

**Cincinnati USA**  
**Industry Cluster Profile:**

**Biotechnology**

**Prepared for**  
**The Cincinnati USA Partnership**

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**August 2004**

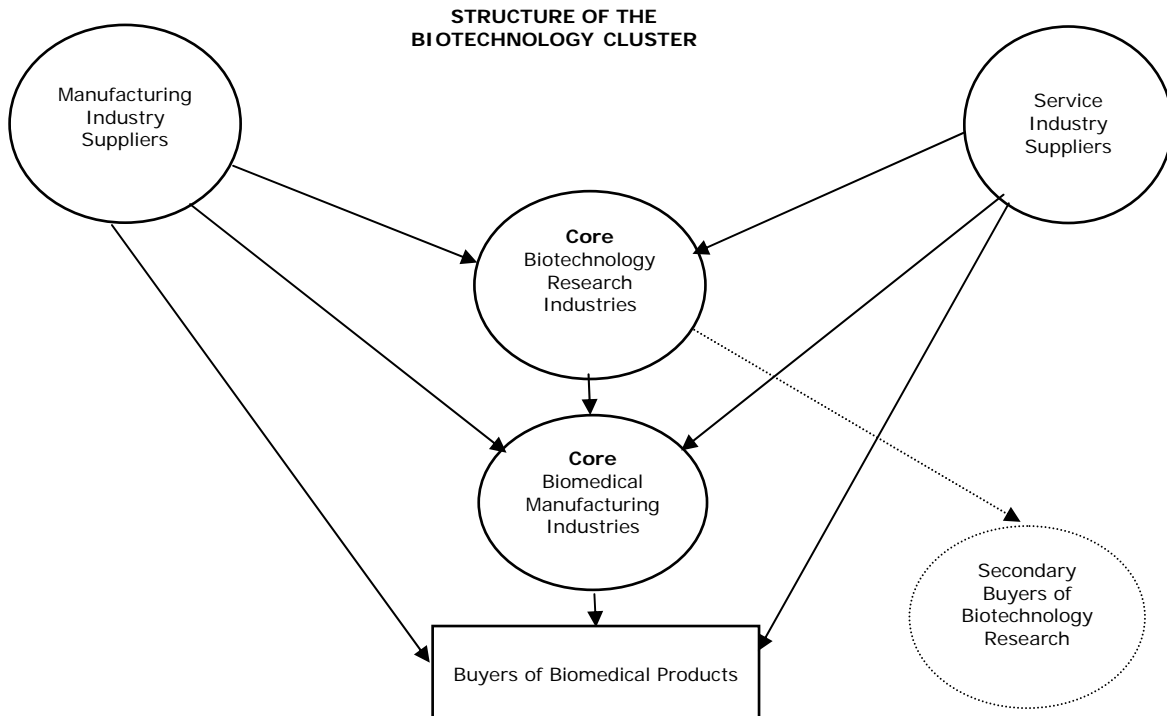
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# Executive Summary

## Cluster Description

- This report contains an industrial profile for the *Biotechnology* cluster, which was identified in a May 2004 report, entitled *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*, as a cluster meriting further analysis.
- The *Biotechnology* cluster is a geographic concentration of inter-connected companies and institutions working in biotechnology, and has become the focal point of economic development efforts in regions across the United States.
- The following diagram represents the structure of the *Biotechnology* cluster:



## National Characteristics

- There are **eight core industries** in the *Biotechnology* cluster, including three biotechnology research industries and five biomedical manufacturing industries.

*There are three core biotechnology research industries:*

*Testing Laboratories*

*Research & Development (R & D) in the Physical & Life Sciences*

*Medical & Diagnostic Laboratories*

*There are five core biomedical manufacturing industries:*

*Pharmaceutical & Medicine Manufacturing  
Electromedical & Electrotherapeutic Apparatus  
Analytical Laboratory Instrument Manufacturing  
Irradiation Apparatus  
Medical Equipment & Supplies Manufacturing*

Two of the eight core industries, ***R & D and Pharmaceuticals***, account for **70 percent of the firms**.

- In the *Biotechnology* cluster, there are **24 additional industries**, including four industries that buy biomedical manufactured products; nine industries that provide manufactured goods to the core industries; and eleven industries that provide services or infrastructure to the core industries.

*Glass, Printing, and Basic Chemicals* are the top three manufacturing purchases for *R & D*. Together, they account for 16 percent of all *R & D* purchases.

*Real Estate Services* is the top service purchase for *R & D*, accounting for 10 percent of all *R & D* purchases.

*Plastics, Semiconductors, Basic Chemicals, and Computers* are the top four manufacturing purchases for the *Biomedical Manufacturing* industries, together accounting for 10 percent of all core manufacturing purchases.

*Management of Companies and Enterprises, Wholesale Trade, and Patent Services* are the top three service suppliers to the *Biomedical Manufacturing* industries, accounting for 24 percent of all core manufacturing purchases.

*Venture Capital* is very important to start-up biotechnology firms.

- Relative to the average demand for various types of workers, core industries in the *Biotechnology* cluster rely heavily on the following categories of occupations:

*Computer & Mathematical Science* occupations  
*Architecture & Engineering* occupations  
*Life Science & Physical Science* occupations  
*Social Scientist & Related* occupations  
*Life, Physical, & Social Science Technician* occupations  
*Production* occupations

- Most of the industries in the *Biotechnology* cluster have a **balanced distribution of firm sizes**. They are not dominated by just a few large firms.
- Most of the industries in the *Biotechnology* cluster have a high percentage of small establishments, indicating that **efficient, low-cost production can occur at many different output levels**.

## Cincinnati USA Strengths in Biotechnology

- The Cincinnati USA region has over 200 biotechnology-related enterprises, including leaders such as

*Cincinnati Children's Hospital Medical Center*  
*Ethicon Endo-Surgery*  
*P & G Pharmaceuticals*  
*University of Cincinnati Medical Center*

- Start-up companies are a very important part of the *Biotechnology* cluster generally; BIO/START is Cincinnati USA's biomedical business incubator, which has launched a number of biotechnology companies into the region.
- One of the region's greatest strengths is its **biotechnology patent activity**. Over the decade of the 1990s, Cincinnati USA, with 972 patents, ranked **10<sup>th</sup>** among all metropolitan areas in the number of biotechnology-related patents received. Based on patents per 100,000 people, Cincinnati USA ranked **7<sup>th</sup>**.
- Over **\$160 million in research funding** was received from the National Institutes of Health (NIH) by institutions in the Cincinnati USA region in 2003. Two institutions, the University of Cincinnati (U.C.) and Cincinnati Children's Hospital Medical Center (CCHMC), were among the top 100 recipients of NIH funding. In 2003, U.C. ranked 59<sup>th</sup>, while **CCHMC** ranked 81<sup>st</sup>, or **3<sup>rd</sup> among all children's hospitals**.
- The Cincinnati USA region shows *strength* in buyer industries, which indicates strength in local outlets for locally manufactured biomedical products.

Regional specialization in the four buyer industries is relatively high; regional concentration in each of the industries approximates the national average for those industries.

Employment in all four buyer industries grew between 1998 and 2001.

For two of the four buyer industries, regional employment growth exceeded national employment growth. (For the other two, regional growth lagged slightly behind national growth.)

Nevertheless, none of the buyer industries should be a focus for economic development. Relatively low average wages and the local, non-export nature of these industries lessen their desirability as development targets.

- The region shows *strength* in five manufacturing supplier industries, which indicates the ability of local biotechnology firms to obtain certain supplies locally. These five industries are as follows:

*Paper Products*  
*Printing*  
*Basic Chemicals*  
*Plastics*  
*Fabricated Metals*

Regional specialization in these five industries exceeds that of the nation.

Except for *Printing*, regional growth exceeded national growth between 1998 and 2001.

Of these five industries, *Basic Chemicals* is a particularly attractive economic development target. Average wages in this industry in 2001 were \$58,778. Moreover, *Basic Chemicals* is a key part of the *Chemicals & Plastics* industrial cluster, as well as the *Biotechnology* cluster, so contributes to the regional economy through this conduit as well.

- The region shows *strength* in three service/infrastructure industries important to biotechnology firms: *Wholesale Trade*, *Advertising*, and *Patent Services*.

Regional industrial concentration exceeds national concentration for each of these industries.

Local employment growth exceeded national employment growth for all three industries between 1998 and 2001.

All three industries make attractive economic development targets, with relatively high average wages and the potential for exporting their services outside the region.

- The region has a relatively high concentration of workers in three of the key biotechnology occupation groups:

*Computer & Mathematical Science* occupations

*Architecture & Engineering* occupations

*Production* occupations

### **Cincinnati USA Biotechnology Cluster Concerns**

- As measured by private-sector employment, the **region is currently weak in core biotechnology industries.**

There are approximately 5600 private-sector employees in the Cincinnati USA region working in biotechnology; they represent less than one percent of the private-sector regional workforce.

Specialization in any of the eight core industries (with *Testing Labs* as the one exception) is rather low. *R & D* has a concentration less than half of that of the nation, while *Pharmaceuticals* has a concentration of only three fourths of that of the nation, though both showed higher regional employment growth than national employment growth between 1998 and 2001.

All core biotechnology industries are attractive targets for economic development, with average 2001 wages as high as \$67,000 in *R & D* and potential for export outside the region.

- There is regional *weakness* in *life science*, *physical science*, and *social science* occupations. These three occupation classes have less of a presence in the Cincinnati USA region than for the nation overall.
- The region is currently *weak* in four manufacturing supplier industries, including both the *Computer* and *Semiconductor* industries, with very low regional concentrations. This observation is troublesome since the successful biotechnology centers of Raleigh, San Diego, and Seattle are characterized by *strength* in both *Computer & Peripheral Equipment Manufacturing* and *Semiconductor & Other Electronic Component Manufacturing*.

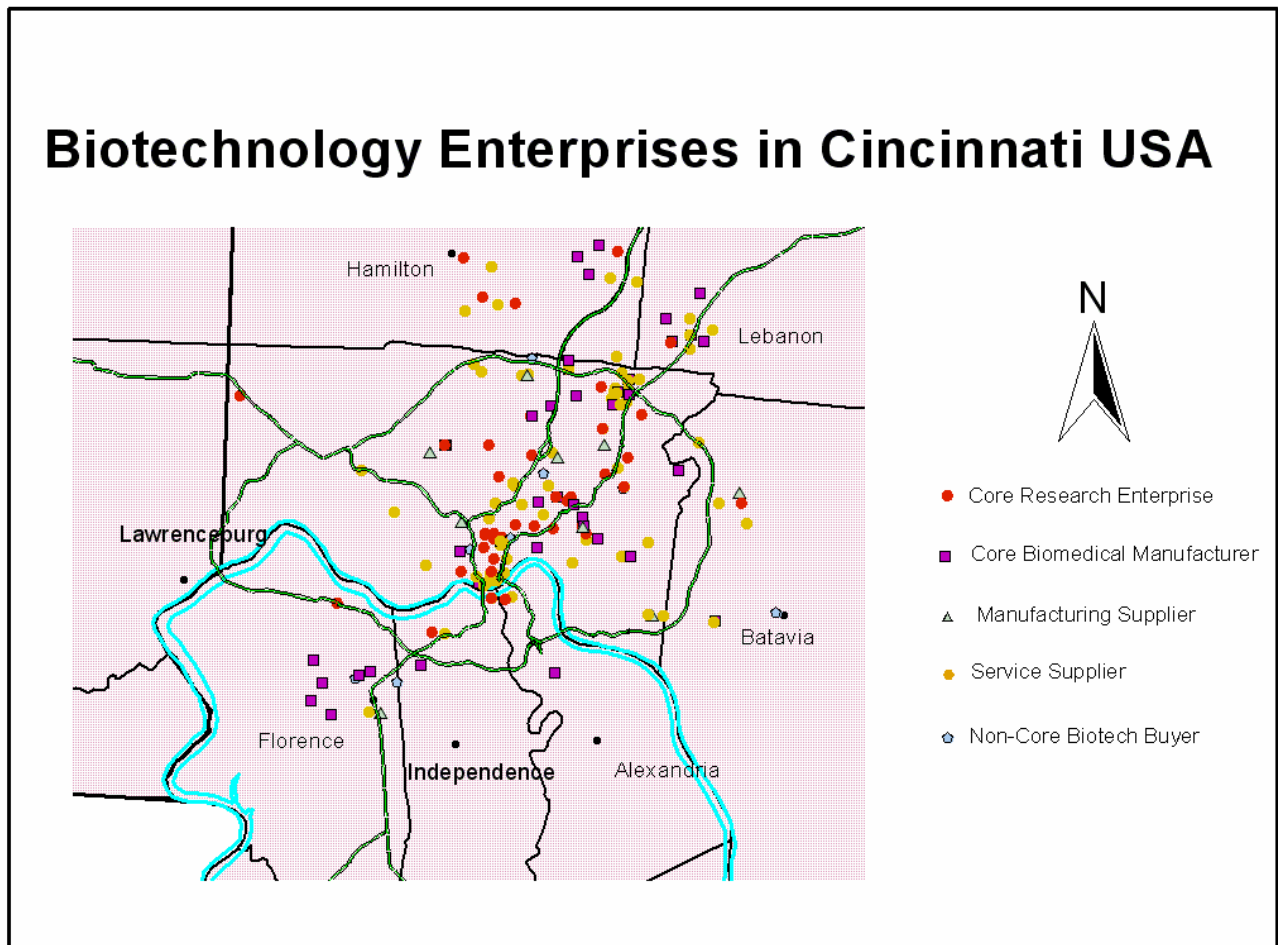
- Data indicate that the biggest single service/infrastructure concern for the Cincinnati USA region currently is *Venture Capital*. Employment in this industry is quite low, and regional growth lagged national growth between 1998 and 2001. With average wages of \$88,000, this industry is an obvious economic development target in its own right.

**The Geography of Biotechnology in Cincinnati USA**

Biotechnology enterprises engaged in research are concentrated in central locations, particularly in Cincinnati and adjacent communities.

Core biomedical and supplier manufacturing enterprises are more dispersed, indicating that firms in these industries may be good candidates for retention, expansion, or attraction in outlying communities.

The map below shows the location of biotechnology enterprises in Cincinnati USA:



## Regional Biotechnology Comparisons

- In comparison to the successful biotechnology centers of Raleigh, San Diego, and Seattle,

Cincinnati *competes well* in terms of patent activity and funding from the National Institutes of Health.

Cincinnati is *not as strong* in the core biotechnology research industries of *R & D* and *Medical Laboratories*, as measured by industrial concentration and regional growth. It surpasses San Diego and Seattle with respect to *Testing Laboratories*.

Cincinnati is *stronger* than Seattle in *Pharmaceuticals*, stronger than Raleigh in *Electromedical Apparatus*, and stronger than Raleigh and Seattle in *Laboratory Instruments*. It trails all three successful centers in *Medical Equipment & Supplies*.

Cincinnati is *as strong* as the three successful centers in the buyer industries.

Cincinnati is *stronger* than the three successful centers in many of the manufacturing supplier industries, but is less strong in both *Computer & Peripheral Equipment Manufacturing* and *Semiconductor & Other Electronic Component Manufacturing*.

Cincinnati shows *considerable weakness* in *Venture Capital* and *Computer Systems Design & Related Services*, but compares favorably to the successful biotechnology centers in *Wholesale Trade, Advertising, Professional Services, Management of Companies & Enterprises, Administrative Services, and Employment Services*.

- In comparison to the three nearby metropolitan areas of Columbus, Cleveland, and Indianapolis,

Cincinnati *competes well* in terms of patent activity and funding from the National Institutes of Health.

Cincinnati is generally *similarly situated* with respect to biotechnology research, though lags slightly behind Cleveland in *Testing Labs*, behind Columbus in *R & D*, and behind Indianapolis in *Medical Labs*.

Cincinnati is generally *similarly situated* with respect to biomedical manufacturing, though Cleveland shows considerable *strength* in *Irradiation Apparatus* and *Medical Equipment & Supplies Manufacturing*, while, due to the location of Eli Lilly, Indianapolis shows *strength* in *Pharmaceutical & Medicine Manufacturing*.

Cincinnati is generally *better situated* with respect to manufacturing supplier industries.

Cincinnati is generally *similarly situated* with respect to the service/infrastructure suppliers.

## Additional Issues, Observations, and Recommendations for Future Study

1. ***At this time, there are excellent economic-development opportunities in biotechnology.*** Core biotechnology industries tend to pay high wages that contribute significantly to the economic well-being of regional residents. They are also classified as export industries, encouraging new money to come into the region from out-of-area buyers. Since the *Biotechnology* cluster is still growing, the industries have not settled into maturity, leaving lots of opportunities for entrepreneurs, established firms, employees, and geographic regions.
2. ***High-tech regions tend to have other high-tech industries and industrial clusters besides biotechnology.*** Those regions, such as Seattle, Raleigh, and San Diego, that have a strong *Biotechnology* cluster are also seen to be strong in other high-technology industries, such as *Computers* and *Semiconductors*, for example. Whether the relationship is one of causation or simple correlation (high-technology industries all require certain occupations and skills) is an open question that needs additional study. The *Biotechnology* cluster is one of three technology clusters recommended in the May 2004 report (*Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*, Economics Center for Education & Research), along with *Digital Equipment & Telecommunications* and *Software & Data Processing*. The relationships between these three clusters need to be explored more thoroughly. It may be the case that, as far as economic development strategy is concerned, it would be best to pursue industries in these three clusters simultaneously even if primary interest is in biotechnology.
3. ***Biotechnology researchers seek face-to-face interaction with other researchers in order to have maximum productivity.*** Employees, particularly researchers, in knowledge-based industries rely on face-to-face interaction to develop new ideas. Phone and e-mail interaction alone are not sufficient. Biotechnology researchers need to be part of a strong community of individuals who interact both formally and informally. We recommend studying the types of economic development actions that could be taken to facilitate interaction, especially between employees in different enterprises. Attention should be given to the possible development of a research park, building from the BIO/START incubator.
4. ***Partnerships are common in the Biotechnology cluster, and the trend is growth in partnership activity.*** According to a July 2004 report by New Economy Strategies, Inc. ([www.new-econ.com](http://www.new-econ.com)), self-contained regional biotechnology clusters are evolving into specialized, networked regions. In other words, in order to compete in a global market, an economic development strategy might include a number of individual regions, such as Cincinnati USA along with Columbus, Cleveland, Indianapolis, Lexington, and Louisville. A mid-west multi-regional effort should be explored to allow individual regional specialization yet inter-regional understanding and cooperation. As partnerships develop between regions, moreover, the trend will mimic inter-firm collaboration in the biotechnology industries. The number of collaborations between biotechnology research firms and pharmaceutical companies, for example, has been growing steadily over the last decade.

5. ***Risk-taking entrepreneurship is required in biotechnology.*** Biotechnology activity starts from basic research and goes through clinical trials, regulatory approval, and business planning, and potentially all the way to commercialization and mass production. Risk and capitalization requirements differ at each level of development. It is important to understand thoroughly the capital requirements for each of the core biotechnology industries and to determine how to facilitate capital acquisition at each stage of the process. Interviews with industrial leaders and financial experts are highly recommended.
  
6. ***Young, energetic entrepreneurs and researchers in biotechnology seek acknowledgment for their contribution to the regional economy.*** In order to entice high-energy, entrepreneurial individuals, who make up a large number of biotechnology professionals, to settle in or relocate to the region, Cincinnati USA has to work on being attractive. Leaving aside the important leisure activities that these individuals desire, there is ample room to create a higher-profile identity for Cincinnati Biotech. The cluster has to be exciting, pleasant, and even fun. Individuals need to feel that they are a part of a high-technology environment, supported strongly by the University of Cincinnati and other Cincinnati USA institutions. Even small university towns that have no real hope of competing "big time" in commercial biotechnology often have good areas of town set aside for their newborn high-technology companies --- demonstrating to the firms and employees the high value placed on their important activities.

#### **Caveat**

Conclusions and recommendations are essentially data-based. No interviews were conducted. No conclusions are based on personal experience.

## Section 1 Introduction

In May 2004, the Economics Center for Education & Research issued a report entitled *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*. The report was prepared for the Cincinnati USA Partnership. In that report, ten industry clusters, including *Biotechnology*, were recommended for further consideration in future economic development efforts.<sup>1</sup> This report follows up on that analysis by providing an in-depth industrial profile for the *Biotechnology* cluster. Where relevant, we will also mention relationships between industries in the *Biotechnology* cluster and those in one or more of the other nine recommended clusters. In this report, we define and describe the *Biotechnology* cluster, both nationally and for the Cincinnati Metropolitan Statistical Area.<sup>2</sup>

### Approach to Cluster Profiling

Michael Porter defines clusters as follows.

Clusters are geographic concentrations of inter-connected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies or common inputs. Finally, many clusters include governmental and other institutions -- such as universities, standard-setting agencies, think tanks, vocational training providers, and trade associations -- that provide specialized training, education, information, research, and technical support.

Porter explains that clusters represent a new spatial form of organization, significantly different from the traditional, hierarchical vertical integration of companies and markets. The fact that companies are clustered together in one region, and that the ongoing exchanges among them foster communication and trust, produces "advantages in efficiency, effectiveness, and flexibility."<sup>3</sup>

The basic economic framework used to study the *Biotechnology* cluster is Porter's *Diamond Model*,<sup>4</sup> used to answer the question of how a region achieves domestic, even international, success in a particular industry. The framework is particularly useful for clusters, like *Biotechnology*, that have hard-to-define boundaries, since its inclusiveness will succeed in keeping all relevant industries in the cluster analysis. For example, because we also take into account suppliers and buyers as the Diamond Model encourages us to do, *those*

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<sup>1</sup> The other nine clusters are *Advanced Design Services; Business Management; Financial Services; Digital Equipment & Telecommunications; Software & Data Processing; Advanced Manufacturing; Aerospace; Chemicals & Plastics; and Motor Vehicle Manufacturing*.

<sup>2</sup> The Cincinnati Metropolitan Statistical Area consists of the following fifteen counties: Hamilton, Butler, Warren, Clermont, and Brown Counties in southwestern Ohio; Boone, Kenton, Campbell, Gallatin, Grant, Pendleton, and Bracken Counties in northern Kentucky; and Franklin, Dearborn, and Ohio Counties in southeastern Indiana.

<sup>3</sup> Michael Porter's cluster definition and explanation of clusters are taken from *Clusters and the New Economics of Competition*, by Michael E. Porter, *Harvard Business Review*, November - December, 1998.

<sup>4</sup> See page 72 in Porter, Michael E. (1990), *The Competitive Advantage of Nations*. New York: The Free Press.

*industries'* importance to biotechnology will be taken into account as well. The four vertices of Porter's "Diamond" are

- the region's factors of production, such as skilled labor or infrastructure, necessary to compete in a given industry;
- the region's home demand as well as export capacity for the cluster's products and services;
- the presence or absence in the region of supplier industries and related industries; and
- the conditions in the region governing how companies are created, organized, and managed, and the nature of rivalry among firms in the region.

Government policy can affect the strength of each of the four vertices of the Diamond.

### **Overview of Biotechnology in Cincinnati USA**

Biotechnology has become the focal point of many state and regional economic development strategies, and the Cincinnati USA region is no exception. Economic development planners seek information on the current state of biotechnology in the region. They also desire to understand what specific strategies can strengthen creation, expansion, recruitment, and retention of biotechnology enterprises. The Cincinnati USA Partnership and BIO/START have together identified over 200 public and private enterprises involved as either core biotechnology entities or manufacturing or service suppliers in the regional *Biotechnology* cluster. Illustrative major enterprises include the following:

- P & G Pharmaceuticals has a 1.3-million-square-foot research & development center in Mason. P & G scientists do cardiovascular, muscular, and metabolic research.
- Ethicon Endo-Surgery, a division of Johnson & Johnson, is located in Blue Ash. This company develops devices that enable interventional diagnosis and treatment in the areas of general and thoracic surgery, breast disease, gynecology, oncology, and urology.
- Cincinnati Children's Hospital Medical Center (CCHMC) is a member of the elite "Big Six" children's hospitals.<sup>5</sup> Out of all children's hospitals in the United States, CCHMC ranked 3<sup>rd</sup> in 2003 in research funding from the National Institutes of Health. Its excellent reputation spills over to other businesses and neighboring medical institutions in the Cincinnati USA community. The CCHMC conducts research in pulmonology, cardiovascular development, gene regulation, cancer biology, and rheumatology.
- The Food and Drug Administration's Forensic Chemistry Center, located in the Cincinnati region, is a national laboratory for rapid method development and research related to forensic issues involving foods, drugs, and other FDA-regulated products.

Biotechnology is a new and growing field. Start-up enterprises are also a very important part of the cluster. BIO/START is Cincinnati USA's biomedical business incubator. It provides specialized wet-lab space and shared technical equipment for entrepreneurs and start-up companies. BIO/START also offers business counseling, entrepreneurial education, and support infrastructure. A goal is to provide an opportunity for biomedical innovations to be commercialized locally. Current tenants include

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<sup>5</sup> The other members of the Big Six, the premier national children's hospitals, are located in Boston, Philadelphia, Atlanta, Houston, and Los Angeles.

- CardioEnergetics, which is working on the development of a heart-assist device to treat congestive heart failure (CHF)
- Cutanogen, which is working on the development of tissue-engineered skin substitutes to restore the qualities of healthy human skin
- Siloam Biosciences, which is working on the development of Point-of-Care testing equipment
- Phase 2 Discovery, which seeks to acquire and develop early stage pharmaceuticals for treating psychiatric and neurologic disorders<sup>6</sup>

## Methodology

The data source used for cluster identification and linkage estimation is the *1997 Benchmark Input-Output Accounts for the United States*, from the Bureau of Economic Analysis. The data are based on NAICS (North American Industrial Classification System). As opposed to the former SIC (Standard Industrial Classification) system which classifies establishments that have similar products, NAICS groups together establishments with similar production processes.

The U.S. Census Bureau's *2001 County Business Patterns* data base is the principal source for employment by industry and occupation in the Cincinnati USA region, as well as in the other regions discussed in this report. It is also based on NAICS. The primary limitation of county business pattern data is that they do not include people who are employed in the public sector, those who work on farms, and those who are self-employed. The first omission is particularly troublesome within the biotechnology industries due to the high number of life and physical scientists who work in large public universities and/or hospitals. Nevertheless, the data are the best available, and we supplement the data where necessary with information from other sources. Moreover, since the data limitations apply universally, the data should be fine for cross-regional comparisons.

This analysis relies on data from a number of other government and private-sector data sources. These sources are cited throughout the report.

## Outline

Section 2 describes the *Biotechnology* cluster at the national level. It describes inter-industry linkages among research and manufacturing firms and their joint suppliers and customers. It also discusses seller concentration and scale economies in production at the national level. Section 3 describes the strength of the *Biotechnology* cluster at the regional level. A discussion of average wages, employment, regional concentration, and growth appears in Section 3. Occupational strengths and weaknesses are also discussed. Several maps depict the geography of biotechnology firms and other enterprises in the Cincinnati USA region. Section 4 compares, using a number of different statistics, the *Biotechnology* cluster in the Cincinnati USA region with the cluster in six other metropolitan areas: three areas chosen as successful biotechnology centers and three chosen as nearby midwestern regions. Main conclusions are found in the Executive Summary to this report.

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<sup>6</sup> In Winter 2004, Dr. Daniel A. Shelly taught a course through the E-Center at the University of Cincinnati entitled *Biotechnology and Pharmaceutical Management*. Students received a basic overview of the biotech and pharmaceutical industries. They also learned about the drug development process. Guest speakers included local industry experts.

## Section 2 Structure of the National Biotechnology Cluster

In this section, we describe the *Biotechnology* cluster at the national level. That is, we identify industries that are an integral part of the cluster and then discuss and quantify the linkages that exist between the various industries and industry groups within the cluster.

### Identification of Core Industries

In the October 2003 Department of Commerce report, *A Survey of the Use of Biotechnology in U.S. Industry*, biotechnology is defined as “the application of molecular and cellular processes to solve problems, conduct research, and create goods and services.” The report further states that “the hallmark of biotechnology is cellular and genetic techniques that manipulate cellular and subcellular building blocks for applications in various scientific fields and industries such as medicine, animal health, agriculture, marine life, and environmental management.” Public, private, and non-profit enterprises are all involved in biotechnology research and development in the United States.

To identify the most central industries in biotechnology research, development, and manufacturing, we use, as the main source, this same Department of Commerce report.<sup>7</sup> Of the 897 respondent biotechnology companies that identified their industry, 333 (37.1%) of them identified 541710, *Research & Development in the Physical & Life Sciences*, as their primary NAICS (North American Industrial Classification System) code. In addition to 541710, we include, as biotechnology research industries, both 541380, *Testing Laboratories*, and 6215, *Medical & Diagnostic Laboratories*, together accounting for 40 (4.5%) of the survey respondents. Hence, accounting for 41.6 percent of the surveyed enterprises, are the following three core industries in biotechnology research:

#### Research in Biotechnology<sup>8</sup>

- 541380, *Testing Laboratories* (payroll \$4.22 billion)
- 541710, *Research & Development in the Physical & Life Sciences* (payroll \$22.93 billion)
- 6215, *Medical & Diagnostic Laboratories* (payroll \$7.52 billion)

Another 301 (33.6%) of the survey respondents identified 3254, *Pharmaceutical & Medicine Manufacturing*, as their primary industry. In addition to 3254, we include, as biomedical manufacturing industries, 334510, *Electromedical & Electrotherapeutic Apparatus*

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<sup>7</sup> Other sources include seven economic development studies that contain regional definitions of biotechnology:

- *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA* (May 2004, Economics Center for Education & Research)
- *Technology-Based Economic Development Strategy* (March 2002, Battelle)
- *Hamilton County's Comparative and Competitive Advantages* (December 2003, Hamilton County Regional Planning Commission)
- *Northern Kentucky New Economy Marketing Strategy—Target Industry Study* (October 2003, Angelou Economics)
- *Target Marketing Strategy* (March 1999, The Wadley-Donovan Group)
- *Kentucky Clusters: Industrial Interdependence and Economic Competitiveness* (June 2001, University of North Carolina)
- *Technology Workforce Assessment of Cincinnati USA* (2003, Cypress Research Group)

<sup>8</sup> Payroll figures are from *2001 County Business Patterns*. Value of shipments figures (available for the manufacturing industries only) are from the *2001 Annual Survey of Manufactures*. Descriptions of industries are available from the *Economic Census*.

*Manufacturing*; 334516, *Analytical Laboratory Instrument Manufacturing*; 334517, *Irradiation Apparatus Manufacturing*; and 3391, *Medical Equipment & Supplies Manufacturing*. Together, these latter four manufacturing industries account for at least 4 percent of the survey respondents. The list of core biomedical manufacturing industries is as follows:

### **Biomedical Manufacturing**

- 3254, *Pharmaceutical & Medicine Manufacturing* (payroll \$14.59 billion; value of shipments \$130.02 billion)
- 334510, *Electromedical & Electrotherapeutic Apparatus Manufacturing* (payroll \$2.81 billion; value of shipments \$13.64 billion)
- 334516, *Analytical Laboratory Instrument Manufacturing* (payroll \$2.04 billion; value of shipments \$8.35 billion)
- 334517, *Irradiation Apparatus Manufacturing* (payroll \$0.83 billion; value of shipments \$4.32 billion)
- 3391, *Medical Equipment & Supplies Manufacturing* (payroll \$12.84 billion; value of shipments \$57.77 billion)

Altogether, these eight core industries account for approximately **80 percent** of the Department of Commerce's survey respondents.<sup>9</sup>

Using the *1997 Benchmark Input-Output Tables for the United States*, we quantify the linkages between industries in the core. We first note that the essential direction of linkage is *from* 541710 (the largest of the research industries) *to* the manufacturing industries. Secondly, unlike some of the other clusters studied for the Cincinnati USA region, the *Biotechnology* cluster does *not* have particularly strong linkages between the core industries in the cluster. In the Appendix to this report, Figure A-1 shows the size of purchase of the service of 541710 by each of the biomedical manufacturing industries in the core.<sup>10</sup> *Pharmaceutical & Medicine Manufacturing* (NAICS 3254) purchased \$1.6 billion from *Research & Development in the Physical & Life Sciences* (NAICS 541710) in 1997. This transaction represents approximately five percent of the sales of 541710 and approximately three percent of the purchases of 3254. Whereas 541710 and 3254 have a moderate link, the remaining manufacturing industries appear to have less of a strong link to 541710. The next strongest association is the 1.82 percent of the purchases of 3391, *Medical Equipment & Supplies Manufacturing*, accounted for by 541710.

### **Structure of the Cluster**

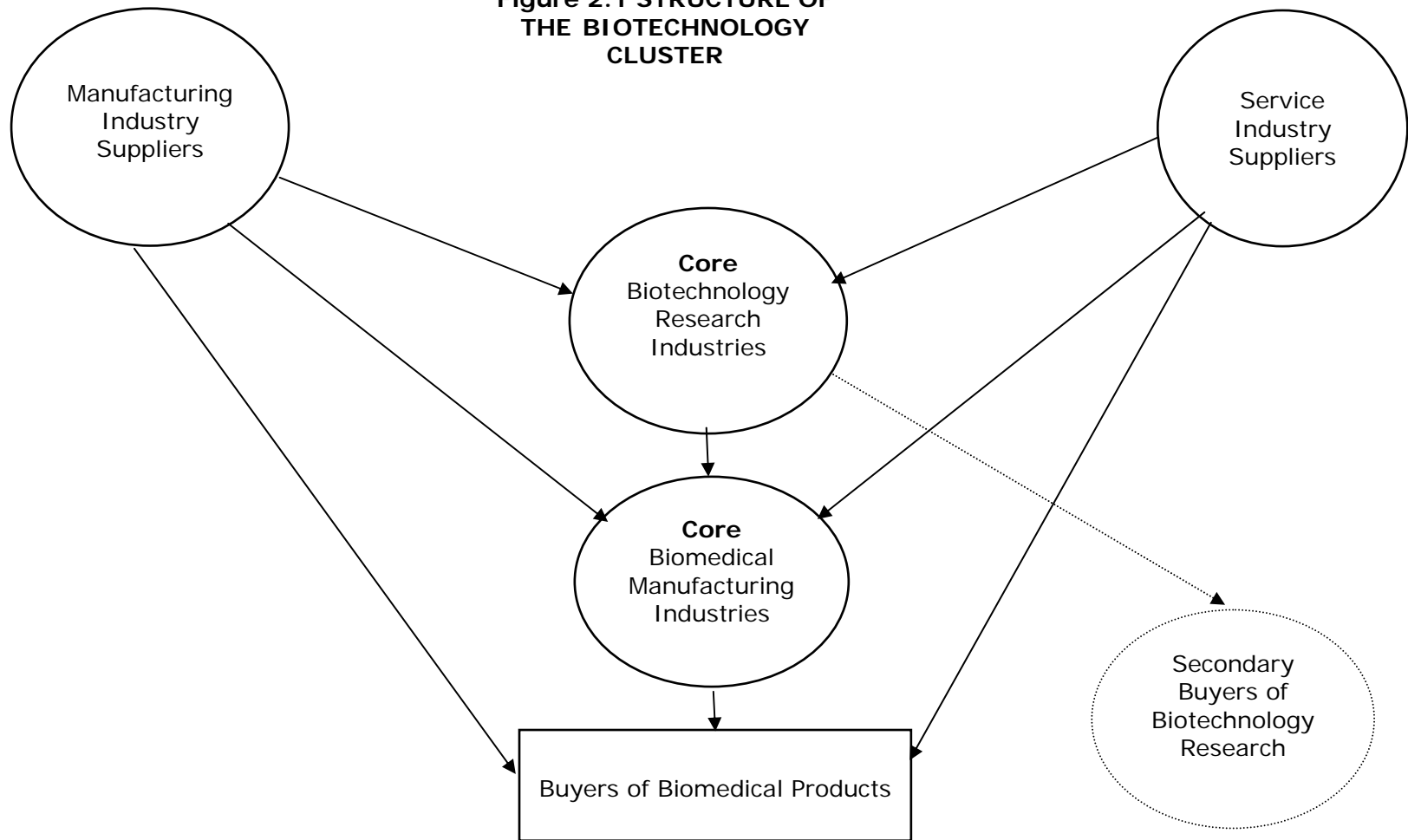
Figure 2.1 shows a diagrammatic overview of the relationship between the eight core industries and other closely related industries. Moving "downstream" from the core first, we note the buyers of the biomedical manufacturing industry products. The primary buyers are identified in the next section of this report. "Upstream" from the core are those industries that supply to the core industries. We consider two types of suppliers separately:

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<sup>9</sup> The remaining 20 percent of respondent firms identified the following industries: 11, 311, 312, 337, 22, 23, 323, 327, 3399, 326, 322, 3251, 3252, 3253, 3255, 3256, 3259, 5112, 5415, 512, 3341, 3344, 3332, 3333, 3334, 3335, 3339, 42, 44, 45, 48, 49, 54 (except 54138, 5415, and 5417), 55, 61, 62, 71, 72, 81, and 56. The highest respondent percentages were 2.6% for 54 and 1.8% for 311 and 312 combined. See the Department of Commerce report, p. 12.

<sup>10</sup> Figure 2.1 is based on the sales of 541710 to biomedical manufacturing industries. The *Input-Output Tables* do not treat either 541380 or 6215 separately from the much larger industry groups (5413 and 621, respectively) to which they belong. On the other hand, 541710 accounts for over 90 percent of the receipts of 5417 (the level of industry aggregation in the *Input-Output Tables*).

**Figure 2.1 STRUCTURE OF THE BIOTECHNOLOGY CLUSTER**



manufacturing suppliers and service/infrastructure suppliers. First, we identify the top manufacturing suppliers to either the biotechnology research industries, the biomedical manufacturing industries, or the final buyers. Second, we identify the top services required by any or all of these three industry groups. A final group of industries, seen in Figure 2.1, that we discuss briefly, are those industries, such as food processing, that use biotechnology research but have a very distinct downstream channel of distribution from biomedical manufacturing.

## Buyers

We identify the following top four buyers of biomedical manufacturing products:<sup>11</sup>

- 541940, *Veterinary Services* (payroll \$5.29 billion)
- 621, *Ambulatory Health Care Services* (payroll \$195.44 billion)
- 622, *Hospitals* (payroll \$180.90 billion)
- 623, *Nursing & Residential Care Facilities* (payroll \$54.67 billion)

Figure A-2, in the Appendix to this report, shows the linkages that exist between the four primary buyers and the five sellers of biomedical manufacturing products. Many of the linkages are quite *strong*. Of the sales of 3254, *Pharmaceutical & Medicine Manufacturing*, 4.65 percent are accounted for by 541940, *Veterinary Services*. 13.36 percent are bought by 621, *Ambulatory Health Care Services*; 23.00 percent by 622, *Hospitals*; and 2.13 percent by 623, *Nursing & Residential Care Facilities*. The other supplier industries are seen to sell primarily to 621 and 622. From the buyer's point of view, we see that pharmaceuticals represent over 20 percent of the purchases of 59140, *Veterinary Services*, and about six percent of *Hospital* (NAICS 622) purchases. *Ambulatory Health Care Services* (NAICS 621) allots over six percent of its purchases to 3391, *Medical Equipment & Supplies Manufacturing*. The highest measured linkage (85.32%) is between 334517, *Irradiation Apparatus Manufacturing*, and 621, *Ambulatory Health Care Services*.

## Manufacturing Suppliers

According to the *1997 Benchmark Input-Output Tables for the United States*, the top nine suppliers of manufactured products to the biotechnology core and biomedical buyers are the following:<sup>12</sup>

- 313, *Textile Mills* (payroll \$8.40 billion; value of shipments \$45.68 billion)
- 3222, *Converted Paper Product Manufacturing* (payroll \$13.31 billion; value of shipments \$83.86 billion)
- 3231, *Printing & Related Support Activities* (payroll \$27.05 billion; value of shipments \$100.79 billion)
- 3251, *Basic Chemical Manufacturing* (payroll \$10.77 billion; value of shipments \$104.43 billion)
- 326, *Plastics & Rubber Products Manufacturing* (payroll \$32.64 billion; value of shipments \$170.72 billion)
- 3272, *Glass & Glass Product Manufacturing* (payroll \$4.83 billion; value of shipments \$22.91 billion)

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<sup>11</sup> As above, payroll figures are from *2001 County Business Patterns*. Value of shipments figures are not available for any of the buyers.

<sup>12</sup> Again, payroll figures are from *2001 County Business Patterns*. Value of shipments figures are from the *2001 Annual Survey of Manufactures*.

- 332, *Fabricated Metal Product Manufacturing* (payroll \$61.80 billion; value of shipments \$253.11 billion)
- 3341, *Computer & Peripheral Equipment Manufacturing* (payroll \$11.37 billion; value of shipments \$89.53 billion)
- 3344, *Semiconductor & Other Electronic Component Manufacturing* (payroll \$28.30 billion; value of shipments \$124.22 billion)

Figure A-3, in the Appendix, quantifies the linkages between each of the manufacturing suppliers and the three groups of industries already identified in this section: the core biotechnology research industries (only 541710 is captured due to the level of aggregation of the *1997 Input-Output Tables*); the core biomedical manufacturing industries; and the buyers of the biomedical manufacturing products.

The most important manufacturing input into the production of biotechnology research is 3272, *Glass & Glass Product Manufacturing*. Purchases from this single manufacturing industry accounted for 6.97 percent of purchases in 1997. Next in importance is 3231, *Printing & Related Support Activities*. Third is 3251, *Basic Chemical Manufacturing*. Fourth is 332, *Fabricated Metal Products*. Top material suppliers to the biomedical manufacturing industries include 326, *Plastics and Rubber Products Manufacturing*; 3344, *Semiconductor & Other Electronic Component Manufacturing*; 3251, *Basic Chemical Manufacturing*; 3341, *Computer & Peripheral Equipment Manufacturing*; and 3222, *Converted Paper Product Manufacturing*. Purchase percentages for these five industries are 3.83 percent, 2.52 percent, 2.00 percent, 1.94 percent, and 1.74 percent, respectively. Note that 313, *Textiles*, sells 2.56 percent of its product to the biomedical manufacturing industries as a group. In terms of buyer purchases, two of the manufacturing suppliers account for over three percent of their purchases: 326, *Plastics & Rubber Products Manufacturing*, and 3251, *Basic Chemical Manufacturing*. The single manufacturing supplier that is linked closely to all three industry groups is 3251, *Basic Chemical Manufacturing*.

### **Service/Infrastructure Suppliers**

The top eleven suppliers of service/infrastructure to the biotechnology core and biomedical buyers are the following:<sup>13</sup>

- 42, *Wholesale Trade* (payroll \$275.90 billion)
- 523910, *Miscellaneous Intermediation; Venture Capital* (payroll \$3.46 billion)
- 531, *Real Estate* (payroll \$44.42 billion)
- 533, *Lessors of Nonfinancial Intangible Assets; Patent Services* (payroll \$1.62 billion)
- 5411, *Legal Services* (payroll \$67.24 billion)
- 5415, *Computer Systems Design & Related Services* (payroll \$84.68 billion)
- 5418, *Advertising & Related Services* (payroll \$22.27 billion)
- 5419 (exc. 541940), *Other Professional, Scientific, & Technical Services* (payroll \$14.69 billion)
- 55, *Management of Companies & Enterprises* (payroll \$213.12 billion)
- 561 (exc. 5613, 5615), *Administrative & Support Services* (payroll \$99.14 billion)
- 5613, *Employment Services* (payroll \$100.92 billion)

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<sup>13</sup> Once again, payroll figures are from *2001 County Business Patterns*. Value of shipments figures are not available for any of the service/infrastructure suppliers.

In the Appendix to this report, Figure A-4 quantifies the linkages between each of the service/infrastructure suppliers and the three groups of industries already identified in this section: the core biotechnology research industries; the core biomedical manufacturing industries; and the buyers of the biomedical manufacturing products.<sup>14</sup> As measured by the percentage of their purchases, the most important services for the biotechnology research industries are 531, *Real Estate*; 561, *Administrative & Support Services*; 5613, *Employment Services*; and 5411, *Legal Services*. Each represents over four percent of the purchases of 541710 (again, 541380 and 6215 are excluded in this part of the analysis). The biomedical manufacturing industries, which are comprised of much larger firms than their biotechnology-research counterparts, rely on, in order of importance, 55, *Management of Companies & Enterprises*; 42, *Wholesale Trade*; 533, *Lessors of Nonfinancial Intangible Assets*; and 5418, *Advertising & Related Services*. Note that 533 includes establishments that are primarily engaged in assigning rights to assets, such as patents.

The buyer industries (541940, *Veterinary Services*; 621 *Ambulatory Health Care Services*; 622 *Hospitals*; and 623 *Nursing & Residential Care Facilities*) identified earlier spent \$41.2 billion on real estate services in 1997 --- which represented 14.63 percent of their total purchases (as well as 11.10 percent of *Real Estate's* sales). 5.86 percent of their purchases were for 561, *Administrative & Support Services*. Four more top purchases, in order of importance, are for 5613, *Employment Services*; 5411, *Legal Services*; 55, *Management of Companies & Enterprises*; and 42, *Wholesale Trade*. Although not on this list, 5415, *Computer Systems Design & Related Services*, supplied \$1.8 billion to the buyer group, accounting for 5.2 percent of 5415's sales.

### Cluster Summary

In summary, the *Biotechnology* cluster, as defined for this analysis, includes

- eight core industries (three devoted to research and five to manufacturing);
- four buyer industries;
- nine manufacturing supplier industries; and
- eleven service/infrastructure supplier industries.

A total of **32** industries (at varying levels of aggregation) are involved in the *Biotechnology* cluster.

### Secondary Buyers of Biotechnology Research

Finally, in Figure 2.1, the dashed oval represents secondary buyer industries that use biotechnology in their manufacturing processes, though not to create biomedical products. These industries include those identified by the respondent biotechnology firms in the 2003 Department of Commerce Report:

- 311, 312, *Food, Beverage, & Tobacco Manufacturing* (\$1,555 million purchase from 541710 in 1997)
- 322, *Paper & Wood Manufacturing* (\$307 million purchase from 541710 in 1997)
- 323, 327, and 3399, *Basic Industries Activity* (\$1,120 million purchase from 541710 in 1997)

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<sup>14</sup> 523910, *Miscellaneous Intermediation*, includes venture capital companies. The *1997 Input-Output Tables* give insufficient information to establish a quantitative link between 523910 and the other industries in the *Biotechnology* cluster.

- 3252, 3253, 3255, 3256, and 3259, *Chemical Manufacturing* (\$2,489 million purchase from 541710 in 1997)
- 3345 (exc. 334510, 334516, & 334517) *Instrument Manufacturing* (\$676 million purchase from 541710 in 1997)
- 3332, 3333, 3334, 3335, and 3339 *Machinery Manufacturing* (\$875 million purchase from 541710 in 1997)

## Elements of Industrial Market Structure at the National Level

Here, we describe two elements of market structure, at the national level, for the 32 industries in the *Biotechnology* cluster. In regional efforts to recruit, grow, retain, and create biotechnology firms, it is useful to keep in mind the size distribution of firms and their establishments at the national level.

The four-firm seller concentration ratio, or  $CR_4$ , is the market share of the top four firms in an industry. It ranges between 0 and 100 and indicates the degree of market power that firms are able to exercise in a market. The higher the concentration ratio, the greater control that the top firms exercise in a market. On the other hand, low values of  $CR_4$  indicate that the industry is fragmented and competitive. Roughly, a concentration ratio lower than 40 signifies a rather competitive market; between 40 and 60, a moderately competitive market; and above 60, a market with imperfect competition. Concentration ratios are based on a national market and tend to understate market power in regional markets, while they tend to overstate market power in international markets. Concentration is measured differently for service industries than for manufacturing industries. In the case of service industries, the concentration ratio represents the share of receipts of the top four firms. In the case of manufacturing industries, the concentration ratio represents the share of shipments of the top four firms. For both groups of industries, our data are from the *1997 Economic Census*.

Figure 2.2 indicates that concentration is very low for almost all of the industries involved in the national *Biotechnology* cluster. In the group of eight core industries, 334517, *Irradiation Apparatus Manufacturing*, has the highest concentration ratio of 58.3. All other concentration ratios lie below 40. For the buyer and supplier industries, the result is the same. None of the related upstream or downstream industries has a four-firm concentration ratio as high as 40. (Note that data are not available for either 541940 or 55.)

Depending on the industry, efficient production takes place in different sized establishments. In some industries, large establishments are required for efficient (least-cost) production, in which case we say that there are significant economies of scale. Although there is no perfect measure of scale economies, we can get some idea of their presence by studying the distribution of establishment sizes for each of the 32 industries identified earlier. This breakdown by firm size is found in Figure A-5 in the Appendix (data are from *2001 County Business Patterns*). As a summary statistic in Figure 2.2, we include the share of establishments that have 100 or more employees.

**Figure 2.2 Concentration Ratio & Percentage of Large Establishments for Industries in the National Biotechnology Cluster**

<b>Industry</b>	<b>CR<sub>4</sub></b>	<b>No. Estabs.</b>	<b>Percent &gt;100 Emps.</b>
Testing Laboratories (541380)	12.1	4,452	19.1%
Research & Development in the Physical & Life Sciences (541710)	31.1	11,299	5.9%
Medical & Diagnostic Laboratories (6215)	28.2	11,026	2.3%
Pharmaceutical & Medicine Manufacturing (3254)	32.3	1,825	21.4%
Electromedical & Electrotherapeutic Apparatus (334510)	22.7	475	25.1%
Analytical Laboratory Instrument Manufacturing (334516)	33.6	595	13.8%
Irradiation Apparatus (334517)	58.3	160	16.9%
Medical Equipment & Supplies Manufacturing (3391)	16.3	12,151	4.8%
Veterinary Services (541940)	NA	25,000	0.1%
Ambulatory Health Care Services (621)	7.8	455,888	1.0%
Hospitals (622)	4.0	7,138	79.0%
Nursing & Residential Care Facilities (623)	13.3	65,088	13.7%
Textile Mills (313)	13.8	4,452	19.1%
Converted Paper Product Manufacturing (3222)	12.0	5,133	24.0%
Printing & Related Support Activities (3231)	9.6	37,895	4.0%
Basic Chemical Manufacturing (3251)	15.6	2,383	17.1%
Plastics & Rubber Products Manufacturing (326)	8.2	15,981	16.9%
Glass & Glass Product Manufacturing (3272)	31.0	2,348	13.7%
Fabricated Metal Product Manufacturing (332)	3.5	60,791	6.1%
Computer & Peripheral Equipment Manufacturing (3341)	37.0	1,916	12.3%
Semiconductor & Other Electronic Component Manufacturing (3344)	34.3	5,973	19.2%
Wholesale Trade (42)	6.2	438,924	2.0%
Miscellaneous Intermediation; Venture Capital (523910)	12.7	6,575	0.8%
Real Estate (531)	2.9	241,115	0.5%
Lessors of Nonfinancial Intangible Assets; Patent Services (533)	20.8	2,129	2.2%
Legal Services (5411)	1.8	176,771	0.6%
Computer Systems Design & Related Services (5415)	15.5	100,852	2.3%
Advertising & Related Services (5418)	10.3	39,290	1.8%
Other Professional, Scientific, & Technical Services (5419, exc. 541940)	12.1	38,640	0.9%
Management of Companies & Enterprises (55)	NA	47,559	11.3%
Administrative & Support Services (561, exc. 5613, 5615)	5.7	269,378	2.7%
Employment Services (5613)	10.5	44,896	19.6%

This statistic indicates that large establishment size is not the norm for the industries associated with the biotechnology cluster. Among the core research industries (541380, *Testing Laboratories*; 541710, *Research & Development in the Physical & Life Sciences*; and 6215, *Medical & Diagnostic Laboratories*), smaller establishments far outnumber larger plants. In 541710, only 5.9 percent of the establishments have 100 or more employees. In 6215, only 2.3 percent of establishments are this large. Except for 3391, *Medical Equipment & Supplies Manufacturing*, core biomedical manufacturing establishments tend to be somewhat larger. Twenty-one percent of pharmaceutical establishments have 100 or more employees, and 25.1 percent of establishments in 334510, *Electromedical & Electrotherapeutic Apparatus Manufacturing*, are that large. Among the buyers and manufacturing and service/infrastructure suppliers, small establishments are common. *Hospitals* (NAICS 622) are an exception, with almost 80 percent of establishments having at least 100 employees. Twenty-four percent of establishments in 3222, *Converted Paper Product Manufacturing*, have 100 or more employees, while large-plant shares lie below 20 percent for the remaining buyers and suppliers.

## Section 3 Description of the Cincinnati USA Biotechnology Cluster

In this section, we describe the *Biotechnology* cluster at the regional level. First, using six different measures of industrial strength, we evaluate each of the 32 industries, identified in Section 2 above, that play some role in the national *Biotechnology cluster*.<sup>15</sup> Second, we report on occupational strengths in the region that are relevant to biotechnology firms. Finally, since *County Business Pattern* data do not account for employees in public enterprises, we discuss several indications of public-sector strength in biotechnology in the Cincinnati USA region.

### Measures of Regional Strength

- Average Wages

To find average wages for 2001, we divide total national payroll by total national employment. Both statistics are found in *2001 County Business Patterns*. The total Cincinnati USA employment across all industries is 940,084 in 2001.

- Employment Base

We measure employment base as percent of MSA employment accounted for by a particular industry's employment in 2001. This statistic is based on *2001 County Business Patterns*, with some estimation based on an Economics Center algorithm.

- Export Industry

New money from outside the region can help facilitate economic development by way of impact multipliers. Some of the industries discussed in Section 2 qualify as export industries, while others do not.

- Location Quotient

Relative industrial specialization is measured by an industry's location quotient for 2001. It is computed by dividing an industry's employment base by the national employment base for the same industry. Again, it is based on *2001 County Business Patterns*. The total employment across industries in the United States in 2001 is 115,061,184.

- National Growth

National trends may indicate where there are opportunities to "catch a wave" that can help to boost the local economy. We measure national growth as percent change in employment at the national level between 1998 and 2001.

- Local Growth Less National Growth

If a cluster is exhibiting strong local growth relative to national growth, this shows either its ability to succeed in the face of an adverse national trend or its success

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<sup>15</sup> For this section, the Economics Center acknowledges the valuable research assistance provided by Connie Menefee, consultant to the Greater Cincinnati Chamber of Commerce, and Ke Chen, Ph.D. candidate in the Department of Geography, University of Cincinnati.

relative to a nationally growing industry. Our final measure is percentage change in local employment from 1998 to 2001 less the percentage change in national employment.

### **Core Strength**

Figure 3.1 depicts regional strength in the eight core industries identified in Section 2. In each of the eight core industries, average wages significantly exceed the overall average industrial wage of \$34,669 in 2001. Indeed, several of the core industries (541710, 3254, and 334517) have average wages exceeding \$60,000. Moreover, each of the eight industries may be considered an export industry, potentially serving the needs of buyers outside the Cincinnati USA region.

As of 2001, the employment base for each of the industries is low. The highest figure, 0.15, means that 0.15 percent of employees in Cincinnati USA work for pharmaceutical companies. Even fewer people, 0.13 percent of Cincinnati USA employees, work in 541710, *Research & Development in Physical, Engineering, & Life Sciences*. Location quotients are low as well. In 2001, only 541380, *Testing Laboratories*, had a location quotient higher than 1, indicating some regional industry specialization.

The growth figures, however, indicate positive movement in the region. Whereas the pharmaceutical industry (NAICS 3254) grew 7.55 percent between 1998 and 2001 in the nation as a whole, the Cincinnati USA region enjoyed 15.65 percent growth over that same time period. While the largest of the core research industries, *Research & Development in the Physical, Engineering, & Life Sciences* (NAICS 541710), grew 24.91 percent nationally, it grew at the incredible rate of 62.50 percent in the region. Whereas the smaller research core industries mimicked this trend, the smaller biomedical manufacturing industries did not (with the exception of 334516, *Analytical Laboratory Instrument Manufacturing*). The regional growth rate for 3391 was -14.27 percent, while the industry had positive growth nationwide.

### **Buyer Strength**

Figure 3.2 depicts regional *strength* in the four buyer industries identified in Section 2. These four industries (541940, *Veterinary Services*; 621, *Ambulatory Health Care Services*; 622, *Hospitals*; and 623, *Nursing & Residential Care Facilities*) are the primary outlets for the manufactured biomedical products. We first note that the average wages in the buyer industries are much lower than for the core biotechnology industries. Indeed, the average wage in 623, *Nursing & Residential Care Facilities*, is just over \$20,000. Average wages in *Veterinary Services* (NAICS 541940) are not much higher. All four buyer industries would be considered essentially local (though there are exceptions in the *Hospital* Industry such as Cincinnati Children's). In 2001, these four industries combined accounted for 10.79 percent of Cincinnati USA employment (out of 940,084 employees total).

Location quotients are all near 1, indicating that Cincinnati USA has approximately the same percent of employees in the industries as the nation as a whole. Growth figures show that Cincinnati USA has outpaced the nation (from 1998 to 2001) in *Veterinary Services* (NAICS 541940) and *Ambulatory Health Care Services* (NAICS 621), and has slightly trailed the nation in growth in *Hospitals* (NAICS 622) and *Nursing & Residential Care Facilities* (NAICS 623).

**Figure 3.1 2001 Biotechnology Core Industrial Strength in Cincinnati USA (NAICS codes in parentheses)**

<b>Industry</b>	<b>Average Wages</b>	<b>Employment Base</b>	<b>Export Industry</b>	<b>Location Quotient</b>	<b>National Growth</b>	<b>Local Growth</b>	<b>Local - National Growth</b>
Testing Laboratories (541380)	\$42,839	0.09 %	Export	1.06	9.37 %	18.31 %	8.94 %
R&D in Physical, Engineering, & Life Sciences (541710)	\$66,711	0.13 %	Export	0.44	24.91 %	62.50 %	37.59 %
Medical & Diagnostic Laboratories (6215)	\$44,418	0.07 %	Export	0.50	8.24 %	11.61 %	3.38 %
Pharmaceutical & Medicine Mfg (3254)	\$62,463	0.15 %	Export	0.75	7.55 %	15.65 %	8.10 %
Electromedical Apparatus Mfg (334510)	\$55,357	0.02 %	Export	0.48	-5.61 %	-31.38 %	-25.77 %
Analytical Laboratory Instrument Mfg (334516)	\$58,412	0.01 %	Export	0.49	-5.12 %	14.75 %	19.87 %
Irradiation Apparatus Mfg (334517)	\$65,992	0.00 %	Export	0.00	-3.49 %	-100.00 %	-96.51 %
Medical Equipment & Supplies Mfg (3391)	\$42,188	0.12 %	Export	0.44	2.88 %	-14.27 %	-17.15 %

**Figure 3.2 2001 Biomedical Product Buyer Industrial Strength in Cincinnati USA (NAICS codes in parentheses)**

<b>Industry</b>	<b>Average Wages</b>	<b>Employment Base</b>	<b>Export Industry</b>	<b>Location Quotient</b>	<b>National Growth</b>	<b>Local Growth</b>	<b>Local - National Growth</b>
Veterinary Services (541940)	\$22,809	0.19 %	Local	0.93	18.47 %	28.36 %	9.89 %
Ambulatory Health Care Services (621 exc. 6215)	\$41,145	3.84 %	Local	0.97	5.59 %	12.80 %	7.22 %
Hospitals (622)	\$35,576	4.16 %	Local	0.94	1.47 %	-0.28 %	-1.75 %
Nursing & Residential Care Facilities (623)	\$20,463	2.60 %	Local	1.12	6.38 %	3.98 %	-2.40 %

The main conclusion from the analysis in this section is that Cincinnati USA is positioned well in the “downstream” biotechnology cluster industries. Although an economic development strategy would not necessarily target the low-wage, local industries, it is important to note that the core biomedical manufacturing industries would have local-outlet strength for their products. (Currently, since the buyers are stronger than the core industries regionally, the former must be importing goods from outside the metropolitan area.)

### **Manufacturing Supplier Strength**

Figure 3.3 depicts regional strength in the nine important manufacturing supplier industries identified in Section 2. Recall that these industries are important suppliers to one or more of the following industry groups: the biotechnology research group; the biomedical manufacturing group; and the buyers of biomedical manufactured products.

Overall, the Cincinnati USA region appears to be positioned well in terms of being able to supply the manufactured-input needs of biotechnology firms. In Section 2 above, *Basic Chemical Manufacturing* (NAICS 3251) was identified as the single important shared manufacturing input to all three groups of industries. With average wages in 2001 of \$58,778 and a location quotient of 1.85, it is clearly an important current economic strength for Cincinnati USA. Moreover, while the nation lost 11.42 percent of employment in *Basic Chemicals* between 1998 and 2001, Cincinnati USA lost only 4.77 percent, hence beating the national loss by 6.64 percentage points. Purchases of 326, *Plastics & Rubber Products Manufacturing*, are very important to biomedical manufacturing firms and buyer industries, and somewhat important to biotechnology research firms as well. Again, Cincinnati USA is well-positioned (though this industry has significantly lower average wages than *Basic Chemicals*). Its location quotient is 1.18, and Cincinnati’s growth rate exceeded the national growth rate by 2.51 percentage points between 1998 and 2001. Location quotients for *Converted Paper Product Manufacturing* (NAICS 3222), *Printing & Related Support Activities* (NAICS 3231), and *Fabricated Metal Product Manufacturing* (NAICS 332) all exceed 1, indicating significant local specialization in many of the material needs of the core biotechnology industries. These strengths mean that core industries locating in the Cincinnati USA region would be able to get the majority of their manufactured inputs locally rather than have to import them from outside the region.

Although a relatively low-wage industry, the *Glass & Glass Product Manufacturing Industry* (NAICS 3272) is particularly important to biotechnology. With approximately seven percent of the biotechnology research core industries’ input-purchase budget devoted to glass products, it might be prudent to consider improving the Cincinnati region’s presence in this important biotechnology input industry.

Several of the industries in this section are industries recommended in the nine other clusters (besides *Biotechnology*) identified in the 2004 Economics Center report *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*.

- 3341 and 3344 are included in *Digital Equipment & Telecommunications*.
- 3341 is also included in *Software & Data Processing*.
- 332 is included in *Advanced Manufacturing* (and could be included in *Motor Vehicle Manufacturing* as well).
- 3251 and 326 are included in *Chemicals & Plastics*.

**Figure 3.3 2001 Manufacturing Supplier Industrial Strength in Cincinnati USA (NAICS codes in parentheses)**

<b>Industry</b>	<b>Average Wages</b>	<b>Employment Base</b>	<b>Export Industry</b>	<b>Location Quotient</b>	<b>National Growth</b>	<b>Local Growth</b>	<b>Local - National Growth</b>
Textile Mills (313)	\$27,239	0.10 %	Export	0.37	-19.97 %	16.44 %	36.40 %
Converted Paper Product Mfg (3222)	\$36,632	0.62 %	Export	1.98	-4.48 %	-0.56 %	3.92 %
Printing & Rel. Support Activities (3231)	\$34,481	1.01 %	Export	1.48	-7.16 %	-9.76 %	-2.60 %
Basic Chemical Mfg (3251)	\$58,778	0.29 %	Export	1.85	-11.42 %	-4.77 %	6.64 %
Plastics & Rubber Products Mfg (326)	\$32,560	1.03 %	Export	1.18	-2.71 %	-0.20 %	2.51 %
Glass & Glass Product Mfg (3272)	\$37,137	0.05 %	Export	0.47	-3.46 %	4.56 %	8.02 %
Fabricated Metal Product Mfg (332)	\$34,944	2.03 %	Export	1.35	-2.74 %	5.60 %	8.34 %
Computer & Peripheral Eqpt. Mfg (3341)	\$56,965	0.00 %	Export	0.01	-17.90 %	81.82 %	99.72 %
Semiconductor & Elec. Component Mfg (3344)	\$46,915	0.17 %	Export	0.33	2.57 %	14.63 %	12.05 %

Economic development efforts focused on these industries would potentially benefit more than a single cluster.

### **Service/Infrastructure Supplier Strength**

Figure 3.4 depicts regional strength in the eleven important service/infrastructure supplier industries identified in the national analysis in Section 2. Note the heterogeneity with respect to average wages and whether the industry is considered export or local. Altogether, 19.75 percent of Cincinnati USA employment occurred in one of these eleven industries in 2001. Strong local specialization (high location quotient) is found in *Wholesale Trade* (NAICS 42), *Advertising & Related Services* (NAICS 5418), *Management of Companies & Enterprises* (NAICS 55), and *Other Professional, Scientific, & Technical Services* (NAICS 5419). Disturbingly, however, the latter two industries have declined during the period 1998 to 2001, while they grew at the national level. The difference between the local growth rate and the national growth rate is -14.71 percentage points for 55 and -30.72 percentage points for 5419. These two industries, with relatively high-paying jobs, should be watched carefully in future economic development efforts. On the other hand, *Wholesale Trade* (NAICS 42) has grown faster regionally than nationally.

The most disturbing statistics in Figure 3.4 relate to industry 523910, *Miscellaneous Intermediation*. Venture capital companies are included within this NAICS industry (along with investment clubs, mineral royalties or leasing dealing, and tax liens dealing). With average wages of \$87,728 in 2001, this industry has a lot to offer the region economically. Currently, however, with a location quotient of 0.29, it seems to have a very weak presence regionally. Furthermore, with a national growth rate of 53.39 percent between 1998 and 1991, Cincinnati USA lagged behind with a growth rate of only 24 percent. With venture capital so very important to start-up firms in the biotechnology cluster, this industry requires serious immediate targeting for the Cincinnati USA region.<sup>16</sup>

Several of the industries in Figure 3.4 are industries recommended in the nine other clusters (besides *Biotechnology*) identified in the 2004 Economics Center report *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*.

- 5415 is included in *Software & Data Processing* as well as in *Advanced Design Services*.
- 5418 and 55 are included in the *Business Management* cluster.
- 523910 is included in *Financial Services*.

### **Public Sector Strength in Biotechnology**

The University of Cincinnati received 256 awards from the National Institutes of Health (NIH) in 2003, totaling \$96.1 million in grant funding. Because of its source, most of this funding could be considered biotechnology-related. The University of Cincinnati ranked 59<sup>th</sup> among all institutions receiving NIH funding. (The Ohio State University ranked 54<sup>th</sup>.) In addition, with 972 patents, the Cincinnati USA region ranks 10<sup>th</sup> among metropolitan areas for biotechnology-related patents for the decade of the 1990s.

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<sup>16</sup> An article in the *Cincinnati Enquirer*, dated July 28, 2004, mentioned that Ohio ranked 29<sup>th</sup> out of 43 states that received venture capital in the first six months of 2004. Kentucky ranked 21<sup>st</sup> with \$52.5 million in venture capital, largely due to Xanodyne Pharmaceuticals in Florence that received \$20 million in June 2004 and Trilogy Health Services of Louisville that took \$26 million.

**Figure 3.4 2001 Service/Infrastructure Supplier Industrial Strength in Cincinnati USA**

<b>Industry</b>	<b>Average Wages</b>	<b>Employment Base</b>	<b>Export Industry</b>	<b>Location Quotient</b>	<b>National Growth</b>	<b>Local Growth</b>	<b>Local - National Growth</b>
Wholesale Trade (42)	\$44,919	6.55 %	Export	1.23	4.37 %	11.70 %	7.33 %
Misc. Intermediation (523910)	\$87,728	0.01 %	Export	0.29	53.39 %	24.00 %	-29.39 %
Real Estate (531)	\$33,268	0.93 %	Local	0.80	11.51 %	14.17 %	2.65 %
Lessors of Intangible Assets (533)	\$63,172	0.02 %	Export	1.01	13.59 %	100.95 %	87.36 %
Legal Services (5411)	\$60,563	0.72 %	Local	0.75	5.80 %	3.66 %	-2.14 %
Computer Sys. Design (5415)	\$67,481	0.98 %	Export	0.90	43.69 %	22.87 %	-20.82 %
Advertising (5418)	\$47,964	0.45 %	Export	1.10	7.80 %	8.80 %	1.00 %
Professional, Svs. (5419, exc. 541940)	\$52,989	0.43 %	Export	1.77	18.08 %	-12.64 %	-30.72 %
Mgmt. of Cos. & Enterprises (55)	\$74,021	3.21 %	Local	1.28	6.49 %	-8.22 %	-14.71 %
Admin. Svs. (561, exc. 5613, 5615)	\$24,271	3.19 %	Local	0.90	14.24 %	9.79 %	-4.45 %
Employment Svs. (5613)	\$23,129	3.26 %	Local	0.86	20.74 %	1.26 %	-19.48 %

## The Geography of Biotechnology in Cincinnati USA

In this subsection, we rely on data quite distinct from the *2001 County Business Patterns* data used in the rest of Section 3. We work with a list of 220 enterprises currently involved in biotechnology in the Cincinnati USA fifteen-county region.<sup>17</sup> These enterprises include private employers as well as public and non-profit entities involved in the *Biotechnology* cluster. In this way, we are able to capture specifically University of Cincinnati Medical Center and federal (FDA and EPA) employment in the biotechnology sector of the regional economy.

We map the geographic locations of these 220 enterprises which are classified in one of the following categories:

- as core biotechnology research enterprises (56 in total);
- as core biomedical manufacturing enterprises (58 in total);
- as manufacturing suppliers (9);
- as service/infrastructure suppliers (86); or
- as secondary buyers of biotechnology research (11 in total).

Figure 3.5 is a map of the entire fifteen-county region. Figure 3.6 is a close-up of the region's center. Biomedical-product buyers (*Veterinary Services, Ambulatory Health Care Services, Hospitals, and Nursing & Residential Care Facilities*) are not shown on the maps in Figures 3.5 and 3.6.

The core research enterprises are fairly concentrated in the center of the metropolitan area. The core biomedical manufacturing firms are somewhat more spread out, along a corridor running from the southwest to the northeast areas of the region. There are fewer in the heart of the metropolitan area, and more outside the I-275 loop. The geography of the service/infrastructure enterprises mimics the centralization of research, while the manufacturing suppliers are geographically more spread out, similarly to the biomedical manufacturing firms themselves.

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<sup>17</sup> This list of enterprises is available from the Greater Cincinnati Chamber of Commerce. It was supplied to the Economics Center from the Chamber for the purposes of writing this industrial profile.

Figure 3.5  
**Biotechnology Enterprises in Cincinnati USA**

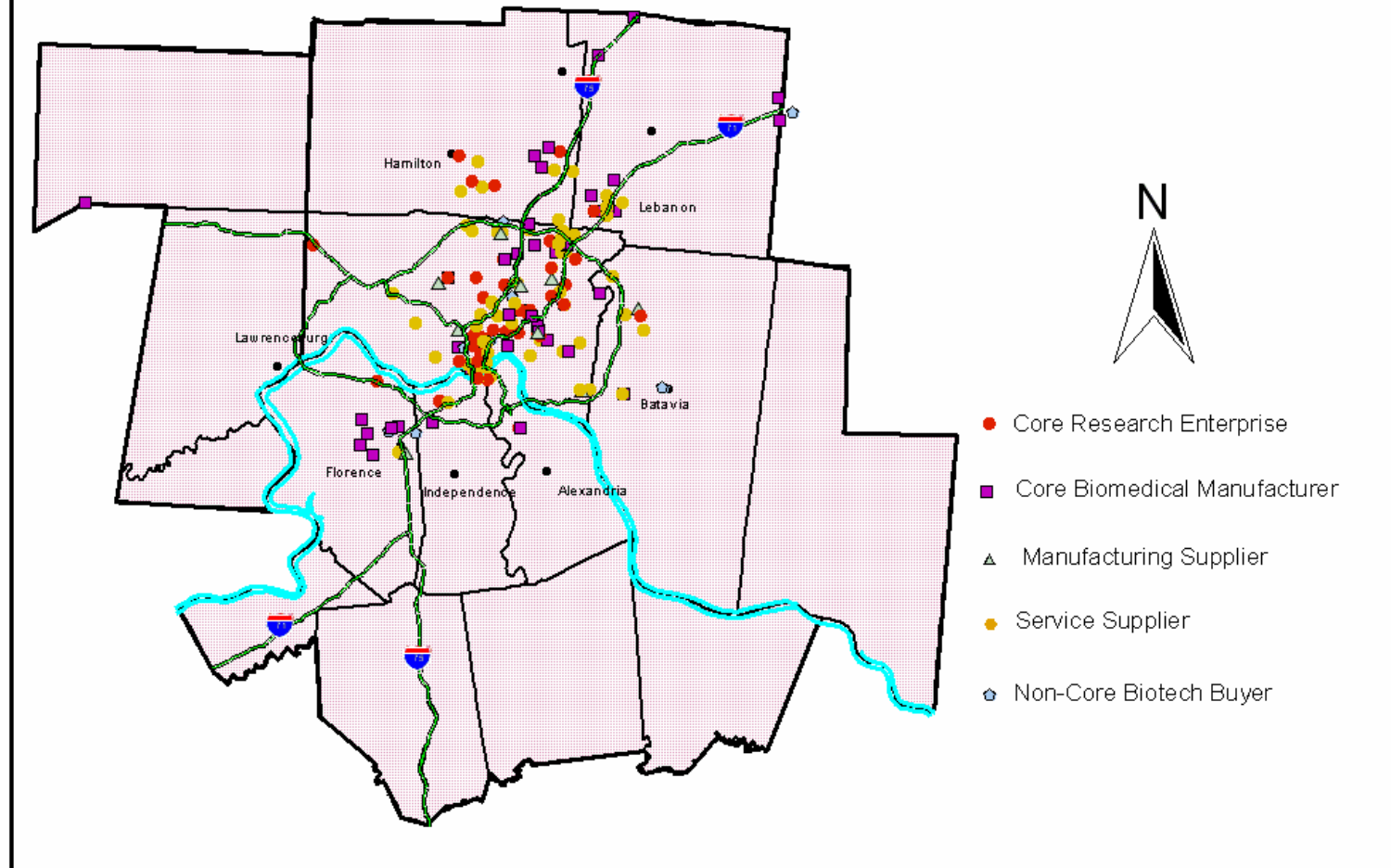
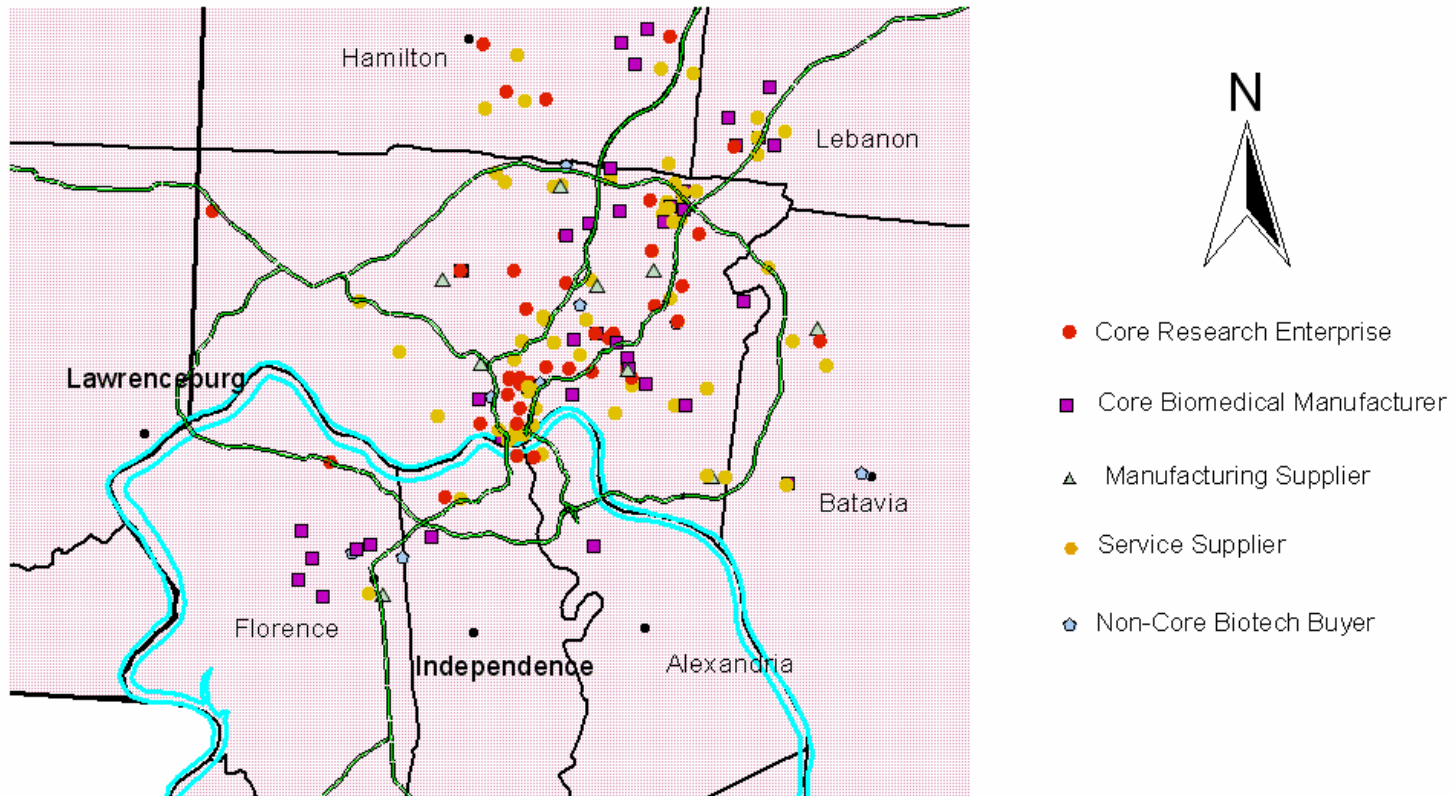


Figure 3.6  
**Biotechnology Enterprises in Cincinnati USA**



## Biotechnology Occupations in Cincinnati USA

Here, we describe the occupations required for the core biotechnology industries identified in Section 2. We do so for the Cincinnati USA region in 2001, hence the omission of industry 334517, *Irradiation Apparatus Manufacturing*, which had no regional employees in 2001. The employment data estimated in Figure 3.7 are derived using the *2002 National Industry-Occupation Employment Matrix* (NIOEM), which shows the employment in the 24 occupation groups (and hundreds of even more detailed occupations) for each industry. The NIOEM is applied to employment-by-industry data for the Cincinnati MSA to estimate 2001 employment by occupation for the metropolitan area.<sup>18</sup>

The core research industries (541380, 541710, and 6215) rely heavily on *computer & mathematical science* occupations, *architecture & engineering* occupations (especially in 541380, *Testing Laboratories*), and *life science & physical science* occupations. *Medical & Diagnostic Laboratories* (NAICS 6215) also has an estimated 263 employees who hold *healthcare practitioner or technical* occupations. A similar heavy emphasis on the former three occupation classes is found in the core biomedical manufacturing industries. Whereas 3254, *Pharmaceutical & Medicine Manufacturing*, has 366 employees in these three occupational categories, the smaller manufacturing industries (334510, 334516, and 3391) have together 199 employees accounted for by these three occupational classes. All seven of the industries employ significant numbers of individuals who hold *office & administrative support* occupations. Both 3254, *Pharmaceutical & Medicine Manufacturing*, and 3391, *Medical Equipment & Supplies Manufacturing*, employ significant numbers of production workers in Cincinnati USA. Altogether, the 5555 employees in the core biotechnology industries make up approximately 0.6% of the Cincinnati USA workforce.<sup>19</sup>

For six of the occupational categories in Figure 3.7, employment in the core biotechnology industries exceeds one percent of the total employment of that category:

- 1.4% of employees with *computer & mathematical science* occupations are employed in core biotechnology industries.
- 4.5% of employees in *architecture & engineering* occupations are employed in core biotechnology industries.
- 5.6% of employees in *life science & physical science* occupations are employed in core biotechnology industries.
- 2.5% of employees in *social scientist & related* occupations are employed in core biotechnology industries.
- 9.9% of employees in *life, physical, & social science technician* occupations are employed in core biotechnology industries.
- 1.2% of employees with *production* occupations are employed in core biotechnology industries.

Occupation location quotients may be found for most of the occupation classes in the Economics Center's May 2004 report. They are reproduced in Figure 3.8 for the six classes just identified.

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<sup>18</sup> Advantages to using this estimation approach are discussed in the Economic Center's 2004 report, *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*.

<sup>19</sup> Neither this total of 5555 nor the individual industry totals match exactly the employment statistics from the *2001 County Business Patterns*. The estimate for total core biotechnology employment from the latter data source is 5663.

**Figure 3.7 Occupational Breakdown of Core Biotechnology Industries in Cincinnati USA**

Occupation Class	Biotechnology Core Industry							
	Testing Labs. (541380)	R & D (541710)	Med. Labs. (6215)	Drugs (3254)	Electro. Appar. (334510)	Lab. Instrus. (334516)	Med. Eqpt. (3391)	Total
Management Occupations	90	155	42	166	20	14	73	560
Business & Financial Operations Occupations	32	115	11	88	12	9	33	300
Computer & Mathematical Science Occupations	43	143	10	48	16	11	16	287
Architecture & Engineering Occupations	411	176	1	63	46	33	63	793
Life Science & Physical Science Occupations	26	139	10	160	1	2	4	361
Social Scientists & Related Occupations	5	34	1	7	1	0	3	49
Life, Physical, & Social Science Technicians	15	81	7	88	0	0	3	195
Community & Social Services Occupations	0	9	0	1	0	0	0	10
Legal Occupations	1	4	0	4	0	0	1	10
Education, Training, & Library Occupations	1	18	0	1	0	0	0	20
Art & Design Occupations	14	9	0	2	1	0	3	29
Media & Communication Occupations	4	13	1	5	1	1	2	27
Healthcare Practitioners & Technical Occupations	3	33	263	13	0	0	11	323
Protective Service Occupations	1	6	0	4	1	0	1	13
Food Preparation & Serving Related Occupations	0	1	0	0	0	0	0	1
Building & Grounds Cleaning & Mainten. Occs.	13	8	2	15	1	1	7	47
Personal Care & Service Occupations	0	0	0	1	0	0	0	1
Sales & Related Occupations	8	24	11	40	6	4	34	127
Office & Administrative Support Occupations	115	191	208	177	24	17	150	882
Farming, Fishing & Forestry Occupations	1	3	0	1	0	0	0	5
Construction & Extraction Occupations	26	7	0	7	1	1	1	43
Installation, Maintenance, & Repair Occupations	13	18	2	65	6	4	22	130
Production Occupations	26	39	3	414	59	41	619	1201
Transportation & Material Moving Occupations	6	10	14	51	2	2	55	140
<b>Total</b>	<b>872</b>	<b>1235</b>	<b>588</b>	<b>1421</b>	<b>199</b>	<b>141</b>	<b>1100</b>	<b>5555</b>

**Figure 3.8 Occupation Location Quotients for Selected Occupation Classes**

Occupation Class	Occupation Location Quotient
Computer & Mathematical Science Occupations	1.05
Architecture & Engineering Occupations	1.06
Life Science & Physical Science Occupations	0.78
Social Scientists & Related Occupations	
Life, Physical, & Social Science Technicians	
Production Occupations	1.33

Similar to an industrial location quotient, an occupation location quotient is the share of regional employees in a given occupation class divided by the share of national employees in the same occupation class. Figure 3.8 depicts regional specialization in three of the occupation classes. Cincinnati USA is above the national average in individuals with *computer & mathematical science* occupations; *architecture & engineering* occupations; and *production* occupations. On the other hand, the region is below the national average in the proportion of individuals holding *life science*, *physical science*, or *social science* occupations. Since these are three of the occupation classes that work heavily in the biotechnology industries, the relatively low location quotient may indicate difficulty of biotechnology firms to obtain workers locally in these three groups of occupations.

According to the *Technology Workforce Assessment of Cincinnati USA* (2003, Cypress Research Group), surveyed biotechnology companies reported the greatest difficulty in recruiting regulatory professionals, ICT (information/communication technology) professionals (especially technical sales representatives, technical support representatives, and programmers/developers), data management/bioinformatics specialists, microbiology technicians, and clinical science researchers. As a percent of the current workforce, bioscience firms anticipated 14-percent open positions for 2003.

## Section 4 Cross-Regional Biotechnology Cluster Industry Comparison

In this section, we compare the Cincinnati USA employment and location quotients with those for six other metropolitan statistical areas (MSAs)/consolidated metropolitan statistical areas (CMSAs):

- San Diego CA MSA
- Raleigh-Durham-Chapel Hill, NC MSA
- Seattle-Tacoma-Bremerton, WA CMSA
- Cleveland-Akron, OH CMSA
- Columbus, OH MSA
- Indianapolis IN MSA

The first three areas are identified as *successful biotechnology centers* by the 2002 Brookings Institution Report, *Signs of Life: The Growth of Biotechnology Centers in the U.S.* The second group of MSAs (Cleveland, Columbus, and Indianapolis) are referred to as “median metropolitan areas” in the Brookings report and are within the same general geographic region as the Cincinnati USA area.<sup>20</sup> By making a comparison with the successful centers, we will shed light on the importance (or lack thereof) of geographic proximity of key suppliers to core biotechnology research firms or core biomedical manufacturing firms. By making a comparison with nearby metropolitan areas, we see weaknesses and strengths relative to midwestern cities that are situated similarly with respect to the growing biotechnology sector. In this section, we do not compare metropolitan areas with respect to the four primary buyer industries.<sup>21</sup>

### Biotechnology Patents and Research Funding

Figure 4.1 compares the Cincinnati-Hamilton, OH-KY-IN CMSA with fourteen other metropolitan areas in terms of the number of biotechnology-related patents received during the 1990s. Cincinnati ranks **10<sup>th</sup>** in the number of biotechnology-related patents, ahead of two of the three successful biotechnology centers used for comparison in this report (Raleigh and Seattle). Based on population, Cincinnati ranks **7<sup>th</sup>**. Raleigh moves up to the top position, but Cincinnati passes New York, Washington, Chicago, and Los Angeles.

Figure 4.2 compares institutions in the Cincinnati-Hamilton, OH-KY-IN CMSA with other top-100 NIH-funded institutions that are located in the comparison regions or nearby. Cincinnati USA has two institutions in the top 100. The University of Cincinnati ranks 59<sup>th</sup> in NIH funding, while Cincinnati Children’s Hospital Medical Center ranks 81<sup>st</sup>. Together, they received \$167 million from the NIH in 2003. This rank causes Children’s to rank **3<sup>rd</sup>** in funding among all children’s hospitals, after Children’s Hospital in Boston and Children’s Hospital of Philadelphia, but ahead of St. Jude Children’s Research Hospital. The three San Diego institutions received together over \$900 million from the NIH in 2003, while the two in the Seattle-Tacoma-Bremerton, WA CMSA were awarded close to \$650 million. The University of North Carolina - Chapel Hill in the Raleigh-Durham-Chapel Hill, NC MSA

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<sup>20</sup> Louisville is identified in the Brookings report as a metropolitan area with “no significant biotech research or commercialization.”

<sup>21</sup> In looking at buyer industries, we did not come up with sufficiently interesting results to warrant reporting on them. Each of the seven metropolitan areas was served to some reasonable degree by the four buyer industries: *Hospitals, Nursing and Residential Care Facilities, Ambulatory Health Care Services, and Veterinary Services.*

**Figure 4.1 Top Fifteen Metropolitan Areas for Biotechnology Related Patents, 1990-1999**

Metropolitan Area	Number of Patents, 1990-1999	Metropolitan Area Rank by	
		Number of Patents	Patents/100,000 pop.
New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSA	6,800	1	8
San Francisco-Oakland-San Jose, CA CMSA	3,991	2	4
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD CMSA	3,214	3	5
Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	3,007	4	6
Washington-Baltimore, DC-MD-VA-WV CMSA	2,162	5	10
San Diego, CA MSA	1,632	6	3
Chicago-Gary-Kenosha, IL-IN-WI CMSA	1,444	7	12
Los Angeles-Riverside-Orange County, CA CMSA	1,399	8	15
Indianapolis, IN MSA	1,036	9	2
<b>Cincinnati-Hamilton, OH-KY-IN CMSA</b>	<b>972</b>	<b>10</b>	<b>7</b>
Raleigh-Durham-Chapel Hill, NC MSA	796	11	1
St. Louis, MO-IL MSA	780	12	9
Seattle-Tacoma-Bremerton, WA CMSA	770	13	11
Detroit-Ann Arbor-Flint, MI CMSA	655	14	14
Houston-Galveston-Brazoria, TX CMSA	634	15	13

Source: 2002 Brookings Institution Report, *Signs of Life: The Growth of Biotechnology Centers in the U.S.*

**Figure 4.2 National Institutes of Health Awards to Selected Institutions Fiscal Year 2003**

Institution	NIH Rank	MSA/CMSA	Number of Awards	Amount in \$millions
Science Applications International Corp.	5	San Diego	3	417.4
University of California San Diego	15	San Diego	625	288.5
Scripps Research Institute	27	San Diego	457	206.0
University of North Carolina Chapel Hill	18	Raleigh	722	271.0
University of Washington	2	Seattle	1,002	440.9
Fred Hutchinson Cancer Research Ctr.	26	Seattle	236	207.4
<b>University of Cincinnati</b>	<b>59</b>	<b>Cincinnati</b>	<b>256</b>	<b>96.1</b>
<b>Cincinnati Children's Hosp. Med. Ctr.</b>	<b>81</b>	<b>Cincinnati</b>	<b>192</b>	<b>70.9</b>
Case Western Reserve University	24	Cleveland	598	225.2
Ohio State University	54	Columbus	332	107.9
Battelle Memorial Institute	99	Columbus	12	51.7
University of Kentucky	74	Lexington	258	76.2
Indiana University	48	Bloomington	396	128.8

Source: <http://grants.nih.gov/grants/award/trends/rnk03all1to100.html>

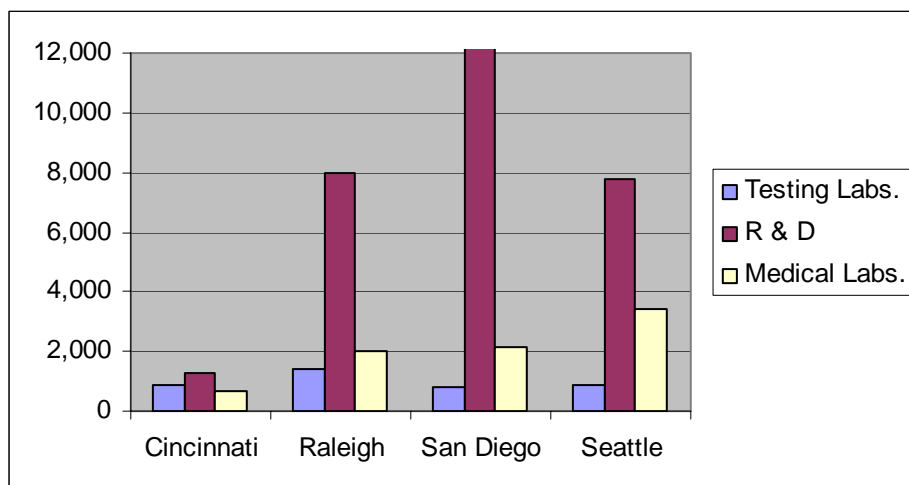
received \$271 million in 2003. Case Western Reserve University in Cleveland, at rank 24, was awarded \$225 million in funding from the NIH in 2003. Approximately \$160 million went to two institutions -- the Ohio State University and the Battelle Memorial Institute -- in the Columbus, OH MSA.

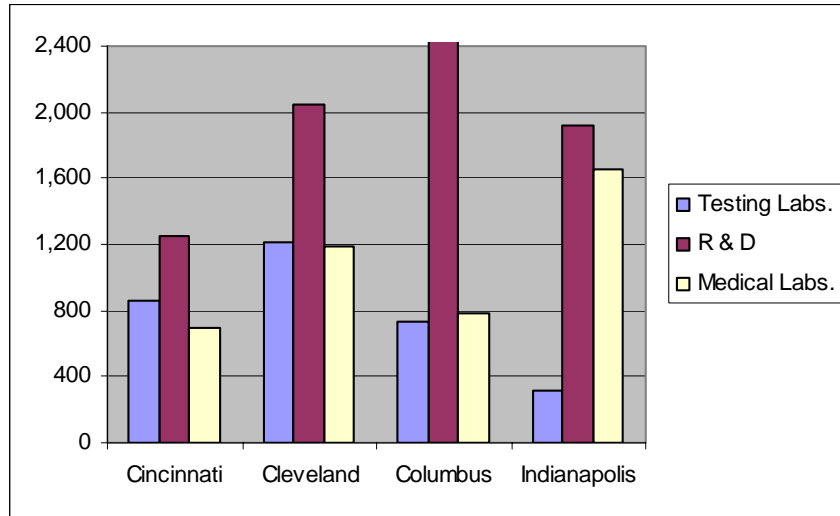
### Employment in Core Biotechnology Research Industries

According to the *2001 County Business Patterns* data, the San Diego MSA had 26,391 employees in core biotechnology research industries in 2001, including 23,468 in the largest of the industries, *Research & Development in the Physical & Life Sciences* (NAICS 541710). According to the same source, Cincinnati's employment across the three industries was 2,793, approximately one tenth of the "person power." The other successful biotechnology centers --- Raleigh and Seattle --- had, respectively, 11,399 and 12,117 employees in core biotechnology research industries. Location quotients indicate that San Diego and Seattle have specialization in both 541710, *Research & Development in the Physical & Life Sciences*, and 6215, *Medical & Diagnostic Laboratories*, while Raleigh specializes in all three of the core research industries, including 541380, *Testing Laboratories*. Figure A-6, in the Appendix to this report, depicts employment and location quotients for the three core research industries for seven metropolitan statistical areas. Figure 4.3 charts the results. Compared to the three successful biotechnology centers, Cincinnati is comparable in the two laboratory industries, but it lags considerably in private R&D industry employment.

In comparing the Cincinnati USA situation with that of nearby metropolitan areas, Figures A-6 and 4.3 show that while the Cincinnati USA area is slightly specialized in 541380, *Testing Laboratories*, the Cleveland area has *no* specialization in any of the three industries. The Columbus area is specialized in both 541380, *Testing Laboratories*, and 541710, *Research & Development in the Physical & Life Sciences*, and had 5,262 (about two times the number in the Cincinnati USA area) employees across all three industries in 2001. Indianapolis, with 3,889 employees across the three industries, has a specialization in 6215, *Medical & Diagnostic Laboratories*. Compared to the three midwestern metropolitan areas, Cincinnati is comparable in the two laboratory industries. In private R&D industry employment, it is comparable to Cleveland and Indianapolis, but it lags behind Columbus.

**Figure 4.3 Summary of Core Biotechnology Research Industry Comparison**





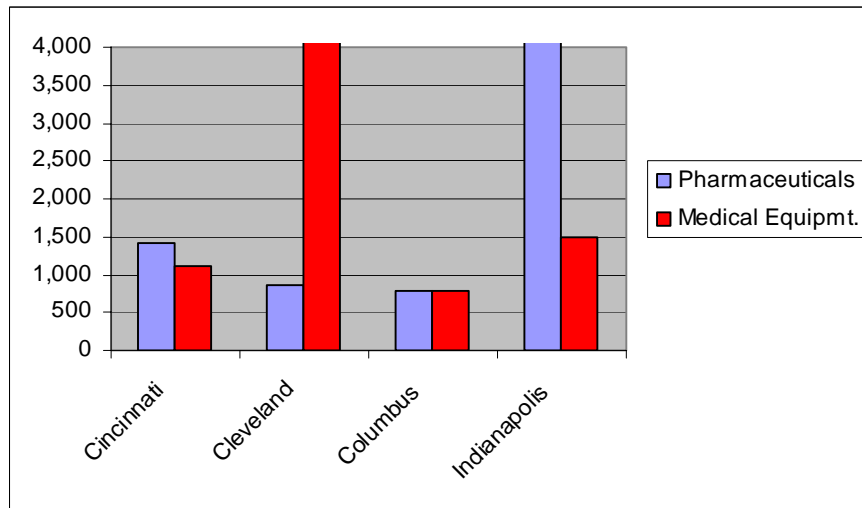
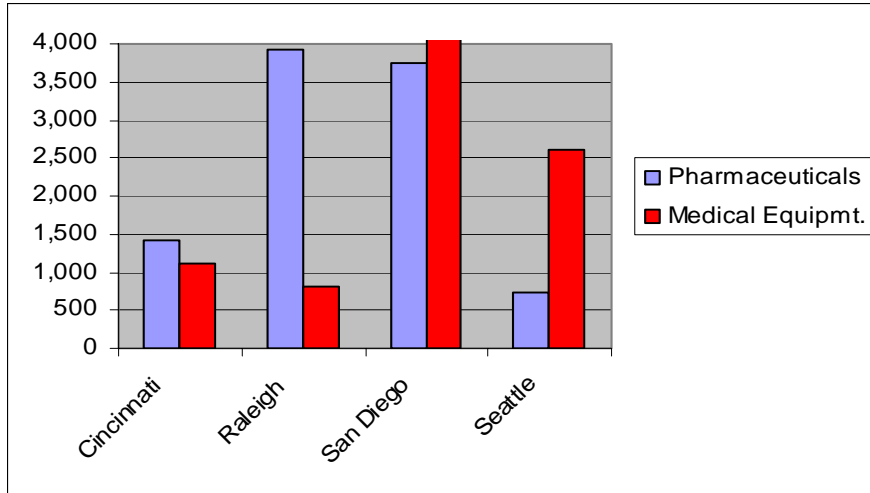
### Employment in Core Biomedical Manufacturing Industries

In the Appendix, Figure A-7 compares the Cincinnati USA region to the same six metropolitan areas with respect to employment in biomedical manufacturing. Whereas Cincinnati USA had 2,870 employees across the five biomedical manufacturing industries identified in Section 2, the Columbus area had only 1,760. Cleveland, on the other hand, had 6,587. With almost 800 employees in 334517, *Irradiation Apparatus Manufacturing*, Cleveland had a location quotient of 6.56, indicating a strong competitive advantage in this particular industry. Moreover, with 4,866 employees in 3391, *Medical Equipment & Supplies Manufacturing*, Cleveland had a location quotient of 1.68. Meanwhile, Indianapolis had 7,500 employees in 3254, *Pharmaceutical & Medicine Manufacturing*, giving it an impressive location quotient of 4.54 for the pharmaceutical industry.

The successful biotechnology centers (the Raleigh, San Diego, and Seattle metropolitan areas) turn out *not* to be successful across the board as far as biomedical manufacturing industries are concerned. San Diego comes the closest with 11,900 employees in the five identified industries. Four out of five of San Diego's location quotients lie above 1. Raleigh, with 4,828 employees in biomedical manufacturing, has high specialization only in 3254, *Pharmaceutical & Medicine Manufacturing*. Seattle, with 7,246 employees in the five biomedical manufacturing industries, is quite specialized in 334510, *Electromedical & Electrotherapeutic Apparatus Manufacturing*. Its location quotient is 6.65.

Figure 4.4 summarizes these comparisons for 3254, *Pharmaceutical & Medicine Manufacturing*, and 3391, *Medical Equipment & Supplies Manufacturing*.

**Figure 4.4 Summary of Core Biomedical Manufacturing Industry Comparison**



In *Pharmaceutical & Medicine Manufacturing*, Cincinnati is comparable to Seattle, but it lags behind Raleigh and San Diego. In *Medical Equipment & Supplies Manufacturing*, Cincinnati is comparable to Raleigh and Seattle, but lags behind San Diego. Overall, Cincinnati is stronger than Columbus in both industries. Cleveland is stronger in medical equipment, while Indianapolis is stronger in pharmaceuticals.

### **Employment in Manufacturing Supplier Industries**

From Figure A-8 (again, in the Appendix) it appears *not* to be the case that successful biotechnology centers require high concentration of key manufacturing suppliers to biotechnology (with two exceptions noted below). In fact, for 3222, *Converted Paper Product Manufacturing*, 3231, *Printing & Related Support Activities*, 3251, *Basic Chemicals*, 326, *Plastics & Rubber Products Manufacturing*, and 332, *Fabricated Metal Product Manufacturing*, none of the three centers has a location quotient exceeding 1. Indeed, some of the location quotients are quite low.

The two manufacturing suppliers that are specialized in the successful biotechnology centers are 3341, *Computer & Peripheral Equipment Manufacturing*, and 3344, *Semiconductor & Other Electronic Component Manufacturing*. In these two high-technology industries, Raleigh employed 11,970 people in 2001. San Diego employed 16,193, and Seattle employed 7,773. All three centers are specialized in computer manufacturing, while Raleigh and San Diego are specialized as well in semiconductor manufacturing. On the other hand, none of the four midwestern metropolitan areas was specialized in either of these industries. The midwestern areas do enjoy specializations in some of the other industries: Cincinnati in 3222, *Converted Paper Product Manufacturing*, and 3251, *Basic Chemicals*; Cleveland in 3251, *Basic Chemicals*, 326, *Plastics*, and 332, *Fabricated Metal Products*; and Columbus and Indianapolis in 3272, *Glass & Glass Products*.

### **Employment in Service/Infrastructure Supplier Industries**

Finally, we compare employment in and location quotients for the eleven buyer/infrastructure industries identified in Section 2 as important support industries for the core biotechnology research and manufacturing industries. Figure A-9, found in the Appendix, once again points out the weak location quotient for Cincinnati's venture capital industry. The statistic of 0.29 means that the Cincinnati USA area has only 29 percent as much employment concentration in 523910, *Miscellaneous Intermediation*, as the nation as a whole. For each of the other service industries, there are no big apparent problems. In fact, for 42, *Wholesale Trade*, 55, *Management of Companies & Enterprises*, and 5419, *Other Professional, Scientific, & Technical Services*, Cincinnati's employment and location quotients are quite strong. In these three industries alone, Cincinnati employed 95,825 people in 2001. In comparing Cincinnati to the nearby metropolitan areas, Cleveland and Indianapolis appear similarly situated with respect to biotechnology service and infrastructure, while Columbus appears to be in considerably better shape with respect to venture capital (NAICS 523910), though in worse shape with respect to 5419, *Other Professional, Scientific, & Technical Services*.

In comparing the Cincinnati USA region with the three successful biotechnology centers in Figure A-9, we make the following observations. All three centers are considerably stronger than the midwestern regions with respect to 5415, *Computer Systems Design & Related Services*. This observation combined with the information from Figure 4.7 that the three areas are strong as well in 3341, *Computer & Peripheral Equipment*, leads to a correlation (not necessarily a causality relationship, though) between strength in biotechnology and strength in digital equipment and/or design. Raleigh had 17,500 employees in 5415 in 2001, giving it a location quotient of 2.61. San Diego, with 17,280 employees in 5415, had a location quotient of 1.46. Finally, Seattle's location quotient of 1.59 accompanied employment of 22,506. Both Raleigh and San Diego show considerable strength in patent offices, or 533, *Lessors of Nonfinancial Intangible Assets*. Seattle shows considerable strength in venture capital, that is, 523910, *Miscellaneous Intermediation*. *Real Estate* (NAICS 531) is a specialization of both San Diego and Seattle, while Raleigh's location quotient shows concentration close to the national average. 5613, *Employment Services*, is not highly concentrated in any of the biotechnology centers, suggesting that a strong presence is *not* necessary for success of the core biotechnology industries.

## Appendix

**Figure A-1 National Intra-Core Industrial Linkages**

Transaction	Biomedical Manufacturing Industry				
	Pharmaceuticals (3254)	Electromed. Apparatus (334510)	Laboratory Instruments (334516)	Irradiation Apparatus (334517)	Medical Equipment (3391)
Sales of R&D in \$millions	1,616	83	58	22	382
% of R & D's Sales	4.98 %	0.26 %	0.18 %	0.07 %	1.18 %
% of Buyer's Purchases	3.10 %	1.21 %	1.31 %	0.86 %	1.82 %

**Figure A-2 National Buyer Linkages**  
(share of seller sales in parentheses; share of buyer purchases in brackets)

Biomedical Manufacturing Industry	Buyer Industry			
	Veterinary Services 541940	Ambulatory Health Care (621)	Hospitals (622)	Nursing & Res. Care (623)
Pharmaceuticals (3254)	\$1,441 million (4.65 %) [21.18 %]	\$4,142 million (13.36 %) [3.47 %]	\$7,131 million (23.00 %) [5.93 %]	\$659 million (2.13 %) [1.89 %]
Electromed. Apparatus (334510)	\$7 million (0.47 %) [0.10 %]	\$489 million (32.93 %) [0.41 %]	\$634 million (42.69 %) [0.53 %]	\$13 million (0.88 %) [0.04 %]
Laboratory Instruments (334516)	\$1 million (0.09 %) [0.01 %]	\$244 million (21.37 %) [0.20 %]	\$5 million * (0.44 %) [<0.01 %]	\$1 million * (0.09 %) [<0.01 %]
Irradiation Apparatus (334517)	\$0 million (0.00 %) [0.00 %]	\$465 million (85.32 %) [0.39 %]	\$5 million * (0.92 %) [<0.01 %]	\$1 million * (0.18 %) [<0.01 %]
Medical Equipment (3391)	\$218 million (1.40 %) [3.20 %]	\$7,239 million (46.65 %) [6.07 %]	\$4,156 million (26.78 %) [3.46 %]	\$487 million (3.14 %) [1.39 %]

\* Estimate

## Appendix (Continued)

**Figure A-3 National Manufacturing Supplier Linkages**  
(share of seller sales in parentheses; share of buyer purchases in brackets)

Manufacturing Industry Supplier	Purchasing Industry Group		
	Biotechnology Research	Biomedical Manufacturing	Buyers of Biomedical Products
Textiles (313)	\$9 million (0.02 %) [0.04 %]	\$1,363 million (2.56 %) [1.57 %]	\$99 million (0.19 %) [0.04 %]
Paper Products (3222)	\$265 million (0.43 %) [1.17 %]	\$1,511 million (2.44 %) [1.74 %]	\$3,566 million (5.76 %) [1.27 %]
Printing (3231)	\$1,089 million (1.80 %) [4.82 %]	\$614 million (1.01 %) [0.71 %]	\$3,043 million (5.02 %) [1.08 %]
Basic Chemicals (3251)	\$860 million (0.77 %) [3.80 %]	\$1,738 million (1.56 %) [2.00 %]	\$9,019 million (8.09 %) [3.21 %]
Plastics (326)	\$347 million (0.25 %) [1.53 %]	\$3,333 million (2.43 %) [3.83 %]	\$10,230 million (7.45 %) [3.64 %]
Glass (3272)	\$1,578 million (1.90 %) [6.97 %]	\$492 million (0.59 %) [0.56 %]	\$1,439 million (1.73 %) [0.51 %]
Fabricated Metal (332)	\$483 million (0.23 %) [2.14 %]	\$1,199 million (0.57 %) [1.38 %]	\$1,386 million (0.66 %) [0.49 %]
Computers (3341)	\$121 million (0.35 %) [0.53 %]	\$1,691 million (4.90 %) [1.94 %]	\$982 million (2.85 %) [0.35 %]
Semiconductors (3344)	\$250 million (0.17 %) [1.11 %]	\$2,196 million (1.53 %) [2.52 %]	\$227 million (0.16 %) [0.08 %]

## Appendix (Continued)

**Figure A-4 National Service/Infrastructure Supplier Linkages**  
(share of seller sales in parentheses; share of buyer purchases in brackets)

Service Industry Supplier	Purchasing Industry Group		
	Biotechnology Research	Biomedical Manufacturing	Buyers of Biomedical Products
Wholesale Trade (42)	\$664 million (0.19 %) [2.94 %]	\$7,607 million (2.17 %) [8.74 %]	\$9,810 million (2.80 %) [3.49 %]
Real Estate (531)*	\$2,279 million (0.61 %) [10.08 %]	\$542 million (0.15 %) [0.62 %]	\$41,165 million (11.10 %) [14.63 %]
Patent Services (533)	\$62 million (0.09 %) [0.27 %]	\$3,405 million (4.71 %) [3.91 %]	\$2,468 million (3.41 %) [0.88 %]
Legal Services (5411)	\$969 million (1.09 %) [4.29 %]	\$469 million (0.53 %) [0.54 %]	\$10,610 million (11.88 %) [3.77 %]
Computer Systems (5415)	\$248 million (0.73 %) [1.10 %]	\$155 million (0.46 %) [0.18 %]	\$1,768 million (5.19 %) [0.63 %]
Advertising (5418)	\$376 million (0.22 %) [1.66 %]	\$1,854 million (1.08 %) [2.13 %]	\$3,456 million (2.02 %) [1.23 %]
Professional Services (5419)	\$631 million (1.40 %) [2.79 %]	\$858 million (1.90 %) [0.99 %]	\$958 million (2.12 %) [0.34 %]
Management (55)	\$173 million (0.06 %) [0.77 %]	\$9,714 million (3.31 %) [11.16 %]	\$10,553 million (3.60 %) [3.75 %]
Admin. Services (561 exc. 5613 & 5615)	\$1,319 million (0.82 %) [5.83 %]	\$1,370 million (0.85 %) [1.57 %]	\$16,492 million (10.23 %) [5.86 %]
Employment Services (5613)	\$1,310 million (1.58 %) [5.79 %]	\$164 million (0.20 %) [0.19 %]	\$13,328 million (16.02 %) [4.74 %]

\*52310 (venture capital) is not included in this figure.

**Appendix (Continued)**

**Figure A-5 Concentration Ratio and Establishment Size Distribution for Industries in the National Biotechnology Cluster**

NAICS	CR <sub>4</sub>	No. Estabs.	Establishment Size Class									
			1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000 +	% > 100
<b>541380</b>	12.1	4,452	1453	632	544	572	400	508	249	76	18	19.1%
<b>541710</b>	31.1	11,299	5,580	1,765	1,380	1,278	629	434	142	57	34	5.9%
<b>6215</b>	28.2	11,026	6,162	1,864	1,352	1,055	334	164	63	23	9	2.3%
<b>3254</b>	32.3	1,825	463	269	234	287	182	194	108	48	40	21.4%
<b>334510</b>	22.7	475	109	63	65	64	55	72	24	17	6	25.1%
<b>334516</b>	33.6	595	184	95	80	96	58	51	17	10	4	13.8%
<b>334517</b>	58.3	160	43	20	27	27	16	12	8	5	2	16.9%
<b>3391</b>	16.3	12,151	6,578	2,221	1,314	1,034	416	346	146	66	30	4.8%
<b>541940</b>	NA	25,000	8,606	7,591	6,386	2,224	157	29	7	0	0	0.1%
<b>621</b>	7.8	455,888	236,626	118,499	60,054	28,741	7,280	3,498	793	282	115	1.0%
<b>622</b>	4.0	7,138	448	138	118	215	581	1,545	1,301	1,193	1,599	79.0%
<b>623</b>	13.3	65,088	16,041	11,763	11,304	9,304	7,761	7,883	895	118	19	13.7%
<b>313</b>	13.8	4,452	1,453	632	544	572	400	508	249	76	18	19.1%
<b>3222</b>	12.0	5,133	685	425	660	1,229	902	1,038	150	32	12	24.0%
<b>3231</b>	9.6	37,895	16,452	8,268	5,522	4,342	1,796	1,110	279	100	26	4.0%
<b>3251</b>	15.6	2,383	595	315	330	465	270	273	79	37	19	17.1%
<b>326</b>	8.2	15,981	3,193	1,906	2,434	3,447	2,300	1,938	534	175	54	16.9%
<b>3272</b>	31.0	2,348	972	405	244	250	155	178	98	30	16	13.7%
<b>332</b>	3.5	60,791	19,143	11,365	11,101	10,773	4,714	2,762	701	197	35	6.1%
<b>3341</b>	37.0	1,916	698	275	277	265	165	101	58	42	35	12.3%
<b>3344</b>	34.3	5,973	1,407	762	797	1,109	749	659	259	139	92	19.2%
<b>42</b>	6.2	438,924	222,409	86,832	63,740	43,860	13,280	6,721	1,496	438	148	2.0%
<b>523910</b>	12.7	6,575	5,204	743	339	182	52	38	10	7	0	0.8%
<b>531</b>	2.9	241,115	182,302	34,256	14,384	6,807	2,043	1,009	229	71	14	0.5%
<b>533</b>	20.8	2,129	1,368	295	206	163	51	32	13	1	0	2.2%
<b>5411</b>	1.8	176,771	128,529	26,714	12,476	6,323	1,637	800	205	74	13	0.6%
<b>5415</b>	15.5	100,852	70,861	11,106	7,637	6,316	2,637	1,637	444	160	54	2.3%
<b>5418</b>	10.3	39,290	24,398	6,646	3,934	2,672	930	490	154	51	15	1.8%
<b>5419</b>	12.1	38,640	28,773	5,186	2,523	1,354	446	257	64	25	12	0.9%
<b>55</b>	NA	47,559	17,528	7,064	6,764	7,028	3,809	2,949	1,298	702	417	11.3%
<b>561</b>	5.7	269,378	165,349	42,530	28,051	19,292	6,879	4,695	1,735	633	214	2.7%
<b>5613</b>	10.5	44,896	14,020	4,005	4,003	7,234	6,836	5,993	1,676	625	504	19.6%

## Appendix (Continued)

**Figure A-6 Comparison of Employment for Core Biotechnology Research Industries  
(location quotients in parentheses)**

Industry	Metropolitan Statistical Area						
	Cincinnati	Cleveland	Columbus	Indianapolis	Raleigh	San Diego	Seattle
Testing Labs. (541380)	853 (1.06)	1,211 (1.29)	730 (1.10)	320 (0.46)	1,440 (2.74)	810 (0.88)	862 (0.78)
R & D (541710)	1,248 (0.44)	2,045 (0.63)	3,750 (1.62)	1,919 (0.79)	7,945 (4.33)	23,468 (7.26)	7,808 (2.01)
Medical Labs. (6215)	692 (0.50)	1,191 (0.74)	782 (0.69)	1,650 (1.38)	2,014 (2.23)	2,113 (1.33)	3,447 (1.80)

**Figure A-7 Comparison of Employment for Core Biomedical Manufacturing Industries  
(location quotients in parentheses)**

Industry	Metropolitan Statistical Area						
	Cincinnati	Cleveland	Columbus	Indianapolis	Raleigh	San Diego	Seattle
Drugs (3254)	1,426 (0.75)	853 (0.38)	790 (0.50)	7,500 (4.54)	3,929 (3.15)	3,738 (1.70)	729 (0.28)
Electro. Appar. 334510	199 (0.48)	72 (0.15)	65 (0.19)	376 (1.05)	10 (0.04)	757 (1.58)	3,818 (6.65)
Lab. Instru. 334516	140 (0.49)	11 (0.03)	60 (0.26)	10 (0.04)	75 (0.40)	259 (0.79)	97 (0.25)
Irrad. Appar. 334517	0 (0.00)	785 (6.56)	65 (0.77)	0 (0.00)	2 (0.03)	176 (1.49)	2 (0.01)
Med. Eqpt. 3391	1,105 (0.44)	4,866 (1.68)	780 (0.38)	1,504 (0.70)	812 (0.50)	6,970 (2.44)	2,600 (0.76)

## Appendix (Continued)

**Figure A-8 Comparison of Employment for Manufacturing Supplier Industries  
(location quotients in parentheses)**

Industry	Metropolitan Statistical Area						
	Cincinnati	Cleveland	Columbus	Indianapolis	Raleigh	San Diego	Seattle
Textiles (313)	928 (0.37)	263 (0.09)	64 (0.03)	73 (0.03)	3,086 (1.87)	423 (0.15)	479 (0.14)
Paper Products (3222)	5,873 (1.98)	5,736 (1.66)	370 (0.15)	2,067 (0.80)	805 (0.41)	761 (0.22)	2,627 (0.64)
Printing (3231)	9,488 (1.48)	10,994 (1.47)	6,504 (1.23)	7,118 (1.28)	3,430 (0.82)	5,970 (0.81)	8,583 (0.97)
Basic Chemicals (3251)	2,773 (1.85)	4,358 (2.50)	267 (0.22)	603 (0.47)	81 (0.08)	306 (0.18)	263 (0.13)
Plastics (326)	9,642 (1.18)	25,268 (2.65)	7,034 (1.04)	6,500 (0.92)	1,994 (0.37)	5,748 (0.61)	6,639 (0.59)
Glass (3272)	504 (0.47)	637 (0.51)	4,424 (4.85)	1,381 (1.50)	388 (0.56)	320 (0.26)	2,280 (1.55)
Fab. Metals (332)	19,127 (1.35)	47,549 (2.84)	11,472 (0.97)	15,048 (1.21)	3,844 (0.41)	11,434 (0.69)	17,359 (0.87)
Computers (3341)	20 (0.01)	264 (0.14)	1,069 (0.80)	363 (0.26)	8,026 (7.53)	7,073 (3.77)	3,208 (1.42)
Semi- conductors (3344)	1,630 (0.33)	2,492 (0.43)	1,331 (0.33)	1,309 (0.31)	3,944 (1.22)	9,120 (1.61)	4,565 (0.67)

## Appendix (Continued)

**Figure A-9 Comparison of Employment for Service/Infrastructure Supplier Industries (location quotients in parentheses)**

Industry	Metropolitan Statistical Area						
	Cincinnati	Cleveland	Columbus	Indianapolis	Raleigh	San Diego	Seattle
Wholesale Trade (42)	61,622 (1.23)	81,920 (1.40)	44,710 (1.08)	46,235 (1.06)	28,456 (0.87)	59,175 (1.02)	87,569 (1.26)
Misc. Intermediation (523910)	93 (0.29)	205 (0.55)	1,303 (4.91)	158 (0.57)	122 (0.58)	337 (0.91)	820 (1.84)
Real Estate (531)	8,768 (0.80)	15,191 (1.20)	8,230 (0.92)	8,570 (0.91)	6,934 (0.97)	23,346 (1.86)	27,521 (1.82)
Lessors of Intangible Assets (533)	211 (1.01)	135 (0.55)	71 (0.41)	184 (1.01)	353 (2.58)	488 (2.02)	85 (0.29)
Legal Services (5411)	6,762 (0.75)	14,322 (1.36)	7,500 (1.00)	6,291 (0.80)	5,052 (0.85)	11,810 (1.13)	16,049 (1.28)
Computer Sys. Design (5415)	9,186 (0.90)	8,883 (0.74)	8,419 (1.00)	7,376 (0.83)	17,500 (2.61)	17,280 (1.46)	22,506 (1.59)
Advertising (5418)	4,191 (1.10)	4,548 (1.03)	3,750 (1.20)	2,041 (0.62)	1,814 (0.73)	4,908 (1.12)	8,054 (1.54)
Professional, Svs. (5419, exc. 541940)	4,015 (1.77)	2,019 (0.76)	937 (0.50)	1,820 (0.93)	1,454 (0.98)	3,156 (1.21)	3,570 (1.14)
Mgmt. of Cos. & Enterprises (55)	30,188 (1.28)	51,922 (1.89)	42,844 (2.21)	20,176 (0.99)	18,628 (1.21)	17,389 (0.64)	42,229 (1.30)
Admin. Svs. (561, exc. 5613, 5615)	30,018 (0.90)	39,926 (1.03)	37,856 (1.38)	47,952 (1.66)	38,066 (1.74)	46,852 (1.22)	42,041 (0.91)
Employment Svs. (5613)	30,656 (0.86)	52,918 (1.27)	31,565 (1.08)	20,075 (0.65)	19,825 (0.85)	35,577 (0.87)	39,988 (0.81)