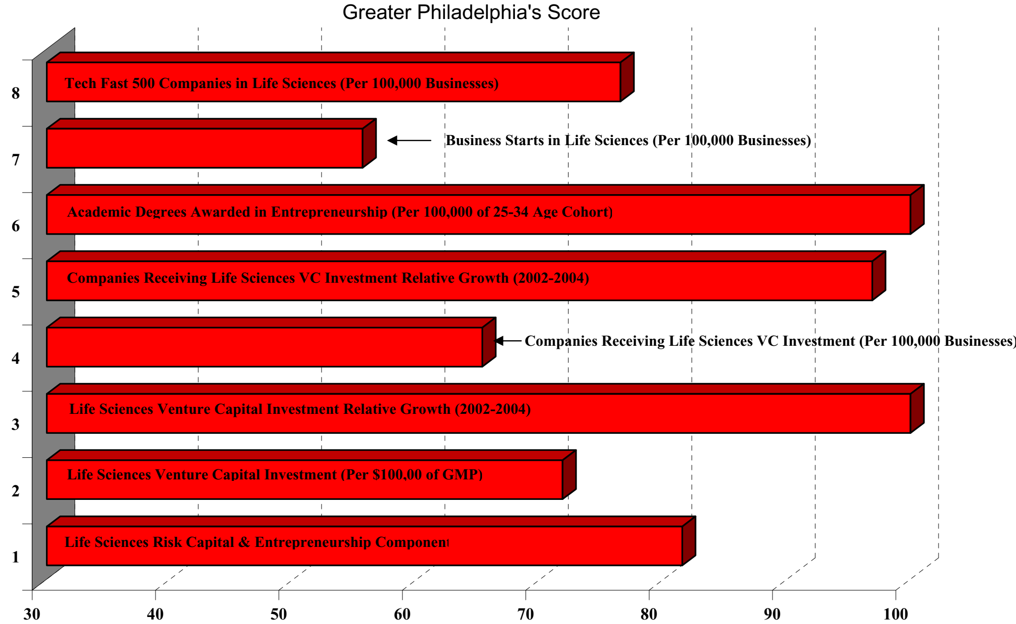
Life Sciences Risk Capital & Entrepreneurship
Eleven Selected Metropolitan Areas, 2005



Source: Milken Institute

Risk Capital and Infrastructure
California's Score

Life Sciences Risk Capital and Entrepreneurship
Greater Philadelphia's Score



Greater Philadelphia's Statistics

	1	2	3	4	5	6	7	8
Philadelphia	81.5	81.2	30.5	15.0	17.5	114.3	5.16	5.8
11 Metro Avg.	70.1	174.2	11.9	30.2	10.7	20.6	12.3	5.8

On the Risk Capital and Entrepreneurial Infrastructure Composite Index, the Greater Philadelphia region scored 81.5 index points ranking it fourth in its universe of peer metro regions. The region's score was nearly 20 points below top scoring

Greater San Francisco, whose superior performance earns it a base level of 100 index points, and double that of last-place Dallas, whose composite score was 39.1. Helping the region earn its fourth-place rank were those categories in which Greater Philadelphia performed especially well, such as life sciences VC investment growth, academic degrees awarded in entrepreneurship, and Technology Fast 500 companies in the life sciences. Better relative performance in life science VC investment and companies receiving life sciences VC investment would noticeably boost the region's overall standing.

Methodology

As in the previous section on R&D assets, data analysis in this section on Risk Capital and Entrepreneurial Infrastructure was carried out on 11 peer metropolitan regions. Pertinent statistics were analyzed from various angles and in various dimensions; in certain cases, data was formulated to capture the greater dynamism and momentum that builds over an extended time period. In all component measures, final scoring was not based only on raw or absolute performance. Instead, these figures were screened further against calculations for relevant proportioning. Ultimate rankings take into account both elements for a balanced ordering of regional performance.

The component measures in this section received the following weighting in composing the overall composite index:

Component Measure	Weighting
Life Sciences VC Investment	30%
Life Sciences VC Investment Growth	8%
Companies Receiving Life Sciences VC Investment	30%
Growth in Companies Receiving Life Sciences VC Investment	8%
Academic Degrees Awarded in Entrepreneurship	8%
Business Start in Life Sciences	8%
Tech Fast 500 Companies in Life Sciences	8%

Data used and compiled in this section came from three major sources: PricewaterhouseCoopers/Venture economics, Dun & Bradstreet and Deloitte. Four biotech venture capital related components came from PricewaterhouseCoopers/Venture economics, a division of Thompson Financial. Dun & Bradstreet provided business starts statistics and Tech Fast 500 companies in life science field originated from "2004 Deloitte Technology Fast 500 list" (http://www.public.deloitte.com/fast500).

Human Capital

Background and Relevance

A region's hard assets—physical endowments such as a suitable climate, congregation of large populations, geographical advantages such as the proximity to ports and availability of raw materials—have long been recognized as the key determinants to regional economic, industry and commerce development. While materials and geographical advantages are still considered key location choice factors, they are less relevant in today's high-tech economy than decades ago. Modern transportation, communication and production efficiency have minimized costs related to labor and the movement of goods.[8] Rather, the current emphasis on innovation and creativity is recognized as the key for an industry and region to dominate in the global economy.

Economic development history and the rise in resource-poor regions in the last quarter-century have convincingly proved the importance of human capital to a region's economic lifeline. In today's highly mobile, increasingly democratized global economy, talented people, particularly those who possess the capacity for scientific and technological innovation and the management of such creative activities, are more in demand than ever before. They are the builders of the economic locomotive that propels a region's economic growth. The location pattern of economic activities, where material goods, innovation and the management of enterprises mix, often demonstrates a complex interdependence among firms and industries.[9] In industrialized economies, these complex interconnected production/service relationships were more a function of transferring semi-finished products and sharing raw material. In knowledge-based economies, the linkages among firms are often based on soft assets: talent, human capital and ideas and innovation.

Though there are many prevailing factors facilitating the formation of knowledge-based clusters, the underlying fundamental that enables their genesis is human capital—pools of talented professionals capable of innovation, creation and capturing and transmitting institutional knowledge. Location in high value-added industrial clustering matters only to the extent that it has the capacity to attract talent with the relevant skills and intellectual capital.[10] The importance of highly qualified talent pools as a reservoir of human capital to a given region cannot be underestimated.

Though many have tried, both from an economics and management point of view, to define the relationships between talent, human capital and intellectual capital, they have not captured the essence of the inner working relationship in quantitative fashion. It is even more challenging to define such relationships and why they matter in a singular economic spatial dimension. A better and more definitive description of talent, human capital and intellectual capital in the context of a single spatial economy is the concept of economies of agglomeration.

Perhaps it is more fruitful and intuitive to start out the description of such complex interlocking relationships in a theoretical framework of external economies of scale. The concentration of industry in a geographical location can be better understood not through the *linkages of activities* of firms in a single economic space, but rather by the *external economies of scale*. When firms—groups of highly talented people—operate on the input side, such economies have generally been known as "external economies of scale" where external refers to the firm. These firms are economies that depend not on the size of the firm, but upon the size of the industry.

As George Stigler explains more clearly, "When one component is made on a small scale it may be unprofitable to employ specialized machines and labor; when the industry grows, the individual firm will cease making this component on a small scale and a new firm will specialize in its production on a large scale…The progressive specialism of firms is the major source of external economies."[11] Clearly, Stigler's assessment can be applied to the commercial activity of the life sciences in the context of research and development, not only on the individual firm level, but to the congregation of talent forming regional human capital or talent pools. Because such an external scale exists, it paves the way for the development of specialization through seemingly random derivatives of a single unit of "talent." The delegation of various technical, management and financing aspects of producing goods, or the delivery of research and development of new ideas, then become critical for a firm or a group of highly specialized talent. Again, the external economies of agglomeration, i.e. groups of talent or human capital, are the critical building block in the formation of regional competitiveness. Individual firms or talent increase the production efficiency at lower costs across the entire industry, benefiting the entire region.

In the world of biotech and other life science research and development, the concept of external economies of scale can be equally applied. Unlike IT product developments, which inherently require shorter cycles and do not go through stringent regulatory tests, biotech and other life science products have far longer research and development cycles. Consider the success story of Advance Tissue Sciences. The company was founded in 1988 specializing in tissue substitutes for burn victims. After a long, industrious 10 years, the product was first approved by the FDA in 1997.[12]

Recent developments with the biopharmaceutical company Isolagen provide an example of how life science clusters attract firms through important linkages in human capital. In April 2005, Isolagen's leadership announced that it was relocating the company's corporate headquarters and manufacturing operations from Houston, Texas to the Greater Philadelphia town of Exton. The management team had developed a positive impression of the Philadelphia area because many of its key members previously worked at Dermik Laboratories, a Sanofi-Aventis subsidiary based in Berwyn. In announcing the company's relocation, executives specifically cited the "draw of the region's skilled pharmaceutical and biotechnology labor pool" and the advantages of "the talent-rich mid-Atlantic pharmaceutical biotech corridor."[13]

In the case of Isolagen, the positive attributes of human capital were not surprisingly augmented by proactive business and public leaders who ensured the availability of attractive real estate for the company's new location and appealing local government incentives—raw talent alone is never by itself a wholly sufficient condition for clustering. Nevertheless, without the necessary talent base, no matter how attractive the government incentives or other locational merits might be, a knowledge-intensive firm like Isolagen would be unable to thrive. The mere fact that the company's management team had previously worked in the Greater Philadelphia region and elected to return is an added testament to the resilience of human capital in ongoing cluster development.

Regional Findings

This report begins its examination of Greater Philadelphia's life sciences human capital by reviewing absolute and comparative levels of graduates in relevant disciplines from local universities and other institutions of higher learning. That review involved an extensive analysis of bachelor, master and Ph.D. degrees granted in more than 20 disciplines that prepare people for knowledge-intensive work in life science fields. The specific disciplines according to degree levels analyzed are described in the following table.

Field of Study	Degree Granted		
	Bachelor's	Master's	Ph.D.
Bioengineering and Biomedical Engineering	✓	✓	✓
Chemical Engineering	✓	✓	✓
Material Engineering	✓	✓	✓
Polymer/Plastics Engineering	✓	✓	✓
Biology	✓	✓	✓
Biochemistry and Biophysics	✓	✓	✓
Cell and Molecular Biology	✓	✓	✓
Microbiology/Bacteriology	✓	✓	✓
Miscellaneous Biological Specializations	✓	✓	✓
Biological Sciences/Life Sciences	✓	✓	✓
Biological and Physical Sciences	✓	✓	✓
Chemistry	✓	✓	✓
Biological Technology/Technician	✓	-	-
Health/Medical Diagnostic & Treatment Services, Other	✓	✓	✓
Health/Medical Laboratory Tech	✓	✓	✓
Basic Medical Sciences	✓	✓	✓
Medical Clinical Sciences	-	✓	✓
Ophthalmic/Optometric Services	✓	✓	-
Pharmacy	✓	✓	✓
Biomedical Engineering-Related Tech	✓	✓	✓
Pharmacology, Human and Animal	✓	✓	✓
Medicinal/Pharmaceutical Chemistry	✓	✓	✓
Health and Medical Biostatistics	✓	✓	✓

Source: National Science Foundation

The Greater Philadelphia region relies on its large, well established higher education infrastructure to graduate people at multiple levels of advanced education in these disciplines. Its institutions can be said to represent, in the vernacular of economics, what amount to "human capital production centers." Whereas companies generate output in technology, these educational institutions generate output in human talent and disseminate knowledge, the two fundamental elements that make technological innovation possible. As such, the economic value and industrial competitive significance of these schools and research centers—even though most operate as nonprofit entities—is immense.

Major centers of human capital production include institutions from within Philadelphia proper—the University of Pennsylvania, Temple University, Drexel University and Philadelphia College of Pharmacy and Science, for example—as well as those in the region's wider catchment area—Swarthmore College, Princeton University and the University of Delaware, among others. In our study, data on the graduate production levels of 41 universities, colleges, or university system campuses has been gathered, examined and interpreted.

The table above presents the degree disciplines whose data we have analyzed from the most recent year available. That information effectively represents a set of baseline statistics. It provides an important basis for understanding the fundamental characteristics of human capital output in the Greater Philadelphia region. This understanding in turn is crucial to an appreciation of the area's life science technology production and innovation capacity. At the same time, the nature of the figures upon which this understanding is based is static (i.e., fixed at a point in time). The information provided constitutes a snapshot cross-section from a single year. Moreover, the final composite rankings that are produced for each degree type—bachelor's, master's and Ph.D.—although entirely accurate, nevertheless are unavoidably influenced by the compiling of the many individual component measures. We therefore augment these data sets with additional contextual data and analysis.

Our contextual data sets include cumulative tallies of life science degrees awarded from bachelor's, master's and Ph.D. programs that are taken without component-measure influences. We also looked at other more embracing component measures such as a region's aggregated population of life science graduate students and the total number of medical doctor degrees awarded. Beyond that, we looked at other dimensions to a region's life science human capital pool—for instance, its population of life science postdocs and the number of life science Ph.D.-granting institutions. This provides a deeper appreciation for the area's living and physical human capital infrastructure. To gain a more dynamic, continuous time-based perspective on the robustness and momentum of a region's accumulating human capital pool, we also examined measures of the number of bachelor's, master's and Ph.D. degrees awarded in life science over the most recent 10 years on record.

Without too much simplification, it can be said that the essential differences between the two types of data is that one set represents fundamental "baseline measures"; the other, bigger picture "contextual measures." Taken together, they provide a more holistic picture of a region's human capital resource potential. Analyzed in conjunction with data on regional life science workforce performance, they paint a telling picture of strengths and weaknesses in how human talent for the industry is being cultivated and utilized.

The remainder of this section on the human capital dimensions of Greater Philadelphia's life science innovation pipeline includes a brief review of some of the region's leading centers of education and research. Following on, it summarizes and explores empirical data on life science human capital output. This was conducted according to both the "baseline" and "contextual" frameworks previously described.

Note that this section is also closely related to the next which explores workforce intensity. Because, from the perspective of agglomeration economics, the purpose of human capital production is to feed into a region's workforce pools, the measures of regional workforce intensity frequently relate back to the understanding developed in this section for Greater Philadelphia's human capital generation capacity.

Leading Centers of Research and Learning

The most prominent among Philadelphia's centers of learning is the University of Pennsylvania. An Ivy League school with a global reputation, "Penn" was founded by no less an enterprising intellectual visionary than Benjamin Franklin. The university heralds as its guiding principals, "entrepreneurship, innovation, invention, outreach, and a pragmatic love of knowledge."[14] With an undergraduate and graduate student body of nearly 20,000, the university is not only a high-quality, but high-volume producer of talent. Its research community includes 1,000 faculty, 1,000 postdoctoral fellows, 3,000 graduate students, and 5,000 support staff operating on a budget of more than half-a-billion dollars per year.

Life Science Human Capital
Philadelphia Firsts

Philadelphia has a rich legacy in America as a pioneer in learning and research. The following offers an overview of some of Philadelphia's "firsts" in cultivating human capital relevant to the life sciences during the city's formative history.

1698: A corporation named "The Overseers of the Publick Schoole founded in Philadelphia" establishes the first public school in the American colonies.

1729: Bachelor's Hall, Kensington becomes home to America's first botanical garden established for the cultivation of medicinal plants.

1732: America's first hospital, the Philadelphia Hospital, is established.

1743: Benjamin Franklin and others found the American Philosophical Institution, the first institution devoted to science in North America.

1765: The College of Philadelphia (in post-Revolutionary times renamed the University of Pennsylvania) opens America's first medical school.

1773: Medical students studying in Philadelphia create the American Medical Society.

1812: The Philadelphia College of Pharmacy is founded.

1852: Philadelphia's Female Medical College (today's Woman's Medical College) confers—for the first time in American history—degrees of medicine to women.

Source: Rudolph Walther, ushistory.org

Penn's School of Nursing is considered among the top two in the U.S. Other schools generating human capital relevant to the life sciences are the School of Arts and Sciences, the School of Medicine, and the School of Veterinary Medicine—all of which rank among the top 10 in their fields. The University of Pennsylvania's School of Medicine is, moreover, distinguished as the first in the nation. (This and other "Philadelphia Firsts" in life science human capital are highlighted in the accompanying grey box.[15]) The medical school's founding faculty integrated two critical elements into their research and teaching that continue to distinguish American medical education today: the organizational principle of situating a medical school within an institution of higher learning and the educational principle of augmenting classroom lectures with real-world bedside teaching.

Temple University, founded in 1888, is the area's other major interdisciplinary, research-based university. The university's main and health-science campuses educate some 27,000 students. Biology is one of Temple's five most popular undergraduate majors.[16] Its life science-related schools and colleges include the School of Dentistry, College of Health Professions, School of Medicine, School of Pharmacy, School of Podiatric Medicine and College of Science and Technology. Over the years, Temple University faculty have led new discoveries, procedures, and inventions in laryngology, preventive medicine and public health, immunology, chemotherapy, radiology, physical medicine, vascular surgery, neuroscience, cardiology and pediatrics.

Going beyond Philadelphia proper to consider the Greater Philadelphia region as a whole, the best-known university beyond Philadelphia's municipal boundaries is Princeton University. Chartered as the College of New Jersey in 1746, Princeton has opertated as an interdisciplinary university since 1896 and offered advanced graduate school education since 1900. Some 700 Princeton faculty instruct 4,600 undergraduate and 2,000 graduate students. Though it does not have the student-body and faculty numbers of a large institution like the University of Pennsylvania, Princeton is an elite Ivy League school with a remarkable scientific research capacity and history. Well known for its traditional physical and theoretical sciences (Albert Einstein and Nobel laureate mathemetician John Nash of "A Beautiful Mind" fame are among its better known scientific personalities), current research disciplines solidly in the modern life sciences include chemical engineering, chemistry, molecular biology, biophysics and neuroscience.

Baseline Human Capital Measures

High-quality educational and research institutions give the Greater Philadelphia area's human-capital base a competitive edge. This can be seen on the Milken Institute's composite index for life sciences human capital where the region ranks third for bachelor's degrees awarded in the life sciences. Using a composite score for its universe of comparable metro areas, Greater Philadelphia (scoring 82.2) was actually only bested by Boston (whose top showing gave it a score of 100) and Greater New York (which scored 88.8). The next closest peer metro regions were Minneapolis (with a score of 73.9) and Greater Raleigh Durham (at 73.6). The remaining order of ranking among peer metros is Greater LA (6th at 65.0), Chicago (62.8), Seattle (60.3), San Diego (56.5), Greater San Francisco (55.4) and Dallas (35.2).

Life Sciences Human Capital	Bachelor's Degrees Awarded, Composite Index	
Metro	Composite Score	Rank
Boston	100.0	1
Greater New York	88.8	2
Greater Philadelphia	**82.2**	**3**
Minneapolis	73.9	4
Greater Raleigh Durham	73.6	5
Greater Los Angeles	65.0	6
Chicago	62.8	7
Seattle	60.3	8
San Diego	56.5	9
Greater San Francisco	55.4	10
Dallas	35.2	11

Looking into Greater Philadelphia's strongest and weakest component measures in disciplines where there is a competitive offering (i.e., at least two metro areas awarding degrees in the subject), its best showing was in bachelor's degrees awarded in miscellaneous health and medical diagnostics and treatment services. Here the region ranked first with 47 annual graduates (averaging to slightly more than six per 100,000 people in the 25-34 age cohort of the local population). Other leading areas were Boston, Greater New York, Greater Raleigh Durham and Seattle. In similar disciplines, Greater Philadelphia ranked third in degrees awarded for health and medical laboratory technology (scoring a high 94.9) and third in degrees for basic medical sciences. Philadelphia also placed well in bachelor's degrees awarded for biology (third with a score of 94.1), biological and physical sciences (2nd at 90.2) and chemistry (2nd at 86.4).

Life Sciences Human Capital	Bachelor's Degrees Awarded in Biology			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Greater Raleigh Durham	704	319.78	100.0	1
Boston	1,072	160.58	96.7	2
Greater Philadelphia	**982**	**129.63**	**94.1**	**3**
Chicago	1,234	88.67	92.3	4
Greater Los Angeles	1,567	73.17	92.2	5
Greater New York	1,548	63.15	90.8	6
Greater San Francisco	733	74.65	87.0	7
San Diego	441	99.04	85.9	8
Dallas	487	54.41	81.1	9
Minneapolis	324	70.80	80.6	10
Seattle	206	42.56	72.7	11

Life Sciences Human Capital	Bachelor's Degrees Awarded in Cell and Molecular Biology			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
San Diego	357	80.17	100.0	1
Greater San Francisco	523	53.26	100.0	2
Seattle	188	38.84	89.1	3
Greater Los Angeles	92	4.30	66.3	4
Minneapolis	39	8.52	64.5	5
Chicago	24	1.72	48.1	6
Greater New York	10	0.41	29.8	7
Greater Raleigh Durham	2	0.91	22.7	8
Greater Philadelphia	**3**	**0.40**	**19.7**	**9**
Boston	2	0.30	14.2	10
Dallas	0	0.00	0.0	11

Although the region does very well in producing graduates in biology, among its weaker scores were those relating to fields of specialized biology: cell and molecular biology (9th), microbiology/bacteriology (8th) and miscellaneous biological specializations (8th) of the 11 peer metros studied. Philadelphia's production of only three per 100,000 university graduates in cell and molecular biology, for example, is bettered more than 100 times by San Diego's 357 graduates. To improve upon its rankings, seeking ways to graduate more students with bachelor's degrees in these specialized fields of biology would be an excellent place for Greater Philadelphia to start. Not only would this result in an even stronger overall showing, but, far more importantly, these specialized disciplines are crucial to the functioning of the biotechnology sector, one of the most promising areas for economic growth and technological innovation in the commercial life sciences.

The Greater Philadelphia region ranked third in awarding master's degrees in the life sciences. although with a lower composite score of 67.4. The leader in this category is Boston (100.0) followed by Greater New York (78.7). Also among the top five and sharing scores in the 60s with Greater Philadelphia were Greater Los Angeles (61.2) and Greater Raleigh Durham (60.6).

Life Sciences Human Capital	Master's Degrees Awarded Composite Index	
Metro	Composite Score	Rank
Boston	100.0	1
Greater New York	78.7	2
Greater Philadelphia	**67.4**	**3**
Greater Los Angeles	61.2	4
Greater Raleigh Durham	60.6	5
Chicago	55.4	6
Greater San Francisco	45.0	7
Dallas	36.0	8
Minneapolis	31.6	9
San Diego	30.2	10
Seattle	25.7	11

Among component measures in disciplines where there is a competitive offering, Philadelphia's strongest showing is in master's degrees awarded in pharmacy and pharmacology studies. The region awarded the most master's degree-holders in these two areas both in absolute numbers and adjusted statistics (average per 100,000 25-34 year-olds). This is an impressive accomplishment considering the much greater educational and economic infrastructures available to large metro areas such as Greater New York, Greater LA and Chicago. Philadelphia's annual output of 75 master's graduates dwarfs Los Angeles' six and Chicago's three. As with its strong showing in advanced pharmaceutical education, Philadelphia also scored extremely well with regard to the number of master's degrees granted in chemistry. Its score of 95.0 placed it third behind top-ranked San Diego and Boston (which scored 99.7). Strength in these disciplines reflects the region's historic leadership in the pharmaceutical and chemical industries.

Life Sciences Human Capital	Master's Degrees Awarded in Pharmacy			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Greater Philadelphia	**75**	**9.90**	**100.0**	**1**
Greater New York	70	2.86	85.7	2
Boston	15	2.25	65.2	3
Greater Raleigh Durham	6	2.73	56.7	4
Seattle	4	0.83	39.0	5
Greater Los Angeles	6	0.28	32.0	6
Minneapolis	2	0.44	24.1	7
Chicago	3	0.22	21.1	8
Dallas	0	0.00	0.0	9
San Diego	0	0.00	0.0	9
Greater San Francisco	0	0.00	0.0	9

Life Sciences Human Capital	Master's Degrees Awarded in Cell and Molecular Biology			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Boston	11	1.65	100.0	1
Dallas	12	1.34	98.1	2
Minneapolis	7	1.53	89.3	3
Chicago	10	0.72	83.2	4
Greater Raleigh Durham	4	1.82	80.7	5
Greater Los Angeles	8	0.37	66.9	6
Greater San Francisco	5	0.51	62.6	7
Greater New York	7	0.29	59.3	8
Greater Philadelphia	**4**	**0.53**	**58.6**	**9**
San Diego	0	0.00	0.0	10
Seattle	0	0.00	0.0	10

The region again could enhance its performance in certain biological specializations. Although it scored solidly for master's degrees awarded in biology (4th at 76.4) and extremely well for masters' awarded in microbiology/bacteriology (2nd at 97.3) the Greater Philadelphia region scored at or close to the bottom of its peer metro rankings for master's degrees awarded in cell and molecular biology (58.6, last among all regions granting these degrees) and miscellaneous biological specializations (55.8, placing it eighth).

The Greater Philadelphia area ranked sixth in an overall composite measure of peer metro areas for Ph.D. degrees awarded in the life sciences. The region's composite score of 74.2 placed it about 25 percent behind the leading peer region of Boston and more than twice ahead of last-place Dallas. The top five metro regions in this category are Boston, Greater Raleigh Durham, Chicago, Greater San Francisco and Minneapolis. Following Greater Philadelphia were Greater New York, Greater Los Angeles, Seattle and San Diego.

Life Sciences Human Capital	Ph.D Degrees Awarded, Composite Index	
Metro	Composite Score	Rank
Boston	100.0	1
Greater Raleigh Durham	99.8	2
Chicago	94.4	3
Greater San Francisco	91.5	4
Minneapolis	79.3	5
Greater Philadelphia	**74.2**	**6**
Greater New York	70.8	7
Greater Los Angeles	64.5	8
Seattle	55.4	9
San Diego	32.8	10
Dallas	32.2	11

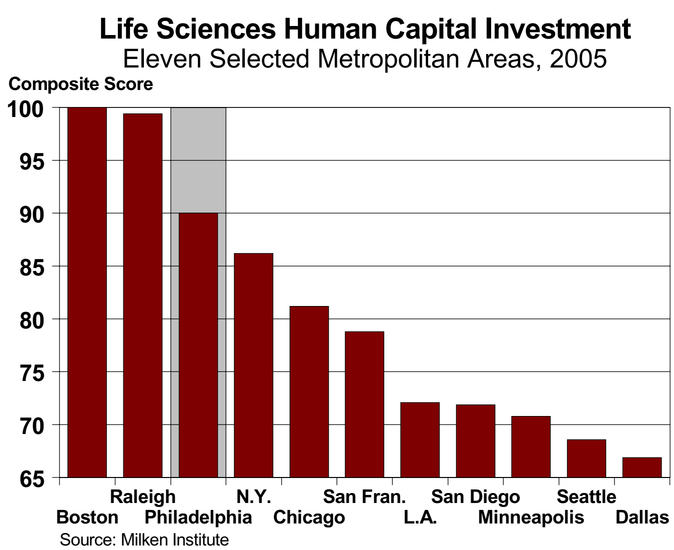
The region's most outstanding showing for life science Ph.D.s was in pharmacy studies where it ranked first, generating more pharmacy Ph.D.s than the combined absolute numbers of second-ranked Minneapolis and third-ranked Greater Raleigh Durham. The other top regions for pharmacy Ph.D.s are Chicago and Seattle. The region's next-best relative ranking for Ph.D.s comes from degrees awarded in chemical engineering, where it placed only behind Minneapolis. Once again, these strengths reflect the region's tradition of industrial and research leadership in these fields.

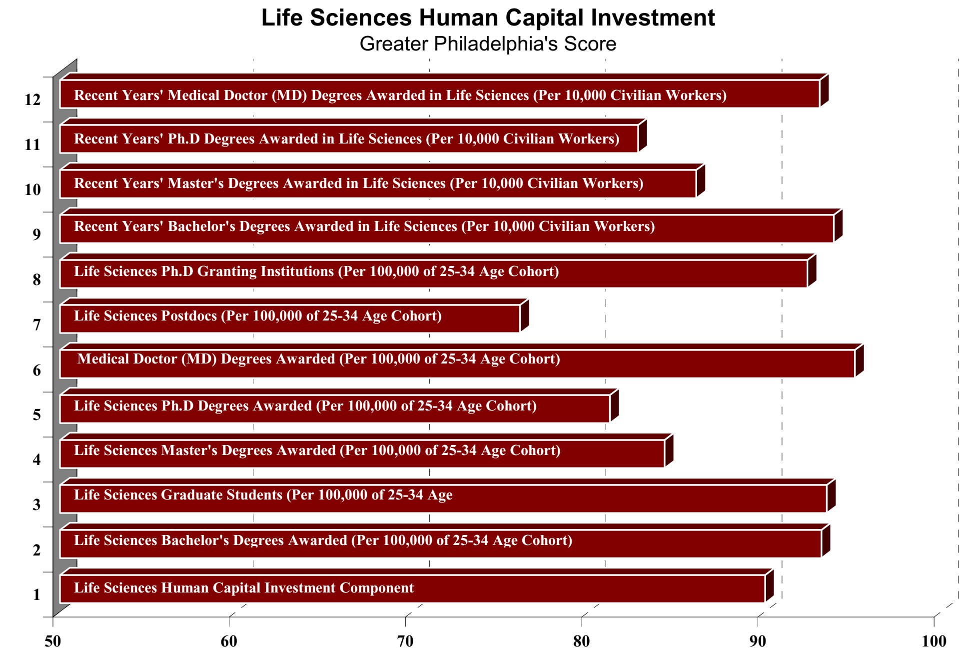
Life Sciences Human Capital	Ph.D Degrees Awarded in Pharmacy			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Greater Philadelphia	**17**	**2.24**	**100.0**	**1**
Minneapolis	11	2.40	93.6	2
Greater Raleigh Durham	5	2.27	80.2	3
Chicago	10	0.72	80.0	4
Seattle	6	1.24	77.2	5
Boston	3	0.45	55.8	6
Greater Los Angeles	2	0.09	33.5	7
Greater New York	2	0.08	32.2	8
Dallas	0	0.00	0.0	9
San Diego	0	0.00	0.0	10
Greater San Francisco	0	0.00	0.0	11

Life Sciences Human Capital	Ph.D Degrees Awarded in Microbiology/Bacteriology			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Greater New York	38	1.55	100.0	1
Greater Raleigh Durham	11	5.00	97.6	2
Boston	15	2.25	90.6	3
Greater San Francisco	12	1.22	77.8	4
Minneapolis	6	1.31	67.6	5
Greater Los Angeles	12	0.56	66.1	6
Chicago	9	0.65	63.6	7
Dallas	3	0.34	35.9	8
Greater Philadelphia	**0**	**0.00**	**0.0**	**9**
San Diego	0	0.00	0.0	9
Seattle	0	0.00	0.0	9

Among the region's opportunities for improvement in Ph.D. human capital production, there are life sciences disciplines in which local institutions matriculate absolutely no Ph.D. graduates. Despite the fact that the Greater Philadelphia ranked second in its human capital output of master's degree holders in microbiology and bacteriology, the region registered no Ph.D.s graduating in this specialization while eight other peer metros—Greater New York, Greater Raleigh Durham, Boston, San Francisco, Minneapolis, Greater Los Angeles, Chicago, and Dallas—generate a combined total of more than 100 graduates per year. Similarly, the region produced no Ph.D.s in the biological sciences/life sciences while more than 100 such Ph.D.s graduate from Boston, Chicago and Dallas. Offering more life science Ph.D. degree specialties in strategically important disciplines like microbiology and the biological sciences would bolster Greater Philadelphia's competitive positioning.

Life Sciences Human Capital Measures





Greater Philadelphia's Statistics

	1	2	3	4	5	6	7	8	9	10	11	12
Philadelphia	90.0	26.7	77.3	5.0	3.5	6.9	18.4	1.5	77.1	10.6	9.0	17.2
11 Metro Avg.	80.5	22.9	58.3	3.9	3.6	5.1	22.3	0.9	64.7	10.2	9.8	14.5

Greater Philadelphia also scored well on the Life Sciences Human Capital composite index. In the Institute's overall composite index, the region placed third with a composite score of 90.0. The only metropolitan regions ahead of Greater Philadelphia were Boston and Greater Raleigh Durham. Lower ranking peer regions that scored within 20 index points of Greater Philadelphia are Greater New York, Chicago, Greater San Francisco, Greater Los Angeles, San Diego and Minneapolis. Seattle and Dallas complete the list.

Life Sciences Human Capital	Composite Index	
Metro	Composite Score	Rank
Boston	100.0	1
Greater Raleigh Durham	99.4	2
Greater Philadelphia	**90.0**	**3**
Greater New York	86.2	4
Chicago	81.2	5
Greater San Francisco	78.8	6
Greater Los Angeles	72.1	7
San Diego	71.9	8
Minneapolis	70.8	9
Seattle	68.6	10
Dallas	66.9	11

The Life Sciences Human Capital composite index is made up of 11 life science components. The Greater Philadelphia region was measured and scored for each of those individual components, then its composite score was derived. Of the components that serve as the basis for the composite measure, the region's best ranking was in its number of life science Ph.D.-granting institutions, where it placed second only to Boston. Greater Philadelphia and Boston in fact have the same number of Ph.D.-granting bodies, 12, however, Greater Philadelphia's larger population of 25-34 year-olds lowers its proportional standing. Other high rankings for Greater Philadelphia are in the dynamic measure for bachelor's degrees awarded in life sciences over the most recent 10 years on record, and aggregated measures such as total number of life science bachelor's degrees awarded, population of life science graduate students, and number of life science master's degrees awarded. In all four of these components, the region ranked third.

Life Sciences Human Capital	Number of Life Sciences PhD Granting Institutions			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Boston	12	1.80	100.0	1
Greater Philadelphia	**12**	**1.49**	**92.4**	**2**
Greater Raleigh Durham	5	2.27	92.0	3
Greater New York	19	0.78	85.2	4
Dallas	9	1.01	74.1	5
Chicago	10	0.72	69.4	6
Greater San Francisco	5	0.51	48.7	7
Greater Los Angeles	6	0.28	47.1	8
San Diego	2	0.45	26.6	9
Minneapolis	2	0.44	26.3	10
Seattle	2	0.41	25.7	11

Life Sciences Human Capital	Medical Doctor (MD) Degrees Awarded			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Chicago	973	6.99	100.0	1
Greater Raleigh Durham	239	10.86	99.5	2
Greater New York	1,422	5.80	98.5	3
Boston	485	7.27	95.5	4
Greater Philadelphia	**552**	**6.85**	**95.1**	**5**
Minneapolis	217	4.74	79.0	6
Seattle	176	3.64	71.1	7
Dallas	266	2.97	69.5	8
San Diego	137	3.08	65.2	9
Greater San Francisco	247	2.52	65.0	10
Greater Los Angeles	413	1.93	62.7	11

The region also scored extremely well in a few categories where its ranking was not commensurately as high due to very stiff competition. Its score for the number of medical doctor degrees awarded, for example, was 95.1 but the region ranked fifth because Chicago, Greater Raleigh Durham, Greater New York and Boston all scored 95.5 or higher. A similar situation applied to Greater Philadelphia's measure for MD degrees awarded over the most recent 10 years on record for which it scored 93.1 and ranked fifth. Again, the same regional cohort (though in a different descending order) of Greater Raleigh Durham, Greater New York, Chicago and Boston all score slightly higher than Greater Philadelphia in a narrow band of top-scoring regions.

For the composite measures it is harder to specify means for improvement. These represent category aggregations, relate to infrastructural conditions, or express the results of a data time series—all of which reflect multiple underlying factors that are more complex to address. For regional leaders aiming to enhance performance in these various areas, working on the weaker baseline human capital components would be the most appropriate course of action. Improvements in the baseline components will bring increased results in the composite measures that they impact over time.

Methodology

Statistics on degree-granting institutions and number and types of degrees awarded came from the National Science Foundation (NSF). Given the breadth of empirical data we were able to obtain, equal weighting was applied to the component measures. Baseline and contextual data sets were separately designed and analyzed to provide a holistic and more true-to-life, multifaceted perspective on regional human capital assets.

As in the previous sections, data gathering and analysis of human capital was carried out on 11 peer metropolitan regions. To adequately capture the extent of this very important element of life science clustering, we measured 67 baseline components that included 23 academic disciplines in which bachelor's degrees are awarded, 22 academic disciplines in which master's degrees are awarded and 22 academic disciplines in which Ph.D. degrees are awarded. These baseline measures were combined to create the 11 broader categories that comprise the overall life science human capital composite index.

All baseline statistics were related to the most relevant general population for degree recipients in a region: the 25- to 34-year-old age cohort. Accordingly, the absolute number of graduates in a given discipline in 2001, the latest year on record, were averaged out per 100,000 people aged 25-34 residing in the region that year. The averaging provided for a sense of concentration of human capital skills and training. The absolute and averaged results were combined to produce the scores that serve to rank the 11 peer regions.

Individual component statistics were applied to the most relevant population groups for the appropriate corresponding years. In some cases, such as life science bachelor's degrees awarded, the most relevant population was the 25- to 34-year-old age cohort in the year 2001. Where more recent data was available, such as data for life science graduate students from the year 2002, the same age cohort was applied but to the year 2002. Other categories of statistics were apportioned to broader population groups and wider time spans. The component measure for recent years' bachelor's degrees awarded in life sciences, for example, covered degrees granted between 1991 and 2001, and related this back to the wider civilian workforce per 10,000 workers. Averaged and absolute statistics once again were combined to produce all scored rankings.

Tables on all component and composite measures for this and other areas of our innovation pipeline research can be found in the Appendix section of this report.

Workforce

Background and Relevance

An economy can go only so far with strong research and development capacity as its only asset. A region's development and a growing economy also depend upon the conversion of theoretical models and ideas into tangible goods and deliverable services to consumers and the marketplace. The full value of research and development can only be captured through product manufacturing or service rendering. Strong research and development attributes do not guarantee yielding superior products and services. A qualified technology and science workforce with the applicable engineering and scientific knowledge, product quality control and production process specialists, and marketing and management professionals are integral components for success.

As mentioned in the previous section, a region's economic advantage lies in its utilization and expansion of external economies of scale. The term "specialism" refers to economic agents in a spatial economy working competitively, yet collaboratively, while achieving lower sharing costs across the industry as a whole and enhancing benefits to the region in general. Hence, the most economically successful places are those with firms whose innovation processes are organized in a collaborative framework with research, development and production engaging in dynamic, interactive learning processes.[17]

A technology and science workforce is a necessary and a natural extension of a region's human capital and intellectual capacity. These two elements, brainpower for innovation, and the technical competence and sophistication for production, are often closely linked. The biopharmaceutical industry in the Mid-Atlantic region demonstrates this closely knit relationship. More often than not, research and development centers are in a central location surrounded by multiple manufacturing plants where scientists, engineers and product production teams congregate and communicate to improve production efficiency. This intense feedback loop is common among high technology oriented industries.

Sustaining a regional industrial economy as complex as a life science cluster needs a workforce with industry-specific skills in the region where the operations take place. This pooling of a specialized technology and science workforce is critical for the industry to expand and for firms to grow. Science and technology workers are key to the creation of economic value in the innovation, product development and mass manufacturing operational processes. These workers do not just access knowledge and apply it to firm-specific objectives, rather and more importantly, they harness new information to generate new knowledge, bringing both inductive and deductive analytical skills to complex problems, creating both new concepts and processes.[18] Acquiring new knowledge, experience and technical know-how are often highly dependent upon the types of operation, detailed divisions of labor, extensive work experience, constant interaction with other colleagues working in the same field and the like. In general, these skill sets are heavily industry and product specific and highly regionalized as well.

Small firms tend to have smaller operational budgets and limited ability to recruit needed qualified technical workers from long distance or retain technical staff full time. Small startups tend to contract out "noncore" technical tasks or administrative work to consultants who are in proximity to the firm's operating location. A region lacking larger pools of this highly skilled, scientific and technically trained workforce and highly qualified administrative support will not be able to grow, attract and nurture young technology-based startups. Major metropolitan areas like Greater Philadelphia are blessed with large service economies, which puts them at an advantage in nurturing small, innovative firms and meeting their management and other professional service needs.

Within the life sciences, industry sectors such as biotech have requirements for a science and technology workforce that are even more demanding than other technology-oriented industries such as Information Technology. Given bioscience's long development cycle, cross multiple disciplinary fields, tight government regulation and larger capital investment upfront, the requirement for a suitable workforce can only be more demanding. A seasoned biotech entrepreneur, Howard Birndorff of Nanogen in San Diego, remarked on the reason life science companies are born and grow in that region. "The fact of the matter is that because of the intense talent pools here, you start a company and you have people that you can hire. To duplicate that is going to be hard to do for another state. That is probably one of the key ingredients."[19]

Whereas human capital measures paint a picture of a region's output of life science industry talent, workforce measures directly portray the nature of people who are actively engaged in life science related labor. In this sense, human capital measures we have examined thus far relate to a latent life science economic capacity. Workforce measures, on the other hand, describe the human capital that is in fact economically productive in the life science fields.

The professions of nearly 30,000 specially trained individuals that make up Greater Philadelphia's life science workforce are captured in our component data sets. As managers, engineers, scientists and technicians, their work spans the fields of biology, biomedical engineering, biochemistry, biophysics, business-to-business sales, chemical engineering, chemistry, electro-mechanics, health services management, material engineering, medical science and microbiology. They are the people that make the region's industries productive, competitive and innovative.

In our component measures, the workforce indicators of intensity of medical and health service managers and intensity of sales representatives (wholesale and manufacturing) portray the administrative and managerial sides of commercial life science activity. Numbering more than 15,000 in the Greater Philadelphia area, they are by far the two largest groupings in its life science workforce. Note that the health services provided by hospitals and specialty clinics delivered in a particular region are often provided to people who come from beyond that region seeking quality health care. In a similar vein, business-to-business sales representatives, though based in a single area, frequently cover larger territories that extend beyond their home base. Thus, both of these component measures reflect not only a region's strengths in life science services and management, but also to a certain degree its capabilities in exporting its life science output.

Other component measures cover scientific, engineering and technical occupations. The scientists engaged in life science professions tend to have biological and medical specializations. *Biological scientists* study living organisms and their relationship to their environment. They held about 75,000 jobs in the U.S. in 2002.[20] Those who conduct research usually work in laboratories utilizing electron microscopes, computers, thermal cyclers and a variety of other sophisticated equipment. *Biologists*, for example, study the effects of chemical agents on infected animals. In a specialty of biology, professional *biochemists* study the action of drugs on body processes by analyzing the chemical combination, actions and reactions involved in metabolism, reproduction, growth and heredity. *Medical scientists*, who at first blush are likely to be thought of as physicians or surgeons, may also conduct clinical research, test products and oversee human clinical trials. Thus they are vitally important not only to the delivery of life science services, but a region's innovation pipeline, as well.

Chemists and materials scientists work with structures and chemical properties of various materials. Their efforts are especially important in fields like early-stage biopharmaceutical research, new drug development and drug delivery methods, such as new medical devices. In the related profession of *chemical engineering*, these knowledge workers apply the disciplines of chemistry and engineering to problems involving the manufacturing of chemistry-based substances. They play crucial roles in the production and applications of pharmaceutical products. In tandem with life scientists and chemists, specialty engineers such as *biomedical engineers* are integral to the development of medical devices such as artificial organs and prostheses, instrumentation, medical information systems, and health management and care delivery systems.

Science technicians, such as *biological* and *chemical technicians* set up, operate and maintain laboratory equipment, monitor experiments, analyze resulting data, and record and interpret results. Science technicians often support scientists and engineers. *Electromechanical technicians*, on the other hand, apply an understanding of mechanical engineering and electronics to their work, which may cover the design, testing and manufacturing of advanced mechanical systems. Professions such as these are critical to the innovative capacity of life science sectors such as medical devices.

Regional Findings

Compared to the workforce statistics of the 10 other leading metropolitan regions examined in this study, Greater Philadelphia's life science workforce scored well. Out of 14 measurements of worker intensity, the region's life science workforce score is near or above 80 in all but two components. In the overall workforce composite index—the combined measure of all 13 worker intensity components—Greater Philadelphia earned a composite score of 88.2. Greater Philadelphia's score is bettered only by the deeply embedded life science clusters of Boston, Greater San Francisco, San Diego and Greater Raleigh Durham. Moreover, in the case of Greater Raleigh Durham, that region only slightly outperformed Greater Philadelphia with a score that was 0.4 higher, making the two regions essentially tied. Furthermore, Greater Philadelphia's score exactly equaled that of bio-pharmaceutical heavyweight Greater New York, an indication of just how well-developed Philadelphia's specialized employment base is.

Life Sciences Workforce	Composite Index	
Metro	**Composite Score**	**Rank**
Boston	100.0	1
Greater San Francisco	95.4	2
San Diego	90.6	3
Greater Raleigh Durham	88.6	4
Greater Philadelphia	**88.2**	**5**
Greater New York	88.2	6
Greater Los Angeles	87.0	7
Chicago	83.2	8
Minneapolis	81.8	9
Seattle	75.8	10
Dallas	72.8	11

The following characteristics emerged from our examination of the Greater Philadelphia region's workforce performance:

- In absolute numbers, the area's largest life science labor pools were of wholesale and manufacturing sales representatives (9,100 workers) and medical and health service managers (6,670 workers).

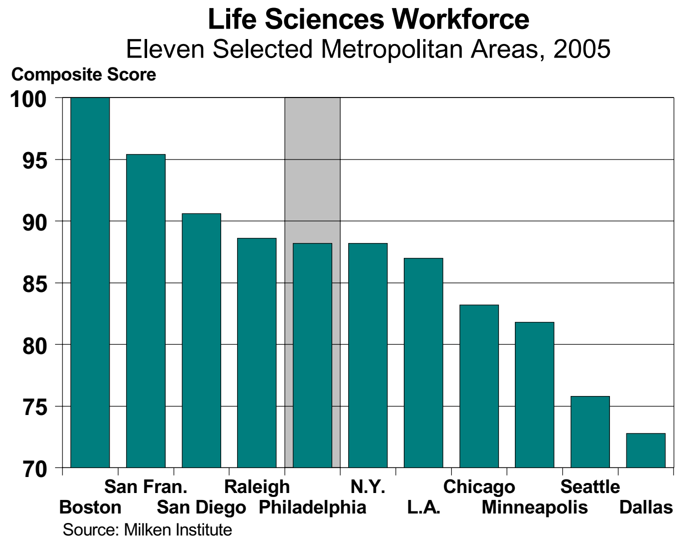
- In more technically oriented fields, the region also has large employment pools of chemists (3,800), medical scientists (2,700), chemical technicians (1,830) and biological technicians (1,600).

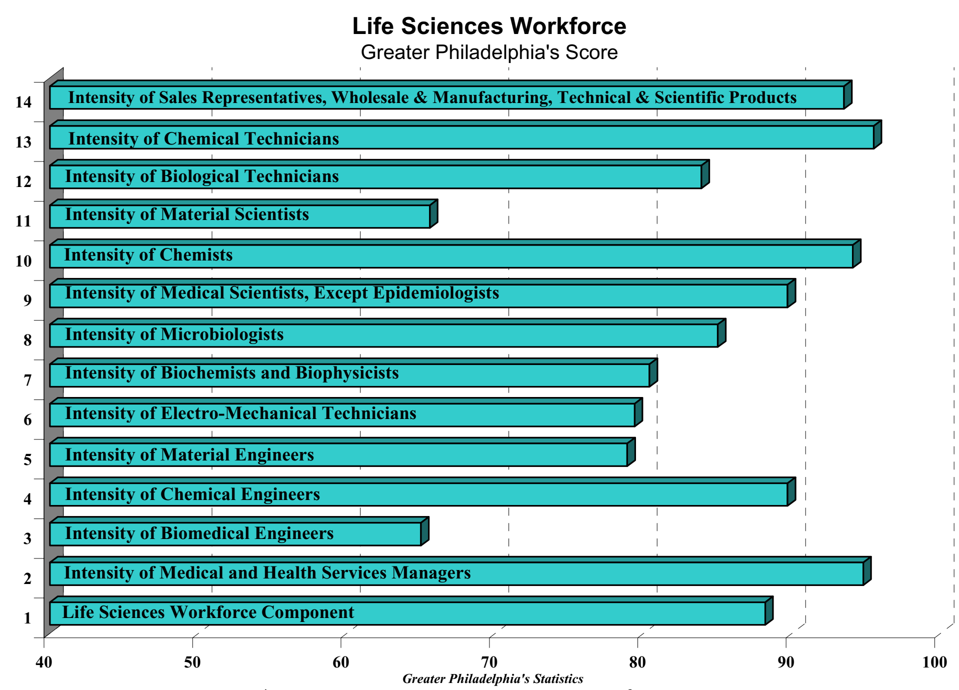
- In terms of workforce intensity (an excellent proxy of labor clustering), Greater Philadelphia scored high for chemical technicians (who earned the region a score of 95.5), medical and health service managers (94.8), chemists (94.1), sales representatives (93.5), and chemical engineers and medical scientists (both groups scored 89.7).

These professions with high scores in the region's workforce intensity measures indicate that Greater Philadelphia continues to capitalize on its historic industrial strengths in chemicals, health care and as a business center for sales and distribution. In measuring for intensity of chemists, for example, we found that the Greater Philadelphia area had approximately 134 working chemists for every 100,000 workers in total. Its score of 94.1 ranked the region third among the 11 peer metros. This score was exceeded only by Raleigh Durham, which scored 100, and Greater New York, which scored 97.6.

Life Sciences Workforce	Intensity of Chemists			
Metro	Number, 2003	Per 100,000 Workers, 2003	Score	Rank
Greater Raleigh Durham	2,330	348.8	100.0	1
Greater New York	8,810	113.6	97.6	2
Greater Philadelphia	**3,800**	**133.8**	**94.1**	**3**
San Diego	2,130	170.3	92.9	4
Boston	2,550	134.3	91.7	5
Greater San Francisco	2,530	89.7	88.0	6
Chicago	2,890	68.3	86.3	7
Greater Los Angeles	2,910	50.9	83.6	8
Minneapolis	1,370	82.0	83.5	9
Dallas	910	34.6	73.1	10
Seattle	520	34.1	69.7	11

Although the region performed strongly overall, if Greater Philadelphia is to improve its workforce intensity and move up vis-à-vis its universe of peer metro areas, it will need to attract more workers in those professions that the other regions—Boston, Greater San Francisco, San Diego and Greater Raleigh Durham—predominantly lead. Analysis of the workforce intensity measures indicates that Greater Philadelphia would gain the most leverage in enhancing biological technical services, biomedical engineering, material engineering, electro-mechanical engineering and material science. Moreover, all these professions, it is worth noting, are important to the biotechnology and medical device sectors. Thus, the region would benefit in terms of long-term job growth and economic competitive advantage from enhanced workforce intensity performance in these in high-potential industry sectors.





Greater Philadelphia's Statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Philadelphia	88.2	234.8	5.3	21.1	12.0	21.8	16.9	11.3	95.1	133.8	4.6	56.3	64.4	320.4
11 Metro Avg.	86.5	170.5	10.3	19.7	16.1	26.3	24.9	14.1	110.0	114.6	7.7	82.7	50.5	443.2

One profession in which the region might consider bolstering its workforce positioning is biomedical engineering. Currently, Greater Philadelphia universities graduate, on average, 31 people per year with a bachelor's degree in bioengineering or biomedical engineering. Normalized for the relevant population, this represents slightly more than four people among every 100,000 aged 25-34 years old. In terms of this human capital output, the area is fifth among its peer group and exceeded only by as large a metropolitan area as Chicago, which on a normalized basis graduated 4.74 people (only 16 percent more). Measured against Philadelphia's score of 59.8, Chicago was only about 11 points above Philadelphia in this important human capital component. Compared to metros such as Seattle, Dallas and Minneapolis, Philadelphia fared better still.

Dallas and Seattle did not have any graduates in bioengineering and biomedical engineering in the time period measured; Minneapolis had one.

Still, on a comparative basis, the potential of this highly skilled human capital base is not being fully realized in the Greater Philadelphia region. Whereas Greater Philadelphia's overall labor force has 5.3 biomedical engineers per 100,000 workers, Chicago has 7.6 (43 percent more) and—in what is a testament to this Midwestern metropolitan area's tremendous workforce drawing power—Minneapolis has 13.8. The Minneapolis area's normalized population of biomedical engineers is 1.6 times greater than Philadelphia's—this despite locally producing the lowest possible number of university graduates in the discipline.

The imbalance appears more starkly in relation to master's degree human capital output. Attainment of a master's education or higher in a specialization is a common prerequisite for senior engineering and scientific positions in life science fields. In its output of master's degree graduates in bioengineering and biomedical engineering, the Greater Philadelphia area scored a high 84.0 and ranked third among its peers. Its absolute and normalized levels of master's degree graduates again exceeded key technology regions like Boston, Minneapolis and Greater San Francisco. Yet despite this human capital advantage, the Greater Philadelphia area nevertheless lagged all three regions in biomedical engineering employment, which is a key factor in the health of its medical device business base.

Life Sciences Human Capital	Bachelor's Degrees Awarded in Bioengineering and Biomedical Engineering			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
Greater Raleigh Durham	74	33.61	100.0	1
San Diego	79	17.74	91.6	2
Boston	60	8.99	78.7	3
Chicago	66	4.74	70.6	4
Greater Philadelphia	**31**	**4.09**	**59.8**	**5**
Greater Los Angeles	51	2.38	57.8	6
Greater San Francisco	32	3.26	56.9	7
Greater New York	36	1.47	46.8	8
Minneapolis	1	0.22	0.3	9
Dallas	0	0.00	0.0	10
Seattle	0	0.00	0.0	10

Life Sciences Human Capital	Master's Degrees Awarded in Bioengineering and Biomedical Engineering			
Metro	Number, 2001	Per 100,000 (25-34)	Score	Rank
San Diego	25	5.61	100.0	1
Chicago	33	2.37	93.0	2
Greater Philadelphia	**18**	**2.38**	**84.0**	**3**
Greater New York	24	0.98	76.8	4
Boston	13	1.95	76.6	5
Minneapolis	10	2.19	74.2	6
Greater Raleigh Durham	7	3.18	73.7	7
Dallas	12	1.34	70.6	8
Greater Los Angeles	17	0.79	69.0	9
Seattle	3	0.62	39.9	10
Greater San Francisco	0	0.00	0.0	11

Life Sciences Workforce	Intensity of Biomedical Engineers			
Metro	Number, 2003	Per 100,000 Workers, 2003	Score	Rank
Greater San Francisco	660	23.4	100.0	1
Boston	420	22.1	95.6	2
San Diego	270	21.6	91.8	3
Minneapolis	230	13.8	83.5	4
Greater Los Angeles	450	7.9	79.8	5
Chicago	320	7.6	76.5	6
Greater Philadelphia	**150**	**5.3**	**65.0**	**7**
Greater Raleigh Durham	40	6.0	56.8	8
Greater New York	120	1.5	43.8	9
Seattle	40	2.6	43.6	10
Dallas	40	1.5	35.1	11

One should be careful not to over-interpret the statistics. Almost certainly, graduates in bioengineering and biomedical engineering remain in the Philadelphia area, but are employed in different occupations. Furthermore, a portion (though how many is unknown) of the bioengineers and biomedical engineers who do work in the Greater Philadelphia region were not all trained locally but received their educations in other parts of the nation or the globe. Thus, the region does not rely exclusively on locally generated talent.

There is nothing in the analysis to indicate that the situation with bioengineers or other strategically important occupations is severe—there may be other factors to explain relative underperformance. Be that as it may, the statistics do indicate that there is an imbalance: compared to similar metro areas, Greater Philadelphia clearly does a better job at graduating degree holders in important specialties but lags behind them in employing people in the related professional fields. This is an imbalance that unmistakably points to a loss of economic opportunity for those individuals and the region as a whole. In the case of bioengineering and biomedical engineering, for example, the region has valuable pools of human assets that could be better utilized to feed into its local biotech and medical device sectors.

To effectively address human capital/workforce issues and opportunities such as these an increased understanding of their root causes is needed. Possible avenues of investigation include:

- *Find ways to close human capital/workforce gaps*. At the most basic level, it would be helpful to know how graduates from Greater Philadelphia institutions choose their degree disciplines and subsequent career paths. Imbalances are occurring between the point of human capital production (i.e., when local students graduate) and workforce acquisition (the types and number of individuals employed in local life science fields).

- *Evaluate why other regions perform better in workforce intensity in fields where Greater Philadelphia is less successful*. What are the tangible and intangible benefits that propel highly trained workers to gravitate to and stay in these other areas?

- *Obtain an in-depth understanding of how local institutions prepare students for careers in the life sciences*. How are Greater Philadelphia institutions matriculating students in disciplines that feed into strategically important professions?

- *Analyze how local university-industry connections function*. What is the interaction between universities and other educational institutions with local life science employers? How heavily are companies involved in curriculum, work-study or internship programs and collaborative research projects?

- *Determine what access Greater Philadelphia's human capital has to regional risk capital and entrepreneurship infrastructure*. Are the weaker components of workforce intensity owing in any way to limitations in the mechanisms that facilitate new enterprise formation?

The foregoing list is not exhaustive, yet it does illustrate aspects to consider in ascertaining the ultimate source or sources of imbalance that characterize the human capital/workforce dimensions of Greater Philadelphia's innovation pipeline.

A recent study on how Philadelphia competes to attract young and talented workers noted that the area experienced a steep decline in its population of 25 to 34 year-olds. With the life science human capital-workforce gap in mind, the following observation gives further impetus to finding ways to understand why Greater Philadelphia's appeal to degree-holders is slipping:

> Philadelphia's decline in college-educated young adults ran counter to national trends. Although Philadelphia ranked 18th in college attainment, it actually saw a drop of 1 percent in the number of college-educated young adults at a time when this group increased nationally by more than 10 percent.[21]

This underscores the need to pay especial attention to how the Greater Philadelphia area manages not only to *train* qualified human capital, but also to *retain* talented individuals as they make their way into the workforce.

On the positive side, Greater Philadelphia has, more than many other areas, resources in place to address its range of opportunities and issues: an engaged political and business leadership, a dynamic life science industry base, and a large, superior-quality higher education community with a remarkable tradition for innovating new directions in learning and research. Studies like this one exemplify a commitment to capitalizing on the region's position as a thriving life science cluster. Continued effort at understanding and addressing ways to enhance the region's competitive standing will help realize the potential of its people and enterprises.

Methodology

Life science workforce data was gathered for 13 components. To capture the gamut of professions that infuse and nurture a life science cluster, we examined not only core scientific fields of labor, such as microbiologists and chemists, but also those in management of health care—medical and health service managers—and supporting and ancillary occupations, such as biological technicians and sales representatives. This mix of occupations also allows for an appreciation of a cluster as it spans research, manufacturing and service fields.

As in the previous section on human capital, statistics on degree-granting institutions, and number and types of degrees awarded came from the National Science Foundation (NSF). In this section's additional treatment of workforce intensity measures, data for these component indicators came from the Bureau of Labor Statistics (BLS), Department of Commerce. The latest workforce data available from the BLS was for 2003. The relevant statistics from that year were used in all instances.

In each component measure, a region's absolute number of life science workers in a specific field was related back to that region's workforce population per every 100,000 workers. This provided the section's central gauge of workforce intensity and insight into the concentration of key life science professions. Absolute and averaged figures were combined to produce the scores that serve to rank the 11 peer regions.

Innovation Output

Background and Relevance

The basic research, discovery, development and final approval stages in bringing biopharmaceutical products and medical devices to market in the U.S. are lengthy, costly and extremely elaborate. Every innovation destined for public use must go through thorough testing and refinement, followed by clinical trials on a sample population, before the medicinal product or device is authorized for sale. Innovations whose market value is to be preserved must also be patented. Innovation output in the life sciences is accordingly highly dependent upon regulatory forces.

The Food and Drug Administration (FDA), a division of the Department of Health and Human Services is the approval agency in the United States for pharmaceuticals and medical devices. The number of medical products, drugs and devices, that the FDA regulates today exceeds 150,000, far more than any previous time in its history. There are approximately 3,000 new drugs under development at present. In addition, there are greater numbers of and more diverse dietary supplements on the market than ever before. U.S. residents also have a much broader range of food choices, including more than six million food imports in 2003, with import numbers increasing rapidly.[22]

Clinical testing for FDA approval typically proceeds through three successive trial phases.[23]

- In Phase I trials, researchers test a new drug or treatment on a small number of healthy volunteers (20 to 80) to establish safe dosages and gather information on absorption, distribution, metabolic effects, excretion and toxicity of the compound. To conduct clinical testing in the United States, an investigational new drug application must be filed with the FDA. Initiation of human testing often occurs outside the U.S.

- In Phase II trials, the study drug or treatment is given to a larger group of people (100-300) who have the disease or condition it is intended to treat. Phase II clinical trials are designed to see whether the drug or treatment is effective and to further evaluate its safety. To provide evidence of a drug's therapeutic benefit, it is necessary to compare its effectiveness with that of standard, medically accepted treatments (which may include a placebo).[24]

- In Phase III trials, the study drug or treatment is typically given to large groups of people (1,000-3,000) to firmly establish its effectiveness, uncover side effects that occur, compare it to commonly used treatments and collect information that will allow the drug or treatment to be used safely.

When developers believe they have sufficient evidence of safety and effectiveness, test results are compiled in detail and a new drug application or biological license application is submitted to the FDA. Priority review is based upon therapeutic significance at the time of application submission.

New drug development is a risky process, with many more compounds failing for every one that makes it to market. Each year, thousands of new pharmaceutical substances are tested, eventually yielding only 10 to 20 new prescription medicines.[25] It is a very lengthy process. Development costs vary across drugs and treatments. Relatively new biotechnologies that are not well understood, may increase the expenses related to bringing new products and treatments to the marketplace.

Evolving market economics also mean that the once rich pickings to be had from maladies such as hypertension and high cholesterol—the so-called "low-hanging fruit" diseases whose root causes were relatively simple to address—have been exhausted. Firms now are focusing on more complicated disorders, such as cancer and Alzheimer's disease, where finding remedies is vastly more complex and costly. This has led to a fundamental shift in the mechanisms of the innovation pipeline, where genetic science is driving research into new areas of discovery. An otherwise positive development, lack of familiarity with the new territory being covered is "resulting in major bottleneck at the biological validation stage due to a lack of context for the new 'hits.' As such, an increasing percentage of drugs are making it to Phase II studies, but being dropped before entering Phase III."[26]

Bringing a new drug to market can cost anywhere between $800 million to $1.7 billion.[27] Although this implies that only big companies with sufficient economies of scale can introduce new medicines, there are other issues associated with scaling up a corporation's size. As big pharmaceutical firms becoming even bigger through the sorts of multiple acquisitions that have characterized the latest stage of industry consolidation, organizational sprawl and lack of integration poses a threat to corporate innovation capacity. Severe price competition from generic drugs and regulations that aim at controlling spiraling health-care costs are exerting further pressures. Hank McKinnell, Chairman and former CEO of Pfizer (the largest research-based pharmaceutical company in the world), spoke as much for the pharmaceutical sector as for the firm he heads when he told investors in April 2005: "We face a serious paradox … The potential for [medical] breakthroughs has never been better, but the operating environment has never been more difficult."[28]

Any substantial product innovation contains economically valuable intellectual property. For the sake of intellectual property protection, the U.S. Patent and Trademark Office (USPTO) issues patents for the exclusive right to make, use, sell, offer to sell, or import an invention into the U.S. Patents generally last for 20 years from the date of filing. Due to the lengthy time required for FDA approval of pharmaceuticals, in 1984, Congress passed the Drug Price Competition and Patent Term Restoration Act (more typically referred to as the "Hatch-Waxman" Act), which permits patent extensions up to a maximum of five years. This is to compensate for market time lost during the drug approval process. When a company believes that its product approval incurred longer than warranted regulatory delays, it can petition for an additional extension.[29]

While Hatch-Waxman has provided a relief valve for one of the biopharmaceutical sector's major pressure points, it has at the same time introduced a new point of contention regarding overall intellectual property protection. Unlike the situation for other fields of patented inventions, the Hatch-Waxman Act provides access to the myriad test results that go into the creation of a patented pharmacological product, to rival biotech and pharmaceutical companies. Under this component of the bill, a generic manufacturer may develop an identical drug during the product's patent period. The only major restriction is on the rival's sale of the product, which is prohibited for as long as the patent remains in effect. Generic manufacturers can then "pounce" on a market with an already developed pharmaceutical the moment a patent expires. Other rivals, even if they lack plans to produce a generic, still have open access to the product's testing results that can be used in other competitive development projects. These conditions do not apply to other knowledge-based industries, such as information technology.

Beyond the controversies and economic challenges associated with them, FDA approvals and patents in the life sciences remain central components in the workings of the industry's innovative processes. From performance in FDA approvals and the various phases of trial testing to the numbers of patents granted and the ways in which these patents impact industry research, FDA and patent measures provide highly revealing indicators of the health and vibrancy of life science sectors.

Since they also relate to an innovation's final stages of development as it enters the market as an economically valuable product, these statistics offer some of the best empirical data available on the net output of the life sciences innovation pipeline. As such, this section's data gathering and analysis of innovation output focuses on measures that describe FDA approvals and patents in the 11 metro regions studied.

Out of a total of 13 component measures, five are based on FDA approval statistics. To balance out the significance of these indicators, the combined FDA statistics are weighted to comprise half of the composite index scores. The remaining eight measures concern various dimensions of life science patents and their qualitative features. The methodologies used to construct the measures can be found at the end of this section.

Regional Findings

The Greater Philadelphia region turned in one of its strongest performances among all of the innovation output component rankings in the FDA new drug approval category. With 24 new drug approvals (NDAs) between 2002 and 2004, Greater Philadelphia had the second largest absolute number of NDAs among the 11 regions studied. This is equivalent to 3.9 NDAs per million inhabitants in the region. The only region with a higher absolute amount of approvals was Greater New York; the only region with a higher amount averaged per million inhabitants was Greater Raleigh Durham. Combining both sets of statistics, the top five regions in this category in descending order were Greater New York, Greater Philadelphia, Greater Raleigh Durham, Boston and Chicago. Strong performance in this measure is made all the more challenging due to rapid complexification of the biopharmaceutical research environment. Since peaking in 1996, new drug approvals have been steadily decreasing despite a constant increase in pharmaceutical R&D spending.[30]

Despite this, the Greater Philadelphia region placed fourth in the FDA new medical devices premarket approval category. Premarket approval is a scientific review process required by the FDA on all Class III medical devices—the most heavily regulated category of devices—to ensure their safety and effectiveness. With six new medical devices winning premarket approval from the FDA between 2002 and 2004, averaged out for the region's some six million people, this is the equivalent of one approval per million members of the population. Greater Philadelphia placed very close to the performance of one of the nation's best known leaders in the medical device industry, Boston, which had five premarket approvals (1.1 per million people) over the same period. Among the top five in this component measure were Minneapolis (9 approvals; 2.9 per million people), Greater Los Angeles and Greater San Francisco.

In the category for FDA Phase I Clinical Trials, Greater Philadelphia again scored solidly among the top five in third place. With 119 products in Phase I testing, this is the equivalent of 1.9 products for every 100,000 members of the region's population. Here again the region has absolute numbers that approximate Boston, which has 121 products in Phase I trials but, owing to a smaller population base, has 2.7 products for every 100,000 people in the regional population. The top five peer metros for this measure are Boston, Greater Raleigh Durham, Greater Philadelphia, Greater San Francisco and Greater New York. Sixth-ranked Greater Los Angeles and seventh-ranked Seattle also scored highly with 92.5 and 91.6 index points respectively, placing them only about 2-3 points behind Greater Philadelphia.

With 572 products at the Phase II stage (9.3 per 100,000 people), the region ranked sixth with a score of 86.7 for its measure of Phase II Clinical Trials. Top-scoring Boston registered 776 products in Phase II trials (17.5 per 100,000 of population) followed by Greater San Francisco, Greater Raleigh Durham, Greater New York and Chicago. Considering its higher ranking for Phase I trials, Greater Philadelphia could easily move up in this category if its current Phase I product tests prove successful, allowing more of the region's pharmaceutical innovations to transition to a higher level of trial investigation.

In the last of our measures regarding FDA approval, the Greater Philadelphia region was again among the top five peer metros with 694 potential new drugs from local labs currently in Phase III testing, equivalent to 11.3 Phase III innovations per 100,000 people. This generated an index score of 91.1 and ranked the region fifth. The other high performing regions in the top five were Greater San Francisco, Boston, Greater Raleigh Durham and Greater New York. Phase III is the most involved of all FDA approval process stages, where several thousand people might participate in Phase III clinical trials. Pharmacological products that pass this phase of testing are eligible for final review by the FDA, their last major regulatory step prior to entering the market.

Greater Philadelphia saw 4,343 patents issued to its commercial life science inventers in the five years ending 2003 (1999-2003), the latest year on record. This is equivalent to 70.8 patents per 100,000 people. Combining both statistics the region scored 84.8 and ranked fifth in its universe of peer metros. Greater San Francisco, with nearly 12,000 patents issued in the life sciences (slightly more than 200 per 100,000 people) is the benchmark top scorer with 100 index points whereas Dallas, with under 800 life science patents (about 14 per 100,000 people), scored 60 index points and placed last. The other regions among the top five in this category were Boston, Minneapolis and San Diego. The component measure for the number of life science patents issued is the first of three basic indicators derived from patent-based data that the Milken Institute used in its assessment of regional innovation output.

In terms of the growth in patents for life science inventions, Greater Philadelphia earned a comparative index score of 84.5 and ranked eighth. The top five in this measure are Greater San Francisco, Greater Los Angeles, San Diego, Minneapolis and Boston. Patent growth is a dynamic indicator, relating to the momentum of innovative output as it applies to patented life science inventions (those hailing from the industry sectors of pharmaceuticals, biotechnology, medical equipment and medical electronics). Regions with upward growth in this measure are building competitive advantage through increasing protection of their intellectual property.

Among all of the life science innovation output measures, the Greater Philadelphia region earned its highest marks in the category of percent of life science patents in area. This measure is based on the ratio of a region's life science patents to its overall patent attainments. It thus reflects the concentration of life science inventiveness and intellectual capital protection among all the industries in a region. Not surprisingly, the exceptionally life science intensive high-tech region of San Diego scored the top-ranking benchmark of 100 index points in this measure. Yet Greater Philadelphia virtually tied this score with 99.9 index points, a remarkable performance. The measure is one illustration of how the region has become particularly innovative in its life science sectors. Following Philadelphia in the top five were Boston, Greater New York and Seattle.

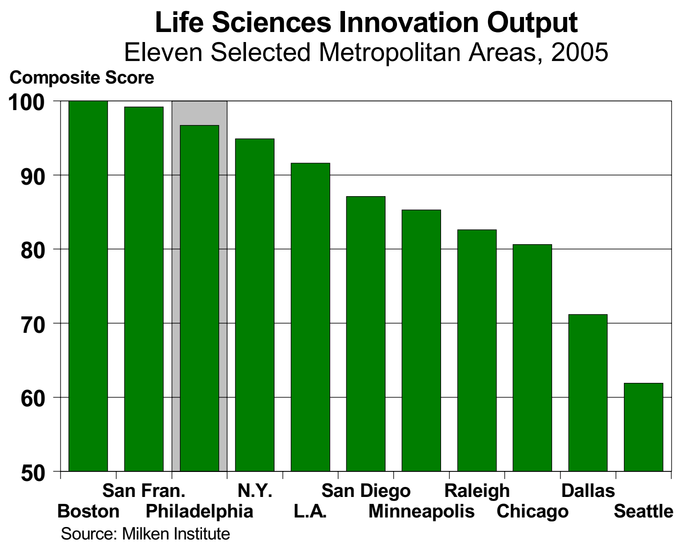
The CHI Research, Inc. component measure, life sciences current impact index, is the first of three more complex indicators derived from patent citation data. Patent citations are made in the initial pages of a new patent. They refer to parents, the technological "prior art" of a newly patented invention. Our measure used data provided by CHI Research, which accumulates statistics on how many citations a patent receives in the patents that follow it, essentially "counting how many times a patent becomes prior art in future technological advances."[31] In this measure, the data used captures the number of times regional companies' previous five years of patents are cited in the current year's crop of new patents. Accordingly, rankings in this measure express the relative present-day influence or "current impact" of a region's commercial life science patents. Although its indexed score was a respectable 89.7 for this measure of innovation output, Greater Philadelphia, placed 10th. The top five performers in this measure were Greater San Francisco, Minneapolis, San Diego, Greater Los Angeles and Boston, the latter which scored 94.9 index points. Boston's fifth place score being only about five points ahead of 10th-place Greater Philadelphia is a sign of how performance among peer metros in this measure heavily crowds the top.

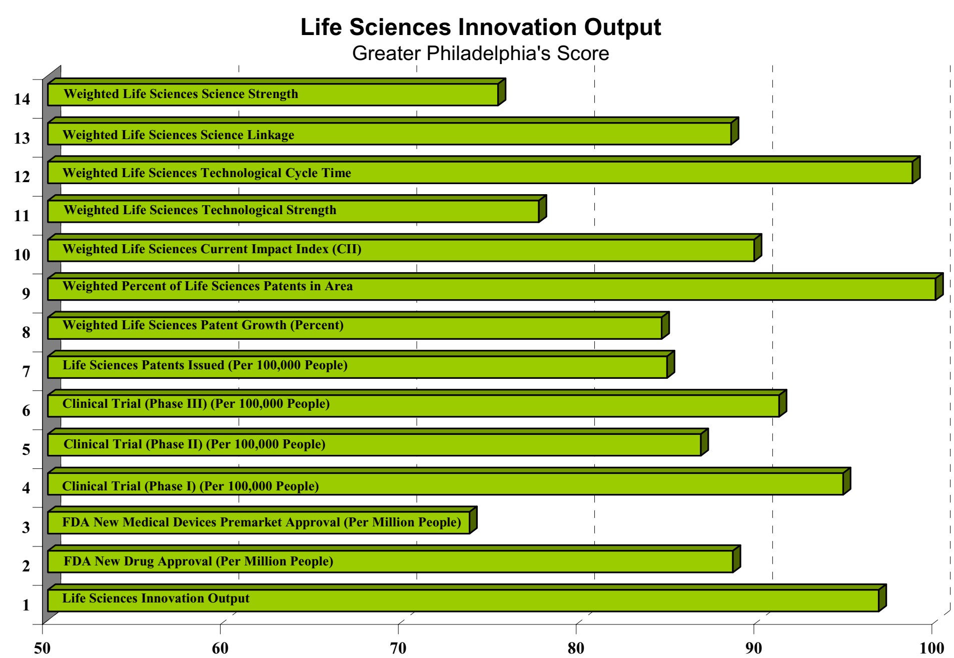
Greater Philadelphia returned to a top five ranking in the component measure for life sciences technology strength. Here its score of 77.6 index points ranked the region fourth, bested only by Boston, Greater San Francisco, and San Diego and followed by Greater Los Angeles. The Technology Strength measure is quality weighted. It takes the number of patents earned by a region and multiplies that by the current impact index (described above). This is helpful in identifying how regions balance out both their quantity and quality of life science patents. The region's performance in technology strength indicates that although the current impact of Greater Philadelphia life science patents ranked low within its cohort of peer metros, looked at from the number of patents companies in Greater Philadelphia generate, the innovative integrity of the region's output is still comparatively high.

In the measure for life sciences technological cycle time, Greater Philadelphia scored a high 98.6 but in a tightly competitive field ranked fifth. Technology cycle time represents the last of the three patent citation indicators that we used. It helps assess the speed of regional innovation and technology turnover by using the median age in years of "prior art" patents cited in the patents issued to regional firms. The lower the cycle time in median years of cited patents, the more a company can be seen to be quickly building upon the latest innovations to develop its own patented inventions. From a regional perspective, the measure reflects how rapidly an area is using the latest existing technology to create new technology. The top five regions in this measure are Chicago, Greater Raleigh Durham, Minneapolis, Dallas and Greater Philadelphia.

The component measure for life sciences science linkages is one of two that goes beyond accounting for patent citations to examine the extent to which the patents coming out of a region are steeped in new scientific developments. Science linkages are based on the average number of pieces of scientific literature (for example, peer-reviewed scientific articles or papers presented at scientific conferences) that are referenced in the front page of a company's patents. A company that uses leading-edge thinking to develop its patented creations is likely to have a comparatively high number of science linkages. The average science linkage for all U.S. patents is one. Pharmaceutical patents typically have five; biotechnology patents, 15 or more. The world's second-largest biotech company based upon market capitalization, Genentech, averages more than 25.[32] In this component measure, Greater Philadelphia turns in one of its two lowest rankings for innovation output, placing 10th with a conversely relatively high score of 88.4. The top five scoring regions were San Diego, Seattle, Greater San Francisco, Boston and Greater Raleigh Durham, which scored 95.9.

Like the component measure for life sciences technology strength, the measure for life sciences science strength is quality weighted. In this case, it takes the number of patents earned by a region and multiplies that by the science linkages indicator. It similarly identifies how regions balance out both their quantity and quality of life science patents, in this instance based on the degree of scientific thinking that goes into a new patent. Also similar to its performance in the component measure for technology strength, in the science strength measure Greater Philadelphia returned to a top five ranking. Scoring a 75.3 index points, the region ranked fourth behind Boston, Greater San Francisco and San Diego, but ahead of Seattle and Chicago. Greater Philadelphia's ranking in science strength indicates that although the science linkages of Greater Philadelphia life science patents are low compared to peer metros, the scientifically advanced qualities of the region's patent output is still relatively high.





Greater Philadelphia's Statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Philadelphia	96.7	3.9	1.0	1.9	9.3	11.3	70.8	84.5	99.9	89.7	77.6	98.6	88.4	75.3
11 Metro Avg.	86.5	2.4	0.9	1.7	10.4	12.2	76.3	87.8	88.4	94.6	74.5	98.3	94.3	72.2

On the innovation output composite index, the Greater Philadelphia region scored a high 96.7 index points and ranked third in its universe of peer metro regions. The first-place performer on the composite index is Boston (whose superlative performance earned it the benchmark 100 index points) closely followed by Greater San Francisco (whose composite score is 99.2). Rounding out the top five are Greater New York (scoring 94.9 index points) and Greater Los Angeles (91.6). Propelling Greater Philadelphia into its high score were the FDA approvals-based component measures for Phase I clinical trials and Phase III clinical trials. Among the patent-based measures, the region did particularly well in its percent of life science patents in the area and life science technology cycle time. Overall, the region performs very well. Even its lowest ranking measures, current impact index and science linkages, are compensated for through high performance in their closely related measures, technology strength and science strength.

Methodology

As in previous sections, data gathering and analysis in this section on innovation output was conducted for 11 peer metropolitan regions. Pertinent statistics were analyzed from various dimensions and angles; in certain cases, data was compiled to reflect the dynamism and momentum that builds over an extended time period. In all component measures, final scoring was not based merely on raw or absolute performance. Instead, these figures were screened further against calculations for relevant proportioning. Ultimate rankings take into account both elements for an even-handed assessment and ordering of regional performance.

The component measures in this section received weighting as follows in order to provide a true-to-life composite index:

Component Measure	Weighting
FDA New Drug Approval	20%
FDA New Medical Devices Premarket Approval	15%
Clinical Trial (Phase I)	5%
Clinical Trial (Phase II)	5%
Clinical Trial (Phase III)	5%
Life Sciences Patents Issued	15%
Life Sciences Patent Growth Percentage	5%
Percentage of Life Sciences Patents in Area	5%
Weighted Life Sciences Current Impact Index (CII)	5%
Life Sciences Technology Strength	5%
Life Sciences Technology Cycle Time	5%
Life Sciences Science Linkages	5%
Life Sciences Science Strength	5%

Weighting per the above parameters allows for equal emphasis on FDA-based and patent-based innovative output component measures. Most component measures received a weighting of 5 percent in structuring the final composite measure. To allow for composite balancing and to adequately proportion those FDA and patent measures that are more fundamentally significant than other narrowly defined indicators, the component measures of new drug approval, new medical devices premarket approval and life sciences patents issued received heavier weighting. These three components taken together contribute 50 percent of the composite's final scoring. To recognize the significance of biopharmaceuticals in the innovation pipeline, among the FDA measures, new drug approval was given a slightly higher weighting than new medical devices premarket approval.

Data used and compiled in this section came from the United States Food and Drug Administration, a division of the Department of Health and Human Services, and CHI Research, Inc. CHI Research data on patents and other patent-related measures are based upon the five-year period ending in 2003. This reduces any potential bias being introduced from the latest year being an outlier while keeping the comparison period as current as possible. All data interpretations and regional scoring and rankings involved independent models employed by the Milken Institute.

Data Sources

Life Sciences Research and Development	
Industrial R&D to Life Sciences	National Science Foundation
Academic R&D to Life Sciences	National Science Foundation
National Science Foundation Research Funding to Life Sciences	National Science Foundation
Number of Small Business Technology Transfer (STTR) Awards to Life Sciences	Small Business Administration
Small Business Technology Transfer (STTR) Awards to Dollars Life Sciences	Small Business Administration
Number of Small Business Innovation Research (SBIR) Awards to Life Sciences	Small Business Administration
Small Business Innovation Research (SBIR) Awards Dollars to Life Sciences	Small Business Administration
Competitive NSF Funding Rate in Life Sciences	National Science Foundation
National Institutes of Health (NIH) Funding to Independent Hospitals	National Institutes of Health
National Institutes of Health (NIH) Funding to Medical Schools	National Institutes of Health
National Institutes of Health (NIH) Funding to Research Institutes	National Institutes of Health
Life Sciences Risk Capital and Entrepreneurship	
Life Sciences Venture Capital Investment	PricewaterhouseCoopers
Life Sciences Venture Capital Investment Growth	PricewaterhouseCoopers
Life Sciences Companies Receiving VC Investment	PricewaterhouseCoopers
Life Sciences Companies Receiving VC Investment Growth	PricewaterhouseCoopers
Academic Degrees Awarded in Entrepreneurship	National Science Foundation
Business Starts in Life Sciences	Harris InfoSource
Tech Fast 500 Companies in Life Sciences	Deloitte

Life Sciences Human Capital Investment	
Bachelor's Degrees Awarded in Life Sciences	National Science Foundation
Graduate Students in Life Sciences	National Science Foundation
Master's Degrees Awarded in Life Sciences	National Science Foundation
Ph.D Degrees Awarded in Life Sciences	National Science Foundation
Medical Doctor (MD) Degrees Awarded	National Science Foundation
Postdocs in Life Sciences	National Science Foundation
Life Sciences Ph.D Granting Institutions	National Science Foundation
Recent Years' Bachelor's Degrees Awarded in Life Sciences	National Science Foundation
Recent Years' Master's Degrees Awarded in Life Sciences	National Science Foundation
Recent Years' Ph.D Degrees Awarded in Life Sciences	National Science Foundation
Recent Years' Medical Doctor (MD) Degrees Awarded	National Science Foundation
Life Sciences Workforce	
Intensity of Medical and Health Services Managers	Bureau of Labor Statistics
Intensity of Biomedical Engineers	Bureau of Labor Statistics
Intensity of Chemical Engineers	Bureau of Labor Statistics
Intensity of Material Engineers	Bureau of Labor Statistics
Intensity of Electro-Mechanical Technicians	Bureau of Labor Statistics
Intensity of Biochemists and Biophysicists	Bureau of Labor Statistics
Intensity of Microbiologists	Bureau of Labor Statistics
Intensity of Medical Scientists, Except Epidemiologists	Bureau of Labor Statistics
Intensity of Chemists	Bureau of Labor Statistics
Intensity of Material Scientists	Bureau of Labor Statistics
Intensity of Biological Technicians	Bureau of Labor Statistics
Intensity of Chemical Technicians	Bureau of Labor Statistics
Intensity of Sales Rep., Wholesale & Mfg., Technical & Scientific Product	Bureau of Labor Statistics
Life Sciences Innovation Output	
US Food and Drug Administration (FDA) New Drug Approval	US FDA
US FDA New Medical Devices Premarket Approval	US FDA
Clinical Trial (Phase I)	US FDA
Clinical Trial (Phase II)	US FDA
Clinical Trial (Phase III)	US FDA
Life Sciences Patents Issued	CHI Research, Inc.
Weighted Life Sciences Patent Percent Growth	CHI Research, Inc.
Weighted Percent of Life Sciences Patents in Area	CHI Research, Inc.
Weighted Life Sciences Current Impact Index (CII)	CHI Research, Inc.
Weighted Life Sciences Technological Strength	CHI Research, Inc.
Weighted Life Sciences Technological Cycle Time	CHI Research, Inc.
Weighted Life Sciences Science Linkage	CHI Research, Inc.
Weighted Life Sciences Science Strength	CHI Research, Inc.

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Overall Composite Index

Background and Relevance

This section provides an overall composite index of where Greater Philadelphia is positioned among the country's top life science centers by combining the innovation pipeline and the current impact assessment measures. The first four categories of innovation pipeline measured how well equipped for growth in life sciences the metros studied are in terms of R&D, risk capital and entrepreneurial infrastructure, human capital and workforce. These input-based measures cover a broad range of important topics such as research and innovation, the availability of financial resources, local talent pool and occupational strengths. The next measure of the region's innovation pipeline, innovation output, examines patents, patent quality measures, clinical trials and the success rate of new drug and medical device approvals.

The current impact assessment measures where Greater Philadelphia currently stands in relation to other leading life science clusters by examining industry employment, concentration, growth and diversity. In addition, the current impact assessment incorporates a measurement of the support infrastructure built around the life science cluster.

The current impact is the position the region holds as an outcome of historical performance on the innovation pipeline measures. In arriving at an overall composite for this study, one can argue that both the current impact assessment and innovation pipeline are of equivalent importance and as a result, should be assigned equal weights of 50 percent.

Metro Findings

The following table provides a ranking of the overall composite index.

Overall Composite Index for Life Sciences

MSA	Innovation Pipeline	Total Current Impact	Overall Composite Index	Rank
Boston	100.0	94.9	100.0	1
Greater San Francisco	93.7	98.0	98.4	2
Greater Philadelphia	89.3	100.0	97.1	3
Greater New York	84.6	99.7	94.6	4
Greater Raleigh Durham	85.5	91.9	91.1	5
San Diego	85.6	91.2	90.7	6
Greater Los Angeles	76.8	92.8	87.0	7
Minneapolis	77.0	74.8	77.9	8
Chicago	74.2	73.7	75.9	9
Seattle	72.2	66.0	70.9	10
Dallas	59.4	48.2	55.2	11
Weights	0.50	0.50		

Greater Philadelphia's third-place ranking on the overall composite index is attributable to its first-place finish on the total current impact index and its third-place ranking on the innovation pipeline index, contributing to its solid overall position.

Of seven core life science current-impact measures, Greater Philadelphia was strongest in the following four: absolute employment level (second, after Greater New York), employment concentration (second, after Greater Raleigh Durham), relative employment growth (second, after Greater Raleigh Durham), and tied for first with three other metros in the number of life science industries growing faster than the nation as a whole. Greater Philadelphia's support infrastructure is another essential ingredient of its life science sector. Greater Philadelphia is second on the current impact index for supporting life science, after Greater New York. Although not the largest in absolute terms for supporting life science industries, Greater Philadelphia scored well in areas of concentration and diversity, solidifying it overall position.

On the innovation pipeline, Greater Philadelphia never fell below fifth among the five composites of R&D (5th), risk capital (4th), human capital (3rd), workforce (5th) and innovation output (3rd). Although Greater Philadelphia doesn't record a first or second ranking on any of the five composites, its consistent third to fifth placements pull it ahead of several regions with more variable performance.

Of the 11 R&D components, Philadelphia scored particularly well on industry R&D (1st) and NIH funding to independent hospitals (2nd, after Boston). Of the seven risk capital and entrepreneurial infrastructure components, Philadelphia performed exceptionally well in the area of life science VC investment growth (1st) and academic degrees awarded in entrepreneurship (1st). Of human capital's 11 components, the region was third in life science bachelor degrees awarded, third in life science graduate students, third in life science master's degrees awarded, second in the number of life science Ph.D. granting institutions (after Boston) and third in recent years' bachelor's degrees awarded in life science.

Of the 13 workforce components, the region's performance is notable in the areas of intensity of medical and health services managers (2nd after Greater New York), intensity of chemists (3rd), and intensity of chemical technicians (2nd after Greater New York). Finally, for innovation output, Greater Philadelphia stands out in the following three components: FDA new drug approvals (2nd after Greater New York), clinical trial-Phase I (3rd), and percent of life science patents in the area (second after San Diego).

Boston and Greater San Francisco ranked first and second, respectively, on the overall life science composite index. Although the two top ranking metros finished in the same order on the innovation pipeline index, Greater San Francisco edged out Boston on the current impact assessment. Since the dispersion between their scores is slightly greater on the innovation pipeline, Boston slipped ahead to number one on the overall composite. Among the life science fields, Boston's strengths lie heavily in life science R&D, medical devices and biotechnology. The Greater San Francisco area, which includes San Jose and Oakland, is particularly noted for its significant presence in the manufacturing of medical devices. In addition, South San Francisco is considered to be the "birthplace of the biotech industry." Perhaps what distinguishes these two life science centers from the rest is their research-intensive surroundings. Both are endowed with arguably some of the world most renowned institutions and research parks. Boston is home to Harvard and MIT while Greater San Francisco claims Stanford, U.C. San Francisco and U.C. Berkeley, just to name a few in both locations. Close proximity to teaching hospitals, medical schools (especially Boston) and research centers, encourages more effective means of communication and interaction among doctors, scientists and faculty. This phenomenon, in turn, creates a positive impact on the development, retention and attraction of human capital and influences business decisions on where to situate.

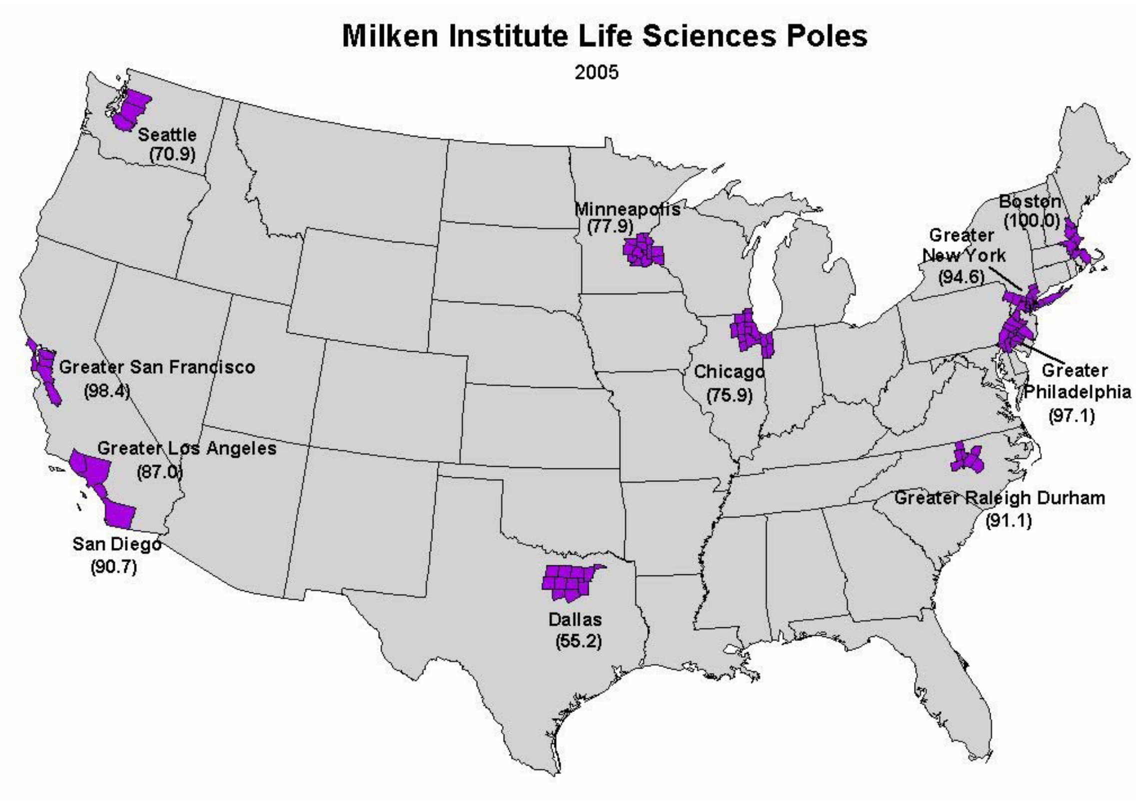
Greater New York ranked fourth on the overall composite index, coming in second on the total current impact assessment just behind Greater Philadelphia and is positioned sixth on the innovation pipeline. Perhaps that region's most significant asset is its support infrastructure built around its life science cluster. Greater New York ranked first in the supporting industries' section of the current impact assessment. Its rich concentration of teaching and research-intensive hospitals is an important asset. The area serves as headquarters for many top pharmaceutical companies such as Pfizer, Merck and Bristol-Myers Squibb.

Greater Raleigh Durham ranked fifth on the overall composite, sixth on the current impact assessment and fifth on the innovation pipeline. The region ranked first in three out of the four current impact measures with respect to the core life sciences: life science employment concentration, employment growth and the number of life science industries growing faster than the national average. Greater Raleigh Durham was first in life science employment concentration. This region has made exceptional progress in improving the breadth and depth of its life science cluster.

San Diego ranked sixth on the overall composite index, seventh on the total current impact assessment and fourth on the innovation pipeline. On the core life science portion of the current impact assessment San Diego ranked second, holding a solid position in biotech and related R&D. Further north, Greater Los Angeles, which is home to Amgen, one of the world's biggest biotech companies, placed fifth on the total current impact assessment and seventh on the innovation pipeline. Orange County, included in the broadly defined Los Angeles area, supported the region's overall position on the current impact due to its favorable performance in medical devices.

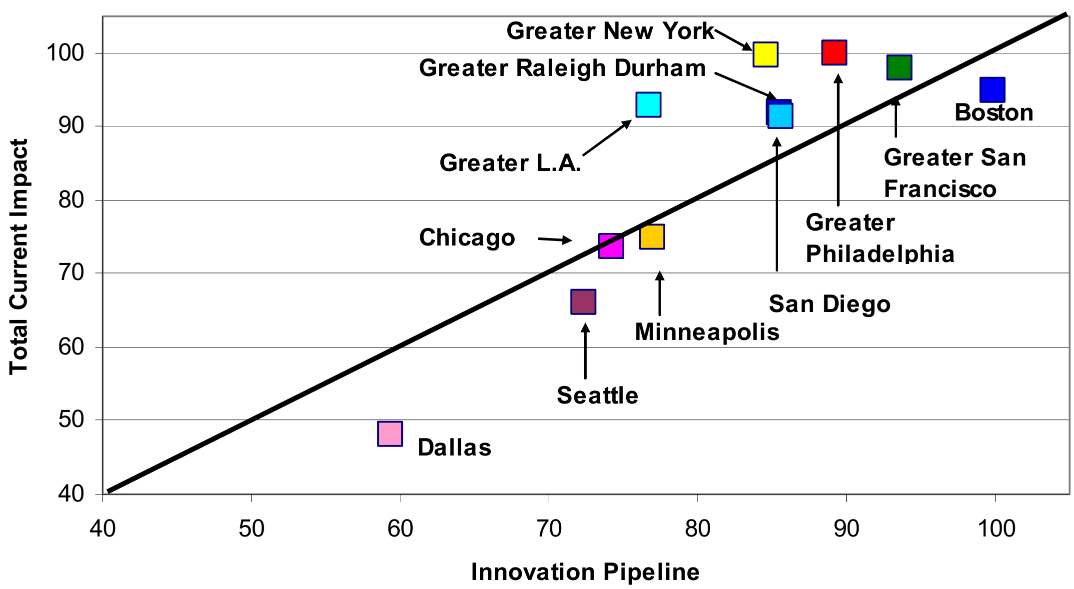
Minneapolis came in eighth on the overall composite. Its key strengths lie entirely in medical devices, portraying the highest concentration of employment in that area among all of the major life science centers.

Chicago, Seattle, and Dallas placed ninth, 10th and 11th, respectively on the overall composite index. They also finish in the same sequence on both the current impact assessment and the innovation pipeline. More importantly, however, all are recognized for their underlying strengths in the life sciences. Chicago, home to Abbott laboratories, scored favorably in pharmaceuticals, while Seattle's life science position was bolstered through its R&D. Last, but not least, Dallas is becoming one of the nation's leading biotech hubs.



The following illustration provides a multi-faceted perspective of the overall composite index. The total current impact composite is represented by the vertical axis, while the innovation pipeline composite is signified by the horizontal axis. The placement of each square explains the correlation between the two composite measures. For example, a region's favorable placement on the innovation pipeline composite may explain its future position on the total current impact assessment. Alternatively, a poor performance on the innovation pipeline may lead to a deteriorating placement on the current impact looking ahead. An encouraging position is to be on the linear black line cutting through the chart. This suggests that given the region's current life science status, its innovation pipeline is heading in the appropriate direction. On the other hand, significant deviation from the black line may have potential implications.

Overall Composite Index for Life Sciences



Greater Philadelphia's placement suggests a relatively healthy position (total current impact composite = 100; innovation pipeline composite = 89.3). However, in order to maintain its vibrant position on the total current impact over time, it must be able to capitalize on its innovation assets.

For comparison purposes, Boston's position on the innovation pipeline suggests that, looking forward, the region is in better position to capitalize on its innovation assets. Greater Los Angeles' position implies that going into the future, the region must do a better job of developing and capitalizing on its innovation measures in order to maintain its competitiveness. Not doing so may potentially jeopardize its future position on the current impact.

Methodology

The overall composite index is based on the following model.

Life Science Overall Composite Index = f (0.5*Innovation Pipeline, 0.5*Total Current Impact Assessment)

For a detailed methodology on each component and its subcomponents, please see the methodology section pertaining to that component.

Conclusions

The Greater Philadelphia life sciences cluster ranks among the elite centers in the country. While rankings from any quantitative evaluation system are sensitive to the criteria chosen and the weights assigned to them, the depth and breadth of our life sciences benchmarking system displays Greater Philadelphia's considerable strengths. Greater Philadelphia placed third on our overall evaluation system, just behind top-scoring Boston and second-place San Francisco.

Perhaps Greater Philadelphia's consistency is best articulated by the fact that it didn't score below fifth or above third on any of the five innovation pipeline composite measures. It was this consistent placement that allowed Greater Philadelphia to surpass regions with higher scores in some areas, but a greater variance among all the indicators. The region's first-place score on the current impact assessment was once again attributable to its consistency; earning this lofty position by placing third on the core life sciences composite index and second on the life sciences supporting industries.

The top four regions scored very close to one another with only 5.4 index points out of 100 separating them on the overall life sciences composite index. Boston earned its overall first-place due to its rich research-intensive surroundings. Boston's score on the innovation pipeline was a strong 6.3 points above the second-ranked region. Greater San Francisco, home to the birth of the biotechnology industry, has a vibrant research infrastructure as well, evident by being outscored only by Boston on the innovation pipeline. Greater New York, fourth overall, was boosted by its top ranking for the life sciences supporting industries. Greater New York's teaching and research-intensive hospitals are important assets.

Of the smaller regions, Greater Raleigh Durham scored highest at fifth overall. Greater Raleigh Durham was first in life science employment concentration and has made exceptional progress in improving the depth and breadth of its life sciences cluster. San Diego was sixth overall and owes its position to strength in biotechnology and related research and development.

Greater Philadelphia's life science industry plays a pivotal role in the region's larger economy. Based upon 2003 data, the extent of its participation is remarkable:

- Altogether, the core life science industry in Greater Philadelphia is responsible for 276,000 jobs or 11.4 percent of all employment in the region. Of those, 53,500 are accounted for directly, while 131,500 and 91,000 are generated through the indirect and induced effects, respectively. For every job within the life sciences in Greater Philadelphia, an additional 4.2 jobs are created in all other sectors. The pharmaceutical industry is responsible for 203,700 of those jobs.

- Similarly, it is responsible for $13.7 billion, or 12.8 percent of total earnings in the region. $4.6 billion is registered directly, while $5.4 billion and $3.7 billion are generated through the indirect and induced impacts, respectively. For each dollar of earnings produced in the life sciences sector, an additional $2.0 worth of earnings are generated beyond it.

- Lastly, the industry is responsible for $15.5 billion, or 7.1 percent of gross metro product in the region. $6.9 billion is registered directly, while $4.8 billion and $3.8 billion are generated through the indirect and induced impacts, respectively. For each dollar of output produced in the life sciences sector, an additional $1.20 worth of output is generated beyond it.

The Greater Philadelphia region is well-positioned for future growth in the life sciences. The region has many comparative advantages, but it could ensure its elevated position by improving areas where it doesn't hold a competitive advantage. There are many competing regions that are nipping at its heels for future supremacy. For the region to enhance its overall ranking within its comparative universe of leading metros, workforce indicators provide a rich source of information on possible areas for improvement. Considering the region's outstanding human capital base, it has the advantage of an already high-quality pool of human resource assets to use in this regard. Another area of focus should be in life science startup firms and the associated risk capital, from pre-seed, to seed to venture finance support that these fledging firms require, along with a strong network of institutions and other support infrastructure.

Greater Philadelphia clearly does a better job at graduating degree holders in important specialties but lags behind in employing people in the related professional fields. This is an imbalance that unmistakably points to a loss of economic opportunity for those individuals and the region as a whole. In the case of bioengineering and biomedical engineering, for example, the region has valuable pools of human assets that could be better utilized to feed into its local biotech and medical device sectors.

To effectively address human capital/workforce issues and opportunities such as these an increased understanding of their root causes is needed. Possible avenues of investigation include:

- *Find ways to close human capital/workforce gaps.* At the most basic level, it would be helpful to know how graduates from Greater Philadelphia institutions choose their degree disciplines and subsequent career paths. Imbalances are occurring between the point of human capital production (i.e., when local students graduate) and workforce acquisition (the types and number of individuals employed in local life science fields).

- *Evaluate why other regions perform better in workforce intensity in fields where Greater Philadelphia is less successful*. What are the tangible and intangible benefits that propel highly trained workers to gravitate to and stay in these other areas?

- *Obtain an in-depth understanding of how local institutions prepare students for careers in the life sciences.* How are Greater Philadelphia institutions matriculating students in disciplines that feed into strategically important professions?

- *Analyze how local university-industry connections function.* What is the interaction between universities and other educational institutions with local life science employers? How heavily are companies involved in curriculum, work-study or internship programs, and collaborative research projects?

- *Determine what access Greater Philadelphia's human capital has to regional risk capital and entrepreneurship infrastructure.* Are the weaker components of workforce intensity owing in any way to limitations in the mechanisms that facilitate new enterprise formation?

The foregoing list is not exhaustive, yet it does illustrate aspects to consider in ascertaining the ultimate source or sources of imbalance that characterize the human capital/workforce dimensions of Greater Philadelphia's future growth. Greater Philadelphia organizations are aware of these issues. The Life Science Career Alliance, a consortium of educational institutions and employers in the Philadelphia region, is addressing many of these occupation issues at the four-year or less study level. Governor Rendell announced a new state grant in May 2005 managed by the Life Science Career Alliance that will provide for job training in the biotechnology and life sciences industries in the Philadelphia area. CareerPhilly, formed by several supporting organizations, has the goal of retaining more students who graduate from the region each year. Many other organizations throughout the region are studying and designing programs to capitalize on these opportunities.

Greater Philadelphia's rich legacy of established pharmaceutical firms has been an important economic and development asset for the entire region. Yet, it has probably been a key reason in why the region has not performed as well in the burgeoning field of biotechnology, at least until recently. Oftentimes, new ideas need new geography. The historical success of pharmaceutical firms in the region did not encourage employees to embark upon the risky path of large molecule research and new firm formation. The prevailing culture was not supportive of the biotech revolution that took place in California and Boston. One of the reasons for the net out-migration of talent developed at Greater Philadelphia's outstanding educational institutions was the low level of new-firm growth and employment opportunities in research, development and manufacturing in biotechnology. This has begun to change, but still has adverse impacts on the region.

The stakeholders in the region are aware of many issues related to new-firm birth and growth. A thorough investigation and programs that address deficiencies in promoting startup formation and improving access to capital throughout the development cycle, should be pursued. Boston and Greater San Francisco hold the top two positions in part due to greater venture capital availability and the superb commercialization networks that have developed. Analysis of the following issues would prove beneficial:

- *Alter the cultural barriers to university/institutional commercialization and spin-offs at existing firms.* Although these cultural barriers are in remission, they haven't been cured. What processes brought about change in other leading regions? How was academic entrepreneurship promoted at other top research centers? Which universities have implemented the most successful technology transfer programs and how might they be adapted for Greater Philadelphia? What support mechanisms can be implemented for technical, professional and managerial talent wishing to start ventures and mitigate the potential stigma associated with new-firm failure?

- *Assist firms in applying for federal discretionary development and commercialization awards.* Despite Greater Philadelphia's outstanding research prowess, the region does not receive a commensurate amount of STTR and SBIR award funding. Providing technical assistance in applying for these competitive funds could help the region garner more awards. This is a low cost method of improving the commercialization efforts of the region. What types of programs are other regions offering their researchers and prospective entrepreneurs? How could they be adapted to fit the unique institutional circumstances of Greater Philadelphia?

- *Develop innovative programs to aid access to pre-seed and seed funding.* Are other regions investing more state and local funding through matching grants in cooperation with private funding? How can government provide incentives and guarantees to encourage riskier investments in noncommercially proven products?

- *Foster interaction between newly formed biotechnology firms and pharmaceutical firms.* This will provide opportunities for joint research projects, while multi-national pharmaceutical firms' investment resources and knowledge in development and commercialization could improve commercialization success throughout the region. Turn what has been a historic disadvantage into an advantage for future development. What are other regions doing to foster interaction? What can state or regional trade groups do to assist?

- *Increase state and local funding in privately managed venture capital pools.* Without local venture capital funding many firms that might have obtained financing in other regions such as Greater San Francisco or Boston will be shut out. While good ideas can obtain funding from any geography, local venture capital is more likely see the commercial potential. What can be done to improve the amount of indigenous venture capital funding? Can guarantees nurture growth at small venture capital funds?

- *Encourage pharmaceutical firms to increase their affiliated venture capital funds to invest in the region.* With the diminished therapeutic pipelines at several pharmaceutical firms, they may be able to diversify their investment portfolios by investing in local firms. Pooling investments with more traditional VCs and government sources may provide the critical mass of investments necessary to compete with other leading regions. What are other regions with a high concentration of large pharmaceutical firms doing to encourage their local venture investments?

- *Build regional collaborations among the various public, private and philanthropic organizations.* Intermediary organizations perform many critical functions such as providing neutral ground for different cultures of academia, industry and government to interact. These networking groups have emerged organically in a few other leading regions, but should be built from the ground up in order to maximize the opportunities for interaction. What regions have been most successful in this area?

The region's life science leadership has been aggressively addressing most of these areas. Former University of Pennsylvania President Judith Rodin initiated a transformation in the university's technology-transfer program in 1995 that has already led to greater startup success in the region. Several organizations, such as The Innovation Partnership, offer grant writing assistance in SBIRs and STTRs. Organizations such as BioAdvance offer early proof-of-concept funding to fill the gap that angel and venture capital investors largely avoid. Delaware launched a new seed fund. New Jersey has its Springboard pre-seed investment program managed by the New Jersey Economic Development Agency (NJEDA).

The Health Care Institute of New Jersey, an association formed by large pharmaceutical firms in the state, facilitates interaction among biotechnology, medical device and other life science sector firms. The State of Pennsylvania has made several large investments in venture capital firms, with Quaker BioVentures of Philadelphia being a recipient. The Ben Franklin Development Authority has provided $32 million in funding to state venture funds since 2000. The NJEDA has used a variety of funding sources to secure limited partner interest in at least three venture capital funds. Princeton, NJ has two life science related funds: Healthcare Ventures and Domain Associates. GlaxoSmithKline has been a leader among large drug companies investing in emerging companies through its 20-year old affiliation with S.R. One. Johnson & Johnson has a biotech funding group jointly headquartered in New Jersey and suburban Philadelphia.

Networking, trade and catalyst organizations are heavily involved throughout the region. Pennsylvania BIO provides a high level of networking and various other forms of support. Pennsylvania BIO played a key role in bringing BIO's 2005 annual conference to the region. Innovation Philadelphia, a private-public economic development group, is heavily involved in facilitating networking opportunities. The Greater Philadelphia Chamber of Commerce is a leader in bringing together life science stakeholders to forge collaborations that promote the interests of the entire region. Many other such organizations exist throughout the Greater Philadelphia region.

Greater Philadelphia has regional assets that other regions can only aspire to. These observations on workforce and entrepreneurial/risk capital support are offered in the context of the region being a premier life sciences center. Maintaining or improving upon its existing strengths and viewing other areas as opportunities will only improve its position in the future.

Current Impact – Core Life Sciences

Core Life Sciences Employment Size
2003

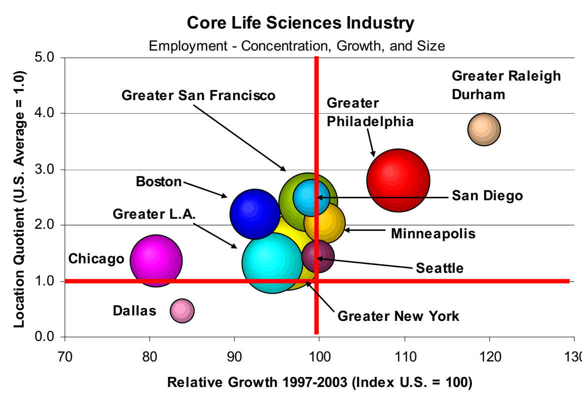
Rank	MSA	Number
1	Greater New York	74,592
2	Greater Philadelphia	53,479
3	Greater Los Angeles	51,533
4	Greater San Francisco	46,593
5	Chicago	39,075
6	Boston	34,864
7	Minneapolis	23,352
8	San Diego	20,258
9	Greater Raleigh Durham	15,922
10	Seattle	14,567
11	Dallas	8,224

Core Life Sciences Location Quotient
2003

Rank	MSA	LQ (US=1)
1	Greater Raleigh Durham	3.72
2	Greater Philadelphia	2.81
3	San Diego	2.50
4	Greater San Francisco	2.41
5	Boston	2.20
6	Minneapolis	2.04
7	Greater New York	1.50
8	Seattle	1.43
9	Chicago	1.35
10	Greater Los Angeles	1.32
11	Dallas	0.46

Core Life Sciences Relative Employment Growth
1997-2003

Rank	MSA	Index (US=100)
1	Greater Raleigh Durham	119.3
2	Greater Philadelphia	109.3
3	Minneapolis	100.6
4	Seattle	99.8
5	San Diego	99.0
6	Greater San Francisco	98.6
7	Greater New York	96.1
8	Greater Los Angeles	94.4
9	Boston	92.4
10	Dallas	83.8
11	Chicago	80.7



Current Impact Measures (CIM) - Scores for Core Life Sciences
Ranked by Composite Index

CORE LIFE SCIENCES		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater San Francisco	62	65	83	82	82	80	100	100
2	San Diego	27	67	83	100	100	100	83	96
3	Greater Philadelphia	72	75	92	46	55	57	100	94
4	Greater Raleigh Durham	21	100	100	77	82	40	100	93
5	Greater Los Angeles	69	36	79	43	100	100	92	90
6	Boston	47	59	77	72	82	67	92	88
7	Greater New York	100	40	81	31	36	57	67	84
8	Minneapolis	31	55	84	47	64	44	92	72
9	Chicago	52	36	68	29	45	50	58	64
10	Seattle	20	38	84	50	55	36	100	63
11	Dallas	11	12	70	24	45	29	67	40

Current Impact – Core Life Sciences

Core Life Sciences - Employment by NAICS Code
Greater Philadelphia, 2003

Industry	NAICS	Burlington, NJ	Camden, NJ	Gloucester, NJ	Bucks, PA	Chester, PA	Delaware, PA	Montgomery, PA	Philadelphia, PA	New Castle, DE	Cecil, MD	Salem, NJ	Mercer, NJ	Total
Pharmaceuticals														
Pharmaceutical Preparation Mfg.	325412	0	0	0	511	5,249	0	13,503	5,875	4,143	0	0	747	30,028
Pharmaceuticals Industry Aggregate		0	0	0	511	5,249	0	13,503	5,875	4,143	0	0	747	30,028
Biotechnology														
Medicinal and Botanical Mfg.	325411	0	0	0	0	0	0	315	157	967	0	0	0	1,438
In-vitro Diagnostic Substance Mfg.	325413	0	0	0	151	0	0	0	0	331	0	0	0	482
Other Biological Product Mfg.	325414	0	0	0	151	0	0	0	0	331	0	0	26	508
Biotechnology Industry Aggregate		0	0	0	301	0	0	315	157	1,629	0	0	26	2,428
Medical Devices														
Laboratory Apparatus and Furniture Mfg.	339111	0	0	195	165	0	0	47	227	31	0	0	105	771
Surgical and Medical Instrument Mfg.	339112	58	218	67	426	1,216	43	361	13	5	0	0	105	2,512
Surgical Appliance and Supplies Mfg.	339113	17	62	419	33	60	126	53	249	31	0	0	17	1,068
Dental Equipment and Supplies Mfg.	339114	3	62	0	194	0	7	65	112	5	0	0	0	447
Ophthalmic Goods Mfg.	339115	3	329	67	33	10	43	8	56	5	0	0	0	554
Dental Laboratories	339116	3	204	11	53	16	56	191	155	92	0	0	101	881
Electromedical Apparatus Mfg.	334510	0	0	0	114	52	19	90	0	0	0	0	10	286
Irradiation Apparatus Mfg.	334517	0	0	0	0	0	0	132	30	0	0	0	0	162
Medical Devices Industry Aggregate		83	874	759	1,018	1,354	295	947	842	170	0	0	338	6,681
R&D in Life Sciences														
R&D in Life Sciences	5417102	0	0	0	0	925	1,658	6,625	0	0	0	0	5,135	14,342
R&D in Life Sciences Industry Aggregate		0	0	0	0	925	1,658	6,625	0	0	0	0	5,135	14,342
Core Life Sciences Total		83	874	759	1,830	7,528	1,953	21,390	6,874	5,942	0	0	6,246	53,479

Core Life Sciences - Location Quotient by NAICS Code
Greater Philadelphia, 2003

Industry	NAICS	Burlington, NJ	Camden, NJ	Gloucester, NJ	Bucks, PA	Chester, PA	Delaware, PA	Montgomery, PA	Philadelphia, PA	New Castle, DE	Cecil, MD	Salem, NJ	Mercer, NJ	Total
Pharmaceuticals														
Pharmaceutical Preparation Mfg.	325412	0.00	0.00	0.00	1.35	16.00	0.00	18.35	6.59	10.09	0.00	0.00	2.93	7.39
Pharmaceuticals Industry Aggregate		0.00	0.00	0.00	1.35	16.00	0.00	18.35	6.59	10.09	0.00	0.00	2.93	7.39
Biotechnology														
Medicinal and Botanical Mfg.	325411	0.00	0.00	0.00	0.00	0.00	0.00	2.75	1.13	15.13	0.00	0.00	0.00	2.28
In-vitro Diagnostic Substance Mfg.	325413	0.00	0.00	0.00	1.36	0.00	0.00	0.00	0.00	2.76	0.00	0.00	0.00	0.41
Other Biological Product Mfg.	325414	0.00	0.00	0.00	2.02	0.00	0.00	0.00	0.00	4.08	0.00	0.00	0.51	0.63
Biotechnology Industry Aggregate		0.00	0.00	0.00	1.23	0.00	0.00	0.66	0.27	6.15	0.00	0.00	0.16	0.93
Medical Devices														
Laboratory Apparatus and Furniture Mfg.	339111	0.00	0.00	14.16	4.20	0.00	0.00	0.62	2.45	0.74	0.00	0.00	3.95	1.83
Surgical and Medical Instrument Mfg.	339112	0.35	1.29	0.85	1.89	6.21	0.24	0.82	0.02	0.02	0.00	0.00	0.69	1.04
Surgical Appliance and Supplies Mfg.	339113	0.12	0.43	6.24	0.17	0.36	0.81	0.14	0.55	0.15	0.00	0.00	0.14	0.52
Dental Equipment and Supplies Mfg.	339114	0.10	2.20	0.00	5.14	0.00	0.24	0.88	1.26	0.13	0.00	0.00	0.00	1.11
Ophthalmic Goods Mfg.	339115	0.07	8.24	3.58	0.62	0.22	1.00	0.08	0.44	0.09	0.00	0.00	0.00	0.97
Dental Laboratories	339116	0.04	2.77	0.32	0.54	0.19	0.70	1.00	0.67	0.86	0.00	0.00	1.53	0.84
Electromedical Apparatus Mfg.	334510	0.00	0.00	0.00	1.04	0.55	0.22	0.42	0.00	0.00	0.00	0.00	0.14	0.24
Irradiation Apparatus Mfg.	334517	0.00	0.00	0.00	0.00	0.00	0.00	2.61	0.48	0.00	0.00	0.00	0.00	0.58
Medical Devices Industry Aggregate		0.15	1.50	2.77	1.30	2.00	0.47	0.62	0.46	0.20	0.00	0.00	0.64	0.80
R&D in Life Sciences														
R&D in Life Sciences	5417102	0.00	0.00	0.00	0.00	2.88	5.52	9.19	0.00	0.00	0.00	0.00	20.55	3.61
R&D in Life Sciences Industry Aggregate		0.00	0.00	0.00	0.00	2.88	5.52	9.19	0.00	0.00	0.00	0.00	20.55	3.61
Core Life Sciences Total		0.06	0.66	1.22	1.03	4.89	1.36	6.20	1.64	3.08	0.00	0.00	5.22	2.81

Current Impact – Pharmaceuticals

Pharmaceuticals Employment Size
2003

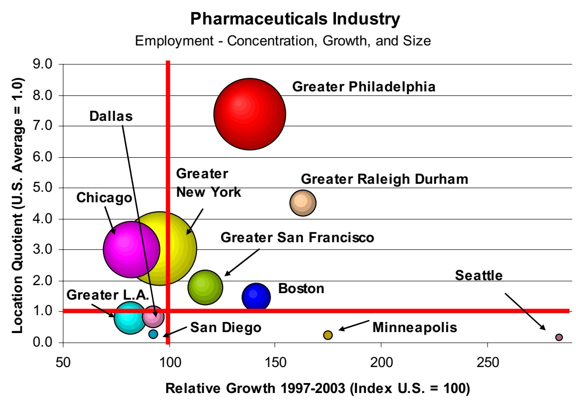
Rank	MSA	Number
1	Greater New York	32,256
2	Greater Philadelphia	30,028
3	Chicago	18,492
4	Greater San Francisco	7,395
5	Greater Los Angeles	6,709
6	Boston	5,005
7	Greater Raleigh Durham	4,107
8	Dallas	3,125
9	Minneapolis	594
10	San Diego	457
11	Seattle	385

Pharmaceuticals Location Quotient
2003

Rank	MSA	LQ (US=1)
1	Greater Philadelphia	7.39
2	Greater Raleigh Durham	4.51
3	Greater New York	3.04
4	Chicago	3.01
5	Greater San Francisco	1.80
6	Boston	1.48
7	Dallas	0.82
8	Greater Los Angeles	0.81
9	San Diego	0.26
10	Minneapolis	0.24
11	Seattle	0.18

Pharmaceuticals Relative Employment Growth
1997-2003

Rank	MSA	Index (US=100)
1	Seattle	283.7
2	Minneapolis	174.8
3	Greater Raleigh Durham	162.9
4	Boston	141.2
5	Greater Philadelphia	137.8
6	Greater San Francisco	117.3
7	Greater New York	95.4
8	San Diego	92.4
9	Dallas	92.3
10	Chicago	82.0
11	Greater Los Angeles	81.7



Current Impact Measures (CIM) - Scores for Pharmaceuticals
Ranked by Composite Index

PHARMACEUTICALS		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater Philadelphia	93	100	49	84	50	50	100	100
2	Greater New York	100	41	34	81	50	50	50	81
3	Greater Raleigh Durham	13	61	57	100	50	50	100	69
4	Greater San Francisco	23	24	41	47	100	100	100	62
5	Chicago	57	41	29	24	50	50	50	55
6	Greater Los Angeles	21	11	29	54	100	100	50	54
7	San Diego	1	4	33	87	100	100	50	53
8	Boston	16	20	50	59	50	50	100	50
9	Seattle	1	2	100	29	50	50	100	45
10	Minneapolis	2	3	62	30	50	50	100	38
11	Dallas	10	11	33	32	50	50	50	34

Current Impact – Medical Devices

Medical Devices Employment Size
2003

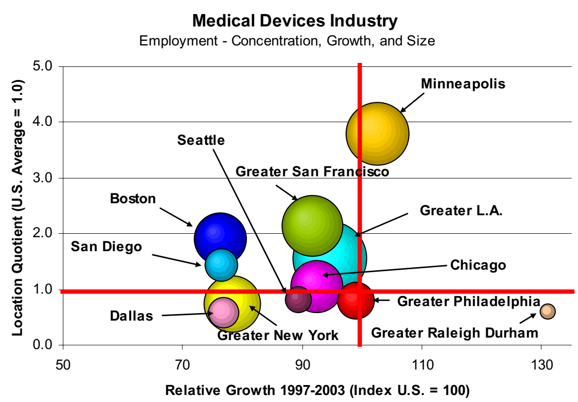
Rank	MSA	Number
1	Greater Los Angeles	26,818
2	Minneapolis	19,133
3	Greater San Francisco	18,165
4	Greater New York	15,851
5	Chicago	13,452
6	Boston	13,271
7	Greater Philadelphia	6,681
8	San Diego	5,180
9	Dallas	4,559
10	Seattle	3,620
11	Greater Raleigh Durham	1,137

Medical Devices Location Quotient
2003

Rank	MSA	LQ (US=1)
1	Minneapolis	3.80
2	Greater San Francisco	2.13
3	Boston	1.90
4	Greater Los Angeles	1.56
5	San Diego	1.45
6	Chicago	1.06
7	Seattle	0.81
8	Greater Philadelphia	0.80
9	Greater New York	0.72
10	Greater Raleigh Durham	0.60
11	Dallas	0.58

Medical Devices Relative Employment Growth
1997-2003

Rank	MSA	Index (US=100)
1	Greater Raleigh Durham	131.0
2	Minneapolis	102.6
3	Greater Philadelphia	99.0
4	Greater Los Angeles	94.6
5	Chicago	92.3
6	Greater San Francisco	91.7
7	Seattle	89.4
8	Greater New York	78.2
9	Dallas	76.8
10	San Diego	76.4
11	Boston	76.4



Current Impact Measures (CIM) - Scores for Medical Devices
Ranked by Composite Index

MEDICAL DEVICES		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Minneapolis	71	100	78	100	80	50	86	100
2	Greater Los Angeles	100	41	72	79	100	100	100	99
3	Greater San Francisco	68	56	70	94	80	50	71	85
4	Boston	49	50	58	74	100	50	71	74
5	Chicago	50	28	70	63	40	100	43	66
6	San Diego	19	38	58	89	60	100	57	65
7	Greater New York	59	19	60	52	20	50	43	54
8	Greater Philadelphia	25	21	76	66	20	50	100	53
9	Seattle	13	21	68	84	40	20	86	50
10	Greater Raleigh Durham	4	16	100	57	40	17	86	46
11	Dallas	17	15	59	51	40	17	43	38

Current Impact – Biotechnology

Biotechnology Employment Size
2003

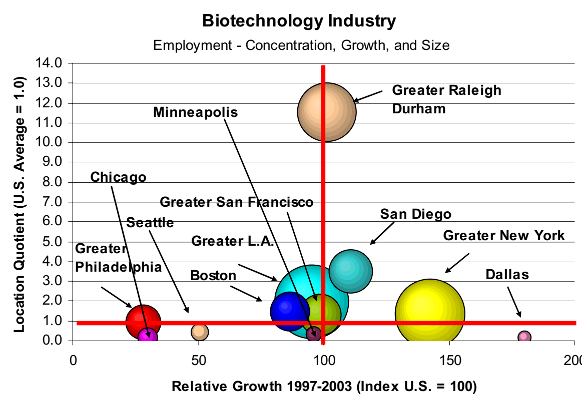
Rank	MSA	Number
1	Greater Los Angeles	10,680
2	Greater New York	9,337
3	Greater Raleigh Durham	6,788
4	San Diego	3,906
5	Greater San Francisco	3,559
6	Boston	3,043
7	Greater Philadelphia	2,428
8	Chicago	746
9	Seattle	646
10	Minneapolis	507
11	Dallas	364

Biotechnology Location Quotient
2003

Rank	MSA	LQ (US=1)
1	Greater Raleigh Durham	11.54
2	San Diego	3.50
3	Greater Los Angeles	1.99
4	Boston	1.40
5	Greater New York	1.36
6	Greater San Francisco	1.34
7	Greater Philadelphia	0.93
8	Seattle	0.46
9	Minneapolis	0.32
10	Chicago	0.19
11	Dallas	0.15

Biotechnology Relative Employment Growth
1997-2003

Rank	MSA	Index (US=100)
1	Dallas	179.6
2	Greater New York	142.3
3	San Diego	111.5
4	Greater Raleigh Durham	101.2
5	Greater San Francisco	98.6
6	Minneapolis	95.6
7	Greater Los Angeles	95.3
8	Boston	86.7
9	Seattle	50.8
10	Chicago	30.1
11	Greater Philadelphia	27.9



Current Impact Measures (CIM) - Scores for Biotechnology
Ranked by Composite Index

BIOTECHNOLOGY		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	Greater Raleigh Durham	64	100	56	50	100	100	67	100
2	San Diego	37	30	62	100	100	100	100	86
3	Greater Los Angeles	100	17	53	25	75	100	33	79
4	Greater New York	87	12	79	18	25	50	100	68
5	Greater San Francisco	33	12	55	37	25	100	100	56
6	Boston	28	12	48	45	25	100	67	52
7	Dallas	3	1	100	14	25	25	100	37
8	Greater Philadelphia	23	8	16	22	50	50	33	33
9	Minneapolis	5	3	53	37	25	25	67	31
10	Seattle	6	4	28	18	25	33	67	24
11	Chicago	7	2	17	9	25	25	67	19

Current Impact – R&D in the Life Sciences

Life Science R&D Employment Size
2003

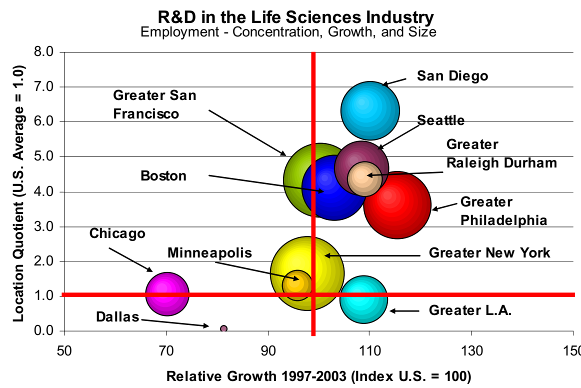
Rank	MSA	Number
1	Greater San Francisco	17,474
2	Greater New York	17,148
3	Greater Philadelphia	14,342
4	Boston	13,544
5	San Diego	10,715
6	Seattle	9,916
7	Greater Los Angeles	7,326
8	Chicago	6,385
9	Greater Raleigh Durham	3,890
10	Minneapolis	3,118
11	Dallas	175

Life Science R&D Location Quotient
2003

Rank	MSA	LQ (US=1)
1	San Diego	6.32
2	Seattle	4.67
3	Greater Raleigh Durham	4.36
4	Greater San Francisco	4.33
5	Boston	4.10
6	Greater Philadelphia	3.61
7	Greater New York	1.65
8	Minneapolis	1.31
9	Chicago	1.06
10	Greater Los Angeles	0.90
11	Dallas	0.05

Life Science R&D Relative Employment Growth
1997-2003

Rank	MSA	Index (US=100)
1	Greater Philadelphia	115.6
2	San Diego	110.2
3	Greater Raleigh Durham	109.1
4	Greater Los Angeles	108.8
5	Seattle	108.5
6	Boston	103.1
7	Greater San Francisco	100.3
8	Greater New York	97.9
9	Minneapolis	95.9
10	Dallas	81.3
11	Chicago	70.3



Current Impact Measures (CIM) - Scores for Life Science R&D
Ranked by Composite Index

LIFE SCIENCE R&D		Size and Performance				Diversity			Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	Rel. Growth (US=100) 97-03	Establishments per 10,000 est. 2003	# of Ind. LQ>2 2003	# of Ind. LQ<0.5 2003	# of Ind. growing>US 2003	Composite Index 2003
1	San Diego	61	100	95	100	100	100	100	100
2	Greater San Francisco	100	69	87	79	100	100	100	99
3	Boston	78	65	89	71	100	100	100	91
4	Greater Philadelphia	82	57	100	35	100	100	100	86
5	Seattle	57	74	94	37	100	100	100	82
6	Greater Raleigh Durham	22	69	94	83	100	100	100	79
7	Greater New York	98	26	85	19	50	100	50	70
8	Greater Los Angeles	42	14	94	27	50	100	100	57
9	Minneapolis	18	21	83	24	50	100	50	47
10	Chicago	37	17	61	16	50	100	50	46
11	Dallas	1	1	70	13	50	50	50	28

Current Impact – Life Sciences Supporting Industries

Life Sciences Supp. Industries Employment Size
2003

Rank	MSA	Number
1	Greater New York	912,740
2	Greater Los Angeles	472,554
3	Chicago	395,916
4	Greater Philadelphia	310,188
5	Boston	262,990
6	Greater San Francisco	249,902
7	Dallas	203,317
8	Minneapolis	153,309
9	Seattle	127,723
10	San Diego	91,167
11	Greater Raleigh Durham	57,426

Life Sciences Supp. Industries Location Quotient
2003

Rank	MSA	LQ (US=1)
1	Greater New York	1.25
2	Boston	1.13
3	Greater Philadelphia	1.11
4	Chicago	0.94
5	Greater Raleigh Durham	0.92
6	Minneapolis	0.91
7	Greater San Francisco	0.88
8	Seattle	0.86
9	Greater Los Angeles	0.83
10	Dallas	0.78
11	San Diego	0.77

Current Impact Measures (CIM) - Scores for Life Sciences Supporting Industries
Ranked by Composite Index

LIFE SCIENCES SUPPORTING INDUSTRIES		Size and Performance		Diversity		Current Impact
Rank	MSA	Employment Level 2003	LQ (US=1) 2003	# of Ind. LQ>1 2003	# of Ind. LQ<0.75 2003	Composite Index 2003
1	Greater New York	100	100	100	80	100
2	Greater Philadelphia	34	89	84	80	78
3	Boston	29	91	63	100	76
4	Chicago	43	75	53	100	70
5	Greater Los Angeles	52	66	68	57	64
6	Greater San Francisco	27	71	58	44	57
7	Greater Raleigh Durham	6	73	58	57	56
8	Minneapolis	17	73	53	31	53
9	Seattle	14	69	42	40	50
10	Dallas	22	62	42	40	48
11	San Diego	10	61	42	40	45

Current Impact – Life Sciences Supporting Industries

Supporting Industries - Employment
Greater Philadelphia, 2003

Industry	NAICS	Burlington, NJ	Camden, NJ	Gloucester, NJ	Bucks, PA	Chester, PA	Delaware, PA	Montgomery, PA	Philadelphia, PA	New Castle, DE	Cecil, MD	Salem, NJ	Mercer, NJ	Total
Optical Instrument & Lens Mfg	333314	60	19	0	93	10	19	99	3	0	0	14	19	336
Medical Equip. & Merchant Wholesalers	423450	481	273	511	290	488	538	566	151	99	0	0	25	3,422
Druggists' Goods Merchant Wholesalers	42421	945	30	30	299	562	171	2,694	1,091	40	20	697	1,218	7,797
Ophthalmic Goods Merchant Wholesalers	42346	45	25	8	31	14	0	0	0	0	0	0	0	123
Optical Goods Stores	44613	99	128	75	211	39	192	337	273	164	0	0	101	1,619
Direct Health & Medical Insurance Carriers	524114	99	30	0	19	120	175	1,289	5,919	1,408	0	0	41	9,100
Medical Laboratories	621511	78	67	95	137	142	117	1,866	260	154	0	10	235	3,161
Offices of Physicians (exc Mental Health)	621111	3,105	3,809	1,777	4,489	3,890	4,237	8,022	10,159	3,961	250	250	3,154	47,103
Offices of Dentists	62121	1,283	1,396	616	2,073	1,394	1,754	3,121	2,591	1,665	132	102	1,229	17,356
Offices of Optometrists	62132	133	164	99	249	138	162	318	458	209	32	15	181	2,158
Offices of all other misc Health Practitioners	621399	26	101	17	68	125	240	952	86	92	10	60	124	1,901
Kidney Dialysis Centers	621492	60	60	60	99	20	100	428	500	60	10	0	87	1,484
Nursing Care Facilities	62311	2,553	2,570	1,079	2,706	2,544	3,514	9,158	7,780	2,261	473	380	1,773	36,791
Pharmacies & Drug Stores	44611	1,596	2,195	912	2,162	1,596	2,399	3,293	5,718	1,916	175	154	1,214	23,330
Diagnostic Imaging Centers	621512	184	152	175	157	30	271	178	243	326	0	10	99	1,825
Offices of Chiropractors	62131	189	231	108	388	183	219	520	318	203	10	8	139	2,516
Offices of Podiatrists	621391	98	130	79	127	99	179	239	227	99	10	10	82	1,379
HMO Medical Centers	621491	10	10	0	25	31	10	24	60	10	0	0	0	180
Freestanding Emergency Medial Centers	621493	10	199	53	39	20	60	20	108	50	19	60	34	672
Home Health Care Services	62161	1,141	1,752	200	675	602	1,776	3,374	3,372	1,538	30	241	1,599	16,300
Blood & Organ Banks	621991	0	0	10	0	10	2	375	141	120	0	0	70	728
General Medical & Surgical Hospitals	62211	4,519	8,634	1,429	6,894	4,903	9,796	13,402	48,334	10,689	500	1,006	8,410	118,516
Other Specialty Hospitals	62231	1,500	10	0	100	750	175	375	3,942	100	0	10	250	7,212
Testing Laboratories	541380	154	146	55	291	125	145	446	61	266	10	10	94	1,803
All other basic Inorganic Chemical Mfg	325188	60	70	375	249	258	60	48	20	250	60	4	0	1,454
All other basic Organic Chemical Mfg	325199	60	6	126	250	100	60	20	19	1,261	0	0	20	1,922
Total Supporting Industries		18,488	22,207	7,889	22,121	18,193	26,371	51,164	91,834	26,941	1,741	3,041	20,198	310,188

Supporting Industries - Location Quotient
Greater Philadelphia, 2003

Industry	NAICS	Burlington, NJ	Camden, NJ	Gloucester, NJ	Bucks, PA	Chester, PA	Delaware, PA	Montgomery, PA	Philadelphia, PA	New Castle, DE	Cecil, MD	Salem, NJ	Mercer, NJ	Total
Optical Instrument & Lens Mfg	333314	1.87	0.57	0.00	2.10	0.26	0.53	1.15	0.03	0.00	0.00	3.90	0.64	0.71
Medical Equip. & Merchant Wholesalers	423450	2.62	1.45	5.77	1.15	2.23	2.63	1.15	0.25	0.36	0.00	0.00	0.15	1.26
Druggists' Goods Merchant Wholesalers	42421	5.75	0.18	0.38	1.32	2.87	0.93	6.13	2.05	0.16	1.00	37.93	7.99	3.21
Ophthalmic Goods Merchant Wholesalers	42346	3.83	2.07	1.41	1.92	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
Optical Goods Stores	44613	0.88	1.11	1.38	1.36	0.29	1.53	1.12	0.75	0.98	0.00	0.00	0.97	0.97
Direct Health & Medical Insurance Carriers	524114	0.20	0.06	0.00	0.03	0.20	0.32	0.97	3.68	1.90	0.00	0.00		1.24
Medical Laboratories	621511	0.44	0.37	1.11	0.56	0.67	0.59	3.93	0.45	0.58	0.00	0.50	1.43	1.21
Offices of Physicians (exc Mental Health)	621111	1.08	1.28	1.28	1.13	1.13	1.32	1.04	1.09	0.92	0.71	0.78	1.18	1.11
Offices of Dentists	62121	1.10	1.17	1.10	1.30	1.00	1.35	1.00	0.69	0.96	0.93	0.78	1.14	1.01
Offices of Optometrists	62132	0.90	1.08	1.39	1.23	0.79	0.99	0.81	0.96	0.95	1.78	0.91	1.32	0.99
Offices of all other misc Health Practitioners	621399	0.31	1.18	0.42	0.59	1.26	2.58	4.27	0.32	0.74	0.99	6.45	1.60	1.55
Kidney Dialysis Centers	621492	0.61	0.59	1.26	0.73	0.17	0.91	1.62	1.56	0.41	0.83	0.00	0.95	1.02
Nursing Care Facilities	62311	1.03	1.00	0.90	0.79	0.86	1.27	1.38	0.96	0.61	1.56	1.37	0.77	1.00
Pharmacies & Drug Stores	44611	1.41	1.88	1.67	1.39	1.18	1.90	1.09	1.56	1.13	1.27	1.22	1.15	1.39
Diagnostic Imaging Centers	621512	1.77	1.42	3.49	1.10	0.24	2.34	0.64	0.72	2.10	0.00	0.86	1.03	1.19
Offices of Chiropractors	62131	1.11	1.32	1.31	1.65	0.90	1.15	1.14	0.57	0.80	0.48	0.42	0.88	1.00
Offices of Podiatrists	621391	1.90	2.45	3.17	1.79	1.61	3.11	1.73	1.35	1.28	1.59	1.73	1.71	1.81
HMO Medical Centers	621491	0.13	0.13	0.00	0.24	0.35	0.12	0.12	0.25	0.09	0.00	0.00		0.16
Freestanding Ambulatory Surgery, Emergency ctr	621493	0.11	2.21	1.25	0.32	0.19	0.61	0.09	0.38	0.38	1.78	6.12	0.42	0.52
Home Health Care Services	62161	0.92	1.37	0.33	0.39	0.40	1.28	1.01	0.83	0.83	0.20	1.73	1.38	0.89
Blood & Organ Banks	621991	0.00	0.00	0.26	0.00	0.10	0.02	1.73	0.54	0.99	0.00	0.00	0.93	0.61
General Medical & Surgical Hospitals	62211	0.62	1.15	0.41	0.69	0.56	1.20	0.69	2.04	0.98	0.56	1.23	1.24	1.10
Other Specialty Hospitals	62231	5.62	0.04	0.00	0.27	2.35	0.59	0.52	4.55	0.25	0.00	0.33	1.01	1.83
Testing Laboratories	541380	0.99	0.91	0.73	1.35	0.67	0.83	1.07	0.12	1.14	0.52	0.57	0.65	0.78
All other basic Inorganic Chemical Mfg	325188	0.78	0.88	10.06	2.34	2.80	0.70	0.23	0.08	2.17	6.37	0.46	0.00	1.27
All other basic Organic Chemical Mfg	325199	0.53	0.05	2.30	1.60	0.74	0.47	0.07	0.05	7.42	0.00	0.00	0.19	1.14
Total Supporting Industries		0.98	1.14	0.86	0.85	0.81	1.25	1.01	1.50	0.95	0.76	1.44	1.15	1.11

Innovation Pipeline – Life Sciences R&D

Industry R&D to Life Sciences

Rank	Metro	US$ Millions, 2002	US$ Per Capita, 2002	Score
1	Greater Philadelphia	2,642.9	433.1	100.0
2	Greater New York	4,614.6	282.7	99.8
3	Boston	1,827.3	411.5	97.3
4	Minneapolis	1,147.8	375.5	93.7
5	Greater San Francisco	1,584.2	268.6	92.8
6	Greater Los Angeles	1,752.1	130.0	87.2
7	San Diego	688.8	237.1	86.6
8	Chicago	1,160.4	125.2	84.4
9	Greater Raleigh Durham	326.2	250.6	82.5
10	Seattle	440.0	140.9	79.5
11	Dallas	224.6	41.0	64.8

Academic R&D to Life Sciences

Rank	Metro	US$ Millions, 2002	US$ Per Capita, 2002	Score
1	Greater Raleigh Durham	727.8	559.1	100.0
2	Greater San Francisco	1,044.8	177.2	93.2
3	Boston	731.1	164.7	90.0
4	Greater New York	1,282.0	78.5	88.0
5	Greater Los Angeles	1,048.4	77.8	86.4
6	Greater Philadelphia	632.9	103.7	85.1
7	Seattle	427.4	136.9	84.5
8	Chicago	694.9	75.0	83.1
9	San Diego	343.2	118.2	81.7
10	Minneapolis	306.3	100.2	79.6
11	Dallas	293.8	53.7	74.1

NSF Research Funding to Life Sciences

Rank	Metro	US$ Millions, 2004	Per $100,000 GMP, 2004	Score
1	Greater Raleigh Durham	18	30.2	100.0
2	Minneapolis	17	11.8	85.3
3	Boston	19	6.7	78.3
4	Greater San Francisco	19	6.2	77.8
5	San Diego	10	8.6	71.8
6	Chicago	14	3.9	66.0
7	Greater New York	16	3.0	64.3
8	Seattle	8	5.9	61.7
9	Greater Philadelphia	9	4.3	59.9
10	Greater Los Angeles	11	2.2	53.0
11	Dallas	2	1.0	11.9

Number of STTR Awards to Life Sciences Firms

Rank	Metro	2002	Per 100,000 Businesses, 2002	Score
1	Boston	14	11.1	100.0
2	Greater Raleigh Durham	4	11.3	87.5
3	Greater San Francisco	8	4.9	85.6
4	Greater Los Angeles	9	2.7	80.6
5	San Diego	3	4.2	74.1
6	Chicago	5	2.2	72.3
7	Minneapolis	3	3.4	71.9
8	Greater Philadelphia	4	2.6	71.8
9	Greater New York	3	0.7	54.3
10	Seattle	1	1.1	48.8
11	Dallas	1	0.8	44.9

STTR Awards Dollars to Life Sciences Firms

Rank	Metro	US$ Thousands, 2002	Per $ Mil. GMP, 2002	Score
1	Greater Raleigh Durham	2,073.5	35.2	100.0
2	Boston	4,478.2	16.0	96.8
3	Greater New York	2,363.8	4.3	82.0
4	San Diego	684.3	5.8	78.7
5	Chicago	1,408.3	3.8	78.4
6	Greater Philadelphia	857.1	4.0	76.4
7	Greater Los Angeles	1,460.9	2.9	76.3
8	Greater San Francisco	922.2	3.0	74.2
9	Minneapolis	319.6	2.2	66.5
10	Seattle	93.7	0.7	50.5
11	Dallas	70.0	0.4	43.0

Number of SBIR Awards to Life Sciences Firms

Rank	Metro	2002	Per 100,000 Businesses, 2002	Score
1	Boston	145	115.4	100.0
2	San Diego	78	109.4	93.2
3	Greater San Francisco	93	56.7	88.0
4	Greater Raleigh Durham	28	79.2	79.5
5	Seattle	41	45.2	77.4
6	Greater Philadelphia	39	25.2	70.8
7	Greater New York	56	12.2	66.8
8	Minneapolis	22	25.0	65.0
9	Greater Los Angeles	40	12.1	63.3
10	Chicago	26	11.3	58.3
11	Dallas	3	2.3	19.8

Innovation Pipeline – Life Sciences R&D

SBIR Awards Dollars to Life Sciences Firms

Rank	Metro	US$ Millions, 2002	Per $ 100,000 GMP, 2002	Score
1	Boston	51.9	18.6	100.0
2	San Diego	25.8	21.9	95.9
3	Greater Raleigh Durham	12.5	21.2	89.7
4	Greater San Francisco	25.7	8.2	86.6
5	Seattle	15.3	11.6	85.6
6	Greater New York	26.1	4.7	81.5
7	Greater Philadelphia	12.1	5.6	76.8
8	Minneapolis	7.2	5.0	71.6
9	Greater Los Angeles	10.8	2.2	66.9
10	Chicago	8.7	2.3	66.0
11	Dallas	0.4	0.2	17.3

Competitive NSF Funding Rate in Life Sciences

Rank	Metro	Number of Awarded Funding, 2004	Funding Rate (%), 2004	Score
1	Greater San Francisco	42	33.3	100.0
2	Greater New York	36	33.3	97.9
3	Greater Raleigh Durham	40	27.4	96.6
4	Chicago	33	20.4	89.8
5	Seattle	17	28.3	85.6
6	San Diego	17	23.9	83.2
7	Minneapolis	17	21.3	81.5
8	Greater Philadelphia	17	19.8	80.5
9	Boston	19	16.1	79.0
10	Greater Los Angeles	15	19.0	78.2
11	Dallas	0	0.0	0.0

NIH Funding to Independent Hospitals

Rank	Metro	US$ Millions, 2003	US$ Per Capita, 2003	Score
1	Boston	925.1	208.3	100.0
2	Greater Philadelphia	77.3	12.6	68.1
3	Greater New York	96.8	5.9	64.3
4	Greater Los Angeles	44.1	3.3	56.2
5	Greater San Francisco	19.5	3.3	51.8
6	Chicago	17.2	1.9	47.3
7	Seattle	7.6	2.4	44.6
8	Dallas	0.6	0.1	0.0
9	Minneapolis	0.0	0.0	0.0
10	Greater Raleigh Durham	0.0	0.0	0.0
11	San Diego	0.0	0.0	0.0

NIH Funding to Medical Schools

Rank	Metro	US$ Millions, 2003	US$ Per Capita, 2003	Score
1	Greater Raleigh Durham	504.5	387.6	100.0
2	Greater San Francisco	654.4	111.0	91.0
3	Greater New York	904.7	55.4	87.4
4	Boston	430.9	97.1	86.7
5	Greater Philadelphia	467.9	76.3	85.2
6	Seattle	290.1	92.9	83.2
7	San Diego	219.6	75.6	79.3
8	Chicago	372.2	40.2	77.8
9	Greater Los Angeles	409.9	30.4	76.1
10	Dallas	248.0	45.3	75.7
11	Minneapolis	129.7	42.4	70.2

NIH Funding to Research Institutes

Rank	Metro	US$ Millions, 2003	US$ Per Capita, 2003	Score
1	San Diego	330.7	113.8	100.0
2	Seattle	258.7	82.9	94.5
3	Boston	251.1	56.6	90.2
4	Greater Raleigh Durham	74.8	57.5	80.0
5	Greater New York	252.3	15.5	76.6
6	Greater San Francisco	135.7	23.0	75.4
7	Greater Los Angeles	153.4	11.4	69.1
8	Greater Philadelphia	87.3	14.2	66.6
9	Dallas	41.0	7.5	53.3
10	Chicago	31.5	3.4	42.7
11	Minneapolis	9.6	3.2	31.7

Life Sciences R&D Composite Index

Rank	Metro	Composite Score
1	Boston	100.0
2	Greater San Francisco	91.0
3	Greater Raleigh Durham	89.0
4	Greater New York	88.0
5	Greater Philadelphia	86.3
6	San Diego	84.0
7	Greater Los Angeles	80.0
8	Seattle	78.8
9	Chicago	77.3
10	Minneapolis	75.1
11	Dallas	44.7

Innovation Pipeline – Life Sciences Risk Capital & Entrepreneurial Infrastructure

Life Sciences VC Investment

Rank	Metro	Average Annual 2002-2004, US$ Mil.	Per $100,000 GMP, 2004	Score
1	Greater San Francisco	1,390.2	445.5	100.0
2	San Diego	529.9	448.7	93.4
3	Boston	790.6	282.9	92.4
4	Greater Raleigh Durham	159.8	271.4	81.0
5	Seattle	193.9	147.6	77.3
6	Greater New York	342.7	62.1	74.2
7	Minneapolis	165.8	114.6	74.2
8	Greater Philadelphia	176.2	81.2	71.8
9	Greater Los Angeles	203.3	40.8	67.1
10	Chicago	37.9	10.2	44.1
11	Dallas	21.1	10.8	40.5

Life Sciences VC Investment Growth

Rank	Metro	Absolute Growth, 2002-2004, US$ Mill.	Relative Growth, 2002-2004	Score
1	Greater Philadelphia	220.9	305.0	100.0
2	Greater San Francisco	383.4	133.5	92.2
3	Boston	272.1	142.2	90.1
4	San Diego	222.3	144.3	88.6
5	Greater New York	66.3	127.3	76.0
6	Seattle	30.3	115.7	67.6
7	Dallas	1.0	104.7	36.3
8	Chicago	-1.3	96.0	32.2
9	Minneapolis	-38.6	82.9	0.3
10	Greater Los Angeles	-188.6	34.5	0.0
11	Greater Raleigh Durham	-176.7	28.2	0.0

Companies Receiving Life Sciences VC Investment

Rank	Metro	Average Annual, 2002-2004	Per 100,000 Businesses, 2004	Score
1	Greater San Francisco	128.1	78.1	100.0
2	San Diego	49.2	69.0	88.7
3	Boston	62.1	49.4	87.3
4	Greater Raleigh Durham	19.4	55.0	76.6
5	Seattle	21.9	24.1	68.3
6	Minneapolis	18.1	20.6	64.6
7	Greater Philadelphia	23.2	15.0	63.5
8	Greater Los Angeles	25.2	7.6	56.5
9	Greater New York	25.1	5.5	52.7
10	Chicago	9.3	4.1	39.1
11	Dallas	5.4	4.2	33.9

Growth in Co.'s Receiving Life Sciences VC Invest.

Rank	Metro	Absolute Growth, 2002-2004	Relative Growth, 2002-2004	Score
1	Greater San Francisco	27.0	124.1	100.0
2	Boston	22.3	144.1	99.7
3	Greater Philadelphia	15.0	175.0	96.9
4	San Diego	11.7	125.7	86.7
5	Seattle	7.0	135.0	79.8
6	Minneapolis	2.3	112.5	58.7
7	Greater New York	-0.7	97.5	48.9
8	Chicago	-1.3	85.7	35.3
9	Greater Raleigh Durham	-4.3	79.7	14.9
10	Dallas	-5.0	37.5	0.0
11	Greater Los Angeles	-9.7	63.8	0.0

Academic Degrees Awarded in Entrepreneurship

Rank	Metro	Number, 1991-2001	Per 100,000 People of 25-34 Age Cohort, 2001	Score
1	Greater Philadelphia	921	114.3	100.0
2	Dallas	407	45.5	84.3
3	Chicago	459	33.0	81.8
4	Boston	96	14.4	61.6
5	Minneapolis	44	9.6	51.6
6	Seattle	26	5.4	41.6
7	San Diego	13	2.9	30.1
8	Greater New York	13	0.5	18.8
9	Greater San Francisco	9	0.9	16.1
10	Greater Los Angeles	5	0.2	11.8
11	Greater Raleigh Durham	0	0.0	0.0

Tech Fast 500 Companies in Life Sciences

Rank	Metro	Number, 2004	Per 100,000 Businesses, 2004	Score
1	Greater San Francisco	17	10.4	100.0
2	San Diego	10	14.0	96.1
3	Greater Philadelphia	9	5.8	76.5
4	Boston	8	6.4	76.1
5	Greater Raleigh Durham	4	11.3	74.7
6	Minneapolis	5	5.7	65.1
7	Seattle	5	5.5	64.4
8	Greater Los Angeles	7	2.1	51.4
9	Greater New York	4	0.9	26.0
10	Dallas	2	1.5	21.6
11	Chicago	1	0.4	4.8

Innovation Pipeline – Life Sciences Risk Capital & Entrepreneurial Infrastructure

Business Starts in Life Sciences

Rank	Metro	Score
1	Boston	100.0
2	Minneapolis	92.7
3	Greater San Francisco	89.9
4	Greater Raleigh Durham	89.5
5	Greater Los Angeles	77.1
6	Greater New York	72.2
7	Chicago	59.2
8	San Diego	58.4
9	Greater Philadelphia	55.6
10	Seattle	34.2
11	Dallas	28.9

Life Sciences Risk Capital Composite Index

Rank	Metro	Composite Score
1	Greater San Francisco	100.0
2	Boston	95.9
3	San Diego	90.8
4	Greater Philadelphia	81.5
5	Seattle	72.6
6	Minneapolis	68.7
7	Greater Raleigh Durham	64.5
8	Greater New York	62.5
9	Greater Los Angeles	50.1
10	Chicago	45.8
11	Dallas	39.1

Innovation Pipeline – Life Sciences Human Capital

Life Sciences Bachelor's Degrees Awarded

Rank	Metro	Number, 2001	Per 10,000 People of 25-34 Age Cohort, 2001	Score
1	Greater Raleigh Durham	1,281	58.2	100.0
2	Boston	2,325	34.8	97.2
3	Greater Philadelphia	2,147	26.6	93.2
4	San Diego	1,204	27.0	89.6
5	Greater Los Angeles	3,135	14.6	87.9
6	Greater San Francisco	1,729	17.6	86.4
7	Greater New York	3,115	12.7	86.0
8	Chicago	1,973	14.2	84.4
9	Minneapolis	922	20.1	84.0
10	Seattle	798	16.5	80.5
11	Dallas	845	9.4	73.6

Life Sciences Graduate Students

Rank	Metro	Number, 2002	Per 10,000 People of 25-34 Age Cohort, 2002	Score
1	Boston	8,160	125.2	100.0
2	Greater Raleigh Durham	3,315	146.9	96.5
3	Greater Philadelphia	6,125	77.3	93.5
4	Greater San Francisco	4,648	49.1	87.3
5	Greater New York	7,934	32.8	86.2
6	Greater Los Angeles	6,748	31.6	84.9
7	Minneapolis	2,206	48.5	83.0
8	Chicago	4,267	30.7	82.0
9	Dallas	2,621	29.0	78.7
10	San Diego	1,640	36.4	78.4
11	Seattle	1,641	34.2	77.7

Life Sciences Master's Degrees Awarded

Rank	Metro	Number, 2001	Per 10,000 People of 25-34 Age Cohort, 2001	Score
1	Boston	583	8.7	100.0
2	Greater Raleigh Durham	210	9.5	94.2
3	Greater Philadelphia	406	5.0	84.3
4	Greater New York	930	3.8	84.1
5	San Diego	157	3.5	68.6
6	Greater San Francisco	275	2.8	67.5
7	Chicago	335	2.4	65.5
8	Greater Los Angeles	365	1.7	58.1
9	Seattle	106	2.2	54.4
10	Dallas	162	1.8	53.2
11	Minneapolis	69	1.5	42.4

Life Sciences PhDs Awarded

Rank	Metro	Number, 2001	Per 10,000 People of 25-34 Age Cohort, 2001	Score
1	Greater Raleigh Durham	243	11.0	106.2
2	Boston	445	6.7	100.0
3	Greater San Francisco	360	3.7	84.2
4	Greater Philadelphia	285	3.5	81.2
5	Minneapolis	152	3.3	74.0
6	Chicago	336	2.4	73.8
7	Seattle	123	2.5	65.8
8	San Diego	111	2.5	64.4
9	Greater New York	371	1.5	63.8
10	Greater Los Angeles	294	1.4	59.4
11	Dallas	94	1.1	42.8

Medical Doctor (MD) Degrees Awarded

Rank	Metro	Number, 2001	Per 10,000 People of 25-34 Age Cohort, 2001	Score
1	Chicago	973	7.0	100.0
2	Greater Raleigh Durham	239	10.9	99.5
3	Greater New York	1,422	5.8	98.5
4	Boston	485	7.3	95.5
5	Greater Philadelphia	552	6.9	95.1
6	Minneapolis	217	4.7	79.0
7	Seattle	176	3.6	71.1
8	Dallas	266	3.0	69.5
9	San Diego	137	3.1	65.2
10	Greater San Francisco	247	2.5	65.0
11	Greater Los Angeles	413	1.9	62.7

Life Sciences Postdocs

Rank	Metro	Number, 2002	Per 10,000 People of 25-34 Age Cohort, 2002	Score
1	Boston	5,080	78.0	100.0
2	Greater Raleigh Durham	1,182	52.4	86.9
3	Greater San Francisco	2,069	21.9	80.2
4	Greater Philadelphia	1,458	18.4	76.1
5	Seattle	837	17.4	72.2
6	Greater Los Angeles	2,142	10.0	71.4
7	Greater New York	2,169	9.0	70.2
8	San Diego	700	15.5	69.9
9	Minneapolis	568	12.5	66.1
10	Chicago	761	5.5	58.4
11	Dallas	400	4.4	52.2

Innovation Pipeline – Life Sciences Human Capital

Number of Life Sciences Ph.D. Granting Institutions (w/ Life Sciences Ph.D. in 2001)

Rank	Metro	Number, 2001	Per 100,000 People of 25-34 Age Cohort, 2001	Score
1	Boston	12	1.8	100.0
2	Greater Philadelphia	12	1.5	92.4
3	Greater Raleigh Durham	5	2.3	92.0
4	Greater New York	19	0.8	85.2
5	Dallas	9	1.0	74.1
6	Chicago	10	0.7	69.4
7	Greater San Francisco	5	0.5	48.7
8	Greater Los Angeles	6	0.3	47.1
9	San Diego	2	0.4	26.6
10	Minneapolis	2	0.4	26.3
11	Seattle	2	0.4	25.7

Recent Years' Bachelor's Degrees Awarded in Life Sciences

Rank	Metro	Number, 1991-2001	Per 10,000 Civilian Workers, 2001	Score
1	Greater Raleigh Durham	13,471	189.7	100.0
2	Boston	22,884	93.7	95.7
3	Greater Philadelphia	23,741	77.1	93.9
4	Greater Los Angeles	28,769	43.0	89.1
5	San Diego	10,010	70.6	88.7
6	Greater New York	29,982	38.3	88.2
7	Greater San Francisco	16,105	49.6	87.6
8	Chicago	19,283	40.3	86.5
9	Minneapolis	8,320	45.9	83.5
10	Seattle	6,736	40.6	81.2
11	Dallas	6,541	22.3	75.1

Recent Years' Master's Degrees Awarded in Life Sciences

Rank	Metro	Number, 1991-2001	Per 10,000 Civilian Workers, 2001	Score
1	Boston	5,150	21.1	100.0
2	Greater Raleigh Durham	1,804	25.4	96.9
3	Greater New York	8,363	10.7	91.7
4	Greater Philadelphia	3,262	10.6	86.1
5	Greater San Francisco	2,778	8.6	81.6
6	Chicago	3,427	7.2	80.0
7	San Diego	1,257	8.9	77.6
8	Greater Los Angeles	3,103	4.6	72.2
9	Dallas	1,579	5.4	70.7
10	Seattle	839	5.1	66.0
11	Minneapolis	867	4.8	65.3

Recent Years' Ph.D. Degrees Awarded in Life Sciences

Rank	Metro	Number, 1991-2001	Per 10,000 Civilian Workers, 2001	Score
1	Greater Raleigh Durham	2,185	30.8	100.0
2	Boston	4,424	18.1	96.3
3	Greater San Francisco	3,464	10.7	86.7
4	Greater Philadelphia	2,774	9.0	82.8
5	Chicago	3,000	6.3	77.8
6	Greater New York	4,197	5.4	77.5
7	Minneapolis	1,458	8.0	77.0
8	San Diego	1,028	7.3	73.3
9	Greater Los Angeles	2,734	4.1	70.6
10	Seattle	982	5.9	69.9
11	Dallas	828	2.8	57.6

Recent Years' Medical Doctor (MD) Degrees Awarded

Rank	Metro	Number, 1991-2001	Per 10,000 Civilian Workers, 2001	Score
1	Greater Raleigh Durham	2,534	35.7	100.0
2	Greater New York	13,836	17.7	99.0
3	Chicago	9,553	20.0	98.7
4	Boston	4,757	19.5	94.3
5	Greater Philadelphia	5,303	17.2	93.1
6	Minneapolis	2,262	12.5	83.2
7	Seattle	1,517	9.1	76.1
8	Greater San Francisco	2,348	7.2	75.0
9	Greater Los Angeles	3,802	5.7	74.1
10	Dallas	2,077	7.1	74.0
11	San Diego	1,175	8.3	73.2

Life Sciences Human Capital Composite Index

Rank	Metro	Composite Score
1	Boston	100.0
2	Greater Raleigh Durham	99.4
3	Greater Philadelphia	90.0
4	Greater New York	86.2
5	Chicago	81.2
6	Greater San Francisco	78.8
7	Greater Los Angeles	72.1
8	San Diego	71.9
9	Minneapolis	70.8
10	Seattle	68.6
11	Dallas	66.9

Innovation Pipeline – Life Sciences Workforce

Intensity of Medical and Health Services Managers

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater New York	18,260	235.5	100.0
2	Greater Philadelphia	6,670	234.8	94.8
3	Dallas	5,840	222.2	93.6
4	Boston	4,730	249.1	93.6
5	Chicago	5,940	140.4	89.5
6	Minneapolis	2,950	176.5	88.0
7	Greater Los Angeles	6,040	105.7	87.0
8	Greater San Francisco	3,130	110.9	84.1
9	Greater Raleigh Durham	1,220	182.6	83.8
10	San Diego	1,650	131.9	82.4
11	Seattle	1,300	85.3	77.2

Intensity of Biomedical Engineers

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater San Francisco	660	23.4	100.0
2	Boston	420	22.1	95.6
3	San Diego	270	21.6	91.8
4	Minneapolis	230	13.8	83.5
5	Greater Los Angeles	450	7.9	79.8
6	Chicago	320	7.6	76.5
7	Greater Philadelphia	150	5.3	65.0
8	Greater Raleigh Durham	40	6.0	56.8
9	Greater New York	120	1.5	43.8
10	Seattle	40	2.6	43.6
11	Dallas	40	1.5	35.1

Intensity of Chemical Engineers

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater Los Angeles	1,550	27.1	100.0
2	Greater New York	1,580	20.4	95.9
3	Boston	580	30.5	94.9
4	Greater Philadelphia	600	21.1	89.7
5	Greater Raleigh Durham	210	31.4	88.3
6	Dallas	460	17.5	85.1
7	Minneapolis	330	19.7	84.5
8	Chicago	610	14.4	84.1
9	Greater San Francisco	350	12.4	78.1
10	San Diego	190	15.2	76.8
11	Seattle	100	6.6	59.9

Intensity of Material Engineers

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater San Francisco	890	31.5	100.0
2	Boston	510	26.9	93.6
3	Chicago	860	20.3	93.4
4	San Diego	270	21.6	85.7
5	Minneapolis	280	16.8	82.3
6	Seattle	240	15.8	80.3
7	Greater Philadelphia	340	12.0	78.9
8	Greater Los Angeles	520	9.1	78.0
9	Dallas	260	9.9	74.1
10	Greater New York	310	4.0	62.3
11	Greater Raleigh Durham	60	9.0	61.9

Intensity of Electro-Mechanical Technicians

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Boston	1,470	77.4	100.0
2	Greater Los Angeles	1,840	32.2	91.3
3	Greater San Francisco	980	34.7	87.9
4	Greater Raleigh Durham	250	37.8	79.7
5	Greater Philadelphia	620	21.8	79.4
6	San Diego	350	28.0	78.4
7	Minneapolis	350	20.9	75.1
8	Chicago	520	12.3	71.5
9	Dallas	270	10.3	65.0
10	Greater New York	410	5.3	60.1
11	Seattle	130	8.5	57.9

Intensity of Biochemists and Biophysicists

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater Raleigh Durham	520	78.6	100.0
2	Greater San Francisco	1,150	40.8	97.7
3	San Diego	600	48.0	94.9
4	Boston	650	34.2	91.4
5	Greater New York	1,510	19.5	90.6
6	Greater Philadelphia	480	16.9	80.4
7	Minneapolis	200	12.0	69.7
8	Dallas	240	9.1	67.7
9	Chicago	270	6.3	64.0
10	Greater Los Angeles	270	4.7	60.4
11	Seattle	60	3.7	46.2

Innovation Pipeline – Life Sciences Workforce

Intensity of Microbiologists

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Boston	450	23.7	100.0
2	Greater New York	1,160	15.0	99.7
3	San Diego	330	26.4	99.4
4	Greater San Francisco	530	18.8	97.4
5	Chicago	500	11.8	89.2
6	Seattle	220	14.4	86.2
7	Greater Philadelphia	320	11.3	85.0
8	Greater Raleigh Durham	100	15.0	80.7
9	Minneapolis	170	10.2	78.4
10	Greater Los Angeles	390	6.8	78.1
11	Dallas	40	1.5	35.5

Intensity of Medical Scientists, Except Epidemiologists

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Boston	4,130	217.5	100.0
2	Greater Raleigh Durham	1,590	238.0	95.2
3	Seattle	2,540	166.8	94.6
4	Greater San Francisco	3,580	126.9	94.1
5	Greater New York	6,250	80.6	93.1
6	San Diego	1,710	136.7	90.4
7	Greater Philadelphia	2,700	95.1	89.7
8	Greater Los Angeles	3,480	60.9	87.0
9	Minneapolis	1,120	67.0	81.2
10	Chicago	710	16.8	65.4
11	Dallas	110	4.2	41.3

Intensity of Chemists

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater Raleigh Durham	2,330	348.8	100.0
2	Greater New York	8,810	113.6	97.6
3	Greater Philadelphia	3,800	133.8	94.1
4	San Diego	2,130	170.3	92.9
5	Boston	2,550	134.3	91.7
6	Greater San Francisco	2,530	89.7	88.0
7	Chicago	2,890	68.3	86.3
8	Greater Los Angeles	2,910	50.9	83.6
9	Minneapolis	1,370	82.0	83.5
10	Dallas	910	34.6	73.1
11	Seattle	520	34.1	69.7

Intensity of Materials Scientists

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Dallas	480	18.3	100.0
2	Boston	340	17.9	96.9
3	Greater San Francisco	230	8.2	80.2
4	Greater Los Angeles	310	5.4	75.6
5	Greater New York	360	4.6	74.1
6	San Diego	100	8.3	73.7
7	Chicago	190	4.5	68.3
8	Greater Raleigh Durham	50	7.6	66.5
9	Greater Philadelphia	130	4.6	65.6
10	Seattle	50	3.3	52.1
11	Minneapolis	30	1.8	37.4

Intensity of Biological Technicians

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater Raleigh Durham	1,940	290.4	100.0
2	Seattle	2,430	159.5	96.0
3	Boston	1,880	99.0	90.0
4	San Diego	1,410	112.7	89.4
5	Greater San Francisco	1,790	63.4	85.7
6	Greater New York	3,020	38.9	84.6
7	Greater Philadelphia	1,600	56.3	83.9
8	Greater Los Angeles	1,590	27.8	77.5
9	Minneapolis	760	45.5	77.2
10	Chicago	430	10.2	59.9
11	Dallas	150	5.7	47.9

Intensity of Chemical Technicians

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater New York	4,540	58.5	100.0
2	Greater Philadelphia	1,830	64.4	95.5
3	Boston	1,390	73.2	95.3
4	Greater San Francisco	1,550	54.9	92.6
5	Greater Raleigh Durham	570	85.3	91.6
6	Chicago	1,690	39.9	89.4
7	Dallas	1,220	46.4	89.1
8	Greater Los Angeles	1,680	29.4	85.8
9	Minneapolis	630	37.7	82.6
10	San Diego	430	34.4	79.1
11	Seattle	470	30.9	78.4

Innovation Pipeline – Life Sciences Workforce

Intensity of Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products

Rank	Metro	Number, 2003	Per 100,000 Workers, 2003	Score
1	Greater San Francisco	14,920	528.8	100.0
2	Seattle	10,180	668.3	99.8
3	Boston	11,270	593.5	99.4
4	Dallas	11,550	439.4	97.2
5	Greater Los Angeles	17,710	310.0	96.7
6	Greater Raleigh Durham	4,930	738.1	96.7
7	Chicago	14,190	335.4	96.2
8	Greater New York	16,820	216.9	93.7
9	Greater Philadelphia	9,100	320.4	93.5
10	Minneapolis	6,210	371.7	92.6
11	San Diego	4,420	353.4	90.4

Life Sciences Workforce Composite Index

Rank	Metro	Composite Score
1	Boston	100.0
2	Greater San Francisco	95.4
3	San Diego	90.6
4	Greater Raleigh Durham	88.6
5	Greater Philadelphia	88.2
6	Greater New York	88.2
7	Greater Los Angeles	87.0
8	Chicago	83.2
9	Minneapolis	81.8
10	Seattle	75.8
11	Dallas	72.8

Innovation Pipeline – Life Sciences Innovation Output

FDA New Drug Approval

Rank	Metro	Total, 2002-2004	Per Million People, 2004	Score
1	Greater New York	60	3.7	100.0
2	Greater Philadelphia	24	3.9	88.5
3	Greater Raleigh Durham	11	8.3	87.3
4	Boston	13	2.9	76.6
5	Chicago	14	1.5	69.3
6	San Diego	8	2.7	69.2
7	Dallas	8	1.4	61.2
8	Greater Los Angeles	10	0.7	55.8
9	Greater San Francisco	6	1.0	53.1
10	Minneapolis	1	0.3	34.5
11	Seattle	0	0.0	0.0

FDA New Medical Devices Premarket Approval

Rank	Metro	Total, 2002-2004	Per Million People, 2004	Score
1	Minneapolis	9	2.9	100.0
2	Greater Los Angeles	17	1.2	98.5
3	Greater San Francisco	10	1.7	93.0
4	Greater Philadelphia	6	1.0	73.7
5	Boston	5	1.1	72.4
6	Greater New York	7	0.4	62.9
7	San Diego	2	0.7	45.8
8	Dallas	2	0.4	35.1
9	Chicago	2	0.2	26.5
10	Greater Raleigh Durham	0	0.0	0.0
11	Seattle	0	0.0	0.0

Clinical Trial (Phase I)

Rank	Metro	Currently Recruiting	Per 100,000 People, 2004	Score
1	Boston	121	2.7	100.0
2	Greater Raleigh Durham	53	4.0	97.1
3	Greater Philadelphia	119	1.9	94.7
4	Greater San Francisco	115	2.0	94.4
5	Greater New York	204	1.2	93.7
6	Greater Los Angeles	175	1.3	92.5
7	Seattle	71	2.3	91.6
8	Chicago	111	1.2	86.6
9	Dallas	44	0.8	70.7
10	Minneapolis	27	0.9	67.2
11	San Diego	18	0.6	57.6

Clinical Trial (Phase II)

Rank	Metro	Currently Recruiting	Per 100,000 People, 2004	Score
1	Boston	776	17.5	100.0
2	Greater San Francisco	879	14.9	98.2
3	Greater Raleigh Durham	282	21.2	95.8
4	Greater New York	1,256	7.7	89.2
5	Chicago	834	8.9	88.8
6	Greater Philadelphia	572	9.3	86.7
7	Seattle	347	11.0	85.9
8	Greater Los Angeles	895	6.6	83.9
9	Dallas	357	6.4	76.5
10	Minneapolis	172	5.6	68.7
11	San Diego	153	5.2	66.7

Clinical Trial (Phase III)

Rank	Metro	Currently Recruiting	Per 100,000 People, 2004	Score
1	Greater San Francisco	968	16.4	100.0
2	Boston	789	17.8	99.8
3	Greater Raleigh Durham	316	23.7	97.9
4	Greater New York	1,402	8.6	91.6
5	Greater Philadelphia	694	11.3	91.1
6	Chicago	895	9.6	90.1
7	Seattle	415	13.2	89.9
8	Dallas	553	9.9	87.0
9	Greater Los Angeles	983	7.2	85.9
10	San Diego	261	8.9	79.6
11	Minneapolis	235	7.6	76.1

Life Sciences Patents Issued

Rank	Metro	1999-2003	Per 100,000 People, 1999-2003	Score
1	Greater San Francisco	11,896	201.9	100.0
2	Boston	5,399	121.6	91.0
3	Minneapolis	3,125	101.3	86.4
4	San Diego	2,902	99.0	85.8
5	Greater Philadelphia	4,343	70.8	84.8
6	Greater New York	5,874	35.9	80.0
7	Greater Los Angeles	4,656	34.2	78.3
8	Greater Raleigh Durham	1,024	76.9	77.8
9	Chicago	3,413	36.6	77.3
10	Seattle	1,485	47.3	75.2
11	Dallas	763	13.7	60.0

Innovation Pipeline – Life Sciences Innovation Output

Weighted Life Sciences Patent Growth %

Rank	Metro	Score, 1999-2003
1	Greater San Francisco	100.0
2	Greater Los Angeles	96.0
3	San Diego	95.3
4	Minneapolis	95.2
5	Boston	89.6
6	Seattle	87.0
7	Greater Raleigh Durham	86.2
8	Greater Philadelphia	84.5
9	Chicago	78.0
10	Dallas	77.4
11	Greater New York	76.2

Weighted % of Life Sciences Patents in Area

Rank	Metro	Score, 1999-2003
1	San Diego	100.0
2	Greater Philadelphia	99.9
3	Boston	97.3
4	Greater New York	91.7
5	Seattle	91.7
6	Greater San Francisco	90.6
7	Greater Raleigh Durham	90.1
8	Greater Los Angeles	85.1
9	Chicago	79.8
10	Minneapolis	78.7
11	Dallas	67.6

Weighted Life Sciences Current Impact Index

Rank	Metro	Score, 1999-2003
1	Greater San Francisco	100.0
2	Minneapolis	99.1
3	San Diego	98.9
4	Greater Los Angeles	97.4
5	Boston	94.9
6	Greater Raleigh Durham	94.5
7	Greater New York	93.1
8	Seattle	92.4
9	Dallas	91.6
10	Greater Philadelphia	89.7
11	Chicago	89.5

Weighted Life Sciences Technology Strength

Rank	Metro	Score, 1999-2003
1	Boston	100.0
2	Greater San Francisco	97.9
3	San Diego	90.6
4	Greater Philadelphia	77.6
5	Greater Los Angeles	74.8
6	Minneapolis	73.4
7	Greater New York	69.8
8	Seattle	68.2
9	Chicago	67.8
10	Greater Raleigh Durham	63.5
11	Dallas	36.3

Weighted Life Sciences Technology Cycle Time

Rank	Metro	Score, 1999-2003
1	Chicago	100.0
2	Greater Raleigh Durham	99.7
3	Minneapolis	99.5
4	Dallas	99.1
5	Greater Philadelphia	98.6
6	Greater New York	98.5
7	Boston	98.4
8	Greater Los Angeles	98.3
9	Greater San Francisco	97.1
10	San Diego	96.4
11	Seattle	96.0

Weighted Life Sciences Science Linkage

Rank	Metro	Score, 1999-2003
1	San Diego	100.0
2	Seattle	98.8
3	Greater San Francisco	98.7
4	Boston	98.2
5	Greater Raleigh Durham	95.9
6	Minneapolis	93.1
7	Chicago	92.6
8	Dallas	92.4
9	Greater Los Angeles	91.3
10	Greater Philadelphia	88.4
11	Greater New York	87.8

Innovation Pipeline – Life Sciences Innovation Output

Weighted Life Sciences Science Strength

Rank	Metro	Score, 1999-2003
1	Boston	100.0
2	Greater San Francisco	93.3
3	San Diego	88.8
4	Greater Philadelphia	75.3
5	Seattle	72.4
6	Chicago	69.0
7	Greater Los Angeles	66.6
8	Minneapolis	65.4
9	Greater New York	64.1
10	Greater Raleigh Durham	63.0
11	Dallas	36.1

Life Sciences Innovation Output Composite Index

Rank	Metro	Composite Score
1	Boston	100.0
2	Greater San Francisco	99.2
3	Greater Philadelphia	96.7
4	Greater New York	94.9
5	Greater Los Angeles	91.6
6	San Diego	87.1
7	Minneapolis	85.3
8	Greater Raleigh Durham	82.6
9	Chicago	80.6
10	Dallas	71.2
11	Seattle	61.9

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