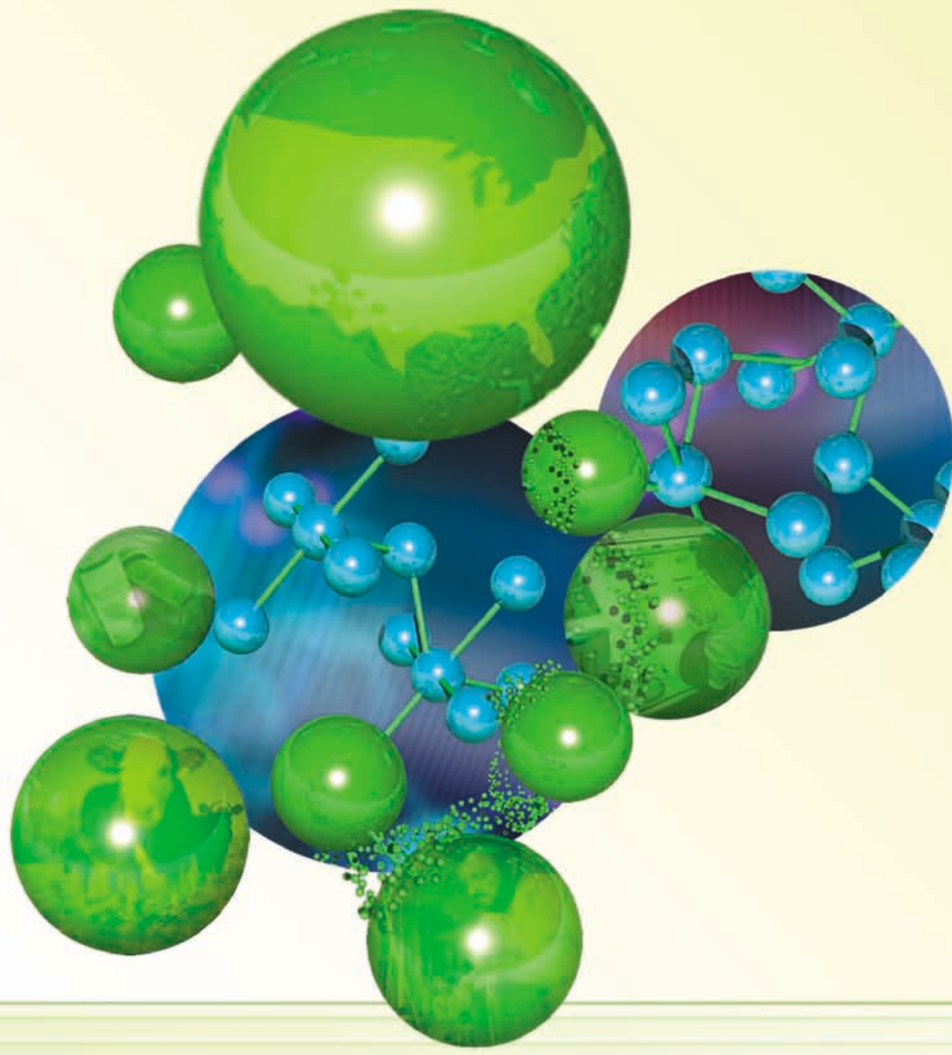
Technology, talent and capital:

State bioscience Initiatives 2008



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BIO—Biotechnology Industry Organization—represents more than 1,150 biotechnology companies, academic institutions, state biotechnology centers, and related organizations worldwide. BIO members are involved in the research and development of health-care, agricultural, industrial, and environmental biotechnology products.

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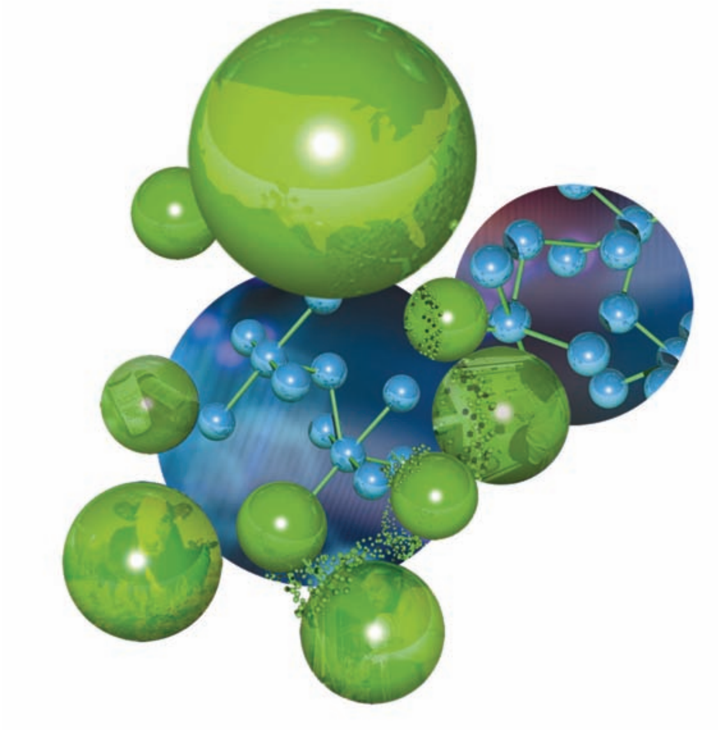

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BIO—Biotechnology Industry Organization

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June 2008

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Battelle Technology Partnership Practice

BIO

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EXECUTIVE SUMMARY

Defining the "Biosciences"

The biosciences are a diverse group of industries and activities with a common link—they apply knowledge of the way in which plants, animals, and humans function. The sector spans different markets and includes manufacturing, services, and research activities. By definition, the biosciences are a unique industry cluster and are constantly changing to incorporate the latest research and scientific discoveries.

The biosciences industry sector is defined as including the following four subsectors:

- Agricultural Feedstock & Chemicals
- Drugs & Pharmaceuticals
- Medical Devices & Equipment
- Research, Testing & Medical Laboratories.

The biosciences are recognized globally as a key driver of modern economic progress, offering enormous potential for linking basic research innovations with new market opportunities. Advances in human, plant, and animal biosciences have led to the growth of companies in many areas, from drug development to molecular diagnostics to biomaterials and biocomposites, biofuels, and other bio-related products. Recognizing this, states and regions throughout the United States are investing to create a business climate that supports the specific needs of the biosciences sector. These efforts focus on technology, talent, and capital, the key ingredients needed to grow a bioscience-driven economy.

Since 2004, Battelle, BIO, SSTI, and PMP Public Affairs Consulting, Inc., have tracked the development of the U.S. biosciences industry on a state and metropolitan statistical area (MSA) basis and the implementation of state policies and programs to support the biosciences industry. This report presents data on national, state, and metropolitan bioscience employment and growth trends during 2001 to 2006, state-level data that serve as indicators of the performance of the biosciences sector, and information on state bioscience programs and policies. Key report findings are presented below.

Key Findings: Biosciences Industry Trends

The total employment impact of the biosciences sector is 7.5 million jobs, taking into account the additional jobs created in the economy as a result of the sector's direct jobs.

Growing bioscience employment base. Total U.S. employment in the biosciences reached 1.3 million in 2006 (the latest year for which data are currently available), up from 1.2 million in 2004 and led by strong growth in the research, testing, and medical lab subsector (Table ES-1).

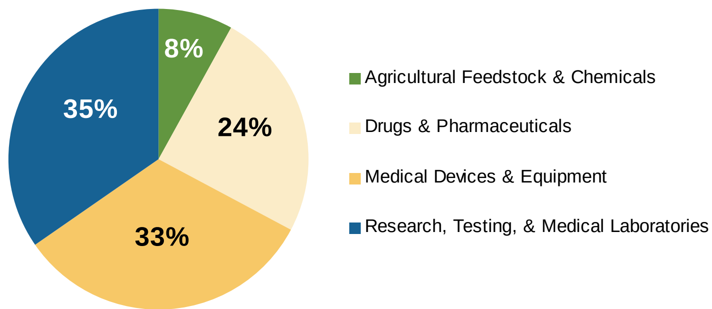
Table ES-1. U.S. Bioscience Employment and Establishments, 2006, and Changes, 2001–2006

Bioscience Subsector	2006 Establishments	Change in Establishments, 2001-06	2006 Employment	Change in Employment, 2001-06
Agricultural Feedstock & Chemicals	2,183	3.8%	105,846	-6.1%
Drugs & Pharmaceuticals	2,654	1.9%	317,149	4.0%
Medical Devices & Equipment	15,215	0.3%	422,993	-0.9%
Research, Testing, & Medical Laboratories	22,857	32.7%	449,991	17.8%
Total U.S. Biosciences	**42,910**	**15.7%**	**1,295,979**	**5.7%**

Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

The research, testing, and medical lab subsector is now the largest component of the biosciences sector, accounting for 35 percent of total bioscience employment (Figure ES-1). The number of research, testing, and medical lab establishments grew by almost 33 percent between 2001 and 2006. Medical devices and equipment account for one-third of bioscience employment, with drugs and pharmaceuticals accounting for one-quarter of bioscience jobs.

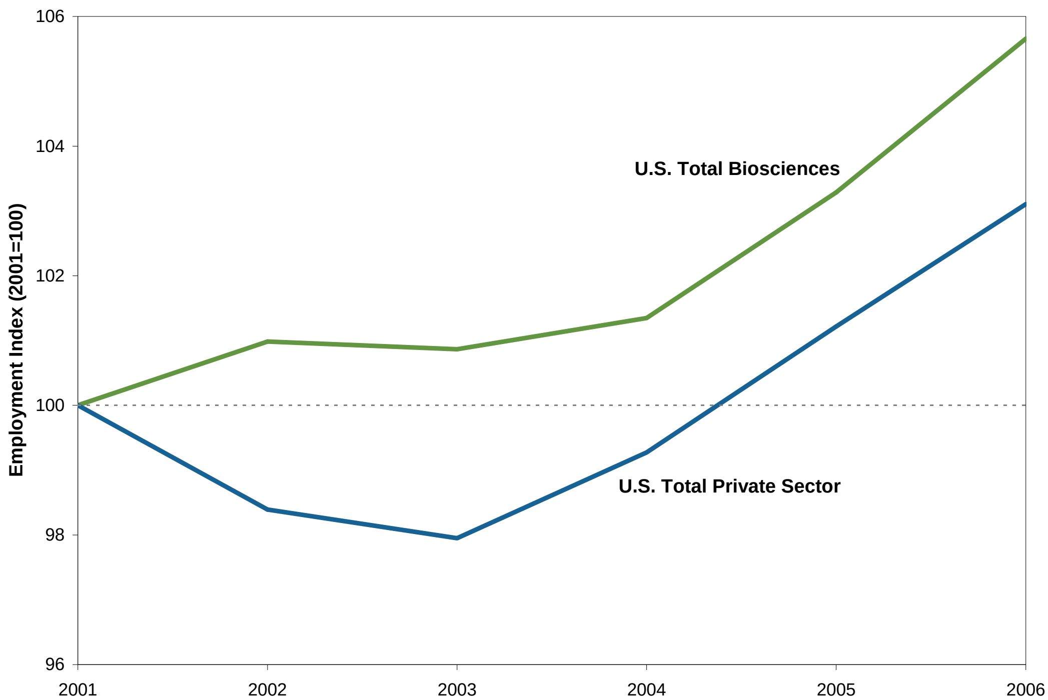
Figure ES-1. Employment Composition of the U.S. Biosciences Sector, 2006



Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

Outpacing the overall private sector. The national biosciences sector continues to outperform the overall private sector (Figure ES-2). Employment in the biosciences grew 5.7 percent since 2001, compared with a 3.1 percent increase in employment in the overall private sector. Three-quarters of this overall job growth has occurred since 2004, with the biosciences adding nearly 53,000 jobs between 2004 and 2006.

Figure ES-2. U.S. Biosciences and Total Private Sector Employment, 2001–2006, Indexed (2001=100)



Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

Providing high-wage jobs. The biosciences sector pays, on average, 68 percent higher salaries than the average private-sector job. The average annual wage of the biosciences sector is approximately $71,000 as compared with an average annual wage of $42,000 for the total private sector. The drugs and pharmaceuticals subsector offers high-wage, high-skill jobs as reflected in its average annual wage of almost $87,000 in 2006 (Table ES-2).

Table ES-2. Average Annual Wages in the Biosciences and Other Major Industries, 2006

U.S. Average Annual Wages per Employee, 2006		
Drugs & Pharmaceuticals	**$**	**86,892**
Information	$	76,257
Professional, Scientific, and Technical Services	$	71,544
Research, Testing, & Medical Laboratories	**$**	**71,284**
Total Biosciences	**$**	**70,959**
Agricultural Feedstock & Chemicals	**$**	**67,870**
Finance and Insurance	$	65,095
Medical Devices & Equipment	**$**	**59,441**
Manufacturing	$	54,865
Construction	$	43,215
U.S. Total Private Sector	**$**	**42,272**
Transportation and Warehousing	$	42,013
Real Estate and Rental and Leasing	$	41,071
Health Care and Social Assistance	$	40,205
Retail Trade	$	25,849

Source: Battelle analysis of BLS QCEW data from the Minnesota IMPLAN Group.

Performing at a high level as demonstrated by levels of R&D, patents issued, and venture capital invested. Academic bioscience R&D expenditures totaled $29 billion in fiscal year (FY) 2006, accounting for more than 60 percent of total U.S. academic R&D. And, this R&D is leading to discoveries with commercial potential. Bioscience-related patents issued totaled 82,000 during 2002 to 2007; although the annual numbers have trended downward over this time period. Venture capital investments in bioscience companies, on the other hand, showed a steady increase during 2002 to 2007, reaching $11.6 billion in 2007—surpassing the previous industry peak of $11.0 billion set in 2000.

Distributed across the United States. Bioscience employment is distributed across the 50 states and Puerto Rico, with numerous states developing strong niches in certain specializations**.** Thirty-five states, the District of Columbia, and Puerto Rico have an employment specialization in at least one of the four bioscience subsectors. Only three states—California, Indiana, and North Carolina—and Puerto Rico have a specialization in three of the four subsectors. While some states are deeply involved in a number of industry subsectors, no one state has a large employment base in all four industry subsectors.

The following pages show the geographical distribution of bioscience employment in each of the four biosciences subsectors: agricultural feedstock and chemicals, which includes ethanol and biodiesel production; drugs and pharmaceuticals; medical devices and equipment; and research, testing, and medical laboratories.

Key Indicators of the Growth of the Biosciences in the United States

- The total employment impact, including direct, indirect, and induced jobs, of the biosciences sector is 7.5 million jobs
- Academic bioscience R&D expenditures totaled $29 billion in FY 2006
- U.S. higher education institutions awarded bioscience-related degrees to more than 143,000 students in the 2006 academic year
- Venture capital investments in bioscience companies reached $11.6 billion in 2007
- More than 82,000 bioscience-related patents were awarded between 2002 and 2007 in the United States

AGRICULTURAL FEEDSTOCK AND CHEMICALS

The agricultural feedstock and chemicals subsector applies life sciences knowledge, biochemistry, and biotechnologies to the processing of agricultural goods and production of organic and agricultural chemicals. The subsector also includes the emerging activity around the production of biofuels.

Examples of Products

Fertilizers, pesticides, herbicides, and fungicides

Ethanol and biodiesel fuels

Biodegradable materials synthesized from plant-based feedstock

Sustainable industrial oils and lubricants

Biocatalysts

Feed additives and ingredients

Corn and soybean oil

Examples of Companies

Archer Daniels Midland

BASF Plant Science

Bayer CropScience

Cargill

Dow AgroSciences

DuPont

Genencor International

Monsanto

The Scotts Company

Syngenta

States that are Both Large and Specialized*

Texas

Illinois

Tennessee

Iowa

Ohio

Metro Areas with the Largest Employment Levels*

Houston-Baytown-Sugar Land, TX

New York-Northern New Jersey-Long Island, NY-NJ-PA

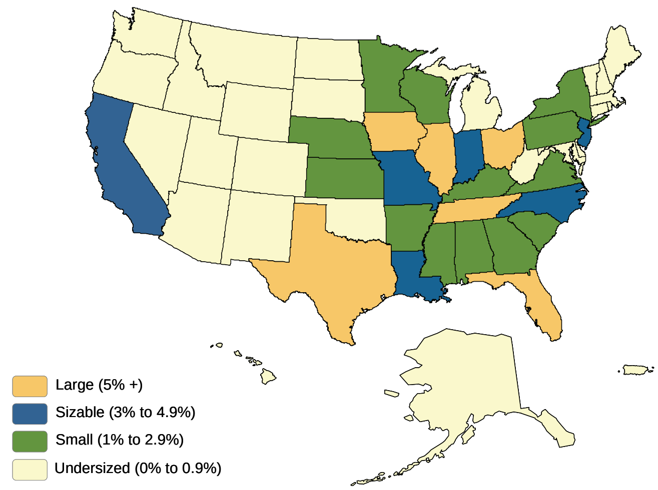
Memphis, TN-MS-AR

Decatur, IL

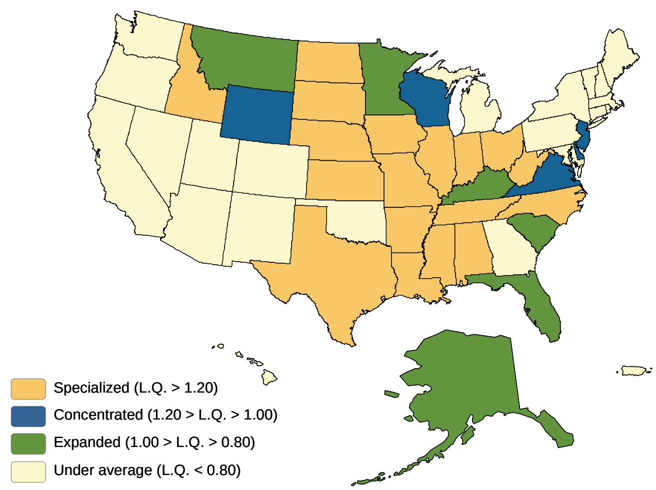
Baton Rouge, LA

*States and MSAs are listed in descending order by subsector employment levels.

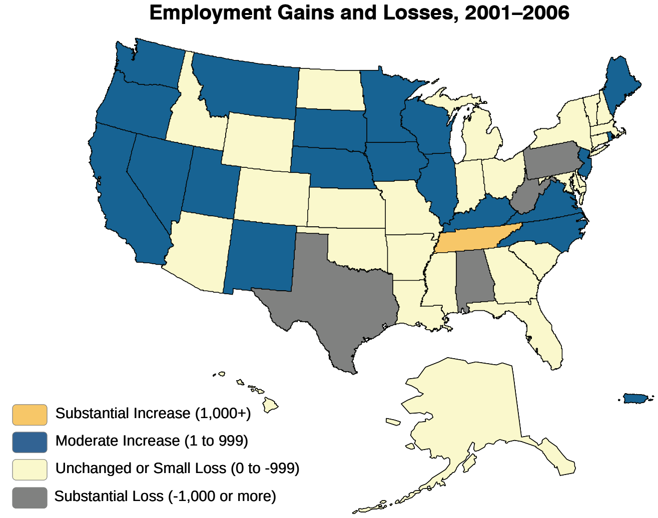
State Share of Total U.S. Employment



Employment Concentration Relative to the U.S.



Employment Gains and Losses, 2001–2006



DRUGS AND PHARMACEUTICALS

The drugs and pharmaceuticals subsector produces commercially available medicinal and diagnostic substances. The subsector is generally characterized by large multinational firms heavily engaged in research and development activities to bring drugs to market.

Examples of Products

Vaccines

Oncology, neurology, immunology, and cardiology treatments

Tissue and cell culture media

Dermatological/topical treatments

Diagnostic substances

Animal therapeutics and vaccines

Examples of Companies

Abbott Laboratories

Amgen

AstraZeneca

Biogen Idec

Eli Lilly & Co.

Genentech

Merck & Co.

Novartis

Pfizer

Roche Diagnostics

Sanofi-Aventis/Sanofi Pasteur

States that are Both Large and Specialized*

California

New Jersey

Puerto Rico

Pennsylvania

North Carolina

Indiana

Illinois

Metro Areas with the Largest Employment Levels*

New York-Northern New Jersey-Long Island, NY-NJ-PA

Philadelphia-Camden-Wilmington, PA-NJ-DE-MD

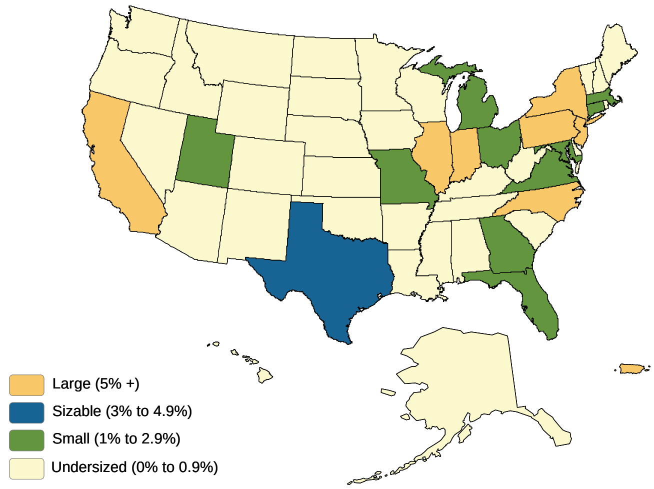
Chicago-Naperville-Joliet, IL-IN-WI

Indianapolis, IN

San Francisco-Oakland-Fremont, CA

*States and MSAs are listed in descending order by subsector employment levels.

State Share of Total U.S. Employment



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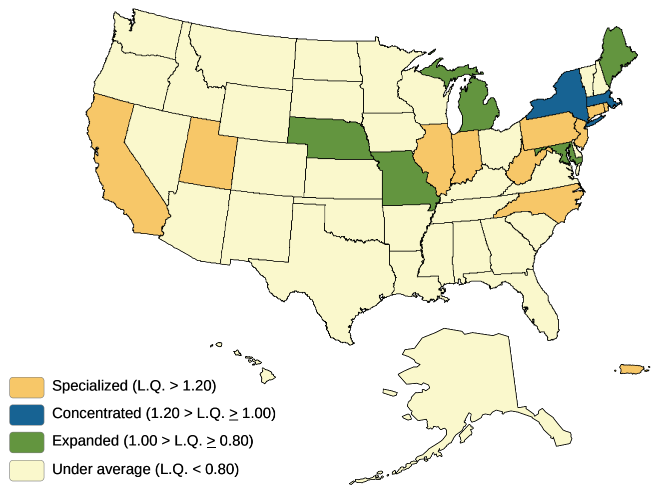

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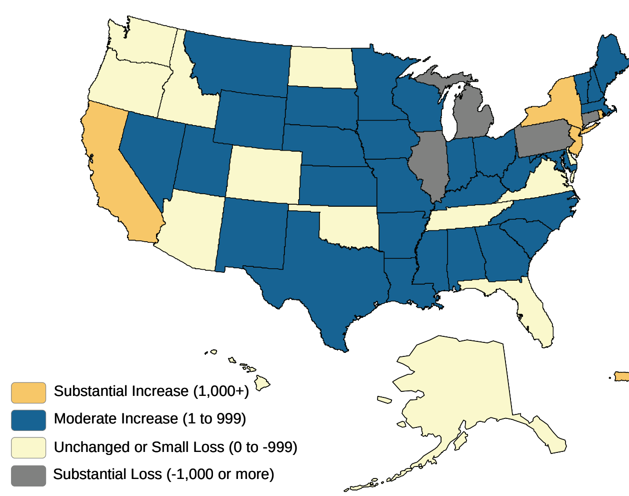


MEDICAL DEVICES AND EQUIPMENT

Firms in the medical device and equipment subsector produce a variety of biomedical instruments and other health care products and supplies for diagnostics, surgery, patient care, and laboratories. The subsector is continually advancing the application of electronics and information technologies to improve and automate testing and patient care capabilities.

Examples of Products

Bioimaging equipment
Surgical supplies and instruments
Orthopedic and prosthetic implants and devices
Laser eye surgery instruments
Automated external defibrillators (AEDs)
Vascular stents and other implantable devices
Dental instruments and orthodontics
Walkers, wheelchairs, and beds

Examples of Companies

Alcon
Baxter International
Boston Scientific Corp.
Cardinal Health
GE Healthcare
Johnson and Johnson
Medtronic
Siemens Medical Solutions
Stryker
Tyco Healthcare
3M Health Care

States that are Both Large and Specialized*

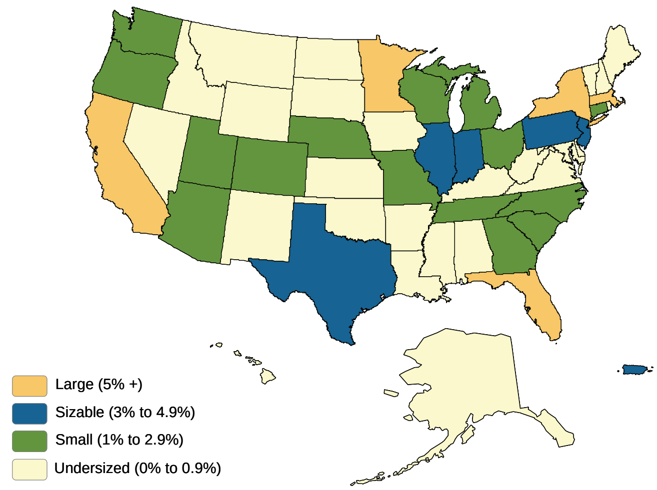
California
Minnesota
Massachusetts

Metro Areas with the Largest Employment Levels*

Los Angeles-Long Beach-Santa Ana, CA
Minneapolis-St. Paul-Bloomington, MN-WI
New York-Northern New Jersey-Long Island, NY-NJ-PA
Boston-Cambridge-Quincy, MA-NH
Chicago-Naperville-Joliet, IL-IN-WI

*States and MSAs are listed in descending order by subsector employment levels.

State Share of Total U.S. Employment



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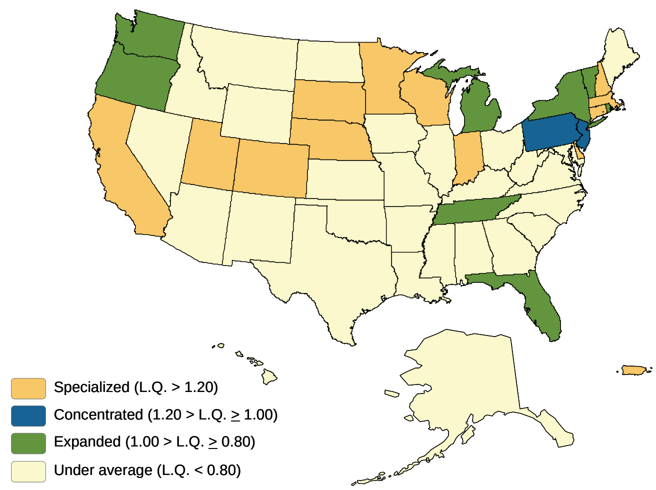
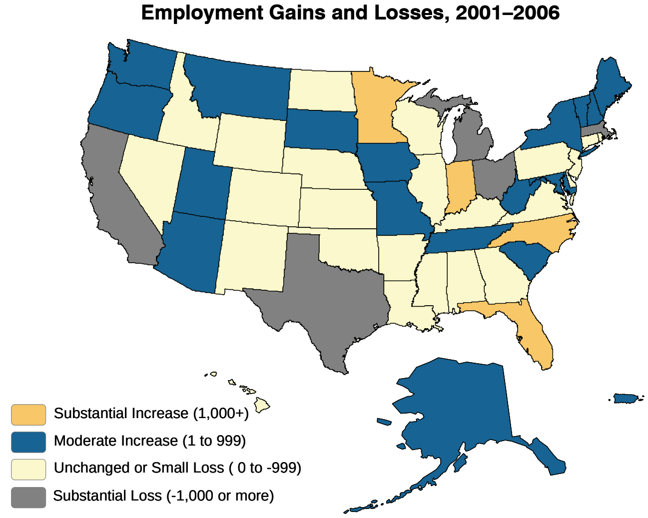


Employment Gains and Losses, 2001–2006



RESEARCH, TESTING, AND MEDICAL LABORATORIES

The research, testing, and medical laboratories subsector includes a range of activities; from highly research-oriented companies working to develop and commercialize new drug discovery/delivery systems, and gene and cell therapies, to more service-oriented firms engaged in medical and other life sciences testing services.

Examples of Products

Functional genomics and drug discovery techniques

Diagnostic testing

Preclinical drug development

Stem cell/regenerative research

Biomarkers

Nanoscale drug delivery systems

Research models and laboratory support services

Examples of Companies

Cellomics

Charles River Laboratories

Covance

Invitrogen

Laboratory Corp. of America

Lexicon Pharmaceuticals

Pharmacopeia

Quest Diagnostics

Stratatech

ViaCell

States that are Both Large and Specialized*

California

Pennsylvania

Massachusetts

New Jersey

Metro Areas with the Largest Employment Levels*

New York-Northern New Jersey-Long Island, NY-NJ-PA

Los Angeles-Long Beach-Santa Ana, CA

Philadelphia-Camden-Wilmington, PA-NJ-DE-MD

Boston-Cambridge-Quincy, MA-NH

Washington-Arlington-Alexandria, DC-VA-MD-WV

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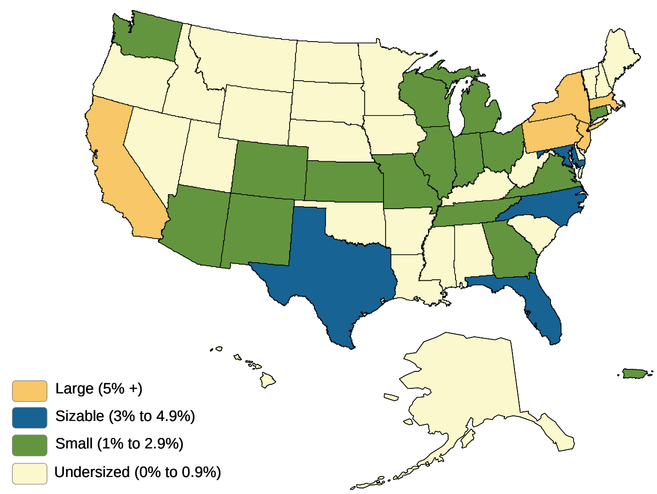

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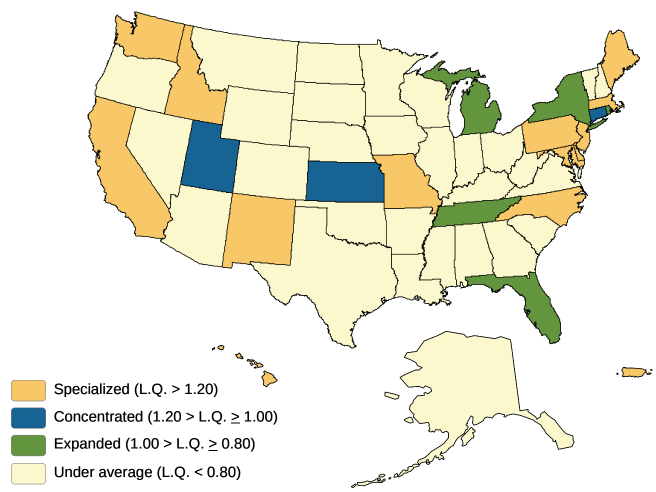

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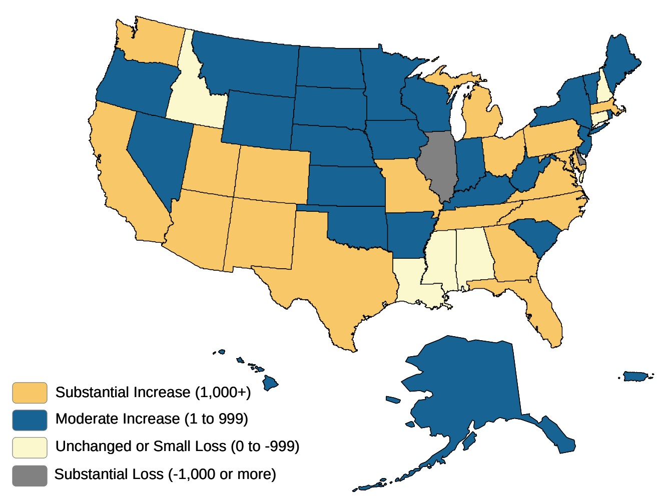


Key Findings: State Bioscience Initiatives

Addressing talent needs. States reported significantly increased activity underway to address the talent needs of the biosciences sector since 2006. Across the board, states reported new program offerings at all levels of education, including K-12, community college, undergraduate, and graduate; new programs combining business with biosciences; and new types of degree offerings to address the need for people with expertise in regulatory affairs and clinical trials. New bioscience and biomedical institutes have been formed, some of which are multi-institutional, and specialized science and technology high schools and biotechnology magnet programs have been instituted. States are working with the biosciences industry to develop career pathways in the biosciences, offering programs to equip teachers with bioscience skills and knowledge, and encouraging existing workers to retrain for careers in the biosciences. About half of the states reported conducting some type of inventory or survey of workforce needs in the biosciences sector.

Key Findings: State Bioscience Initiatives

States are engaged in the following:

- Addressing talent needs
- Investing in the biosciences to address global issues
- Recognizing that business climate issues vary by company size
- Establishing legislative caucuses and committees focused on the biosciences
- Advancing bold initiatives in the biosciences, including investments in stem cell research
- Reassessing bioscience investments in light of budget realities
- Continuing to address risk capital gaps
- Creating new commercialization vehicles
- Funding translational research in the context of existing programs

Investing in the biosciences to address global issues. States have become much more active in supporting the application of the biosciences to agriculture, energy, and industrial products. Nearly half the states reported committing funds for bioenergy research and facilities in which to conduct such research during the past 2 years. Some state funding has been provided as match for the three U.S. Department of Energy (DOE) Bioenergy Research Centers awarded in 2007. Other states, including Oklahoma and Colorado, created dedicated bioenergy research centers.

Recognizing that business climate issues vary by company size. As the biosciences industry matures, states are recognizing that the state policies affecting “business climate” impact larger bioscience companies differently than small, early-stage companies and are making changes in tax and incentive programs to address these issues. State tax policies in particular play a much larger role in business retention, expansion, and location decisions for larger companies with significant numbers of employees. Eleven states reported that they allow corporations to calculate their taxes by using a single sales factor, a change that can benefit corporations with large operations but mostly out-of-state sales. States have also adopted tax incentives that support growing bioscience companies.

Establishing legislative caucuses and committees focused on the biosciences. State policymakers are recognizing the importance of the biosciences as evidenced by the creation of dedicated legislative committees and caucuses. Organized to identify those members in the Legislature with an interest in the biosciences, such groups provide a forum where issues affecting the biosciences can be discussed. Currently, 12 states have a dedicated life-science committee or caucus, up from only three just 2 years ago. In three states, a dedicated committee has been created: the California Assembly Select Committee on Biotechnology (1993), Illinois General Assembly Bio-Technology Committee (2007), and Minnesota House Biosciences and Emerging Technology Committee (2007).

States with Legislative Caucuses

Florida
Georgia
Iowa
Kansas
Maryland
Massachusetts
Michigan
Minnesota
Missouri
Ohio
Pennsylvania
Virginia

Advancing targeted initiatives in the biosciences, including investments in stem cell research. States are creating large, multipurpose funds that are strategically investing in the state's bioscience infrastructure. Often, these funds can be used for R&D facilities, faculty recruitment, translational research, and commercialization. Nine states—California, Connecticut, Illinois, Maryland, Massachusetts, New Jersey, New York, Ohio, and Wisconsin—awarded almost $300 million for stem cell R&D and $555 million for facilities to house stem cell researchers in FY 2007 and 2008. California accounted for almost $500 million of the total, with New Jersey accounting for $250 million. Taken together, these states have pledged to spend more than $4 billion over the next 10 years on stem cell research.

Reassessing bioscience investments in light of budget realities. State budget challenges have led some states to consider or actually curtail investments in technology development programs and, in some cases, in bioscience initiatives specifically. The Florida Legislature decided not to invest additional funds in its Innovation Incentive Program, which has been used to attract several bioscience research centers to the State. Other states are considering delaying planned bioscience investments.

Continuing to address risk capital gaps. States are increasing their investments in funds that address the need for early-stage risk capital through public-private partnerships. In 2006, there were still few programs designed to address the need for pre-seed and seed-stage bioscience investment. In 2008, 33 states reported programs that provide funding for this stage of development. Annual funding for these programs ranges from as little as $100,000 to a high of $15 million, with the typical fund being about $2.5 million. Twenty-six states reported that they have state-supported pre-seed funds. Such funds tend to fall into three levels of investment: $50,000 to $200,000, $200,000 to $500,000, and $500,000 to $1 million.

Creating new commercialization vehicles. States, universities and medical centers are giving increased attention to moving research into technology and commercial products. This post-technology transfer set of activities and functions, including proof of concept, prototype, engineering optimization, and business and market positioning, are resulting in modifications of existing organizations and creation of new organizations.

Funding translational research in the context of existing programs. Complementing the emphasis of the National Institutes of Health Roadmap, states reported funding translational research within existing bioscience R&D programs. However, few reported initiatives specifically aimed at promoting translational research. One unique statewide initiative is the Arizona Translational Resource Network, an initiative of the Arizona Biomedical Research Commission. This statewide initiative is focused on facilitating collaborations in clinical research, including harmonizing business practices and advancing Internal Review Board (IRB) education and collaborative IRB mechanisms. In 2007, Oregon appropriated a $5.25 million seed grant for start-up of the Oregon Translational Research and Drug Development Institute (OTRADI); appropriations also include funding for faculty recruitment at the participating universities. South Carolina created the Southeastern Clinical and Translational Research Institute, which is a collaboration of the Medical University of South Carolina, the University of South Carolina, and the Medical College of Georgia, aimed at building new models for translational research.

What is Translational Research?

Translational research identifies basic research findings with implications for improving healthcare and advances those discoveries through preclinical developments and clinical research in human subjects. The ultimate desired outcome for translational medicine is improved clinical care, often involving new therapeutics, devices, or diagnostics.

But, translational research is a highly iterative process—much more than just a one-way road from bench to bedside. It is just as important for clinical observations to inform research questions and approaches and thus increase the likelihood that scientific research will lead to improved clinical care.

Translational research encompasses a broad range of scientific, regulatory, and clinical disciplines not typically found in any one organization. Advances in translational medicine thus depend upon bringing together discovery (research centers, hospitals and medical centers, and biosciences industry) and applied research entities as well as development organizations (contract research organizations, pharmaceutical companies, biotechnology companies, and medical device companies).

Conclusion

The bioscience sector is truly coming of age. New discoveries are increasingly finding their way into new applications and products leading to new medical treatments, new sources of energy, and new industrial products made out of bio-based materials. The impact of the progress in the biosciences is being felt across the United States, as demonstrated by bioscience job growth, up 5.7 percent between 2001 and 2006, and the number of bioscience establishments, up 15.7 percent nationwide during the same time period. This growth is spread across the United States with clusters of bioscience firms focused on specialized niches of the biosciences found in states and regions. Thirty-five states, the District of Columbia, and Puerto Rico have an employment specialization in at least one of the four bioscience subsectors: agricultural feedstock and chemicals; drugs and pharmaceuticals; medical devices and equipment; and research, testing, and medical laboratories.

State and regional economic development organizations throughout the United States are becoming increasingly sophisticated in their understanding of the biosciences and of building the biosciences sector and are adopting and implementing policies and programs that support its growth. States are

- Undertaking initiatives to help bioscience companies grow and prosper. There is greater understanding needs vary depending on the stage of development of a company. State are providing business and financial assistance to start-up and emerging companies and creating tax and regulatory environments supportive of expanding and growing companies.
- Addressing capital needs by providing funding for precommercialization/proof-of-concept activities, creating seed funds, implementing policies that encourage private investment in early-stage and later-stage venture capital, and supplying capital for facilities financing.
- Working closely with bioscience companies to identify skill needs and develop programs and initiatives to develop a workforce that is prepared to pursue careers in the biosciences.

The biosciences industry sector continues to evolve, and states must continue to examine and revamp their policies in view of these changes. During the past 4 years, states have made substantial investments in creating a strong bioscience infrastructure. A challenge for state policymakers will be to continue to support this level of investment in light of decreases in federal funding in some areas and continued fiscal pressure facing state governments as the U.S. economy weakens. But, doing so will result in significant benefits: better healthcare for citizens, alternative fuels that can decrease U.S. dependence on oil and improve environmental quality, and good, well-paying jobs that will create economic opportunities and an improved quality of life.

INTRODUCTION

BIOSCIENCE 08

The biosciences are recognized globally as a key driver of modern economic progress, offering enormous potential for linking basic research innovations with new market opportunities. Advances in human, plant, and animal biosciences have led to the growth of companies in many areas, from drug development to molecular diagnostics to biomaterials and biocomposites, to biofuels, and other bio-related products. Recognizing this, states and regions throughout the United States are investing to create a business climate that supports the specific needs of the biosciences sector. These efforts focus on technology, talent, and capital, the key ingredients needed to grow any technology-based economy.

Battelle, BIO, SSTI, and PMP Public Affairs Consulting, Inc., have tracked the development of the U. S. biosciences industry on a state and metropolitan area basis and the implementation of state policies and programs to support the biosciences industry with prior reports released in 2004 and 2006.

This report presents updated data on national, state, and metropolitan bioscience employment and growth trends during 2001 to 2006. It also presents state-level data that serve as indicators of the performance of the biosciences sector. These include data on bioscience research and development (R&D) awards, patents issued, degrees awarded, number of people employed in bioscience occupations, and venture capital invested in bioscience companies. These data are presented for all 50 states and Puerto Rico. Lastly, building upon the detailed state profiles contained in the 2006 report, this report includes information on state bioscience programs and policies that have been initiated or implemented within the past 2 years and provides summary data on state programs that are either targeted to the biosciences sector or include the biosciences as part of a broader initiative. The data on state programs were collected by means of a Web-based survey that was sent to a state government contact and the state's biosciences industry association, if one existed, in the 50 states and Puerto Rico. Forty-four states and Puerto Rico responded to the survey.

Defining the "Biosciences"

The biosciences are a diverse group of industries and activities with a common link—they apply knowledge of the way in which plants, animals, and humans function. The sector spans different markets and includes manufacturing, services, and research activities. By definition, the biosciences are a unique industry cluster and are constantly changing to incorporate the latest research and scientific discoveries.

The biosciences industry sector is defined as including the following four subsectors:

- Agricultural Feedstock & Chemicals
- Drugs & Pharmaceuticals
- Medical Devices & Equipment
- Research, Testing & Medical Laboratories.

Key Findings: Biosciences Industry Trends

Growing bioscience employment base. Total employment in the biosciences in the United States reached 1.3 million in 2006 (the latest year for which data are currently available), up from 1.2 million in 2004 led by strong growth in the research, testing, and medical lab subsector. This subsector is now the largest component of the biosciences sector, accounting for 35 percent of total biosciences employment. The number of research, testing, and medical lab establishments grew by almost 33 percent between 2001 and 2006.

The total employment impact of the biosciences sector is 7.5 million jobs, taking into account the additional jobs created in the economy as a result of the sector's direct jobs.

Outpacing the overall private sector. The national biosciences sector continues to outperform the overall private sector. Employment in the biosciences grew 5.7 percent since 2001, compared with a 3.1

percent increase in employment in the overall private sector. Three-quarters of this overall job growth has occurred since 2004, with the biosciences adding nearly 53,000 jobs between 2004 and 2006.

Providing high-wage jobs. The biosciences sector pays, on average, 68 percent higher salaries than the average private-sector job. The annual average wage of the biosciences sector is approximately $71,000 as compared with an average annual wage of $42,000 for the total private sector. The drugs and pharmaceuticals subsector offers high-wage, high-skill jobs as reflected in its average annual wage of almost $87,000 in 2006.

Distributed across the United States. Bioscience employment is distributed across the 50 states and Puerto Rico, with numerous states developing strong niches in certain specializations**.** Thirty-five states, the District of Columbia, and Puerto Rico have an employment specialization in at least one of the four bioscience subsectors. Only four states—California, Indiana, North Carolina, and Puerto Rico—have a specialization in three of the four subsectors. While some states are deeply involved in a number of industry subsectors, no one state has a large employment base in all four industry subsectors.

Key Findings: State Bioscience Initiatives

Key Findings: State Bioscience Initiatives

States are engaged in the following:

- Addressing talent needs
- Investing in the biosciences to address global issues
- Recognizing that business climate issues vary by company size
- Establishing legislative caucuses and committees focused on the biosciences.targeted initiatives in the biosciences, including investments in stem cell research
- Reassessing bioscience investments in light of budget realities
- Continuing to address risk capital gaps
- Creating new commercialization vehicles
- Funding translational research in the context of existing programs

Addressing talent needs. States reported significantly increased activity underway to address the talent needs of the biosciences sector since 2006. Across the board, states reported new program offerings at all levels of education, including K-12, the community college, undergraduate, and graduate; new programs combining business with biosciences; and new types of degree offerings to address the need for people with expertise in regulatory affairs and clinical trials. New bioscience and biomedical institutes have been formed, some of which are multi-institutional, and specialized science and technology high schools and biotechnology magnet programs have been instituted. States are working with the biosciences industry to develop career pathways in the biosciences, offering programs to equip teachers with bioscience skills and knowledge, and encouraging existing workers to retrain for careers in the biosciences. About half of the states reported conducting some type of inventory or survey of workforce needs in the biosciences sector.

Investing in the biosciences to address global issues. States have become much more active in supporting the application of the biosciences to agriculture, energy, and industrial products. Nearly half the states reported committing funds for bioenergy research. North Carolina's Department of Agriculture and Consumer Services has created a North Carolina Biofuels Campus on the site of an old tobacco research station. The state appropriated $5 million for a biofuels center at the site that will identify next-generation crops and processes for both biodiesel and ethanol. Iowa s created a $100 million Iowa Power Fund that will fund research on clean energies, and Tennessee has committed $72 million over 5 years to the University of Tennessee (UT) Biofuels Research Initiative, which includes funding for a pilot cellulosic ethanol plant.

Recognizing that business climate issues vary by company size. As the biosciences industry matures, states are recognizing that policies affecting "business climate" impact larger bioscience companies differently from those that impact small, early-stage companies. States are making changes in tax and incentive programs to address needs. State tax policies in particular play a much larger role in business retention, expansion, and location decisions for larger companies with significant numbers of employees. Eleven states reported that they allow corporations to calculate their taxes by using a single sales factor, a change that can benefit corporations with large operations but most of their sales out of state. States have also adopted tax incentives that support growing bioscience companies. Massachusetts's Job Creation Incentive Payment provides Massachusetts life-sciences manufacturers, which hire 10 or more new employees in a calendar year, a 50 percent rebate of the payroll taxes paid by the new employees. Texas recently reinstated a pharmaceutical biotechnology clean-room sales tax exemption for clean rooms built to be used in manufacturing.

Establishing legislative caucuses and committees focused on the biosciences. State policymakers are recognizing the importance of the biosciences as evidenced by the creation of dedicated legislative committees and caucuses. Organized to identify those members in the legislature with an interest in the biosciences, such groups provide a forum where issues affecting the biosciences can be discussed. Currently, 12 states have established life-science committee or caucuses, up from only three just 2 years ago. In three states, a dedicated committee has been created: the California Assembly Select Committee on Biotechnology (1993), Illinois General Assembly Bio-Technology Committee (2007), and Minnesota House Biosciences and Emerging Technology Committee (2007).

States with Legislative Caucuses

- Florida
- Georgia
- Iowa
- Kansas
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Missouri
- Ohio
- Pennsylvania
- Virginia

Advancing bold initiatives in the biosciences, including investments in stem cell research. States are creating large, multipurpose funds that are strategically investing in bioscience infrastructure. Often these funds are used for R&D facilities, faculty recruitment, translational research, and commercialization. Washington State's Life Sciences Discovery Fund, which will make $350 million in grants over 10 years from tobacco-settlement proceeds, began funding advanced research in human health, including translational, scale-up, and demonstration programs, among them many public-private partnerships. The Fund began operations in 2006 with seed funding from the state and private philanthropy, made grants from philanthropic sources in 2007, and made its first grants from tobacco funds in 2008. Other examples include the Texas Emerging Technology Fund (TETF) (funded at $100 million per year over multiple fields) for facility development, faculty recruitment, and commercialization and Missouri's $335 million Lewis and Clark Discovery Fund, which funds life science facilities and infrastructure. Nine states—California, Connecticut, Illinois, Maryland, Massachusetts, New Jersey, New York, Ohio, and Wisconsin—awarded almost $300 million for stem cell R&D and $555 million for facilities to house stem cell researchers in fiscal years (FY) 2007 and 2008. California accounted for almost $500 million of the total, with New Jersey accounting for $250 million. Taken together, these states have pledged to spend over the next 10 years more than $4 billion on stem cell research.

But, budget realities may threaten future state bioscience investments. State budget challenges have led some states to consider or actually curtail investments in technology development programs and, in some cases, in bioscience initiatives specifically. The Innovation Incentive Program in Florida, which has been used to attract five, mostly bioscience, research centers to the State, received $200 million in FY 2007 and $250 million in FY 2008. But, with a projected budget shortfall of $2 billion, the Florida Legislature has voted not to add new investments to the fund. In Nevada, the Governor and Legislature are considering delaying $127 million in projects for the University of Nevada Health Sciences System in an effort to close a $1 billion budget shortfall. In California, proposals were made to both limit the amount of the R&D tax credit and the net operating loss deductions to 50 percent of a taxpayer's net income for industry, including the biosciences.

Continuing to address risk capital gaps. States are increasing their investments in funds that address the need for early-stage risk capital through public-private partnerships. In 2006, there were still few programs designed to address the need for pre-seed and seed-stage bioscience investment. In 2008, 33 states reported programs that provide funding for this stage of development. Annual funding for these programs ranges from as little as $100,000 to a high of $15 million, with the typical fund being about $2.5 million. Twenty-six states reported that they have state-supported pre-seed funds. Such funds tend to fall into three levels of investment: $50,000 to $200,000, $200,000 to $500,000, and $500,000 to $1 million.

Creating new commercialization vehicles. States, universities and medical centers are giving increased attention to moving research into technology and commercial products. This post-technology transfer set of activities and functions, including proof of concept, prototype, engineering optimization, and business and market positioning, are resulting in modifications of existing organizations and creation of new organizations. Washington University in St. Louis has created a Tech Transfer LaunchPad initiative to catalyze the creation of new ventures based on promising UW innovations. Colorado State University has created two new enterprises, NeoTREX to advance cancer treatments and MicroRx to bring products addressing infectious disease to the market. The Maryland Technology Development Corporation's (TEDCO's) Tech Start program partners technology transfer offices with principal investigators and entrepreneurs to explore possibilities for and to pursue, if warranted, company formation around the technology.

Funding translational research in the context of existing programs. Complementing the emphasis of the NIH Roadmap, states reported funding translational research within existing bioscience R&D programs. However, few reported initiatives specifically aimed at promoting translational research. One unique statewide initiative is the Arizona Translational Resource Network, an initiative of the Arizona Biomedical Research Commission. This statewide initiative is focused on facilitating collaborations in clinical research, including harmonizing business practices and advancing Internal Review Board (IRB) education and collaborative IRB mechanisms. In 2007, Oregon appropriated a $5.25 million for start-up of the Oregon Translational Research and Drug Development Institute (OTRADI), the second of three "signature research centers" planned by the Oregon Innovation Council. A collaboration among all the State's principal research universities, OTRADI will provide commercialization support to start-up bioscience companies, starting with shared availability of a new High Throughput Screening Facility. The appropriations also include funding for faculty recruitment at the participating universities. South Carolina created the Southeastern Clinical and Translational Research Institute, which is a collaboration of the Medical University of South Carolina, the University of South Carolina, and the Medical College of Georgia, aimed at building new models for translational research.

What is Translational Research?

Translational research identifies basic research findings with implications for improving healthcare and advances those discoveries through preclinical developments and clinical research in human subjects. The ultimate desired outcome for translational medicine is improved clinical care, often involving new therapeutics, devices, or diagnostics.

But, translational research is a highly iterative process—much more than just a one-way road from bench to bedside. It is just as important for clinical observations to inform research questions and approaches and thus increase the likelihood that scientific research will lead to improved clinical care.

Translational research encompasses a broad range of scientific, regulatory, and clinical disciplines not typically found in any one organization. Advances in translational medicine thus depend upon bringing together discovery (research centers, hospitals and medical centers, and biosciences industry) and applied research entities as well as development organizations (contract research organizations, pharmaceutical companies, biotechnology companies, and medical device companies).

Organization of Report

This report is organized in four sections. The first focuses on the biosciences industry sector and its subsectors, presenting data on employment and growth trends at the national, state, and metropolitan area levels. The second focuses on the performance of the biosciences sector and includes data on a number of indicators, such as venture capital investments and patents. The third section of the report discusses the critical factors that impact a state or region's capacity to grow a robust bioscience sector. The final section presents findings on state initiatives that support the growth of the biosciences. Individual state profiles can be found on the CD-ROM included in the back pocket of this report. The report and each of the 51 state profiles can also be downloaded from the BIO Web site at http://www.bio.org.

U.S. Bioscience Sector and Subsectors

Overview: Defining the Biosciences

The biosciences as an "industry" maintain a unique set of characteristics. They represent a varied set of companies that span manufacturing, services, and research activities, a highly skilled workforce, and a whole range of products and services classified among nearly 30 industry segments. Much more than other sectors, the biosciences are dynamic and evolve with the latest research and scientific discoveries with tremendous widespread impact on food, medicine, and alternative fuels. The common link among this diverse set of companies is an application of knowledge as to how living organisms function.

The biosciences transcend industry classification, making the sector difficult to define. The existing federal statistical system does not identify one single industry code that encompasses all bioscience activities; therefore, defining the industry requires a careful examination of all industries engaged in bioscience-related activity. In assisting numerous states and regions in developing their bioscience industry base, Battelle has identified four major subsectors that represent the core of current and likely future bioscience economic activity. The four major subsectors of the biosciences include the following:

- **Agricultural feedstock and chemicals**—Firms engaged in agricultural production and processing, organic chemical manufacturing, and fertilizer manufacturing. This includes the emerging industry activity in the production of ethanol.
- **Drugs and pharmaceuticals**—Firms that develop and produce biological and medicinal products and manufacture pharmaceuticals and diagnostic substances.
- **Medical devices and equipment**—Firms that develop and manufacture surgical and medical instruments and supplies, laboratory equipment, electromedical apparatus including MRI and ultrasound equipment, dental equipment and supplies, and ophthalmic products.
- **Research, testing, and medical laboratories**—Companies engaged in research and development in the biosciences, testing laboratories, and stand-alone medical laboratories and other diagnostic centers. This includes firms involved in early-stage (often pre-clinical) research and development activities around new pharmaceuticals and medical devices.
- Research and economic activity within a fifth center of bioscience activity might include academic health centers, research hospitals, and other research-driven institutions. Many U.S. hospitals partner with universities and other research institutes to further advances in the biosciences with a particular focus on healthcare applications. Unfortunately, current industrial classifications and available data do not allow for an isolation of these research-oriented establishments outside of the larger hospitals sector. Though it can not be reliably quantified, the sector should be recognized as an important element of the bioscience industry cluster.

Table 1 presents the component industries that make up each of the four bioscience subsectors. While the industry has evolved over time, the Battelle industry definition is the same as that utilized in the 2006 BIO report. The data and methodology, likewise, remain the same and allow for a comparable time series from the prior report.

Table 1. The Bioscience Subsector Industries

NAICS Code	NAICS Description
AGRICULTURAL FEEDSTOCK & CHEMICALS	
311221	Wet corn milling
311222	Soybean processing
311223	Other oilseed processing
325193	Ethyl alcohol manufacturing
325199	All other basic organic chemical manufacturing
325221	Cellulosic organic fiber manufacturing
325311	Nitrogenous fertilizer manufacturing
325312	Phosphatic fertilizer manufacturing
325314	Fertilizer (mixing only) manufacturing
325320	Pesticide and other agricultural chemical manufacturing
DRUGS & PHARMACEUTICALS	
325411	Medicinal and botanical manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Other biological product manufacturing
MEDICAL DEVICES & EQUIPMENT	
334510	Electromedical apparatus manufacturing
334516	Analytical laboratory instrument manufacturing
334517	Irradiation apparatus manufacturing
339111	Laboratory apparatus and furniture manufacturing
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
RESEARCH, TESTING, & MEDICAL LABORATORIES	
541380*	Testing laboratories
541710*	R&D in the physical, engineering, and life sciences
621511	Medical laboratories
621512	Diagnostic imaging centers

*Includes only the portion of these industries engaged in biological or other life sciences activities.

The bioscience subsectors each operate in distinct markets, with their own sets of product and service offerings, suppliers, and regulatory environments. To varying degrees, the subsectors do intersect in beneficial ways. For example, bioscience research directly impacts the development of new drugs and devices and leads to new uses for agricultural feedstocks; testing laboratories enable breakthroughs in medical devices; and agricultural research contributes to further innovation in drugs and pharmaceuticals as well as research and testing.

Each major subsector varies in its degree of bioscience sophistication and adoption of related technology. Similarly, each firm within these groups will vary. Therefore, while some subsector companies are leaders in their field and utilize cutting-edge bioscience technologies, others are not currently utilizing these same technologies. In reality, this means that the depth, scale, and scope of a bioscience-related establishment can vary considerably in any given state or region. The overall presence of this activity within a state or local area, however, provides further potential for economic growth and clustering among various bioscience establishments.

It is possible, in fact probable, that the major bioscience subsectors do not entirely cover the full extent of bioscience activity within a state. Firms and enclaves of economic activity may exist that have adopted bioscience-related technologies, but lie outside the industrial structure defined here.

Bioscience Employment Metrics: the Approach

To measure the size, relative concentration, and overall economic impact of the biosciences in the United States, Battelle tabulated employment, establishment, and wage data for each state, the District of Columbia, Puerto Rico, and every metropolitan statistical area (MSA). The data were calculated for each of the four bioscience industry subsectors for 2001 and 2006, the most current and comparable annual data available.

The Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) program data were used as the primary data source for this industry analysis. The QCEW provides the most accurate employment data at the sub-national level. The data represent a virtual "census" of workers covered under the Unemployment Insurance System, as reported by employers.

MSA data that measure relative employment concentration in this analysis are tabulated and presented in groups by the overall private-sector employment level of the MSA. Each MSA is classified as either large, medium, or small with respect to private-sector employment. A "large" MSA has total regional employment at or above 250,000. A "medium" MSA has total employment greater than or equal to 75,000, but less than 250,000. A "small" MSA has employment less than 75,000. By presenting key employment metrics among metro areas of a similar overall size, the data provide a more useful comparison.

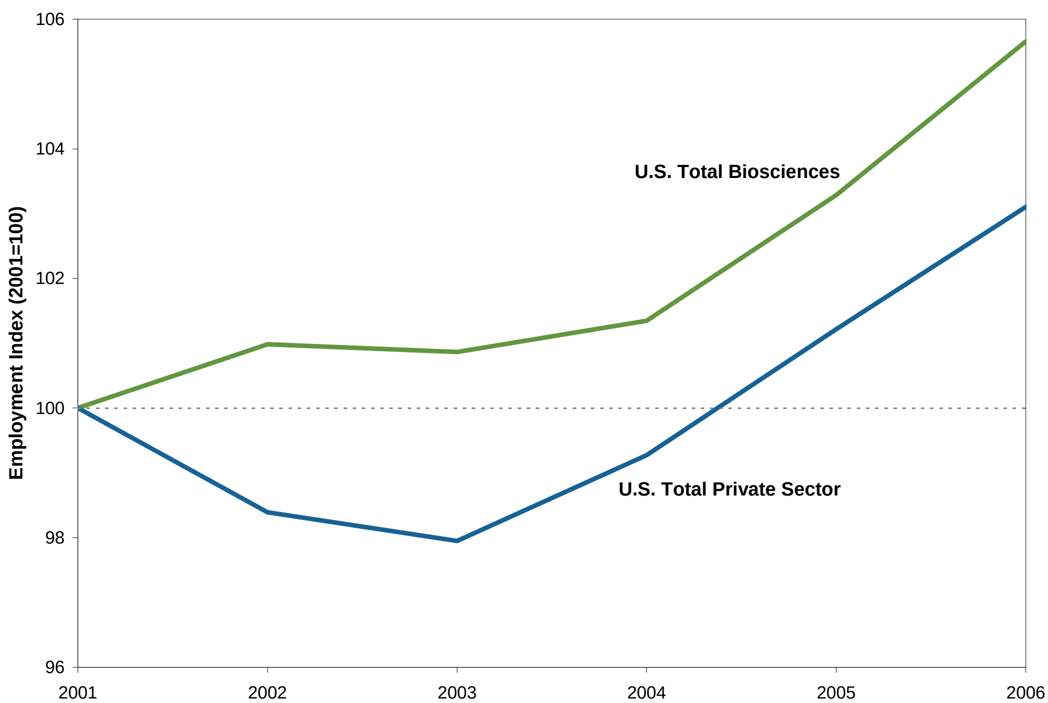
For a full discussion of the data and methodology used in this analysis, refer to the Appendix to this report.

The Size, Composition, Growth, and Impact of the U.S. Bioscience Sector

National Overview

Bioscience employment reached nearly 1.3 million in 2006 after outpacing the overall private sector over the recent 5-year period. The sector rose by 5.7 percent since 2001 compared with a more modest 3.1 percent gain in the overall national private sector (Figure 1). Three-quarters of this overall job growth has occurred since 2004, with the biosciences adding nearly 53,000 jobs in this more recent 2-year period.

Figure 1. U.S. Bioscience and Total Private Sector Employment, 2001–2006, Indexed (2001=100)



Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

Bioscience companies now operate nearly 43,000 individual business establishments across the four major subsectors, a figure that has risen at a rapid 15.7 percent rate since 2001 (Table 2).

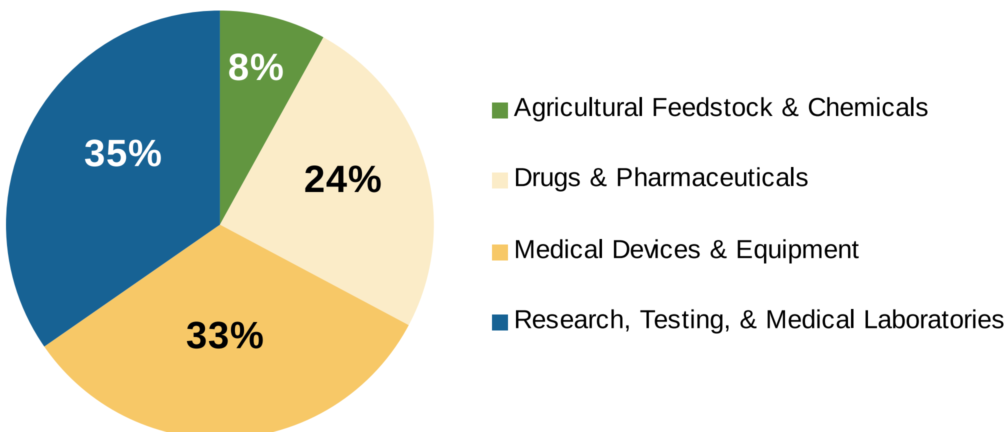
Table 2. U.S. Bioscience Employment and Establishments, 2006, and Changes, 2001–2006

Bioscience Subsector	2006 Establishments	Change in Establishments, 2001-06	2006 Employment	Change in Employment, 2001-06
Agricultural Feedstock & Chemicals	2,183	3.8%	105,846	-6.1%
Drugs & Pharmaceuticals	2,654	1.9%	317,149	4.0%
Medical Devices & Equipment	15,215	0.3%	422,993	-0.9%
Research, Testing, & Medical Laboratories	22,857	32.7%	449,991	17.8%
Total U.S. Biosciences	**42,910**	**15.7%**	**1,295,979**	**5.7%**

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Driving the recent national growth of the biosciences is research, testing, and medical laboratories, which is now the largest of the four major subsectors. At 450,000 jobs, the subsector spans almost 23,000 individual business establishments and accounts for 35 percent of total bioscience jobs (Figure 2). The subsector has seen impressive job growth in recent years, adding 17.8 percent or nearly 68,000 jobs to its employment base since 2001. More than half of this net job growth has occurred since 2004, with research, testing, and medical laboratories increasing employment by 36,000 jobs or 8.8 percent in this 2-year period.

Figure 2. Employment Composition of the U.S. Bioscience Sector, 2006



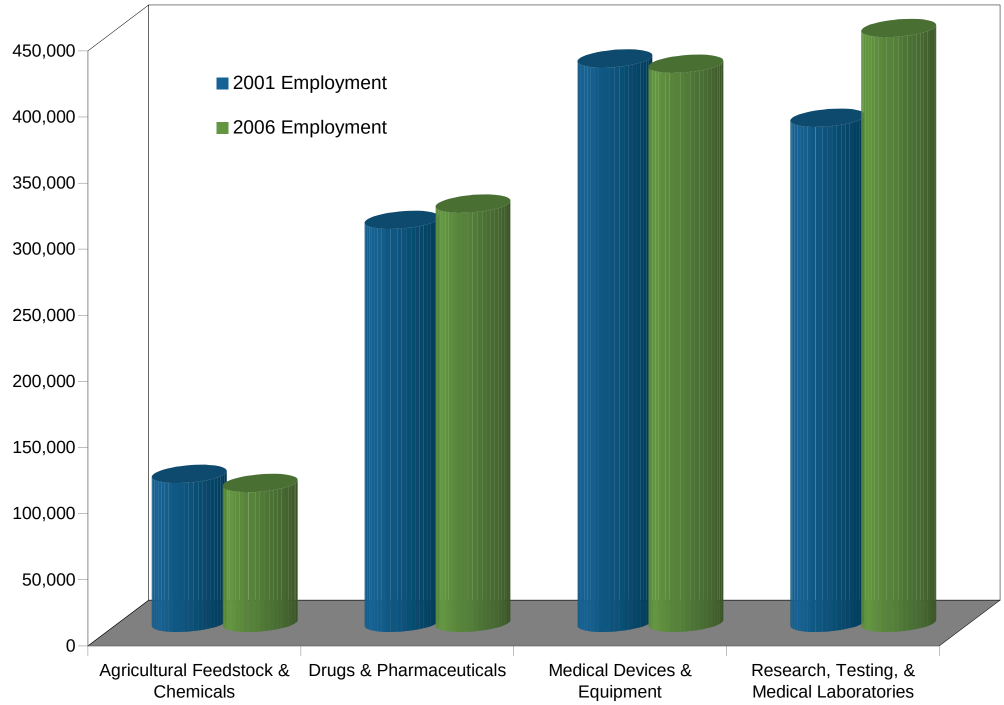
Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group

Medical device and equipment manufacturers comprise the second-largest component of the biosciences, operating more than 15,000 national establishments in 2006 with 423,000 employees. This subsector represents one in three bioscience jobs and a major manufacturing emphasis of the bioscience sector. Since 2001, employment among medical device firms has remained relatively flat, down just 0.9 percent, reflecting in large part the impact of the 2001 recession on overall manufacturing and sluggish years that followed (Figure 3). Over the more recent 2-year period, however, the industry has grown by 2.8 percent or 11,500 jobs, and is back on a growth path.

The drugs and pharmaceuticals subsector accounts for nearly one-quarter of all bioscience jobs and a steady source of sector job growth. Private subsector companies have increased their employment base by 4 percent over 5 years, reaching 317,000 in 2006. These large, often multinational firms operate the largest bioscience operations, with an average of 120 employees per establishment. Since 2004, the industry has grown by 1.3 percent or about 4,000 jobs.

Agricultural feedstock and chemical producers employ 8 percent of the national bioscience sector in almost 2,200 business establishments. Subsector employment in 2006 totaled 106,000, which is down 6.1 percent since 2001. Despite job loss overall since 2001, the agricultural feedstock and chemicals subsector has added almost 1,000 jobs since 2004.

Figure 3. U.S. Employment by Bioscience Subsector, 2001 and 2006



Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group

Biosciences Broader Economic Impact: Employment Multipliers

While the biosciences remain a relatively small industry sector, accounting for 1.1 percent of total U.S. private-sector employment, the full impact of this high-value growth sector of the economy goes beyond the direct level of employment and earnings presented in this report. The biosciences, like other industries, have interdependent relationships with suppliers of other goods and services. The sector both supports and depends upon other regional and national economic entities to supply everything from marketing or legal services to transportation or janitorial services to assist in running daily operations. As a result, the industry has a regional and national impact that is greater than its sum of employment or earnings might suggest.

State employment "multipliers" are used to measure the additional regional impact of adding bioscience jobs. Multipliers quantify the broad ripple effect outlined above where one industry (in this case, the biosciences) creates and supports additional economic activities. The Bureau of Economic Analysis (BEA) has developed regional factors to conduct this type of impact analysis using its Regional Input-Output Modeling System also known as RIMS II.[1]

Battelle has calculated state and national employment impact factors for each major bioscience subsector using the direct-effect employment multipliers provided by BEA.[2] The multipliers represent the total change in number of jobs in all industries (direct, indirect, and induced effects) that result from a change of one job in the corresponding industry sector. At the national level, the multipliers range from 3.3 for the research, testing, and medical laboratories subsector, to 11.2 for agricultural feedstock and chemicals.

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[1] For more information on the BEA RIMS II multipliers used in this report, refer to the Appendix.
[2] All State and national subsector multipliers and total employment impacts are presented in the State Profile tables within this report. Multipliers for Puerto Rico are not available from BEA.

The total indirect and induced employment impact of the 1.3 million U.S. bioscience jobs is an additional 6.2 million jobs throughout the remainder of the economy. Together, these direct, indirect, and induced bioscience impacts account for a total employment impact of 7.5 million jobs. This amounts to an overall bioscience direct-effect employment multiplier of 5.8.

Bioscience Wages

Bioscience workers continue to earn more, on average, than their counterparts in most other major industries. In 2006, bioscience workers earned $70,959 nationally, on average (Table 3). These earnings are nearly $29,000 more than wages in the overall U.S. private sector. The wage premium in the biosciences reflects both the highly skilled makeup of its workforce, as well as the strong demand for these workers around the country. Bioscience workers earn 1.68 times the private sector average (or 68 percent more), a ratio that has increased from 1.61 (or 61 percent more) in 2001.

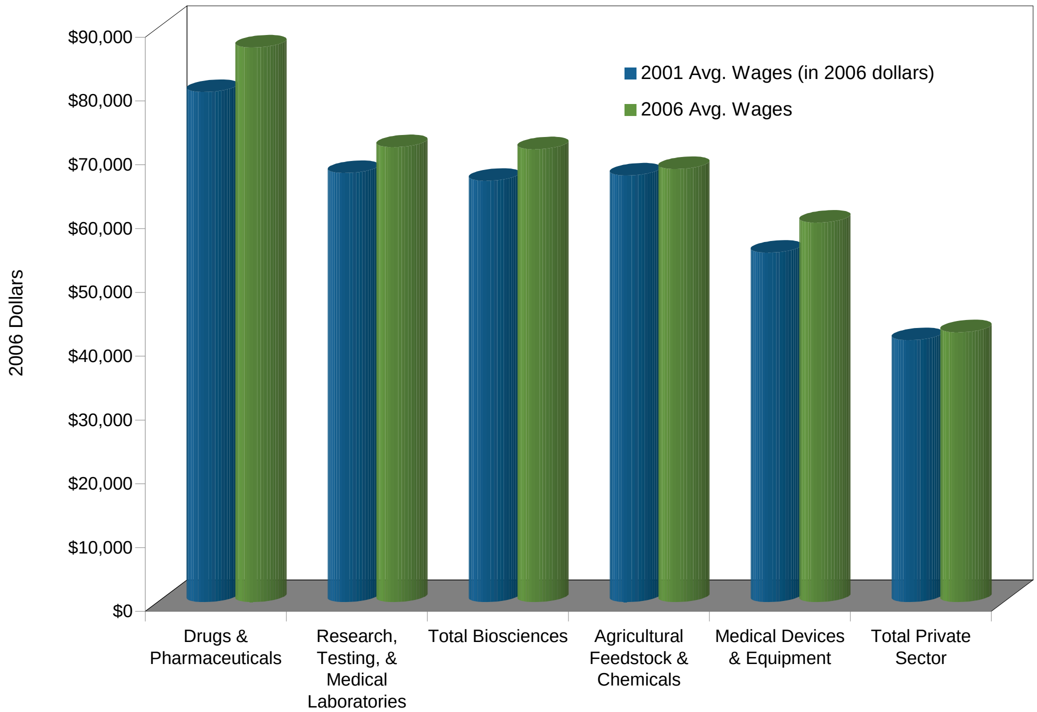
Table 3. Average Annual Wages in the Biosciences and Other Major Industries, 2006

U.S. Average Annual Wages per Employee, 2006		
Drugs & Pharmaceuticals	**$**	**86,892**
Information	$	76,257
Professional, Scientific, and Technical Services	$	71,544
Research, Testing, & Medical Laboratories	**$**	**71,284**
Total Biosciences	**$**	**70,959**
Agricultural Feedstock & Chemicals	**$**	**67,870**
Finance and Insurance	$	65,095
Medical Devices & Equipment	**$**	**59,441**
Manufacturing	$	54,865
Construction	$	43,215
U.S. Total Private Sector	**$**	**42,272**
Transportation and Warehousing	$	42,013
Real Estate and Rental and Leasing	$	41,071
Health Care and Social Assistance	$	40,205
Retail Trade	$	25,849

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Average wage growth in the biosciences continues to outpace growth for the overall private sector. Since 2001, real (inflation-adjusted) earnings have increased by 7.5 percent, compared with 3.0 percent for the U.S. private sector (Figure 4). Among the subsectors, workers in drugs and pharmaceuticals and in medical devices have seen their wages rise by an average of nearly 9 percent. Wages in research, testing, and medical laboratories are up 6 percent since 2001.

Figure 4. Real Average Annual Wages in the Biosciences and the Total Private Sector, 2001 and 2006



Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

The following section provides a more in-depth examination of employment trends among each of the four major bioscience subsectors. Data were tabulated for each state, the District of Columbia, Puerto Rico, and each MSA to determine the size and relative job concentration within each subsector. In addition, employment growth and declines were calculated to illuminate recent trends.

Employment size measures the absolute level of jobs within each region. To allow for meaningful comparisons across regions, the region's share of total U.S. employment was analyzed. States with more than 5 percent of national employment are labeled "large"; states with more than 3 percent but less than 5 percent are termed "sizable."

Employment concentration is a useful way in which to gauge a region's subsectors relative to the national average. State and regional location quotients (LQs) measure the degree of job concentration within the region relative to the nation.[3] States or regions with an LQ greater than 1.0 are said to have a concentration in the subsector. When the LQ is significantly above average, 1.20 or greater, the state is said to have a "specialization" in the industry.

The level of **employment growth or loss** during the 2001 to 2006 period provides a snapshot of recent progress in growing a state's bioscience sector. In this analysis, job growth or loss was measured by absolute employment gains or losses, as percentage changes appear to overstate trends in those states with a smaller subsector employment base.

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[3] Location quotients (LQs) are a standard measure of the concentration of a particular industry in a region relative to the nation. The LQ is the share of total regional employment in the particular industry divided by the share of total industry employment in the nation. An LQ greater than 1.0 for a particular industry indicates that the region has a greater relative concentration, whereas an LQ less than 1.0 signifies a relative underrepresentation. An LQ greater than 1.20 denotes employment concentration significantly above the national average. In this analysis, regional specializations are defined by LQs of 1.20 or greater.

AGRICULTURAL FEEDSTOCK AND CHEMICALS

The agricultural feedstock and chemicals subsector applies life sciences knowledge, biochemistry, and biotechnologies to the processing of agricultural goods and production of organic and agricultural chemicals. The subsector also includes the emerging activity around the production of biofuels.

Examples of Products

Fertilizers, pesticides, herbicides, and fungicides

Ethanol and biodiesel fuels

Biodegradable materials synthesized from plant-based feedstock

Sustainable industrial oils and lubricants

Biocatalysts

Feed additives and ingredients

Corn and soybean oil

Examples of Companies

Archer Daniels Midland

BASF Plant Science

Bayer CropScience

Cargill

Dow AgroSciences

DuPont

Genencor International

Monsanto

The Scotts Company

Syngenta

States that are Both Large and Specialized*

Texas

Illinois

Tennessee

Iowa

Ohio

Metro Areas with the Largest Employment Levels*

Houston-Baytown-Sugar Land, TX

New York-Northern New Jersey-Long Island, NY-NJ-PA

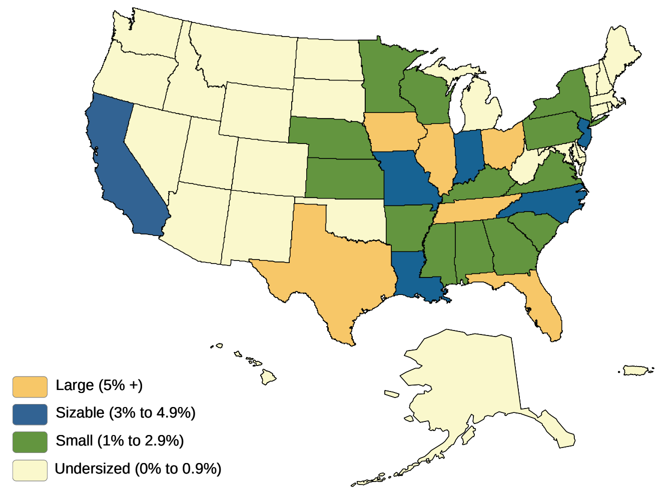
Memphis, TN-MS-AR

Decatur, IL

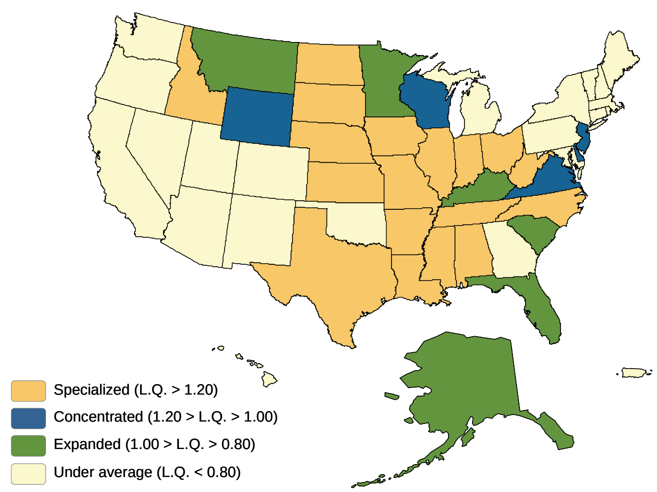
Baton Rouge, LA

*States and MSAs are listed in descending order by subsector employment levels.

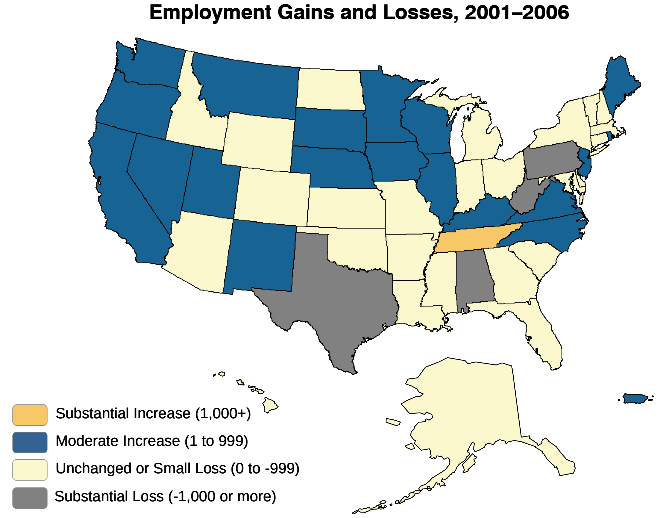
State Share of Total U.S. Employment



Employment Concentration Relative to the U.S.



Employment Gains and Losses, 2001–2006



Agricultural Feedstock and Chemicals

Overview

Agricultural feedstock and chemical producers employ 8 percent of the national bioscience sector in almost 2,200 business establishments. Subsector employment in 2006 totaled 106,000, which is down 6.1 percent since 2001. Workers in agricultural feedstock and chemicals earned nearly $68,000 in 2006, on average, which is $25,000 more than the average private sector wage.

The major components of the agricultural bioscience subsector consist of agricultural feedstocks and organic and agricultural chemicals. The chemicals component is the larger, but has experienced steeper job losses in recent years—down 13 percent since 2001, compared with a loss of just 1 percent for the feedstock component.

Despite broad declines among the detailed components in the agricultural bioscience sector, major job growth has occurred within the ethanol manufacturing industry. Growing demand for ethanol, biodiesel, and other alternative biofuels led to a 71 percent employment increase from 2001 to 2006. In 2006 and 2007, numerous states were building ethanol production plants and working to build large capacity for alternative fuel production. It is likely that, since 2006, employment in this industry has risen at an even greater rate.

State Agricultural Feedstock and Chemicals Employment

Employment Size. The national subsector is widely distributed among states, with the largest 10 states accounting for just 60 percent of total employment.

- **Large States:** Texas, Illinois, Tennessee, Iowa, Ohio, and Florida[4]
- **Sizable States:** California, Indiana, North Carolina, Missouri, Louisiana, and New Jersey

Employment Concentration. Eighteen states have a specialized agricultural bioscience subsector, more than for any of the four subsectors. These concentrations are generally in the Midwest and South.

- **Specialized States:** Iowa, Tennessee, Nebraska, Louisiana, South Dakota, Arkansas, Indiana, Illinois, Alabama, Idaho, Missouri, North Dakota, North Carolina, Mississippi, West Virginia, Kansas, Ohio, and Texas
- **Concentrated States:** Delaware, Wyoming, Wisconsin, New Jersey, and Virginia

Employment Growth. The employment decline in the agricultural feedstock and chemicals subsector totaled almost 7,000 jobs during the 2001 to 2006 period. Though overall employment was down, 19 states and Puerto Rico experienced moderate job gains (increases of fewer than 1,000 jobs). Tennessee is the only state to experience a large employment increase (more than 1,000 jobs).

Large and Specialized States. Five states have both a large employment base and a specialized concentration of jobs in the agricultural feedstock and chemicals subsector (Table 4).

Table 4. States with Large and Specialized Employment in the Agricultural Feedstock and Chemicals Subsector, 2006

State	Establishments 2006	Employment 2006	Location Quotient	Share of U.S. Employment
Texas	222	10,240	1.33	9.7%
Illinois	103	9,343	2.00	8.8%
Tennessee	43	6,832	3.14	6.5%
Iowa	109	6,594	5.70	6.2%
Ohio	83	6,197	1.46	5.9%

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

[4] All State listings by employment size and concentration in this section are in descending order.

Metropolitan Areas

Tables 5 and 6 present those MSAs with the overall largest employment levels (size) in agricultural feedstock and chemicals and those with the highest LQs (concentration) among their respective size categories.

Table 5. Metropolitan Statistical Areas with the Largest Employment Levels in Agricultural Feedstock and Chemicals, 2006

Metropolitan Statistical Area	2006 Employment
Houston-Baytown-Sugar Land, TX	5,559
New York-Northern New Jersey-Long Island, NY-NJ-PA	3,889
Memphis, TN-MS-AR	3,835
Decatur, IL	3,801
Baton Rouge, LA	2,324
Chicago-Naperville-Joliet, IL-IN-WI	2,292
Lakeland, FL	2,284
Indianapolis, IN	1,836
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	1,534
Cleveland-Elyria-Mentor, OH	1,462
Mobile, AL	1,418
Richmond, VA	1,381
Champaign-Urbana, IL	1,305
Los Angeles-Long Beach-Santa Ana, CA	1,231
Kansas City, MO-KS	1,201
Milwaukee-Waukesha-West Allis, WI	1,160
Cincinnati-Middletown, OH-KY-IN	1,145
Tampa-St. Petersburg-Clearwater, FL	1,080
Cedar Rapids, IA	1,048
Greensboro-High Point, NC	1,017
Beaumont-Port Arthur, TX	976
Knoxville, TN	975
Omaha-Council Bluffs, NE-IA	908
Lafayette, IN	891
New Orleans-Metairie-Kenner, LA	848

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Table 6. Metropolitan Statistical Areas with the Highest Location Quotients in Agricultural Feedstock and Chemicals, 2006

Metropolitan Statistical Area	Location Quotient	2006 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Baton Rouge, LA	8.54	2,324
Memphis, TN-MS-AR	7.36	3,835
Knoxville, TN	3.64	975
Greensboro-High Point, NC	3.31	1,017
Richmond, VA	2.90	1,381
Madison, WI	2.84	717
Houston-Baytown-Sugar Land, TX	2.79	5,559
Indianapolis, IN	2.51	1,836
Omaha-Council Bluffs, NE-IA	2.47	908
New Orleans-Metairie-Kenner, LA	2.21	848
Cleveland-Elyria-Mentor, OH	1.66	1,462
Milwaukee-Waukesha-West Allis, WI	1.61	1,160
Dayton, OH	1.57	506
Kansas City, MO-KS	1.49	1,201
Toledo, OH	1.47	392
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Lakeland, FL	12.59	2,284
Mobile, AL	10.02	1,418
Cedar Rapids, IA	9.33	1,048
Beaumont-Port Arthur, TX	7.68	976
Longview, TX	7.17	544
Peoria, IL	5.39	842
Charleston, WV	4.88	547
Charleston-North Charleston, SC	3.32	730
Lubbock, TX	3.26	310
Fayetteville, NC	3.06	267
Chattanooga, TN-GA	3.04	604
Augusta-Richmond County, GA-SC	2.78	454
Stockton, CA	2.67	484
South Bend-Mishawaka, IN-MI	2.46	286
Wilmington, NC	2.22	249
Small MSAs (Total Private Employment Less Than 75,000)		
Decatur, IL	82.64	3,801
Danville, IL	23.70	571
Champaign-Urbana, IL	18.33	1,305
Victoria, TX	17.32	693
Decatur, AL	15.57	707
Blacksburg-Christiansburg-Radford, VA	15.50	738
Lafayette, IN	13.99	891
Morristown, TN	11.65	489
Ames, IA	11.31	306
Pascagoula, MS	10.18	433
Sioux City, IA-NE-SD	9.38	568
St. Joseph, MO-KS	9.13	397
Cleveland, TN	7.09	239
Lima, OH	6.33	298
Valdosta, GA	5.44	227

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

DRUGS AND PHARMACEUTICALS

The drugs and pharmaceuticals subsector produces commercially available medicinal and diagnostic substances. The subsector is generally characterized by large multinational firms heavily engaged in research and development activities to bring drugs to market.

Examples of Products

Vaccines

Oncology, neurology, immunology, and cardiology treatments

Tissue and cell culture media

Dermatological/topical treatments

Diagnostic substances

Animal therapeutics and vaccines

Examples of Companies

Abbott Laboratories

Amgen

AstraZeneca

Biogen Idec

Eli Lilly & Co.

Genentech

Merck & Co.

Novartis

Pfizer

Roche Diagnostics

Sanofi-Aventis/Sanofi Pasteur

States that are Both Large and Specialized*

California

New Jersey

Puerto Rico

Pennsylvania

North Carolina

Indiana

Illinois

Metro Areas with the Largest Employment Levels*

New York-Northern New Jersey-Long Island, NY-NJ-PA

Philadelphia-Camden-Wilmington, PA-NJ-DE-MD

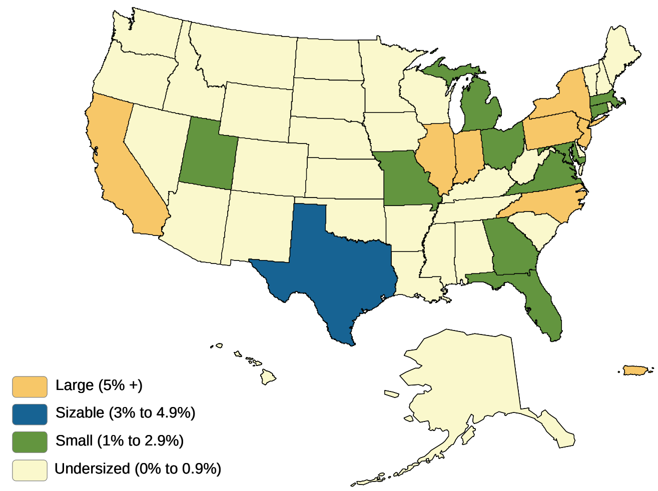
Chicago-Naperville-Joliet, IL-IN-WI

Indianapolis, IN

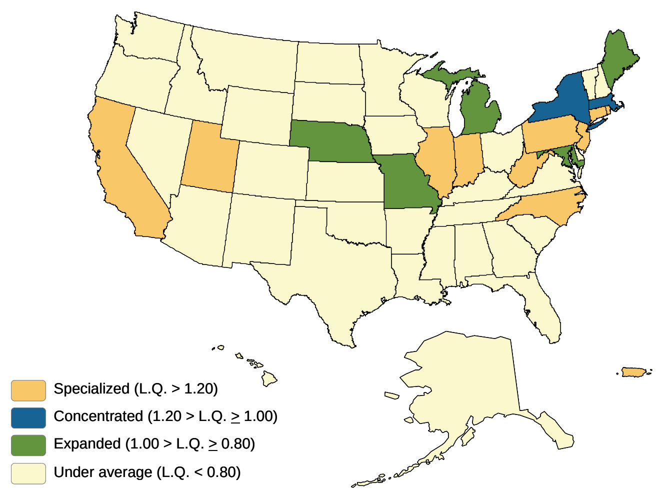
San Francisco-Oakland-Fremont, CA

*States and MSAs are listed in descending order by subsector employment levels.

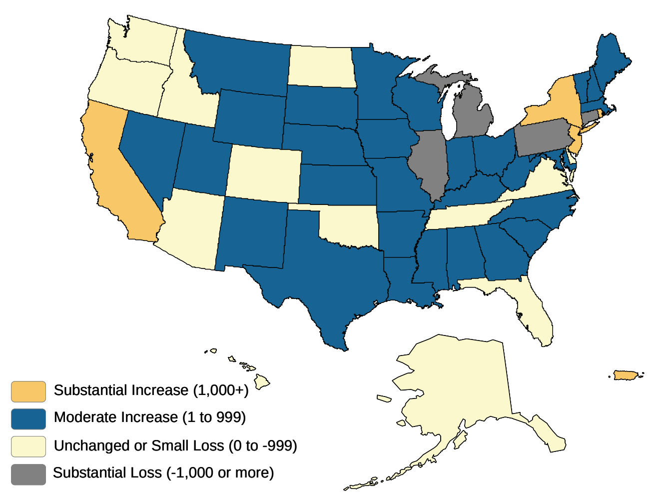
State Share of Total U.S. Employment



Employment Concentration Relative to the U.S.



Employment Gains and Losses, 2001–2006



Drugs and Pharmaceuticals

Overview

The drugs and pharmaceuticals subsector has steadily grown since 2001, increasing its job base by 4 percent to 317,000. U.S. drug production spans 2,600 individual business establishments, which tend to be large operations with an average of 120 employees, more than for any of the bioscience subsectors. Despite widespread job loss in the overall manufacturing sector in recent years, pharmaceutical producers have increased their establishment base by 2 percent and continue to add jobs (although recent news reports suggest there have been job losses since then). Wages in this subsector are, on average, higher than in any of the other segments—nearly $87,000 in 2006.

The majority of jobs in the drugs and pharmaceuticals subsector are in the large pharmaceutical preparation manufacturing industry. This component has driven steady subsector growth by adding 3 percent to employment since 2001. The in-vitro diagnostic substances component is smaller but has experienced faster growth, increasing nearly 20 percent since 2001.

State Drugs and Pharmaceuticals Employment

Employment Size. Industrial activity in drugs and pharmaceuticals is more highly concentrated among fewer states than the other bioscience subsectors. The ten states with the largest number of jobs account for 73 percent of national subsector employment. California and New Jersey, the largest two states, combine to make up more than one-quarter of national pharmaceutical employment.

- **Large States:** California, New Jersey, Puerto Rico, Pennsylvania, New York, North Carolina, Indiana, and Illinois
- **Sizable States:** Texas

Employment Concentration. Ten states and Puerto Rico have a specialized concentration of jobs in drugs and pharmaceutical production.

- **Specialized States:** Puerto Rico, New Jersey, Indiana, Connecticut, North Carolina, Utah, Pennsylvania, Rhode Island, West Virginia, Illinois, and California
- **Concentrated States:** New York and Massachusetts

Employment Growth. The drugs and pharmaceuticals subsector has experienced steady growth, adding more than 12,000 jobs overall since 2001. National job growth has been widespread, with 34 states increasing employment at some level. California leads in job growth, with state companies adding more than 5,000 jobs since 2001.

Large and Specialized States. Seven states have both a large employment base and a specialized concentration of jobs in the drugs and pharmaceuticals subsector (Table 7).

Table 7. States with Large and Specialized Employment in the Drugs and Pharmaceuticals Subsector, 2006

State	Establishments 2006	Employment 2006	Location Quotient	Share of U.S. Employment
California	405	44,475	1.21	14.0%
New Jersey	248	40,379	4.32	12.7%
Puerto Rico	87	26,251	12.61	8.3%
Pennsylvania	111	22,298	1.63	7.0%
North Carolina	72	19,409	2.10	6.1%
Indiana	39	19,255	2.76	6.1%
Illinois	118	19,084	1.36	6.0%

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Metropolitan Areas

Tables 8 and 9 present those MSAs with the overall largest employment levels (size) in drugs and pharmaceuticals and those with the highest LQs (concentration) among their respective size categories.

Table 8. Metropolitan Statistical Areas with the Largest Employment Levels in Drugs and Pharmaceuticals, 2006

Metropolitan Statistical Area	2006 Employment
New York-Northern New Jersey-Long Island, NY-NJ-PA	52,497
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	18,649
Chicago-Naperville-Joliet, IL-IN-WI	17,850
Indianapolis, IN	13,592
San Francisco-Oakland-Fremont, CA	12,018
Los Angeles-Long Beach-Santa Ana, CA	12,002
Oxnard-Thousand Oaks-Ventura, CA	7,549
Boston-Cambridge-Quincy, MA-NH	7,252
Durham, NC	6,902
Kalamazoo-Portage, MI	4,452
San Diego-Carlsbad-San Marcos, CA	4,382
Raleigh-Cary, NC	4,212
Bridgeport-Stamford-Norwalk, CT	3,901
New Haven-Milford, CT	3,757
St. Louis, MO-IL	3,754
Dallas-Fort Worth-Arlington, TX	3,748
Baltimore-Towson, MD	2,985
Washington-Arlington-Alexandria, DC-VA-MD-WV	2,585
Miami-Fort Lauderdale-Miami Beach, FL	2,457
Minneapolis-St. Paul-Bloomington, MN-WI	2,337
San Jose-Sunnyvale-Santa Clara, CA	2,305
Morgantown, WV	2,248
Cincinnati-Middletown, OH-KY-IN	2,142
Riverside-San Bernardino-Ontario, CA	2,126
Vallejo-Fairfield, CA	1,969

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Table 9. Metropolitan Statistical Areas with the Highest Location Quotients in Drugs and Pharmaceuticals, 2006

Metropolitan Statistical Area	Location Quotient	2006 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Oxnard-Thousand Oaks-Ventura, CA	10.43	7,549
Indianapolis, IN	6.94	13,592
New Haven-Milford, CT	4.46	3,757
Raleigh-Cary, NC	4.09	4,212
Bridgeport-Stamford-Norwalk, CT	3.94	3,901
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	3.04	18,649
New York-Northern New Jersey-Long Island, NY-NJ-PA	2.89	52,497
San Francisco-Oakland-Fremont, CA	2.66	12,018
Madison, WI	2.35	1,591
Greenville, SC	2.33	1,558
Worcester, MA	1.81	1,289
Chicago-Naperville-Joliet, IL-IN-WI	1.78	17,850
Syracuse, NY	1.58	1,034
San Diego-Carlsbad-San Marcos, CA	1.52	4,382
Rochester, NY	1.49	1,629
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Kalamazoo-Portage, MI	13.99	4,452
Durham, NC	12.27	6,902
Vallejo-Fairfield, CA	7.03	1,969
Norwich-New London, CT	5.40	1,302
Provo-Orem, UT	4.31	1,615
Evansville, IN-KY	4.15	1,692
Lincoln, NE	4.05	1,353
Boulder, CO	3.97	1,366
Waco, TX	3.71	812
Holland-Grand Haven, MI	2.47	649
Ogden-Clearfield, UT	2.27	877
Santa Cruz-Watsonville, CA	2.15	455
Augusta-Richmond County, GA-SC	2.13	935
Trenton-Ewing, NJ	1.80	780
Lexington-Fayette, KY	1.76	923
Small MSAs (Total Private Employment Less Than 75,000)		
Morgantown, WV	20.55	2,248
Rocky Mount, NC	10.39	1,429
St. Joseph, MO-KS	7.33	856
Harrisonburg, VA	7.15	954
Kankakee-Bradley, IL	7.06	672
Terre Haute, IN	6.95	1,054
Greenville, NC	6.89	934
Athens-Clarke County, GA	6.71	999
Lafayette, IN	6.56	1,121
Bloomington, IN	5.88	851
Lebanon, PA	5.83	608
Logan, UT-ID	4.43	444
Napa, CA	4.39	654
Albany, GA	3.13	404
Gainesville, GA	2.58	415

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

MEDICAL DEVICES AND EQUIPMENT

Firms in the medical device and equipment subsector produce a variety of biomedical instruments and other health care products and supplies for diagnostics, surgery, patient care, and laboratories. The subsector is continually advancing the application of electronics and information technologies to improve and automate testing and patient care capabilities.

Examples of Products

Bioimaging equipment
Surgical supplies and instruments
Orthopedic and prosthetic implants and devices
Laser eye surgery instruments
Automated external defibrillators (AEDs)
Vascular stents and other implantable devices
Dental instruments and orthodontics
Walkers, wheelchairs, and beds

Examples of Companies

Alcon
Baxter International
Boston Scientific Corp.
Cardinal Health
GE Healthcare
Johnson and Johnson
Medtronic
Siemens Medical Solutions
Stryker
Tyco Healthcare
3M Health Care

States that are Both Large and Specialized*

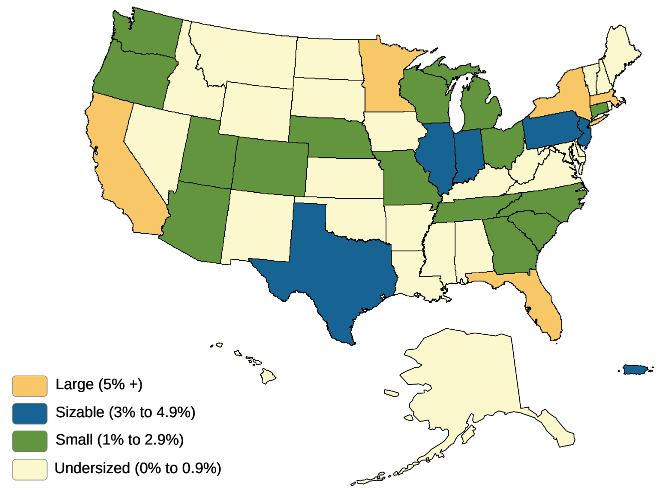
California
Minnesota
Massachusetts

Metro Areas with the Largest Employment Levels*

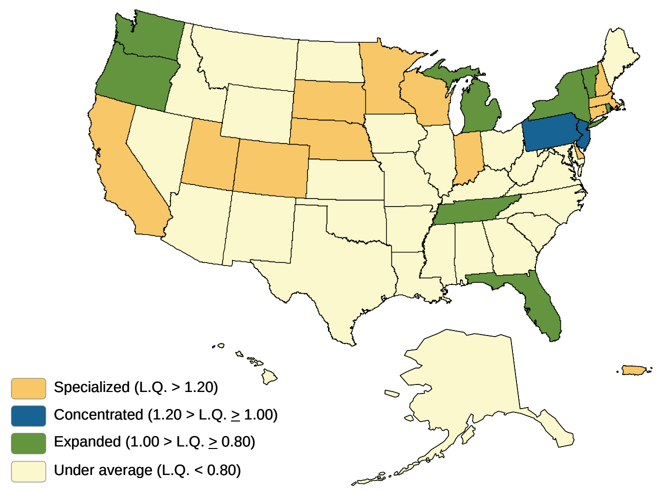
Los Angeles-Long Beach-Santa Ana, CA
Minneapolis-St. Paul-Bloomington, MN-WI
New York-Northern New Jersey-Long Island, NY-NJ-PA
Boston-Cambridge-Quincy, MA-NH
Chicago-Naperville-Joliet, IL-IN-WI

*States and MSAs are listed in descending order by subsector employment levels.

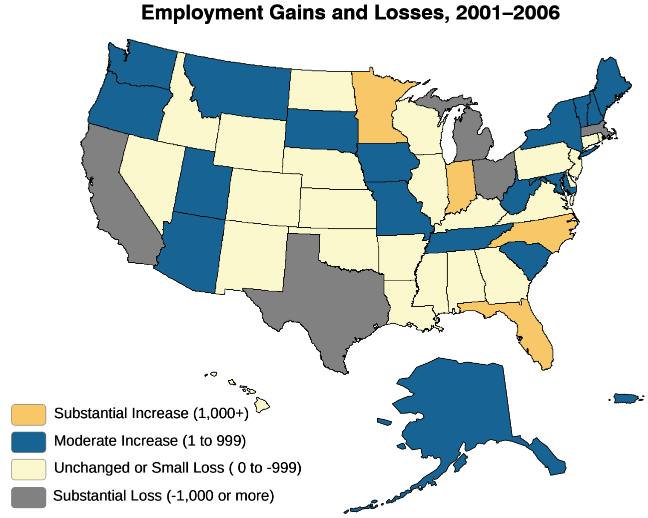
State Share of Total U.S. Employment



Employment Concentration Relative to the U.S.



Employment Gains and Losses, 2001–2006



Medical Devices and Equipment

Overview

Medical device and equipment manufacturers operate more than 15,000 national establishments with 423,000 employees. The subsector employs one in three bioscience workers and represents a major manufacturing component within the bioscience sector. Average annual earnings for workers in medical devices were $59,441 in 2006, and while these exceed wages for many major industries and the national private sector, this subsector has the lowest average wage in the biosciences.

Since 2001, employment among medical device firms has remained relatively flat (down 0.9 percent), reflecting in large part the impact of the 2001 recession on manufacturing and the sluggish years that followed. Over the more recent 2-year period, however, the industry has increased by 2.8 percent and is back on a growth path.

Among the component industries in the medical device subsector, electromedical apparatus manufacturers and dental laboratories have experienced job growth over the recent 5-year period. The electromedical industry, which produces products such as MRI, ultrasound, pacemaker, and endoscopic equipment, increased employment by 10 percent. Dental laboratories added 5 percent to its employment base since 2001.

State Medical Device and Equipment Employment

Employment Size. Medical device production is widespread, with establishments in every state, DC, and Puerto Rico. The top 10 employer states account for 60 percent of the national subsector.

- **Large States:** California, Minnesota, Florida, Massachusetts, and New York
- **Sizable States:** Pennsylvania, Indiana, Texas, New Jersey, Puerto Rico, and Illinois

Employment Concentration. Twelve states and Puerto Rico have a specialized concentration of medical device jobs. Puerto Rico continues to have the highest LQ.

- **Specialized States:** Puerto Rico, Minnesota, Utah, Massachusetts, Delaware, Indiana, Connecticut, New Hampshire, Nebraska, California, South Dakota, Wisconsin, and Colorado
- **Concentrated States:** New Jersey and Pennsylvania

Employment Growth. Medical devices and equipment has lost about 4,000 jobs overall since 2001; however, it has returned to a growth industry since 2004. Despite overall declines, 17 states and Puerto Rico had moderate job gains over the 5-year period to 2006. Four states—Minnesota, Indiana, Florida, and North Carolina—experienced large employment gains (more than 1,000 jobs).

Large and Specialized States. Three states have both a large employment base and a specialized concentration of jobs in the medical devices and equipment subsector (Table 10).

Table 10. States with Large and Specialized Employment in the Medical Devices and Equipment Subsector, 2006

State	Establishments 2006	Employment 2006	Location Quotient	Share of U.S. Employment
California	2,214	72,073	1.47	17.0%
Minnesota	422	29,763	3.48	7.0%
Massachusetts	448	22,498	2.16	5.3%

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Metropolitan Areas

Tables 11 and 12 present those MSAs with the overall largest employment levels (size) in medical devices and equipment and those with the highest LQs (concentration) among their respective size categories.

Table 11. Metropolitan Statistical Areas with the Largest Employment Levels in Medical Devices and Equipment, 2006

Metropolitan Statistical Area	2006 Employment
Los Angeles-Long Beach-Santa Ana, CA	29,722
Minneapolis-St. Paul-Bloomington, MN-WI	27,178
New York-Northern New Jersey-Long Island, NY-NJ-PA	18,926
Boston-Cambridge-Quincy, MA-NH	16,704
Chicago-Naperville-Joliet, IL-IN-WI	12,383
San Jose-Sunnyvale-Santa Clara, CA	11,298
San Francisco-Oakland-Fremont, CA	10,997
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	9,712
Miami-Fort Lauderdale-Miami Beach, FL	8,844
Salt Lake City, UT	7,886
Dallas-Fort Worth-Arlington, TX	7,269
Tampa-St. Petersburg-Clearwater, FL	6,120
Seattle-Tacoma-Bellevue, WA	5,952
Milwaukee-Waukesha-West Allis, WI	5,723
San Diego-Carlsbad-San Marcos, CA	5,647
Indianapolis, IN	5,433
Riverside-San Bernardino-Ontario, CA	5,352
Pittsburgh, PA	4,857
Denver-Aurora, CO	4,579
Atlanta-Sandy Springs-Marietta, GA	4,383
Cleveland-Elyria-Mentor, OH	4,288
New Haven-Milford, CT	4,097
Providence-New Bedford-Fall River, RI-MA	3,946
Portland-Vancouver-Beaverton, OR-WA	3,921
Rochester, NY	3,749

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Table 12. Metropolitan Statistical Areas with the Highest Location Quotients in Medical Devices and Equipment, 2006

Metropolitan Statistical Area	Location Quotient	2006 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Minneapolis-St. Paul-Bloomington, MN-WI	4.86	27,178
Salt Lake City, UT	4.24	7,886
Syracuse, NY	4.02	3,707
San Jose-Sunnyvale-Santa Clara, CA	3.80	11,298
New Haven-Milford, CT	3.46	4,097
Madison, WI	2.92	2,786
Worcester, MA	2.73	2,730
Rochester, NY	2.44	3,749
Boston-Cambridge-Quincy, MA-NH	2.20	16,704
Milwaukee-Waukesha-West Allis, WI	2.11	5,723
Indianapolis, IN	1.97	5,433
Memphis, TN-MS-AR	1.87	3,686
Bridgeport-Stamford-Norwalk, CT	1.84	2,565
Providence-New Bedford-Fall River, RI-MA	1.77	3,946
Jacksonville, FL	1.76	3,440
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Boulder, CO	5.24	2,537
Kalamazoo-Portage, MI	5.20	2,327
Santa Barbara-Santa Maria-Goleta, CA	3.61	2,033
Reading, PA	3.50	1,899
Santa Rosa-Petaluma, CA	3.18	1,940
Scranton--Wilkes-Barre, PA	3.08	2,523
York-Hanover, PA	2.27	1,295
Rochester, MN	2.22	760
Saginaw-Saginaw Township North, MI	2.14	608
Manchester-Nashua, NH	2.12	1,379
Deltona-Daytona Beach-Ormond Beach, FL	2.02	1,102
Ann Arbor, MI	1.99	952
Gainesville, FL	1.98	652
Huntington-Ashland, WV-KY-OH	1.83	621
St. Cloud, MN	1.80	555
Small MSAs (Total Private Employment Less Than 75,000)		
Bloomington, IN	15.05	3,066
Glens Falls, NY	12.97	2,043
Flagstaff, AZ	9.70	1,552
Sumter, SC	7.53	885
Dubuque, IA	4.05	724
State College, PA	3.93	631
Niles-Benton Harbor, MI	3.48	702
Elmira, NY	3.11	362
Jackson, MI	2.61	460
Corvallis, OR	2.40	233
Logan, UT-ID	2.37	334
Michigan City-La Porte, IN	2.32	327
Jacksonville, NC	2.26	253
Pocatello, ID	2.22	231
Parkersburg-Marietta, WV-OH	2.00	438

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

RESEARCH, TESTING, AND MEDICAL LABORATORIES

The research, testing, and medical laboratories subsector includes a range of activities; from highly research-oriented companies working to develop and commercialize new drug discovery/delivery systems, and gene and cell therapies, to more service-oriented firms engaged in medical and other life sciences testing services.

Examples of Products

Functional genomics and drug discovery techniques

Diagnostic testing

Preclinical drug development

Stem cell/regenerative research

Biomarkers

Nanoscale drug delivery systems

Research models and laboratory support services

Examples of Companies

Cellomics

Charles River Laboratories

Covance

Invitrogen

Laboratory Corp. of America

Lexicon Pharmaceuticals

Pharmacopeia

Quest Diagnostics

Stratatech

ViaCell

States that are Both Large and Specialized*

California

Pennsylvania

Massachusetts

New Jersey

Metro Areas with the Largest Employment Levels*

New York-Northern New Jersey-Long Island, NY-NJ-PA

Los Angeles-Long Beach-Santa Ana, CA

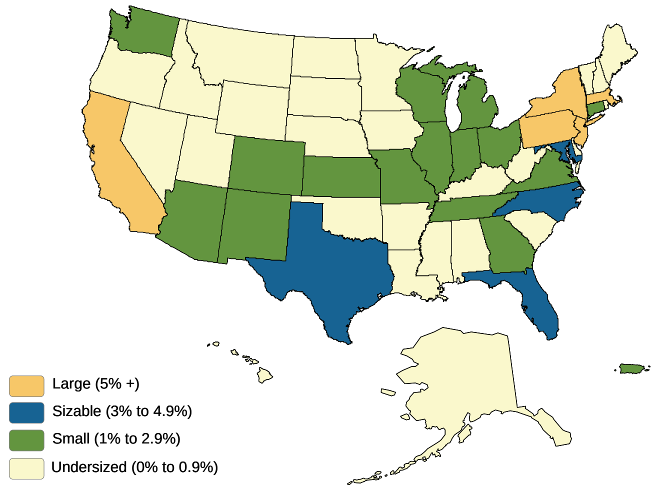
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD

Boston-Cambridge-Quincy, MA-NH

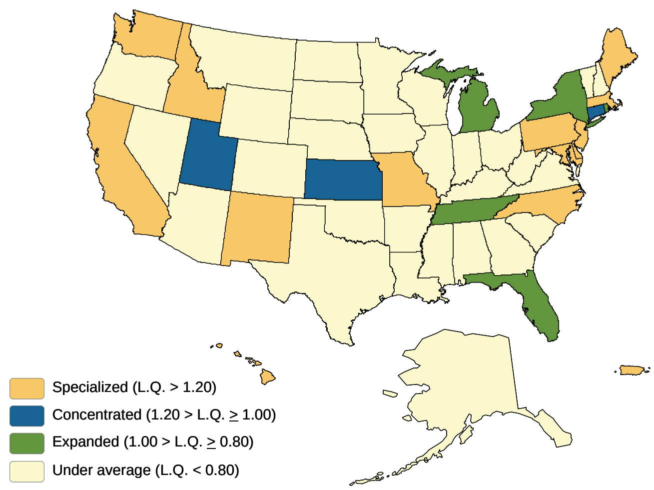
Washington-Arlington-Alexandria, DC-VA-MD-WV

*States and MSAs are listed in descending order by subsector employment levels.

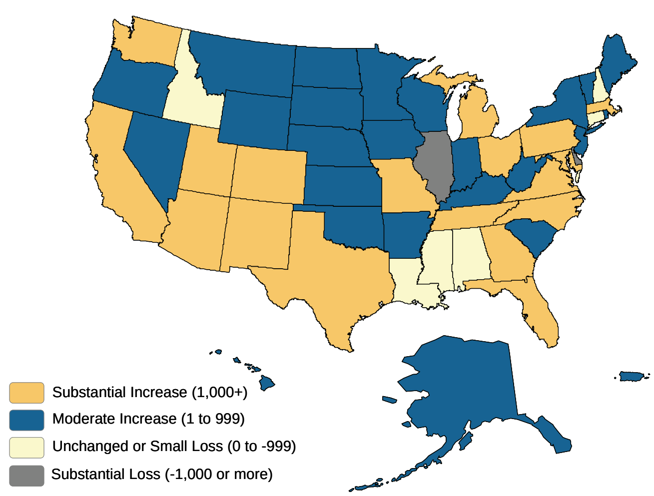
State Share of Total U.S. Employment



Employment Concentration Relative to the U.S.



Employment Gains and Losses, 2001–2006



Research, Testing, and Medical Laboratories

Overview

Research, testing, and medical laboratories is the largest of the four bioscience subsectors, a position that should continue given the rapid expansion of subsector companies in recent years. Since 2001, the subsector has grown its employment base by 17.8 percent, or almost 68,000 national jobs; in 2006, it accounted for 35 percent of U.S. bioscience employment. Workers in this life sciences R&D and laboratory activity earned, on average, more than $71,000 in 2006.

Compared with the other bioscience subsectors, the research, testing, and medical laboratories subsector is unique in that its firms do not engage in manufacturing specific products. R&D and lab services companies in the biosciences play a critical role in breakthrough research and the development of new products, in addition to administering biomedical diagnostic and lab services. The subsector is evenly split among the R&D component (53 percent of employment) and the medical laboratories and diagnostic imaging component (46 percent). Life sciences testing labs comprise the remaining 1 percent.

Each of the component industries of the research, testing, and medical laboratories subsector has added jobs since 2001, with the two largest industries—life sciences R&D and medical labs—increasing by 15 percent and 14 percent, respectively. Employment in diagnostic imaging centers has grown by 34 percent over the 5-year period.

State Research, Testing, and Medical Laboratories Employment

Employment Size. The largest of the bioscience subsectors, research, testing, and medical laboratories employment is widespread and rapidly growing. Similar to other subsectors, the 10 largest states account for 61 percent of national jobs. California, with more than 75,000 jobs, is by far the largest state in the subsector, followed by Pennsylvania.

- **Large States:** California, Pennsylvania, New York, Massachusetts, and New Jersey
- **Sizable States:** Florida, Texas, Maryland, and North Carolina

Employment Concentration. Thirteen states, the District of Columbia, and Puerto Rico have specialized employment concentrations relative to the national average in research, testing, and medical laboratories.

- **Specialized States:** District of Columbia, Massachusetts, New Mexico, Maryland, New Jersey, Idaho, Pennsylvania, Puerto Rico, Delaware, California, Washington, Maine, Hawaii, North Carolina, and Missouri
- **Concentrated States:** Connecticut, Kansas, and Utah

Employment Growth. Rapid national growth among research, testing, and medical laboratories firms has been geographically widespread, with a total of 42 states and Puerto Rico adding jobs in the subsector since 2001. Among these growth states are an impressive 18 States that have grown their job base by 1,000 jobs or more. Pennsylvania and California have led the job growth, adding about 10,000 and 9,000 jobs since 2001, respectively.

Large and Specialized States. Four states have both a large employment base and a specialized concentration of jobs in the research, testing, and medical laboratories subsector (Table 13).

Table 13. States with Large and Specialized Employment in the Research, Testing, and Medical Laboratories Subsector, 2006

State	Establishments 2006	Employment 2006	Location Quotient	Share of U.S. Employment
California	3,294	75,616	1.45	16.8%
Pennsylvania	967	32,855	1.69	7.3%
Massachusetts	820	25,637	2.32	5.7%
New Jersey	925	24,880	1.88	5.5%

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Metropolitan Areas

Tables 14 and 15 present those MSAs with the overall largest employment levels (size) in research, testing, and medical laboratories and those with the highest LQs (concentration) among their respective size categories.

Table 14. Metropolitan Statistical Areas with the Largest Employment Levels in Research, Testing, and Medical Laboratories, 2006

Metropolitan Statistical Area	2006 Employment
New York-Northern New Jersey-Long Island, NY-NJ-PA	36,367
Los Angeles-Long Beach-Santa Ana, CA	26,323
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	23,837
Boston-Cambridge-Quincy, MA-NH	22,367
Washington-Arlington-Alexandria, DC-VA-MD-WV	19,014
San Diego-Carlsbad-San Marcos, CA	14,489
San Francisco-Oakland-Fremont, CA	13,752
Chicago-Naperville-Joliet, IL-IN-WI	12,181
San Jose-Sunnyvale-Santa Clara, CA	10,784
Detroit-Warren-Livonia, MI	9,374
Baltimore-Towson, MD	8,512
Miami-Fort Lauderdale-Miami Beach, FL	8,494
St. Louis, MO-IL	7,747
Seattle-Tacoma-Bellevue, WA	7,032
Pittsburgh, PA	6,566
Dallas-Fort Worth-Arlington, TX	6,418
Durham, NC	6,271
Kansas City, MO-KS	6,113
Houston-Baytown-Sugar Land, TX	5,689
Atlanta-Sandy Springs-Marietta, GA	5,150
Phoenix-Mesa-Scottsdale, AZ	5,119
Tampa-St. Petersburg-Clearwater, FL	4,599
Salt Lake City, UT	3,557
Albany-Schenectady-Troy, NY	3,539
Albuquerque, NM	3,431

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Table 15. Metropolitan Statistical Areas with the Highest Location Quotients in Research, Testing, and Medical Laboratories, 2006

Metropolitan Statistical Area	Location Quotient	2006 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
San Jose-Sunnyvale-Santa Clara, CA	3.35	10,784
San Diego-Carlsbad-San Marcos, CA	3.29	14,489
Albuquerque, NM	2.80	3,431
Albany-Schenectady-Troy, NY	2.73	3,539
Boston-Cambridge-Quincy, MA-NH	2.72	22,367
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	2.55	23,837
Washington-Arlington-Alexandria, DC-VA-MD-WV	2.12	19,014
Baltimore-Towson, MD	2.05	8,512
San Francisco-Oakland-Fremont, CA	1.99	13,752
Kansas City, MO-KS	1.86	6,113
Raleigh-Cary, NC	1.86	2,912
New Haven-Milford, CT	1.85	2,378
Salt Lake City, UT	1.76	3,557
Pittsburgh, PA	1.70	6,566
St. Louis, MO-IL	1.68	7,747
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Durham, NC	7.31	6,271
Kennewick-Richland-Pasco, WA	6.56	2,028
Trenton-Ewing, NJ	4.04	2,672
Wilmington, NC	3.55	1,624
Norwich-New London, CT	3.36	1,235
Ann Arbor, MI	2.66	1,384
Barnstable Town, MA	2.66	833
Boulder, CO	2.56	1,347
Oshkosh-Neenah, WI	2.00	622
South Bend-Mishawaka, IN-MI	1.96	929
Spokane, WA	1.86	1,260
Lincoln, NE	1.54	785
Eugene-Springfield, OR	1.46	728
Erie, PA	1.39	630
Huntsville, AL	1.33	824
Small MSAs (Total Private Employment Less Than 75,000)		
Idaho Falls, ID	8.34	1,578
Burlington, NC	4.45	920
Johnstown, PA	3.20	622
Muncie, IN	2.78	449
Mount Vernon-Anacortes, WA	2.43	361
Santa Fe, NM	2.28	413
Bay City, MI	2.05	260
Bangor, ME	2.04	471
Columbia, MO	2.04	484
Warner Robins, GA	2.00	262
Ames, IA	1.97	218
Valdosta, GA	1.88	323
Cheyenne, WY	1.49	174
Corvallis, OR	1.46	154
Lima, OH	1.42	274

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Industry Summary and Conclusion

The U.S. bioscience sector is well established and is outpacing the national private sector in job and establishment growth. Bioscience companies operate nearly 43,000 individual establishments and employ 1.3 million highly skilled workers. A wage premium for bioscience workers is evidence of the depth of the industry talent pool and the increasing demand for these workers. In 2006, the average bioscience worker earned $71,000, 68 percent more than their counterparts across the private sector where average wages were just over $42,000.

National bioscience growth has been impressive in recent years, with the sector's employment base rising 5.7 percent since 2001, compared with a 3.1 percent increase in the overall private sector. This overall net growth was driven by large gains in research, testing, and medical laboratories where employment has increased by 17.8 percent. Job growth at this rate is even more impressive as this subsector is the largest of four in the biosciences. The drugs and pharmaceuticals subsector has maintained steady growth, and is up 4 percent since 2001. Medical devices and equipment employment has been flat overall since 2001; however, the industry is again growing, adding 2.8 percent since 2004. Agricultural feedstock and chemicals has shed jobs (down 6.1 percent) but is experiencing promising growth in ethanol production, a trend that is expected to increase dramatically.

Employment growth in the national bioscience sector is projected to continue. The overall bioscience growth rate will be 1.0 percent, matching the projection for the overall private sector through 2016, according to the latest Bureau of Labor Statistics' industry employment projections for the 10-year period ending in 2016. The drugs and pharmaceuticals subsector is projected to grow by 2.4 percent annually. Also expected to grow at a rapid rate is research, testing, and medical laboratories, with a projected 1.6 percent annual growth rate. Employment in medical devices and equipment is projected to remain flat, with an expected 0 percent annual rate. The agricultural feedstock and chemicals subsector will continue to lose employment at a rate of 1.8 percent annually.

Bioscience firms conduct business in all of the 50 states, the District of Columbia, and Puerto Rico. The distribution is widespread, with numerous states developing strong niches in certain specializations. While some states are deeply involved in a number of industry subsectors, no one state has a large employment base in every one.

Highlights from the state-by-state industry employment analysis include the following:

- In size, 14 states and Puerto Rico have a large employment base (5 percent or more of national employment) in at least one of the bioscience subsectors. Seven of those states—California, Florida, Illinois, Massachusetts, New Jersey, New York, and Pennsylvania—have a large base in at least two subsectors. Only two of those states—California and New York—are classified as having a large job base in three of the four subsectors. No states are classified as having a large job base in all four subsectors.
- In employment concentration, 35 states, the District of Columbia, and Puerto Rico have an employment specialization in at least one of the four bioscience subsectors. Twelve states are specialized in two industry subsectors. California, Indiana, North Carolina, and Puerto Rico have a specialization in three of four subsectors. No state is specialized in all four.
- Twelve states and Puerto Rico have both a large and specialized bioscience base in at least one of the subsectors (Table 16). That is, they have an employment level that represents at least 5 percent of the U.S. total and they have an LQ that meets or exceeds 1.20. Four states—Illinois, Massachusetts, New Jersey, and Pennsylvania—are both large and specialized in two of the subsectors. California is the only state both large and specialized in three of the four subsectors.

Table 16. States with Large and Specialized Bioscience Subsectors

States	Agricultural Feedstock & Chemicals	Drugs & Pharmaceuticals	Medical Devices & Equipment	Research, Testing, & Medical Laboratories
California		●	●	●
Illinois	●	●		
Indiana		●		
Iowa	●			
Massachusetts			●	●
Minnesota			●	
New Jersey		●		●
North Carolina		●		
Ohio	●			
Pennsylvania		●		●
Puerto Rico		●		
Tennessee	●			
Texas	●			

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

As the national and state bioscience sectors grow, local areas are expanding and refining their own niche in the biosciences. Metropolitan areas both large and small are supporting the biosciences and reaping the economic and social benefits of fostering a local bioscience cluster or individual subsector. Hundreds of metropolitan areas throughout the United States are engaged in some commercial or research endeavors in the biosciences.

Highlights from the metropolitan area employment analysis include the following:

- Of the nation's 361 MSAs, 202 have an employment specialization in at least one of the four bioscience subsectors in 2006. This figure has risen from 193 MSAs in the previous BIO report (using 2004 data).
- Fourteen regions are specialized in three of the four subsectors, including:
  - Boston-Cambridge-Quincy, MA-NH
  - Boulder, CO
  - Buffalo-Niagara Falls, NY
  - Durham, NC
  - Indianapolis, IN
  - Kalamazoo-Portage, MI
  - Knoxville, TN
  - Lincoln, NE
  - New Haven-Milford, CT
  - San Diego-Carlsbad-San Marcos, CA
  - San Francisco-Oakland-Fremont, CA
  - St. Joseph, MO-KS
  - Syracuse, NY
  - Worcester, MA
- Madison, Wisconsin, is the only metropolitan area with a specialized job concentration in all four subsectors of the biosciences in 2006. In the previous version of this report using 2004 data, Madison also achieved this distinction in broad but deep industry concentration.

Beyond Employment

As state, regional, and local stakeholders strive for economic development gains in the biosciences in terms of jobs, establishments, and income, many other factors play into the success, health, and robustness of a region's biosciences industry. Though a full examination of many of these factors (e.g., regional bioscience core competencies, corporate business models, regional networks, and supplier relationships) is beyond the scope of this report, additional analysis of various secondary data sources can provide additional insights, both directly and comparatively, into the status of state bioscience performance.

Other Key Bioscience Performance Metrics

- Academic Bioscience R&D
- NIH Funding
- Bioscience Occupational Employment
- Bioscience Degrees Granted
- Bioscience Venture Capital Investments
- Bioscience-Related Patents

In the following section, six additional bioscience performance metrics, ranging from funding to innovation, are analyzed—first, a national perspective of the metric is examined, and then information is provided on leading states on both total magnitude and a more comparable ratio relative to population.[5] The metrics include academic bioscience R&D expenditures, total National Institutes of Health (NIH) funding, occupational employment in select bioscience-related fields, degrees awarded by higher education institutions in bioscience-related fields, venture capital investments in bioscience companies, and bioscience-related patents "invented" within the state.[6] Not surprisingly, California leads in each of the six metrics on a "total" basis. However, as shown in the following discussion, bioscience performance can also be driven by local academic and industrial characteristics and, when controlling for population size, other states emerge as bioscience players.

Academic Bioscience R&D

Academic institutions are a significant driver of bioscience development in most areas of the country. Bioscience R&D expenditures accounted for more than $29 billion (or more than 60 percent of all U.S. academic R&D) in FY 2006, with many individual states significantly exceeding that share. At a national level, this amounts to $98.10 per U.S. citizen spent by the nation's academic institutions on bioscience-related research. Academic bioscience R&D has steadily increased from FY 2002 to FY 2006, as shown in Figure 5, growing by 36.9 percent over the period.

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[5] For comparability, the various metrics are converted into a per capita measure (or into a per million of population metric). In some instances, when a State's population is less than 1 million, the number shown in the table may be greater than the actual magnitude of the metric. Population data are from the U.S. Census Bureau's 2006 and 2007 estimates, used as appropriate.

[6] Figures and charts are based on Battelle calculations of the following data: **Academic R&D Expenditures:** National Science Foundation (NSF) Survey of Research and Development Expenditures at Universities and Colleges; **NIH Funding:** National Institutes of Health – Dollars Awarded by State; **Higher Education Degrees:** National Center for Educational Statistics, Integrated Postsecondary Education Data System (IPEDS); **Occupational Employment:** U.S. Bureau of Labor Statistics, Occupational Employment Statistics (OES) survey; **Venture Capital:** Thomson Reuters VentureXpert Database; **Patents:** U.S. Patent & Trademark Office data as available from the Thomson Reuters' Delphion Patent Analysis Database. For a detailed description please refer to the data and methodology appendix.

Figure 5. U.S. Academic Bioscience R&D Expenditures, FY 2002–FY 2006

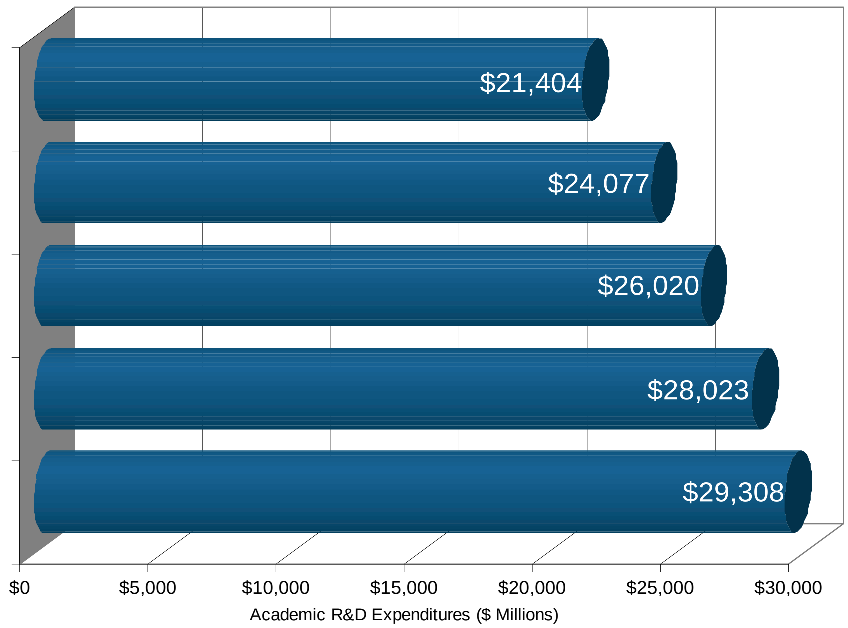
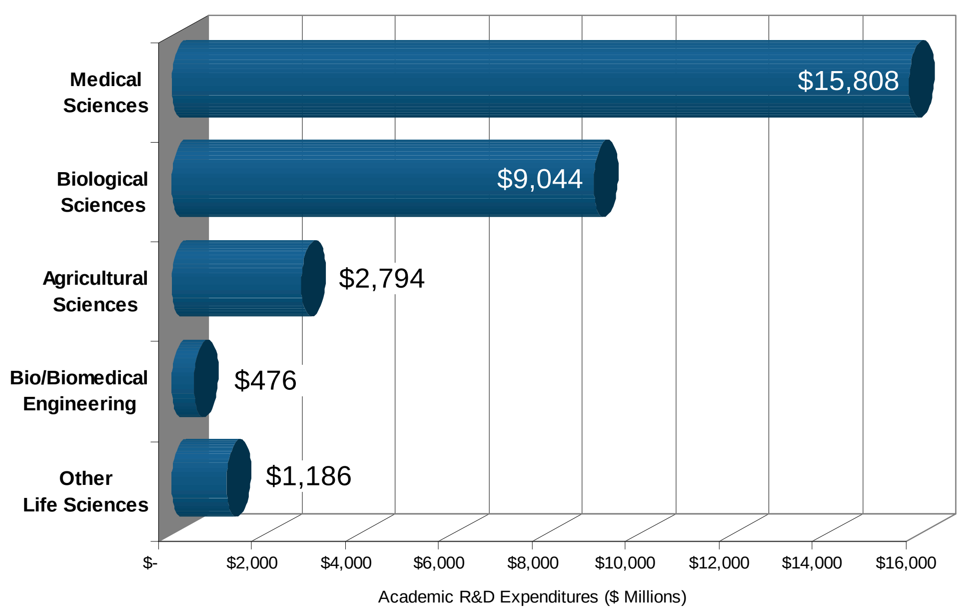


Figure 6 shows that medical sciences research, at nearly $16 billion, accounts for the majority of the bioscience research (53 percent) and, in fact, accounts for one-third of all academic R&D in the United States.

Figure 6. U.S. Academic Bioscience R&D Expenditures by Discipline, FY 2006



As shown in Table 17, the larger states and states with large academic infrastructures lead in total academic bioscience R&D. However, on a per capita basis, other states—especially states with strong agricultural R&D capacities such as Nebraska, Iowa, and Missouri—are seen as research leaders as well.

Of note, California's actual increase of $1.17 billion (up from $2.84 billion in FY 2002 to $4.01 billion in FY 2006) exceeded all but five other states' totals for FY 2006. From a growth "rate" perspective, of those States that had at least $100 million in FY 2002 (threshold set to avoid small number effects), six states—Arkansas, Ohio, Tennessee, Kentucky, New Mexico, and Maryland—had growth rates of 50 percent or greater.

Table 17. Leading States—Academic Bioscience R&D Expenditures, FY 2006

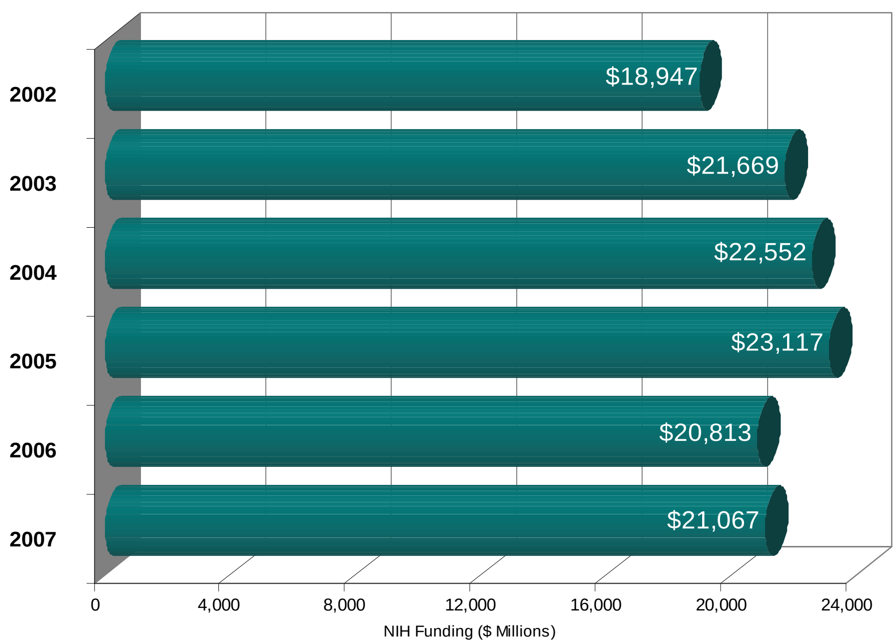
Academic Bioscience R&D			
Leading States	Total in $ Thousands	Leading States	Per Capita
California	$4,008,809	District of Columbia	$306.82
New York	$2,528,232	Maryland	$234.50
Texas	$2,217,069	Massachusetts	$174.02
Pennsylvania	$1,478,008	Vermont	$172.59
Maryland	$1,313,685	Connecticut	$161.29
North Carolina	$1,310,490	North Carolina	$147.75
Illinois	$1,127,038	Nebraska	$141.46
Massachusetts	$1,119,740	New York	$131.12
Ohio	$1,048,200	Iowa	$130.43
Florida	$560,576	Missouri	$127.08

Source: Battelle calculations—based on NSF data and U.S. Census Bureau population estimate.

NIH Funding

Though other federal agencies fund bioscience-related R&D, the National Institutes of Health is considered to be the "gold standard" of biomedical research funding.[7] NIH funding is a significant component of academic medical sciences research and is ultimately included in the academic bioscience R&D expenditures data above. However, NIH also funds research and educational initiatives within non-university affiliated medical research institutions, hospitals, and other healthcare-related organizations. In 2007, NIH invested more than $21 billion in extramural U.S.-based medical research and education, with more than 76 percent of this amount going to higher education institutions. Overall, NIH funding grew by 11.2 percent from FY 2002 to FY 2007. However, as shown in Figure 7, this 2007 amount is down from the peak funding that occurred in 2005—2 years after the official end of the NIH "doubling" period.[8]

Figure 7. U.S. Extramural NIH Funding, FY 2002–FY 2007



[7] Bioscience-related R&D is also funded by the Department of Defense, the Veterans Administration, NASA, the Environmental Protection Agency, as well as other federal agencies.

[8] From FY 1998 through FY 2003, Congressional appropriations for the NIH were purposefully "doubled" from $13.7 billion to $27.1 billion to dramatically increase the level of federal support to biomedical research.

Table 18 shows that, as with academic bioscience R&D, the larger states capture the largest amounts of NIH funding. However, when accounting for U.S. and state population, extramural NIH funding amounts to $69.84 per person nationally, with many smaller states such as Rhode Island, Connecticut, and Vermont garnering a comparably significant amount of funding.

Table 18. Leading States—NIH Funding, FY 2007

NIH Funding			
Leading States	**Total in $ Thousands**	**Leading States**	**Per Capita**
California	$3,163,252	Massachusetts	$346.70
Massachusetts	$2,236,110	District of Columbia	$332.72
New York	$1,934,768	Maryland	$173.81
Pennsylvania	$1,399,308	Rhode Island	$135.59
Texas	$1,083,465	Connecticut	$133.97
Maryland	$976,541	Washington	$121.47
North Carolina	$931,189	Pennsylvania	$112.55
Washington	$785,736	Vermont	$107.14
Illinois	$723,581	North Carolina	$102.77
Ohio	$628,294	New York	$100.26

Source: Battelle calculations—based on NIH data and U.S. Census Bureau population estimate.

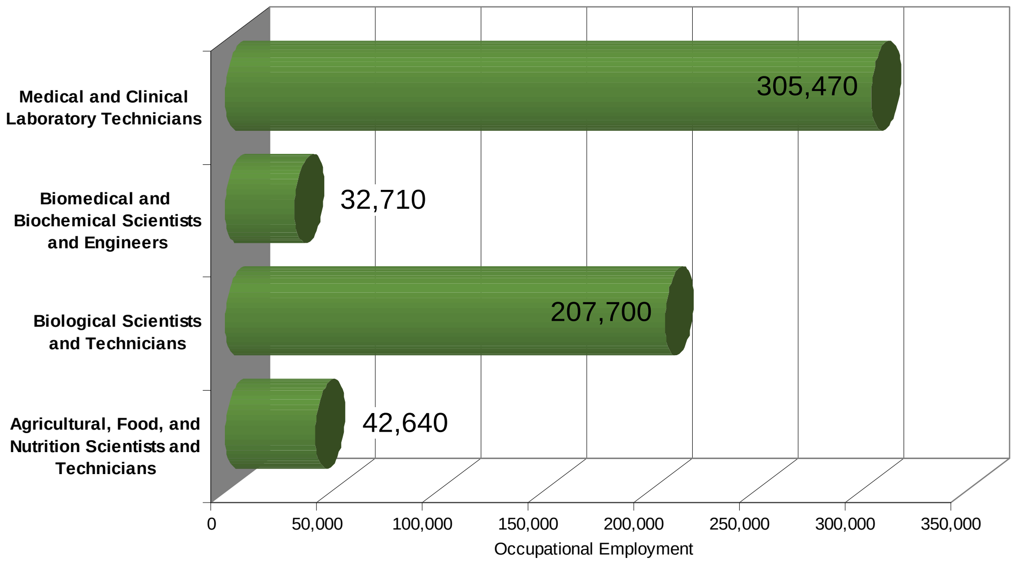
State-level growth rates for NIH funding are not quite as dramatic as for overall academic bioscience R&D. Of those states that had at least $100 million in NIH funding in FY 2002, eight states—Tennessee, Illinois, Kentucky, Rhode Island, Arizona, South Carolina, Indiana, and Connecticut—had growth rates of 20 percent or greater from FY 2002 to FY 2007.

Bioscience Occupational Employment

The size and nature of regional bioscience occupational employment also provide insight into national and state bioscience development. Occupational employment data are unconstrained by industrial classifications and can be focused on job functions that are unique to the biosciences. This analysis considers only those occupations that are more firmly rooted in commercial and industrial applications and does not include the majority of healthcare workers (e.g., doctors and nurses) where population size would be the principal driver of the size of these occupations in a region.

In total, the United States employed 588,520 workers in the occupational areas covered in this analysis. As shown in Figure 8, more than half (52 percent) are employed as medical and clinical laboratory technicians, with an additional 35 percent employed as biological scientists and technicians (with medical scientists accounting for more than 78,000 workers in this field).

Figure 8. U.S. Bioscience Occupational Employment by Field, 2006



California accounts for more than twice the bioscience occupational employment than the next highest state—Pennsylvania—generally revealing that occupational employment is still relatively tied to population size (Table 19). States with strong industrial biosciences sectors, however, are elevated in the standings. When controlling for population size, a number of smaller states emerge with respect to their bioscience workforce.

Table 19. Leading States—Bioscience Occupational Employment, FY 2006

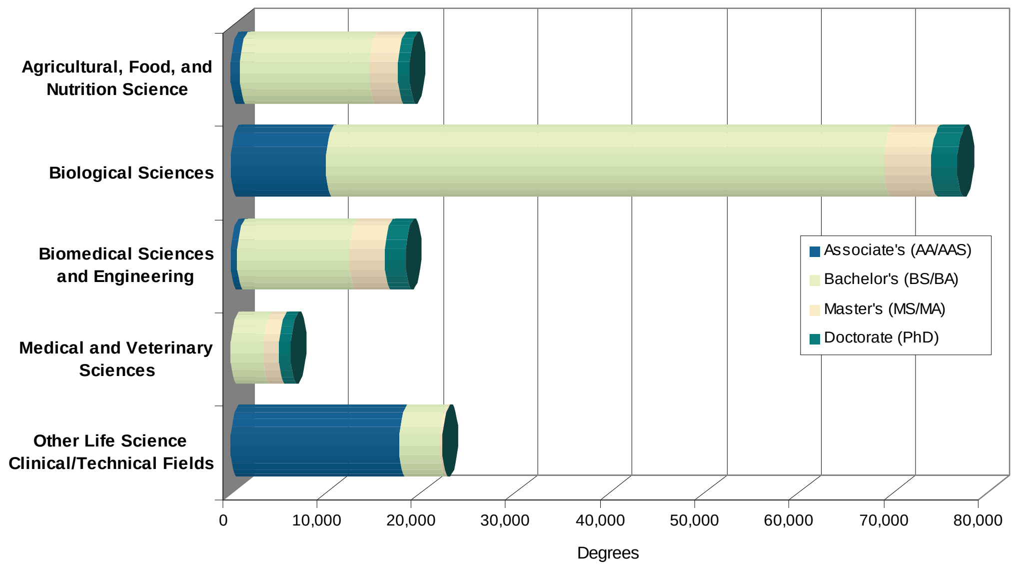
Bioscience Occupational Employment			
Leading States	Total Occ. Employment	Leading States	Per 1 M Population
California	69,600	District of Columbia	5,295
Pennsylvania	34,780	Massachusetts	4,784
New York	34,520	Maryland	3,258
Texas	34,170	North Dakota	2,824
Massachusetts	30,780	Pennsylvania	2,804
Illinois	23,757	Connecticut	2,683
Florida	21,870	Minnesota	2,625
New Jersey	18,580	Washington	2,615
North Carolina	18,510	Nebraska	2,512
Ohio	18,460	Utah	2,466

Source: Battelle calculations—based on BLS data and U.S. Census Bureau population estimate.

Bioscience Degrees Granted

In the 2006 academic year (AY), U.S. higher education institutions granted bioscience-related degrees (ranging from associate’s to doctorate) to more than 143,000 students. Figure 9 details these degrees by discipline and type. Of note is the sheer magnitude of biological sciences bachelor’s degrees produced on an annual basis—accounting for more than 40 percent of all bioscience degrees awarded. From a workforce perspective, it is important to note that only in the category of other life science clinical/technical fields—that maps almost completely to the largest bioscience occupational employment field of medical and clinical laboratory technicians—do associate’s degrees account for the majority. This indicates the significant role that community colleges and technical schools (the primary source of these technical associate’s degrees) play in the overall growth and development of a region’s bioscience economy.

Figure 9. U.S. Higher Education Bioscience Degrees by Discipline, AY 2006



The robustness of states' bioscience educational infrastructure is demonstrated in Table 20, which shows that both large and smaller states with significant medical schools emerge as key sources of the future bioscience workforce.

Table 20. Leading States—Bioscience Higher Education Degrees, AY 2006

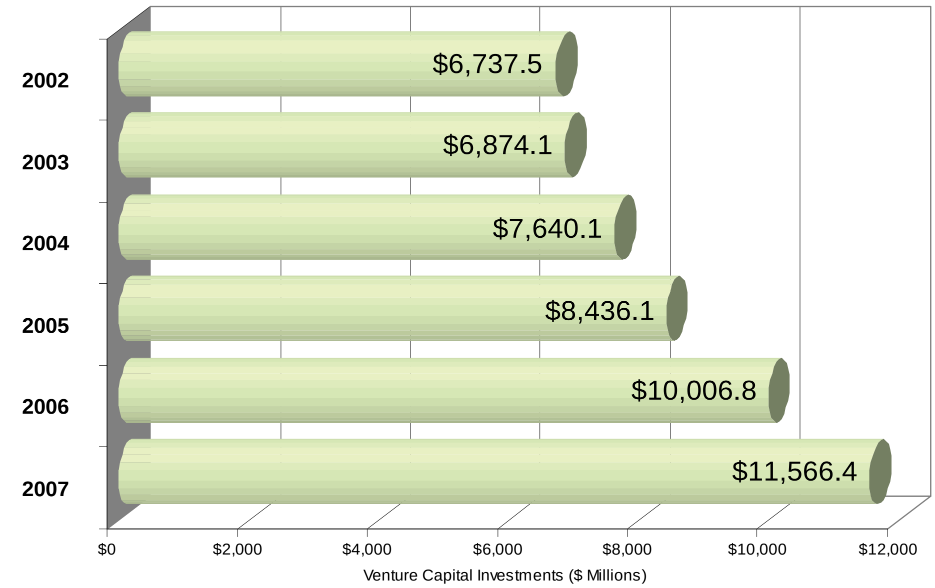
Bioscience Higher Education Degrees			
Leading States	Total Degrees	Leading States	Per 1 M Population
California	17,051	Massachusetts	5,293
Illinois	9,622	District of Columbia	5,005
Texas	9,096	Maryland	3,159
New York	8,510	Rhode Island	3,142
Pennsylvania	7,506	Connecticut	3,057
Florida	5,717	Washington	3,040
Ohio	5,351	Pennsylvania	2,998
Michigan	4,721	Vermont	2,638
Massachusetts	4,321	North Carolina	2,635
North Carolina	4,174	New York	2,573

Source: Battelle calculations—based on NCES IPEDS data and U.S. Census Bureau population estimate.

Bioscience Venture Capital Investments

In entrepreneurial development and business formation, venture capital investment is seen as a significant indicator of a region's bioscience success. From 2002 through 2007, bioscience-related venture capital investments showed a steady increase, reaching $11.6 billion in 2007 (Figure 10)—surpassing the previous industry peak of $11.0 billion set in 2000 (not shown here).

Figure 10. U.S. Bioscience Venture Capital Investments, 2002–2007



Among the major segments, human biotechnology accounted for the largest share (more than 29 percent) of bioscience venture capital investments during 2002 to 2007. Pharmaceutical and medical therapeutics are the next largest segments, accounting for more than 18 percent each (Figure 11).

Figure 11. U.S. Bioscience Venture Capital Investments by Segment, 2002–2007

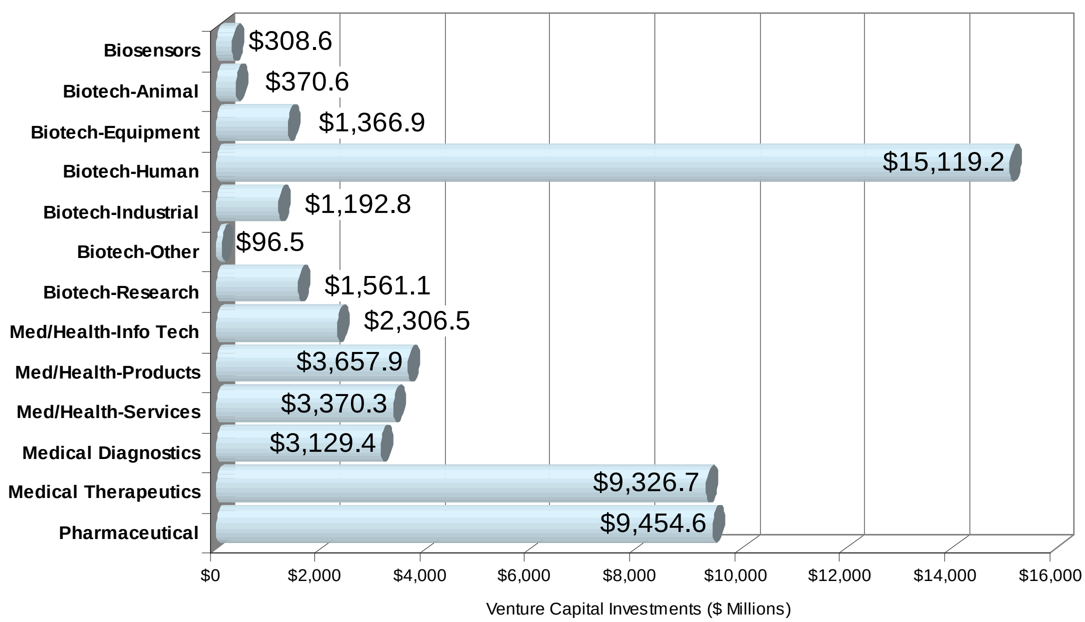


Table 21 provides details regarding bioscience venture capital investments by stage. The biosciences, like other industries, see a small share of investments going toward start-up/seed-stage efforts—less than 3 percent of venture capital investment in the biosciences went toward these deals. Expansion investments are the largest stage in terms of number of deals, companies invested in, and total investment funds.

Table 21. U.S. Bioscience Venture Capital Investments by Stage, 2002–2007

Bioscience Venture Capital Investment					
Stage	Number of Deals	Number of Companies Invested In	Total VC Investments	Average Per Deal in $ Millions	Average Investment Per Company in $ Millions
Start-Up/Seed	540	454	$1,532	$2.84	$3.37
Early Stage	1,363	950	$7,597	$5.57	$8.00
Expansion	1,742	1,093	$18,629	$10.69	$17.04
Later Stage	1,193	637	$16,009	$13.42	$25.13
Buyout or Acquisition	205	156	$3,756	$18.32	$24.08
Other	946	566	$3,738	$3.95	$6.60
Total	5,989	3,856	$51,261	$8.56	$13.29

Source: Battelle calculations—based on Thomson Reuters VentureXpert data.

California dominates among the states—accounting for more than 40 percent of all bioscience venture capital investment during 2002 to 2007 (Table 22). It is interesting to note that, even though Massachusetts' second-ranked total is $13 billion less than California's total, Massachusetts exceeds California by more than $500 per 1 million population.

Table 22. Leading States—Bioscience Venture Capital Investments, 2002–2007

Bioscience Venture Capital Investment			
Leading States	Total in $ Millions	Leading States	$ Per 1 M Population
California	$20,743	Massachusetts	$1,099
Massachusetts	$7,091	California	$567
New Jersey	$2,778	Maryland	$348
Pennsylvania	$2,772	District of Columbia	$337
Maryland	$1,957	New Jersey	$320
Washington	$1,833	Minnesota	$284
North Carolina	$1,527	Washington	$283
Minnesota	$1,474	Rhode Island	$277
Texas	$1,338	Pennsylvania	$223
New York	$1,225	Colorado	$209

Source: Battelle calculations—based on Thomson Reuters VentureXpert data and U.S. Census Bureau population estimate.

Table 23 provides details of leading states by bioscience venture capital segments in terms of total dollars invested during 2002 to 2007. As a top five player in all 13 segments, California's overall venture capital dominance is reiterated. Massachusetts follows, with top five status in 11 of the bioscience segments; and Pennsylvania is next as a top five state in eight of the segments. Overall, 17 states achieve top five investment totals in one or more bioscience segments.

Table 23. Top Five States—Bioscience Venture Capital Investments by Segment, 2002–2007

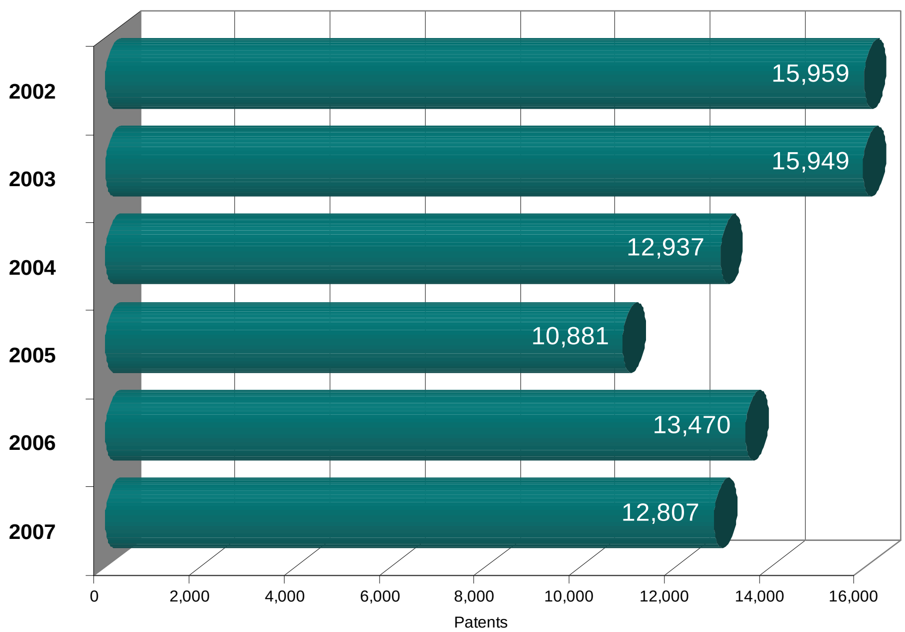
State	Biosensors	Biotech						Med/Health			Medical Diagnostics	Medical Therapeutics	Pharmaceutical
		Animal	Equipment	Human	Industrial	Other	Research	IT/Software	Products	Services			
CA	●	●	●	●	●	●	●	●	●	●	●	●	●
CO					●				●				
FL									●				
IL						●							
MD	●	●			●			●					●
MA	●		●	●	●	●	●	●	●		●	●	●
MN			●						●			●	
MO		●											
NJ				●	●					●			●
NM	●												
NY			●								●		
NC		●		●			●						
PA			●			●	●	●		●	●	●	●
RI						●	●						
TN								●		●			
TX										●			
WA	●	●		●							●	●	

Source: Battelle calculations—based on Thomson Reuters VentureXpert data.

Bioscience-Related Patents

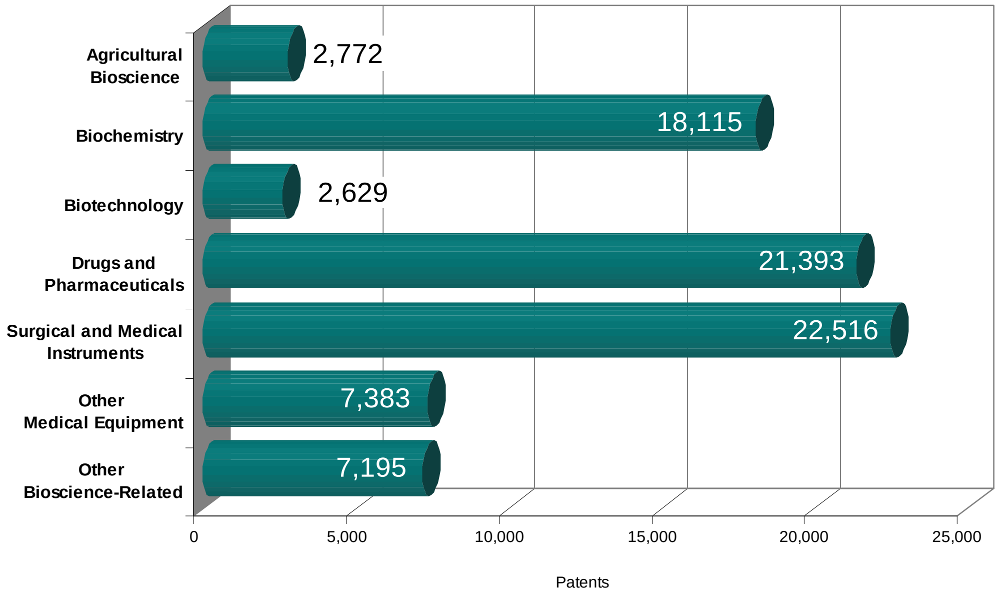
Bioscience-related patent numbers reached 82,000 over the 6-year period examined. However, the annual numbers have trended downward over 2002 to 2007—though 2007 does exceed 2005, the lowest number in the period (Figure 12).

Figure 12. U.S. Bioscience-Related Patents by Year, 2002–2007



Three areas or patent class groups—surgical and medical instruments, drugs and pharmaceuticals, and biochemistry—account for the majority of bioscience-related patents (27, 26, and 22 percent of all bioscience patents, respectively) (Figure 13).

Figure 13. U.S. Bioscience-Related Patents by Class Group, 2002–2007



Within these patent class groups, the number of patents in 2007 exceeds the number in 2002 in only four specific U.S. patent classes—chemistry: natural resins or derivatives, peptides or proteins; multicellular living organisms; medical and laboratory equipment; and surgery: light, thermal, and electrical applications.

Table 24 shows the top four states (and six of the top 10) in total numbers of patents are also leading (top 10) states when controlling for population. The comparative strength of a number of smaller states is also apparent, as Hawaii, Delaware, and Rhode Island are all top 10 states in bioscience patents per 1 million population.

Table 24. Leading States—Bioscience-Related Patents, 2002–2007

Bioscience-Related Patents			
Leading States	Total Patents	Leading States	Per 1 M Population
California	24,293	Hawaii	2,310
Massachusetts	9,443	Delaware	1,774
Pennsylvania	8,522	Massachusetts	1,464
New Jersey	6,012	Rhode Island	962
New York	5,139	Minnesota	922
Minnesota	4,790	Connecticut	794
Maryland	3,680	Alabama	707
Florida	3,388	New Jersey	692
Texas	3,301	Pennsylvania	685
Alabama	3,274	California	665

Source: Battelle calculations—based on USPTO/Delphion data and U.S. Census Bureau population estimate.

Texas and Alabama hold unique positions—both are among the top 10 in total bioscience patents, yet neither state makes the top five in any single bioscience patent class group (Table 25).

Table 25. Top Five States—Bioscience-Related Patents by Class Group, 2002–2007

State	Agricultural Bioscience	Biochemistry	Biotechnology	Drugs and Pharmaceuticals	Surgical and Medical Instruments	Other Medical Devices and Equipment	Other Bioscience-Related
CA	●	●	●	●	●	●	●
FL	●				●		
GA	●						
HI	●						
IL			●				
IA			●				
MD		●					
MA		●		●	●	●	●
MN			●		●		
MO			●				
NJ				●		●	●
NY		●		●		●	●
OR	●						
PA		●		●	●	●	●

Source: Battelle calculations—based on USPTO/Delphion data.

SUCCESS FACTORS OF BIOSCIENCES INDUSTRY GROWTH

Technology, talent, and capital are key focus areas for regions and states wishing to prosper in the biosciences. States and regions throughout the United States are becoming increasingly sophisticated in their understanding of building a biosciences industry cluster. Bioscience firms tend to grow in proximity to sources of bioscience discoveries that include research universities, academic medical centers, and other bioscience companies. States and regions that wish to make the biosciences a driver of their economies are investing in their bioscience research bases and the technology infrastructure that supports them. But, to prosper and grow, bioscience companies also need access to talent across a wide spectrum of skills and occupations and capital at all stages of development from precommercialization to company formation and expansion. An examination of leading bioscience centers in the United States shows that they share common characteristics that have contributed to their success. These key success factors are discussed below.

Key Success Factors

- Engaged research institutions with active leadership
- Intensive networking across sectors and with industry
- Available risk capital covering all stages of the business cycle
- Discretionary federal or other R&D funding support
- Workforce and talent pool on which to build and sustain efforts
- Access to specialized facilities and equipment
- Stable and supportive business, tax, and regulatory policies
- Patience and a long-term perspective

Engaged Research Institutions

Many regions have important or even outstanding R&D assets in the biosciences, particularly around their higher-education institutions and medical centers or teaching hospitals. Without major research stature, reputation, and standing within given fields, no region can succeed with a bioscience-driven strategy for its economic growth. An outstanding research university is required to become serious about the biosciences. But, it takes more than simply research stature. It requires the capability to engage industry, directly or indirectly, to convert this intellectual knowledge into economic activity. To do so requires one or more of a region’s research universities committed to engaging with and helping to build and sustain a bioscience community locally. At least one institution needs to be willing to play the role of Stanford and Berkeley in the San Francisco Bay Area, the Massachusetts Institute of Technology in Boston, the University of California at San Diego (UCSD), or the three universities of Research Triangle Park. To succeed, a region must have a university that has already made this commitment or a state government willing to using discretionary R&D funding to induce its public and private research universities to undertake that commitment.

Intensive Networking

As many observers of high-tech clusters have noted, the most successful clusters facilitate extensive and intensive networking among technology companies and their managers and employees. In a very few leading communities like Silicon Valley, this networking has occurred naturally, with formal organizations like Joint Venture: Silicon Valley Network coming only later. However, in the majority of American regions, such organizations need to be *built* from the ground up, because otherwise the desired degree of networking will not occur. These technology intermediary organizations—whether they are regional or state biotech organizations, regional or state technology councils, or some other combination—perform several interrelated and important functions:

- Providing neutral organizational ground where the very different cultures of academia, industry, and government can meet over a common regional growth agenda
- Providing a point of contact, as do many of BIO's affiliates, where sectoral trade associations can come together to promote a common agenda
- Spurring the formation of joint ventures or virtual-company formation in sectors with large numbers of smaller players
- Leading special interest groups of people with similar job functions (chief executive officer [CEO], chief financial officer, chief information officer, etc.) in various technology businesses across many sectors
- Building tighter supply chains, reducing the time to market for innovative firms by connecting them with vendors of products and services
- Indicating to technical, professional, and managerial employees that they have other options if a given venture fails.

Available Risk Capital

One characteristic shared by leading bioscience states and regions is that they are home to a robust capital community that is both oriented toward early-stage investment and committed to local investment. It is critical to have local pre-seed and seed capital funds with experience investing in bioscience companies. These states and regions also have networks of successful bioscience entrepreneurs who act as angel investors, willing to invest in very early stage start-up companies. Building a base of angel investors and pre-seed and seed capital funds able and willing to invest in bioscience companies is a challenge for states with emerging biosciences sectors. But, without this "farm club" of earliest stage capital, there will be no deal flow for more formal venture-capital investments as firms mature.

While it is critical to have financing available for each stage of development from early-stage, proof-of-concept, and prototype development, a state or region must eventually be able to access national and regional venture-capital pools as bioscience firms mature and move closer to the market. In short, leading states and regions address a continuum of capital needs from prototype through seed to later-stage formal venture financing.

Leading bioscience states and regions have access to the following types of capital:

- ***Commercialization funding,*** which can be used to assess and undertake a review of the commercial potential of completed R&D. This assessment must be done before a business can be spun off, and may include prototype development, reduction-to-practice exploration, and other steps.
- ***Pre-seed and seed funding,*** *i.e.*, financing to support very early stage start-up companies.
- ***Venture financing***, which is the capital needed prior to initial public offering (IPO). Given the long time frame required for the regulatory review process that must be completed before many (but not all) bioscience companies can introduce products in the marketplace, bioscience firms will often require multiple rounds of venture financing.

Discretionary Funding

To build generic R&D assets into an effective attractor of technology investment requires leverage of substantial, ongoing, external, discretionary funding. While technology leaders like Silicon Valley, Route 128 in the Boston area, and San Diego were able to leverage decades of heavy defense contracting, and while Baltimore/Washington leveraged growing congressional support of federal laboratories owned by the National Institutes of Health, the National Institute of Standards and Technology, and the Food and Drug Administration, most states must use state funding as a lever for acquiring strategic external investments from the following:

- **Merit-oriented federal science agencies**, focusing on proposals that require nonfederal investment in facilities or instrumentation in order to be competitive
- **Line-item appropriations** for strategic facilities or science programs, particularly those that require good-faith local matching
- **Local corporations** willing to invest part of their R&D portfolios in the region if they can leverage their support with other funding
- **Local foundations** that are increasingly seeing technology-based economic development as consistent with their goals for economic opportunity.

Workforce and Talent Pool

Like any knowledge-based industry, bioscience companies need a supply of qualified, trained workers. To meet the demands of newly emerging fields, new curricula and programs are being developed by educational institutions working in close partnership with the biosciences industry. In addition to having world-class researchers, successful bioscience regions have an adequate supply of management, sales, marketing, and regulatory personnel and serial entrepreneurs experienced in the biosciences. States and regions are expanding bioscience course offering, creating new degree programs, and establishing career pathways for students wishing to to the state, and to attract and retain bioscience graduates.

Access to Specialized Facilities and Equipment

Facility costs are among the most significant expenses for a new bioscience firm. These firms need access to wet-lab space and specialized equipment. Since most bioscience firms initially lease space rather than purchase it, an available supply of facilities offering space for bioscience companies is critical. Ensuring that the private marketplace offers the right amount and type of space suitable for the development and growth of bioscience firms can be a major challenge. Regions have sought to meet this need by developing incubator and accelerator facilities and helping firms to finance facilities and leasehold improvements. To provide firms with access to specialized equipment, states and regions have invested in research centers and shared-use facilities, such as bioprocessing scale-up facilities.

Supportive Business, Tax, and Regulatory Policies

Bioscience companies need a regulatory climate and environment that encourage and support the growth and development of their industry. Tax policies that recognize the long development cycle required to bring new bioscience discoveries to the market can provide additional capital for emerging companies as well as ensure an even playing field in state and local tax policies between older, traditional industries and emerging industries such as the biosciences. Responsiveness by state and local governments to regulatory, permitting, and other requirements can significantly impact where bioscience firms stay, grow, or expand.

Patience and a Long-Term Perspective

One final lesson from every successful technology community is that success takes time. Silicon Valley and Route 128 trace their origins in electronics to the 1950s, and in the biosciences to the 1970s. Research Triangle Park represents a 50-year strategy that has only recently found its footing in the biosciences and is still working to develop full capability in the entrepreneurial sector.

This year’s report finds that states and regions are making progress in growing their bioscience economies not only in the biomedical area but in other applications such as industrial products and bioenergy as well.

The 2 years from 2004 to 2006 represent a period of implementation for state bioscience initiatives. Many of the policies and programs that were proposed or recently initiated in 2004 have come to fruition. A very significant number of facilities that were being funded have been constructed and are housing research programs and researchers. State R&D dollars are being spent on research in biomedicine, agriculture, and energy. And states continue to explore ways to help start-up and emerging companies obtain the capital they need to be able to bring new products to the market. As the biosciences sector matures, state governments are working closely with their educational institutions and the bioscience business community to develop new educational offerings and to encourage more people to enter bioscience occupations to ensure that they will be well positioned to meet the future workforce needs of the industry. At the same time, many bioscience firms still face challenges in obtaining the resources they need to develop and get their products to market. Finding entrepreneurial CEOs with experience in creating and growing bioscience companies is often a challenge. While private-public partnerships have been developed to help companies meet their capital needs, firms with promising technologies remain that are unable to obtain enough capital to get them through the development process, particularly as the venture industry continues to focus on later-stage financing and must deal with the challenges of a difficult IPO marketplace. And, as regions grow their industry bases, their needs for special space, including wet-lab space, must be addressed in spite local developers' lack of experience with biospace needs and requirements.

Developing and Commercializing Bioscience Discoveries

As discussed previously, having an excellent bioscience research base within a state or region's universities, academic medical centers, and nonprofit research organizations is a critical prerequisite to growing a strong biosciences sector. The first step for areas that wish to be competitive in the biosciences marketplace is to ensure that its institutions have the necessary resources to develop world-class strengths in specific areas of the biosciences. states seek to achieve a steady flow of new discoveries and to facilitate the translation of new technologies into new commercial products by engaging in the following:

- Investing in bioscience R&D
- Investing in bioscience R&D facilities and equipment
- Supporting faculty development programs
- Encouraging and facilitating interactions between bioscience companies and academic researchers
- Encouraging entrepreneurship and the commercialization of university intellectual property.

Funding Bioscience R&D

Thirty states reported that they that provide funding for bioscience R&D, 10 of these programs are limited to the biosciences[9], and the others fund research in various technology areas including the biosciences. States typically fund research that is closer to commercialization and therefore not appropriate for federal funding. This includes applied and translational research or research that is expected to leverage funding from other sources such as federal and private R&D. States also provide

[9] The data in this chapter are based on survey responses from 44 states and Puerto Rico. Alaska, Alabama, Arkansas, Idaho, Vermont and Wyoming were not able to complete a survey.

funding for new investigators to help young researchers get to the point at which they can compete for federal and industrial funding.

State appropriations are the most common source of support for state bioscience R&D; but, nine states reported that they are using tobacco-settlement funds to support bioscience R&D. In Kansas, the Economic Growth Act created the Kansas Bioscience Authority and a funding mechanism based on the growth of state income-tax withholdings from employees of bioscience-related companies. State taxes that exceed the base-year measurement of such taxes accrue to the Authority for investment in additional bioscience growth. Arizona passed a ballot initiative in 2000 that dedicated the proceeds from a six-tenths of a cent increase in state sales tax for a period of 20 years to statewide education at all levels. This source of revenue has been used to support bioscience R&D and bioscience facilities at Arizona's universities.

Table 26 lists the state programs that provide support for bioscience research, the uses and sources of funds, and the levels of funding for FY 2007 and FY 2008. Please note that some of these initiatives have multiple uses and may be found in other tables as well.

Table 26. State Support for Bioscience Research in FY 2007 and FY 2008

State	Program	Use of Funds				Annual Bioscience Funding (Millions)		Source of Funds
		Applied Research	Trans-lational	New Investig ator	Match	FY 07	FY 08	
AZ	21st Century Fund AZ Biomedical Research Commission Technology and Research Initiative Fund	●	●	●	●	$55	$55	Appropriation Dedicated tax
DE	Various programs	●		●	●	$3	$2	
GA	Georgia Research Alliance and Georgia Cancer Coalition	●	●	●	●	$40	$40	Appropriation Tobacco settlement
IL	Innovation Challenge Technical Assistance and Matching Grant Programs	●	●		●	$1.3		Appropriation
IN	21st Century Research and Technology Fund				●	$25*	$25*	Appropriation
KS	Kansas Research Matching Fund Kansas R&D Voucher Program	●	●	●	●	$26.5**	$36.5**	Incremental tax on bioscience companies Appropriation Economic Development Initiative Fund
KY	SBIR/STTR Phase I and II Matching Funds Program	●	●	●	●	$2.05	$8.3	Appropriation
LA	Pennington Biomedical Research Center		●			$71		Appropriation
MD	Cancer Research		●			NA	NA	Tobacco settlement
MA	Massachusetts Life Sciences Matching Grant Opportunity Program			●			$4	Appropriation
	Massachusetts Life Sciences Center Matching Grants; MTC/JAII Innovation Fund and Matching Grant Programs; Mass Tech Transfer Center Seed and Commercialization Grants	●	●	●	●	$2	$15	Appropriation Tobacco settlement
ME	Maine Technology Institute Development Awards, Seed Grants, SBIR Phase 0, Maine Economic Improvement Fund. (Not Bioscience Specific)	●	●	●	●	$23	$26	Appropriation
MI		●	●		●	NA	NA	Tobacco settlement
MS	Various programs	●				$1		Appropriation

State	Program	Use of Funds				Annual Bioscience Funding (Millions)		Source of Funds
		Applied Research	Trans-lational	New Investig ator	Match	FY 07	FY 08	
MO	Life Sciences Research Trust Fund	●	●	●	●		$13.1	Appropriation Tobacco settlement
MT	Montana Board of Research and Commercialization Technology	●	●		●	NA	NA	Appropriation
NE		NA	NA	NA	NA		$14 million	Tobacco settlement
NV		●	●			NA	NA	Appropriation
NJ	Edison Innovation Intellectual Property Program, Edison Innovation R&D Fund	●	●	●	●	$2 million	$2 million	Appropriation NJEDA revolving loan fund
NY	Various NYSTAR programs	●	●	●	●	$60 million	$60 million	Appropriation
NC	Various North Carolina Biotechnology Center grant programs	●	●	●		NA	NA	Appropriation
ND	UND Energy and Environmental Research Center, UND Center for Innovation	●	●		●	NA	NA	Appropriation
OH	Ohio BioProducts Innovation Center	●	●	●	●	$25 million	$25 million	Appropriation Tobacco settlement Bond issue
OK		●		●	●			
PA	Commonwealth Universal Research Enhancement Program (CURE)				●	$75 million	$75 million	Tobacco settlement
RI	Science and Technology Advisory Council (STAC) and Slater Technology Fund	●	●			$4.5 million	$4.5 million	Bond issue
SD		●	●	●		$2 million	$2 million	Appropriation
TX	Alliance for Nano Health	●			●	$25 million	$25 million	Appropriation
UT	USTAR							
VA	Commonwealth Higher Education Research Initiative (HERI) and Commonwealth Technology Research Fund (CTRF)	●	●		●	$39.1 million		Appropriation
WA	Life Sciences Discovery Fund and the Washington Technology Center	●	●				$40 million	Appropriation Tobacco Settlement

*Includes funds provided to companies to support commercialization projects.

** Includes funds for Eminent Scholars and Rising Star Programs

Stem Cell Research

As mentioned previously, a number of states invested in bioscience research and bioscience research facilities in the past 2 years. California and New Jersey have each made significant investments in stem cell research. The **California Institute for Regenerative Medicine (CIRM)** invested $174 million in stem cell R&D and $321 million in facilities to support stem cell research in FY 2007 and FY 2008. This included 74 Leon J. Thai SEED Grants to bring new ideas and new investigators into the field of human embryonic stem cell research and 22 New Faculty Awards to encourage the next generation of clinical and scientific leaders in stem cell research. In May 2008, CIRM announced $271 million to help build 12 stem cell research facilities. The grants will result in more than $800 million in new research facilities. When institutional commitments for the recruitment of new faculty and other costs are added, a total of $1.1 billion will be invested in regenerative medicine. California has pledged to invest $3 billion in stem cell research over 10 years.

New Jersey awarded $230 million to construct a facility to house the **Stem Cell Institute of New Jersey** and another $20.7 million in stem cell research grants. The Institute is a collaboration of the University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School and Rutgers, The State University of New Jersey. The Institute conducts research, training, and clinical studies on the application of stem cells to the treatment of disease.

Other states that are supporting stem cell research include the following:

- **Connecticut's Stem Cell Research Program** has awarded $13 million in research grants out of a total commitment of $100 million.
- **Illinois** has committed $15 million for stem cell research of which $5 million has currently been awarded.
- The **Maryland Stem Cell Research Fund** supports stem cell research and makes awards to predoctoral students and postdoctoral fellows who wish to conduct research on human stem cells in Maryland. To date, $38 million has been awarded.
- Massachusetts has committed $6 million to stem cell research.
- New York's Legislature has committed $100 million in FY 2007 and FY 2008 to the **Empire State Stem Cell Trust** and made a commitment of $600 million over 10 years to fund basic, applied, translational, and other research that advances scientific discovery in the field of stem cell biology; $14.5 million has been awarded to date.
- **Ohio's Biomedical Research and Commercialization Program** awarded $28 million for biomedical research, including stem cell research.
- **Wisconsin** has committed $14 million for stem cell research; $6 million was awarded for research grants and $4 million for capital costs in FY 2007 and FY 2008.

Table 27 is a summary of state support for stem cell research, including state programs, descriptions of the programs, funds awarded for research and capital in FY 2007 and FY 2008, and total funds committed.

Table 27. State Support for Stem Cell Research in FY 2007 and FY 2008

State	Program	Description	Funds Awarded FY07–08 ($ Millions)		Total Funds Committed ($ Millions)
			Research	Capital	
CA	CA Institute for Regenerative Medicine (CIRM)	Provides funding for research and training in human embryonic stem cell science	$174	$321	$3,000
CT	CT Stem Cell Research Program	Awards grants to support stem cell research	$30		$100
IL		Funds stem cell research	$5		$15
MD	MD Stem Cell Research Fund	Funds stem cell research and awards to predoctoral students and postdoctoral fellows who wish to conduct research on human stem cells in Maryland	$38		$38
MA		Funding for stem cell research			$6
NJ	Stem Cell Institute of New Jersey	Research grants and construction of a facility to house the Stem Cell Institute of New Jersey	$20.7	$230	$250.7
NY	Empire State Stem Cell Trust	Funds basic, applied, translational and other research that advances scientific discovery in the field of stem cell biology	$14.5		$600 over 10 years, $100 committed in FY07 and FY 08
OH	Biomedical Research and Commercialization Program	Provides grants which support biomedical and biotechnology research, including stem cell research	$28		
WI			$6	$4	$14

Bioenergy and Bioagricultural Research

States throughout the United States are actively promoting the use of biomass for energy and other bioproducts. As shown in Table 28 (which is a summary of state bioenergy investments, including state programs, research and capital funds committed in FY 2007 and FY 2008, and total funds awarded as of December 31, 2007), 23 states reported state investments in bioenergy research and facilities in which to conduct such research in the past 2 years. Some of the state dollars were provided as matches for the three U.S. Department of Energy (DOE) Bioenergy Research Centers that were awarded in 2007, including the following:

- The DOE BioEnergy Science Center led by Oak Ridge National Laboratory in Tennessee, which also involves the University of Georgia
- The Great Lakes Bioenergy Research Center, led by the University of Wisconsin at Madison and Michigan State University
- DOE Joint BioEnergy Institute, led by Lawrence Berkley National Laboratory.

Other states have created their own Bioenergy Research Centers. The Oklahoma Bioenergy Center was created in 2007 to coordinate biofuels research at Oklahoma State University, the University of Oklahoma, and the Samuel Roberts Noble Foundation. The Noble Foundation, located in Ardmore, Oklahoma, is the largest private foundation conducting plant science and agricultural research in the United States. The focus of the Center, which is proposed to be funded at $40 million over 4 years with $10 million appropriated in 2007, is on sustainable economic production of cellulosic ethanol. Colorado appropriated $2 million to create and fund the Colorado Renewable Energy Collaboratory. The Collaboratory, a joint partnership of three universities and the National Renewable Energy Laboratory, will fund bioenergy research projects.

The Kansas Bioscience Authority has invested over $8 million in FY 2008 to develop a collaborative biosecurity research program at Kansas State University to fund collaborative research with other academic institutions and researchers nationwide at the University's Biosecurity Research Institute, a modern, level-three biosafety agriculture facility.

Table 28. State Bioenergy Investments In FY 2007 and FY 2008

State	Program	Research Funds Committed ($ Millions)		Capital Funds Committed ($ Millions)		Total Funds Awarded as of 12/31/2007 ($ Millions)
		FY 07	FY 08	FY 07	FY 08	
CA	California Energy Commission's Public Interest Energy Research Program	$0.7	TBD			$0.7
CO	Colorado Renewable Energy Collaboratory	$2				$0.5
DE	*Funding can be used for capital or research	*	*	$1.1	$1.1	$2.2
GA	Matching funds for DOE BioEnergy Science Center	$0.5	$0.4		$1.3	
IL		$5.6	$5.8	$1	$1	$3
IA	Iowa Power Fund will fund research on clean energies		$100			
KS	*Awarded to date	$11	$2.5 *	$0.5	$0.3	$13.5
KY	Kentucky New Energy Ventures		$5			$5
MA		$0.25		$0.75		
MI	Matching funds for DOE Great Lakes Bioenergy Science Center				$18.2	
MN	Part of $40 million Next Generation Energy Initiative			$2.4		$2.4
MO	Bioenergy Research Center Opportunity Fund		$4.4			$4.4 million
MT		$0.075	$0.47			$0.55
NC				$5		
ND				$1.5	$1.5	
OK	Oklahoma Bioenergy Center		$10			
PA		$1	$1			$2
SC	Planning and matching grants of $10,000 to $200,000	NA	NA			NA
SD		$1	$3.4			$4.4
TN	*University of Tennessee Biofuels Initiative includes funding for a pilot cellulosic ethanol plant	$72 over 5 years		*		
TX		$10				$10
VA	Virginia Coastal Energy Research Consortium		$1.6			
WI	Contribution to the DOE Great lakes Bioenergy Research Center	$5	$15			$10

Funding Bioscience R&D Facilities

University bioscience research programs can flourish only to the extent that they have access to an excellent physical infrastructure. This includes state-of-the-art laboratory facilities, equipment, telecommunication capacities, computer systems and software, and the buildings to house all of these elements. It also includes the creative use of land and other holdings in support of the R&D enterprise.

Ironically, despite the huge growth in federal support of bioscience research in recent years, federal support for infrastructure is proportionately less plentiful than project support (which is heavily weighted toward research personnel costs). There are some equipment grants available, but the competition is quite fierce. The upshot is that a combination of state and local government support, philanthropy, and corporate donations must fill the gap to address facility and equipment needs.

The 2006 report noted that, in the aggregate, states were spending billions of dollars to construct, expand, and modernize their academic and medical research facilities, with funding for these facilities coming from state, federal, and private sources. Since 2006, many new bioscience research facilities have been completed and are now fully operational; but, states continue to provide many millions of dollars for bioscience research facilities. Twenty-eight states reported making significant investments in bioscience facilities between 2006 and 2008. ***Massachusetts Life Science Center Capital Improvement Loan Act*** will provide $550 million in grants to infrastructure projects in support of life science projects between FY 2008 and FY 2012. The ***Puerto Rico Science, Technology, and Research Trust*** will award $511 million in competitive grants for the construction of R&D infrastructure. Florida has invested more than $300 million in its ***Centers of Excellence Program***; about half of the Centers are focused on the life sciences. ***Missouri's Lewis and Clark Discovery Initiative*** will provide the Sstate's public colleges and universities 29 is a listing of state bioscience research facility programs, descriptions of those programs, total investments, and years of investments. It should be noted that some programs support university research facility development across a number of technology areas, including the biosciences; others are specifically targeted to the biosciences. Also, some programs provide support for both R&D and facilities. In cases where programs serve multiple purposes, they are included in each table.

Table 29. State Support for Bioscience Research Facilities

State	Bioscience Research Facility Programs	Description	Total Investment ($ Millions)	Years of Investment
AZ	University Research Infrastructure Financing	The Arizona Legislature in 2003 approved a $440 million appropriation to build research facilities at the State's universities, resulting in construction of a dozen facilities through 2007	$440	2003
CA	Shared Research Lab Grants Program	CIRM awarded 17 grants for stem cell facilities in 2007 and 12 in 2008	$321	2007–2008
FL	Centers of Excellence Program	Funding for nine university/industry research centers, four of which focus on life sciences	$300	Over 3 years
GA	Georgia Research Alliance Centers of Research Excellence	Georgia Research Alliance invests in infrastructure for Centers of Research Excellence at its affiliated universities	$37	FY 07–08
IL	Research and Development Facilities Investments	Various research facilities	$19	2006–2008
IA	Grow Iowa Values Fund	Funds allocated by State Board of Regents	$30	FY 2007
KS	Kansas Bioscience Centers of Innovation Program	Centers of Innovation will be competitively awarded specialized application and research centers	$1	2008
LA	Louisiana Cancer Research Consortium in New Orleans	A collaboration between Tulane University and LSU Health Sciences Center in New Orleans to advance cancer research through the construction of a new 175,000 square foot research facility	$102	2007
ME	Maine Technology Asset Fund	A competitive fund for investment in R&D and commercialization that is open to all research entities and companies in Maine, including the biosciences	$50	2008–2010
MA	Massachusetts Life Sciences Center Capital Improvement Act	For grants related to site remediation, preparation, and ancillary infrastructure improvement projects in support of life science projects	$500	FY 08–12
MI	21st Century Jobs Fund and predecessor, Michigan Life Sciences Corridor	$3.5 million investment in Biotech R&D incubation facility to reuse former Pfizer facility and $18.2 million in Centers of Excellence	$22	FY 07–08
MN	Minnesota Partnership for Biotechnology and Medical Genomics	Collaborative venture among the Mayo Clinic, University of Minnesota, and State of Minnesota, includes support for research and facilities	$70	2003–2007
MO	Lewis and Clark Discovery Initiative	Will provide Missouri's colleges and universities with $335 million in total funding for facility and infrastructure improvements	$95.6	Enacted 2007
NJ	Edison Innovation Zones	"Technology neighborhoods" that encompass universities, research institutions and related businesses	$2, annually	FY 07–09
NC	NC Research Campus	Campus under construction in Kannapolis	$20	FY 07
ND	Center of Excellence for Life Science and Advanced Technologies	Work with the University of North Dakota (UND) center for disease control, genomics, and bioinformatics. Also work with the Center for Innovation at UND to provide support to emerging entrepreneurs with technical support and direction for access to venture capital	NA	NA
OH	Wright Centers of Innovation and Wright Mega-Centers of Innovation	Grants to support large-scale research and technology development platforms	$147.3	2003–2008
OR	Signature Research Centers	Oregon Translational Research and Drug Development Institute	$5.25	2007
PA	Redevelopment Assistance Capital	Funds facilities in various areas of technology including the biosciences	$32.6	2006–2008

State	Bioscience Research Facility Programs	Description	Total Investment ($ Millions)	Years of Investment
PR	Puerto Rico Science and Technology Trust and PRIDCO	Competitive grants and construction of R&D infrastructure	$511	2007–2015
RI	Rhode Island Research Alliance	Collaborative Research Awards	$4.5	2006–2008
SC	Centers of Economic Excellence	Led by one or more world-class scientists supported by a group of senior faculty members, as well as a research team consisting of junior faculty members, research faculty, and graduate students	$144	2002–2008
SD	2010 Research Centers	Five research Centers focused in the biosciences created since 2005	$14 n	4 years
TN	Joint Research Institutes	Research institutes involving the University of Tennessee and Oak Ridge National Laboratory	NA	NA
TX	Texas Emerging Technology Fund	Funding for faculty development and facilities	$60	2006–2008
	Cancer Prevention and Research Institute of Texas	Grants for cancer research and research facilities	$3,000 over 10 years	2008–2018
UT	Utah Science Technology and Research (USTAR)	Construction of two interdisciplinary research and education facilities at the University of Utah and Utah State University	$160	2006–2010
VA	Commonwealth Higher Education Research Initiative (HERI)	Funded six new research facilities, including a biosafety level 3 laboratory, a new clinical cancer center, and medical science, infectious disease, and critical technology/applied science facilities in Virginia.	$63.2	2006–2008
WV	Robert C. Byrd Biotechnology Science Center	Building housing biotechnology research and teaching at Marshall University	$10	
WI	Wisconsin Institutes for Discovery	Multidisciplinary research center	$150 total, $50 from state	

Faculty Development Programs

States and regions recognize that building a strong bioscience R&D base and, subsequently, a strong biosciences industry requires having world-class researchers who are able to attract funding and able and willing to see their research discoveries turned into commercial products and services. States are taking two approaches to building academic excellence in the biosciences. First, they are providing funding to recruit established scientists and researchers to their universities and provide them with the necessary infrastructure to conduct their research. Second, they are supporting talented junior faculty to retain bioscience talent within the state.

Eighteen states and Puerto Rico reported having faculty development programs, five of which are limited to the biosciences. The Georgia Research Alliance's Eminent Scholars Program has been used for many years to recruit renowned scientists to Georgia's universities. By FY 2008, the program was supporting 40 bioscience scholars at an annual cost of approximately $11 million. Kansas invested $7 million in FY 2008 to support three bioscience scholars through the **Kansas Bioscience Alliance's Eminent Scholars and Rising Stars Program**. Indiana, Massachusetts, North Carolina, and Puerto Rico also have bioscience-specific faculty development programs.

Table 30 is a listing of state faculty development programs, annual expenditures, one-time investments, and the number of bioscience scholars supported. The last column in Table E indicates whether or not the programs are limited to the biosciences.

Table 30. State Faculty Development Programs In FY 2007 and FY 2008

State	Faculty Development Programs	Annual Exp ($ Millions)		One-time Investment ($ Millions)	# of Bioscience Scholars Supported		Limited to Biosciences
		FY07	FY08		FY07	FY08	
CT	Eminent Scholars Program	NA	NA		NA	NA	No
FL	World-class Scholars Program			$20			No
GA	Georgia Research Alliance Eminent Scholars Program; Georgia Research Alliance Distinguished Investigators Program	$11	$14.5; about $10.7 in bioscience		35	40	No
IN	Life Sciences R&D Growth Fund			$20			Yes
KS	Eminent Scholars and Rising Stars Programs	$0	$7		0	3	Yes
KY	Research Challenge Trust Fund						No
MA	Massachusetts Life Sciences New Investigator Program Faculty Start-up Program		$4 $4				Yes
NY	NYSTAR Faculty Development Program	$4	$3.9				No
NC	Oliver Smithies Faculty Recruitment Grant program	$0.450	$0.450		3	2	Yes
OH	Ohio Research Scholars Program		$150		1	TBD	No
PA	Keystone Innovation Starter Kits	$3	$3				No
PR	The Puerto Rico Cancer Center	$1.5	$1.74		4	4	Yes
SC	Centers of Economic Excellence Endowed Chairs Program		$30			16	No
TN	Governor's Chairs Program Chairs of Excellence Program				1 17	1 17	No
TX	Research Superiority (part of Texas Emerging Technology Fund)	$25	$25	$50	8	9	No
VA	Commonwealth Eminent Scholars Program		$38				No
WA	Innovation Research Teams "Stars Program"		$0.430	$2.2 FY 07–09		2	No
WV	West Virginia Research Trust Fund			$50			No
WI	Cluster hires at the UW-Madison and UW System	$1	$1		6	6	No

Industry-University Partnerships

New global realities are reshaping the landscape in which U.S. regions and states must compete. International competition, the increasing pace of development and rapid diffusion of technologies, the growing convergence of technologies, along with a new focus on "open innovation," continue to reshape the competitive technology landscape. A new paradigm has emerged in which leading technology companies are looking to universities and innovative emerging companies for new technologies, rather than investing as many resources in internal high-risk R&D work as in the past. As a result, more and more companies are looking for opportunities to partner with research universities. Universities are looking to corporations and entrepreneurs to provide an avenue to move their discoveries into applications. Such relationships are extremely important in the biosciences as the link between basic science and new product development is very strong.

But, the academic and corporate worlds differ in many ways. Intellectual property protection, differences in time horizons, and other issues often present challenges to industry-university partnerships. States have developed various mechanisms, such as providing matching grants for research partnerships and creating centers where industry and academic researchers can work together on collaborative projects, to encourage and facilitate such partnerships.

Not surprisingly, given the changing landscape for innovation, states are increasingly focusing on the industry-university interface. As shown in Table 31, which is a listing of state programs supporting industry-university partnerships, the size of grants, annual budgets, and matching requirements, 28 states and Puerto Rico reported specific initiatives to encourage industry-university partnerships in 2008, up from 19 states in 2006. New programs created since 2006 include the following:

- Science Foundation Arizona's **Strategic Research Groups** (SRG) program and **Small Business Catalytic Fund**. The former provides up to $10 million to facilitate collaborations between nonprofit research laboratories, hospitals and academic institutions and industry. Seed funding of $2 million a year for up to 4 years is provided to each SRG and another $2 million is provided to recruit and fund a start-up package for a director. The biosciences field is one of three targeted for SRGs. The Small Business Catalytic Fund supports R&D partnerships between a principal investigator and an Arizona company to ensure a product's success and to accelerate time to market.
- The **Massachusetts Life Sciences Center's Research Matching Grant Program**, which was launched in early 2008. This $12 million initiative will fund new faculty, new research investigators, and new cooperative research in partnership with industry. Each investment includes a 1:1 match from the participating academic institution or industry partner. Massachusetts also provides funding for Research Centers through its John Adams Innovation Institute, a division of the Massachusetts Technology Collaborative.
- Pennsylvania's **University Research Fund**, administered by the Ben Franklin Technology Development Authority (BFTDA). The Fund is designed to create synergy between university-based R&D and the transfer of technology for economic development purposes. Each project funded must include private-firm sponsorship.

The above programs are similar to programs in other states that provide matching funds for university-industry collaborative research. New Jersey is taking a new approach to this issue with its **Technology Fellowship Program**, which places postdoctoral fellows in New Jersey technology companies. The State contributes $160,000 per fellow for 2 years. The company provides benefits for the fellow and contributes $25,000 toward his or her salary in the second year. The fellow receives a salary of $65,000 in the first year and $75,000 in the second year. The program is designed to build collaboration between New Jersey universities, thesis advisors, and companies to encourage the transfer of technology to the marketplace.

In addition to providing support for collaborative projects, states also encourage interactions between the research and industrial communities. The State of Hawaii is contributing funds to improve the interaction between the **University of Hawaii** and industry to acquaint industry with technology transfer opportunities; provide the University with guidance from industry on commercialization, workforce, and curriculum needs; facilitate cooperative research; and provide internship and mentorship opportunities. The Biosciences Alliance of Iowa has created a **Networking Fund** that provides financial assistance to organizations that hold networking events that bring together entrepreneurial businesses, established companies, and members of the university research community to discuss new technologies and the innovations that the technologies support.

Table 31. State Programs Supporting Industry-University Partnerships in FY 2007 and FY 2008

State	Program	Grant Size	Annual Budget Millions		Matching Requirement
AZ	Strategic Research Groups and Small Business Catalytic Fund	$1.8 million (SRG) $200,000 (SBCF)	$20	$20	
CA	University of California Discovery Grants	$250,000 for up to 4 years	$30	$30	1:1 by California company
FL	Industry Matching Research Grant Program	$100,000	NA	NA	3:2 match if field- specific competition; 2:1 in open competition
GA	Technology Partnership Fund	$100,000	$1.2 (Bio only)	$1.4 (Bio only)	1:1 cash match from a Georgia-based company
HI	SBIR/STTR Matching Funds	$25,000	$0.46	$0.26	
KS	Kansas R&D Voucher Program Kansas Technology Enterprise Corporation (KTEC) Centers of Excellence	Up to $2 million	$7.5	$7.5	Varies by program
KY	Kentucky R&D Voucher Program	$100,000 a year up to 2 years	$2.9	$2.8	None
LA	Board of Regents Competitive Research Grants Program	No maximum	NA	NA	1:1 industry match required
ME	Maine Technology Asset Fund	No maximum	$25	$25	1:1 match required
MD	Maryland Industrial Partnerships program	$100,000	$2.3	$2.3	Requires at least 10% cash match for a start-up company and fees increase with size or age of the company
MA	Massachusetts Life Sciences Center Cooperative Research Program (MLSCCRP) MTC/JAII – Research Center Matching Grant Fund	$750,000 (MLSCCRCP) Up to $2 million	$2	$6	1:1 for MLSCCRP. Typically 1:1 industry match for MTC/JAII but varies by program
MI	21st Century Jobs Fund	No maximum	$35		None
MS	Mississippi Seed Fund	$100,000		$1.7	Loans (convertible into equity) are made to companies, 50% must be spent at a partner university. A 25–50% cash match is required from the company
MT	Montana Board of Research and Commercialization Technology	$500,000	$3.5	$3.5	At least 25% of the total cost of the project must come from other sources than Montana tax dollars
NH	New Hampshire Innovation Research Center	$150,000	$0.68	$0.68	second
NJ	Technology Fellowship Program	$160,000		$2.135	$25,000 in second year and benefits for both years
NY	NYSTAR Centers for Advanced Technology Program	$1 million	$15	$14.7	Graduated depending on age of Center
NC	Collaborative Funding Grant Program	Up to $240,000 over 3 years	$0.3	$0.3	Requires industry match based on size of the company

State	Program	Grant Size	Annual Budget Millions		Matching Requirement
OH	Third Frontier Project	Up to $60 million	$210	$207	Capital funds req 2: 1 Operating funds req 1:1
OK	Oklahoma Applied Research Support (OARS) Program, Economic Development Generating Excellence (EDGE)	$300,000 (OARS) No maximum (EDGE)	$3.6 $0	$3.3 $6.9 million	OARS requires a 1:1 match of State funds with non-state funds
OR	Signature Research Centers – OTRADI for bioscience		$5.25 for 2007–09		
PA	BFTDA University Research Program	No maximum	$14.5	$14	Typically, 1: 1 match
PR	INDUNIV (Industry-University Research Consortium)	$100,000	$0.1	$0.1	None
RI	Research Alliance Collaborative Research Award Program	$200,000	$1.5	$1.5	None
SC	Centers of Economic Excellence Program	$ 2 million–$5 million			1:1 match
SD	2010 Initiative	$1 million	2.7	3.2	No
UT	Centers of Excellence				
VA	Commonwealth Technology Research Fund (CTRF)	No maximum	$2	$1	1:1 with non-state funds
WA	Washington Technology Center Life Science Discovery Fund	$100,000 No maximum	$2.9	$2.9	Based on size of recipient from 20–100% in cash Encouraged but not required

Commercializing University Intellectual Property

It is widely recognized today that universities have an important role to play as generators of technology and drivers of economic development. As a result, there has been an explosion of new initiatives that seek to move research discoveries from the lab to the marketplace. States are providing funding to universities to build technology transfer and commercialization capacity and supporting freestanding commercialization centers that provide in-depth assistance to create and grow companies. Also, commercialization funds that provide small amounts for proof-of-concept activities are becoming increasingly common.

Colorado State University, the University of Delaware, and the University of Washington reported new initiatives aimed at accelerating the commercialization of their technologies. Colorado State University has created **Superclusters**, alliances that draw together experts from different academic research fields to address a critical global challenge. To date, Superclusters are being pursued in three areas: cancer, infectious diseases, and clean energy. Senior and experienced pharmaceutical professionals have been brought on to identify and facilitate the commercialization of technologies related to cancer and vaccine development. The University of Colorado funds its separate proof-of-concept program for internal technologies and early-stage spin-out companies. The University of Delaware created a new **Office of Economic Innovation and Partnerships** that will focus on university tech transfer and commercialization. University of Washington **TechTransfer LaunchPad** initiative was created to catalyze the creation of new ventures based on promising UW innovations. When an innovator expresses an interest in starting a company based on his or her UW innovation, UW TechTransfer staff review the case and meet with the researcher to discuss the start-up plan and possible LaunchPad assistance.

In addition to these university initiatives, three states—Florida, Massachusetts, and North Carolina—have established statewide initiatives designed to commercialize technologies originating in all of the universities across the state. The **Florida Institute for Commercialization of Public Research (FICPR)**, launched in early 2008, is designed as a "one-stop shop" for venture capital funds and companies to consider technologies available for commercialization from Florida's 11 public universities.

It is housed at the Florida Atlantic University Research Park and is being managed initially by the Enterprise Development Corporation, a nonprofit organization that assists emerging science and technology companies. FICPR will assign business mentors and help develop business plans to position university-developed technologies, expected to be primarily in the biosciences, for private investment.

The **Massachusetts Technology Transfer Center (MTTC)** provides services to support the work of the Commonwealth’s technology transfer offices with Massachusetts-based companies and investors. Projects supported through the MTTC include Research Partnering and Investment Forums, market viability studies, business plan development, entrepreneurial education, entrepreneurial development, and project funding to support proof-of-concept research and the development of data to support tech transfer and licensing.

The **Business Acceleration and Technology Out-Licensing Network (BATON)** program facilitates the creation of sustainable biotechnology companies emanating from North Carolina universities and research institutions. The BATON program works with university tech transfer professionals to identify unlicensed technologies that support commercialization via the formation of a start-up company. An entrepreneur is identified who is willing to form the company, develop a viable business model and milestone-driven development plan, and strategically engage community stakeholders willing to contribute expertise and service to the opportunity. Funding through the North Carolina Biotechnology Center’s TEAM loan may be used to leverage the in-kind or discounted services contributed by the stakeholders.

More and more, universities are providing funding for activities needed to determine the commercial potential of a discovery and to advance the technology to the point at which a commercial partner can be found. Such commercialization funds support prototype development, testing and validation, and marketing research. An example of this type of program is Oregon Health and Science University’s (OHSU’s) **Innovation and Seed Fund (ISF)**, an expansion of an earlier fund called the Bioscience Innovation Fund (BSIF). The ISF will address the full spectrum of commercialization needs, including development funding, start-up services, and seed funding. Over the past 2 years, OHSU has invested more than $900,000 in projects reviewed and recommended by an advisory committee composed of local entrepreneurs.

Helping Bioscience Companies Grow and Prosper

In addition to providing the environment in which technology is developed and introduced in the marketplace, states and regions wishing to realize the economic development potential of the biosciences must ensure the presence of a business climate that supports both small, emerging and large, established bioscience companies. This requires providing support to entrepreneurs and start-up companies to improve their chances for success, ensuring that capital is available to meet firms’ needs at each stage of development, and establishing tax and regulatory policies that help (rather than hinder) industry growth. Figure 14 shows bioscience firms’ needs at various stages of their life cycle and the state initiatives designed to address them.

Figure 14. Key Needs of Bioscience Firms at Various Stages of Development and Corresponding State Initiatives

	STAGE OF DEVELOPMENT				
	Discovery	**Translational Research and Commercialization**	**Company Start-up**	**Early-stage Company Growth**	**Rapid Company Growth**
KEY NEEDS	Market application scanning	Technology assessment	In-depth counseling and advice • Business plan • Marketing strategy	Business mentoring	Link to strategic partners
	Identifying businesses with interest in commercializing technology	Market and competitor assessment	Putting together management team/Interim CEOs	Management advice	Information on market, industry, and economic trends
		Guidance with regard to IP protection	Pre-seed and seed capital	Human resource planning	Funding for growth and continued new product development
		Funding for pre-commercialization research	Space and incubation services	Introduction to early-stage investors	
STATE BIOSCIENCE INITIATIVES	**TECHNOLOGY**				
	Research facilities				
	Eminent Scholars				
	Bioscience R&D grants				
		University tech transfer		R&D tax credits	
	CAPITAL				
		Proof-of-concept funding			
			Pre-seed/Seed funding	Venture capital	
			Entrepreneurial support programs		
	SPACE				
			Incubators	Facilities Financing	
	TALENT				
			Entrepreneurs in residence		Technician programs
					Internships
				NOL carryover policies	
				Tax incentives	
				Worker training programs	

Entrepreneurial Support Programs

Supporting entrepreneurs and the growth of entrepreneurial companies must be a critical component of any state's or region's strategy to accelerate the growth of its bioscience economy. The resources that they need include management talent, technology, capital, professional expertise, and a host of other services. They often need assistance in determining economic feasibility and identifying markets and distribution channels. They may also need access to specialized equipment and laboratories and to expertise to solve technical issues that arise during product development. They must be able to recruit key personnel and have access to small amounts of pre-seed capital.

Support services that bioscience entrepreneurs value include business mentoring by successful serial bioscience entrepreneurs; in-depth counseling and advice to make the entrepreneur ready to present plans before angel and other informal investors; access to capital sources at the pre-seed, seed, and later stages; and help in forming a business team of managers with commercial vision. Bioscience CEOs also often need advice in finding lab space and dealing with regulatory and other issues that are specific to the biosciences sector. As a result, 11 states reported entrepreneurial support programs specifically targeted to the biosciences. Table 32 is a listing of state-funded entrepreneurial support programs and descriptions of those programs.

Bioscience entrepreneurial support programs created in the past 2 years include the following:

Fitzsimons BioBusiness partners (FBBp) is a business development organization located in the Fitzsimons Life Science District serving the Colorado bioscience community. FBBp helps to prepare nascent bioscience ventures for their first round of private professional investment.

In 2007, state funds helped iBIO, Illinois's statewide bioscience association, to create PROPEL, an entrepreneurial support program modeled on the UCSD CONNECT "Springboard" program to prepare life science entrepreneurs to launch businesses and seek venture-capital funding. iBio also houses a state-funded Entrepreneurship Center. The iBIO Entrepreneurship Center provides formation-stage and early-stage life-sciences companies with technical assistance and access to matching grants and innovation challenge grants funded by the Illinois Department of Commerce and Economic Opportunity (DCEO). Launched in early 2008, the iBIO Entrepreneurship Center represents the State of Illinois's second industry-focused entrepreneurship program.

Heartland BioVentures, Kansas Bioscience Authority's business-assistance program, provides help with management counsel and recruitment, clinical collaborations, and business development to early-stage bioscience companies.

MdBio, an established bioscience entrepreneurial support program, is launching a new initiative in 2008 that will provide a forum for chief scientific officers (CSOs) and chief medical officers (CMOs) to come together to discuss technical topics.

Numerous bioscience incubators provide technical and financial support to entrepreneurs and start-up companies, including the Sid Martin Biotechnology Incubator at the University of Florida, the Edison Technology Incubators, and the Virginia Biosciences Development Center. Pennsylvania's three Life Sciences Greenhouses serve as comprehensive business development centers for bioscience companies.

Table 32. State-Funded Bioscience Entrepreneurial Support Programs

State	Program	Description
CO	Fitzsimons BioBusiness partners	A business development organization located in the Fitzsimons Life Science District serving the Colorado bioscience community
FL	Sid Martin Biotechnology Incubator	A bioscience incubator located at the University of Florida that assists emerging bioscience firms
IL	PROPEL iBIO Entrepreneurship Center (EC)	PROPEL is an entrepreneurial support program modeled on the UCSD CONNECT “Springboard” program to prepare life science entrepreneurs to launch businesses and seek venture-capital funding iBIO EC provides technical assistance and funding to early-stage life science companies
KS	Heartland BioVentures	KBA’s business-assistance program that provides help with management counsel and recruitment, clinical collaborations and business development to early-stage bioscience companies
LA	Louisiana Wet Lab Incubator Initiative	$30 million in state assistance to develop three bioscience innovation centers that provide low-cost wet- lab incubator space and integrated business development services
ME	Applied Technology Development Centers	Technology incubators at the University of Maine, Orono, and the University of Southern Maine, while not bioscience specific, support entrepreneurs in all of the targeted sectors.
MD	MdBio	MdBio is forming a new committee in 2008 to provide a forum for bioscience member company CSOs and CMOs to discuss technical topics of relevance
MN	BioBusiness Alliance’s Business Resource Net	An initiative of the BioBusiness Alliance of Minnesota that provides support to bioscience companies
OH	Edison Technology Incubators	The State of Ohio’s Edison program provides support to several bioscience incubators
PA	Life Sciences Greenhouses	Pennsylvania has three regionally based Greenhouses that are comprehensive centers for the commercialization of bioscience research.
VA	Virginia Biosciences Development Center (VBDC) and the Carilion Biomedical Institute	The Virginia Biosciences Development Center is a bioscience incubator located in the Virginia BioTechnology Research Park Carilion Biomedical Institute assists in commercializing technology developed in partnership with Virginia Tech and the University of Virginia

Capital Programs

The discovery and development of new technologies is a very expensive process running that can cost millions of dollars. What many people do not realize is that there are major costs incurred after the initial R&D has been completed. These include the cost of assessing the competition, the likely market, and the price points for competitive advantage; developing a prototype; preparing a marketing and sales plan; and scaling up for manufacturing. Finally, actual product distribution, sales, and marketing must be undertaken. Sufficient capital must be available to fund these activities in order for business growth and economic development to occur.

While these needs apply to all technology-based companies, many bioscience companies, at least those involved in biomedicine, need to access larger amounts of capital for longer time periods to cover the long development process for products that must go through clinical trials and obtain regulatory approval before they can be introduced into the market.

Yet, few sources of funding bridge the gap between the points at which (1) a discovery has been identified and demonstrated and (2) a business case has been validated and venture or other debt capital can be obtained. It is also difficult to obtain seed and early-stage investment because venture funds, as they have become larger, tend to make larger, later-stage investments. As a result, angel investors have also moved downstream (further away from pre-seed and seed investments), making more post-seed and later-stage investments than previously. So, in addition to the difficulty of obtaining translational research and precommercialization funding, firms are facing a gap at the start-up phase where they need $500,000 to $2 million. Figure 15 shows the necessary activities, financing sources, and levels of investment for technology companies at various stages of their development.

Increasingly, state governments are trying to address these needs by providing funding for precommercialization/proof-of-concept activities, creating seed funds, and implementing policies that encourage private investment in early-stage and later-stage venture capital.

Figure 15. Bioscience Company Financing Needs

	Concept	Translational Research/ Precommercialization	Pre-seed/Seed	Early-Stage	Growth
ACTIVITIES	Conduct R&D Identify discoveries with possible commercial potential	Assess potential of technology Identify market Develop prototype Test and validate Demonstrate proof of concept at lab scale Protect IP Optimize engineering License or form business	Establish business function Secure initial financing	Prepare business strategy Put serial management team in place Secure follow-on financing Begin initial sales and marketing	Begin full-scale production Staff up for sales and marketing
FINANCING SOURCES	Conventional peer-reviewed federal grant support	• Within university: Grants funded with university, state, or industry dollars • Nonuniversity: Grants funded by public and philanthropic support • SBIR I	• Friends and family • Pre-seed/seed funds • Angel investors • SBIR II	• Early seed-stage venture capital • Publicly supported investment funds	• Venture funds • Equity • Commercial debt • Industry (strategic alliances, mergers, and acquisitions)
LEVEL OF INVESTMENT	Varies	$50,000 to $500,000	Up to $1 million	$1 million to $2 million	> $2 million

Precommercialization/Proof-of-Concept Funding

In the past 2 years, the number of states offering precommercialization/proof-of-concept funding has significantly increased, with 33 states (including Puerto Rico) reporting the presence of such funds, up from 23 states in 2006. Such funding is provided prior to the formation of a business. Eligibility to receive this funding varies among the programs. About half of the programs fund university principal investigators and/or for-profit companies. Ten or slightly less than a third of the programs fund university principal investigators only in an active university-industry partnership, and eight fund for-profit companies only in an active industry-university partnership. Seven of the programs provide funding to university technology transfer offices.

Annual funding ranges from a low of $100,000 in West Virginia to a high of $15 million in Pennsylvania in FY 2008. The size of a typical fund is $2.5 million to $3 million. The size of a maximum award ranges from $15.000 to $3 million. Forty percent of the funds made awards between $15,000 and $100,000; another 40 percent made awards between $100,000 and $500,000; and 20 percent made awards in excess of $500,000. The bioscience-specific funds tended to have a higher maximum award amount.

The following precommercialization funds are targeted to the biosciences:

- The Colorado Bioscience and Life Science Fund, a 5-year, $26.5 million program, was signed into law in April 2008. The Fund will provide grants to Colorado start-up companies and research institutions seeking to commercialize new biotechnology drugs, biofuels, medical devices, and nanotechnology. The grants are capped at $15,000 for research institutions and $250,000 for companies. The funds can be used to support proof-of-concept projects, translational research, and incubators and to provide financing for start-up companies formed to commercialize university-developed technologies.

- The Connecticut BioSeed Program, a $5 million fund that can make investments of up to $500,000, provides seed capital to support the initial financial needs of Connecticut bioscience start-up companies. These funds are intended to sustain a company until it is able to secure investors for a Series A round of financing.
- The North Carolina Economic Development Investment Fund makes awards of up to $250,000 to bioscience companies for proof-of-concept activities.
- Pennsylvania's Life Sciences Greenhouses provide funding for precommercialization activities.

Table 33 is a listing of state commercialization funds, maximum awards, one-time funding, and annual funding.

Table 33: Precommercialization/Proof of Concept Funding In FY 2007 and FY 2008

State	Commercialization Funds*	Maximum Award	One-Time Funding	Annual Funding	
AZ	Arizona Technology Enterprises (ASU); Univ. of Arizona Tech Transfer Office; Catapult Bio	$50,000		$250,000–$300,000	$2.5–3 million
CA	Entrepreneurial Joint Venture Matching Grant Program (CSUPERB)	$25,000–$30,000			
CO	Colorado Bioscience Discovery Evaluation Grant Program	$150,000	$2.5 million	$ 2 million	
	Colorado Bioscience and Life Science Fund	$250,000 for companies; $15,000 for research institutions	$26.5 million over 5 years		
CT	BioSeed Program	$500,000	$5 million		
DE	Technology Based Seed Funds	$100,000		$1 million	$1 million
FL	State University Research Commercialization Assistance Grant Program		$2 million		
GA	VentureLab	$50, 000 for Phase I; $100,000 for Phase II; $250,000 for Phase III		$4 million	$4 million
IL	Entrepreneur in Residence Program; PROPEL and iBIO Entrepreneurship Center; other Entrepreneurship Centers (12); Innovation Challenge Technical Assistance and Matching Grant Programs	Entrepreneur in Residence: $80,000 Entrepreneurship Centers: $10,000 Innovation Challenge Grant Program: $50,000		$3.8 million	$1.65 million
IA	Demonstration Fund	$150,000		$2.5 million	$2.5 million
KS	Bioscience Innovation and Matching Fund KTEC Proof of Concept Fund	$2 million		$5.5 million	$8 million
KY	ICC Concept Pool	$25,000		$2.7 million	$2.5 million
ME	Maine Technology Institute Development Awards, Seed Grants, SBIR Phase 0, Cluster Enhancement Grants	$500,000		$6.3 million	$8.5 million
MD	University Technology Development Fund	$50,000		$450,000	$400,000
MA	MTC/JAII Centers of Excellence Program; Matching Fund Programs; Innovation Fund Programs; Mass Tech Transfer Center Technology Commercialization Programs	Varies by program	$50 million		
MI	21st Century Jobs Fund Michigan Pre-Seed Capital Fund			$15 million	$9 million
MS	Mississippi Seed Fund	$15,000	$4 million		
MO	Missouri Life Sciences Trust Fund,	No maximum			$2.6 million
	Missouri Technology Incentive Program	Phase I–$5,000 Phase II–$50,000			$1.25 million
MT	Montana Board of Research and Commercialization Technology	$500,000		$3.5 million	$3.5 million
NJ	Edison Innovation R&D Fund	$600,000		$5 million	$5 million
NY	NYSTAR Technology Transfer Incentive Program	$500,000		$4 million	$3.9 million

State	Commercialization Funds*	Maximum Award	One-Time Funding	Annual Funding	
NC	North Carolina Economic Development Investment Fund (BIO only)	$250,000		$1 million	$1 million
OH	Entrepreneurial Signature Program	$100,000	$84.4 million		
OK	Oklahoma Applied Research Support Program	$45,000/year for up to three years		$1.6 million	$1.14 million
OR	University Venture Development Fund	NA		$7 million	$7 million
PA	Life Sciences Greenhouse		$100 million	$12 million	$15 million
PR	PRIDCO-SBTR-Tied Grants	$375,000		$400,000	$400,000
RI	Slater Technology Fund			$3 million	$3 million
SD	Part of 2010 Initiative	$1 million		$3.8 million	$5.7 million
TX	Texas Emerging Technolgy Fund	$3 million	$25 million	$12.5 million	$12.5 million
VA	Commonwealth Technology Research Fund (CTRF)	No maximum		$2 million	$1 million
WA	UW Technology Gap Investment Fund and WSU Cougar Gap Fund	$50,000		<$1 million	<$1 million
WV	Small Business Innovation Research (SBIR) Program			$100,000	$100,000
WI	Innovation and Economic Development Research Program	$50,000		$600,000	$600,000

*Includes both state-funded programs and university-funded programs.

Pre-Seed and Seed Funding

Pre-seed funds make equity or near-equity investments in early-stage companies. They were defined in the survey as providing investments of up to $2 million. Twenty-five states and Puerto Rico reported one or more state-supported pre-seed funds. The funds varied in the level of investment, with seven funds investing $100,000 or less, ten funds investing $100,000 to $500,000, and fiveinvesting from $500,000 to $1 million. Only the following three funds were limited to making bioscience investments:

- Pennsylvania's Life Sciences Greenhouses, which make investments of between $200,000 and $500,000 in early-stage life-science companies
- The Puerto Rico Bio Science Investment Fund, a $250 million fund that invests in bioscience companies
- Virginia's Center for innovative Technology's GAP BioLife Fund that makes $50,000 to $100,000 equity investments in Virginia-based life science companies.

In Michigan, the state's 12 "SmartZones"—tax-advantaged districts each equipped with university-affiliated incubation or commercialization programs—jointly launched a return-oriented ***Michigan Pre-Seed Capital Fund***, which by March 2008 had invested $5 million in 22 companies, many in the biosciences.

Table 34 is a listing of state pre-seed funds, the total sizes of the funds, and the typical sizes of investments.

Table 34: State-supported Pre-Seed Funds

State	Pre-Seed Funds	Total Size of Fund	Typical Size of investment
CO	Colorado Fund I	$40 million	$500,000–$1 million
CT	Eli Whitney Fund	$45 million (approximately)	$500–$1 million
DE	Tech -Bbased Seed Fund I, Tech Based Seed Fund II, Pre-Venture Funding, Delaware Strategic Fund	$32.5 total all funds 2006–2008	$50,000–$100,000
FL	Florida Opportunity Fund	$30 million	
GA	ATDC Fund	$8 million	$200,000–$500,000
HI	Investment in multiple funds	$50 million	$200,000–$500,000
IL	Illinois Department of Commerce and Economic Opportunity Indirect Equity Fund (Angel & Seed Fund); Illinois State Treasurer's Technology Development Bridge; IllinoisVENTURES and LLC	$3.44 million $75 million $40 million	$500,000–$1 million
IN	Indiana Seed Fund	$6 million	$100,000–$200,000
KS	KTEC Equity Fund	$1.5 million plus additional funding for proof of concept	$200,000–$500,000
KY	Commonwealth Seed Capital	$21 million	$200,000–-$500,000
LA	Investments in several funds	$65 million	$500,000–$1 million
ME	Maine Technology Institute Accelerated Commercialization Fund; Small Enterprise Growth Fund	$8 million	$200,000–$500,000
MD	Maryland Venture Fund; Challenge Investment Program/ TEDCO's MTTF Program	$6 million $5.5 million	$50,000–$100,000
MA	Massachusetts Technology Development Corp	NA	$200,000–$500,000
MI	21st Century Investment Fund and Venture Michigan Fund	$109 million $95 million	More than $1 million
MS	Mississippi Seed Fund	$4 million	$50,000–$100,000
MO	Missouri Venture Partners	$15 million	Up to $50,000
NM	Flywheel Gap Fund LANL Venture Acceleration Fund	$2 million $600,000	$50,000–$100,000
NY	NYSTAR's Small Business Technology Investment Fund	NA	NA
OH	Third Frontier Pre-Seed Fund Initiative	$263 million	$10,000–$200,000
OK	OCAST Technology Business Finance Program, managed by i2E	$1.15 million annually	$100,000–$200,000
PA	Life Sciences Greenhouses	$100 million	$200,000–$500,000
PR	Bio Science Investment Fund	$250 million	NA
RI	Slater Technology Fund	$ 3million	$50,000–$100,000
TX	Emerging Technology Fund	$200 million	$500,000–$1 million
VA	CIT GAP BioLife Fund	$500,000	$50,000–$100,000

In addition to investing directly in companies and/or pre-seed and seed funds, states are using tax incentives to encourage private investment in early-stage companies and/or in funds that make early-stage investments. Nineteen states offer tax credits to angel investors who invest in technology companies, five of which are targeted specifically to angel investors who invest in bioscience companies. Ten states reported providing tax credits to individuals who invest in early-stage venture funds. North Carolina and Wisconsin offer tax incentives to those who invest in bioscience early-stage venture funds. Table 35 summarizes state capital tax credits to angel and bioscience angel investors and investors in early-stage and bioscience early-stage venture funds.

Table 35: State Seed Capital Tax Credits

State	State Tax Credits Provided to:			
	Angel investors	Bioscience Angel Investors	Investors in Early-Stage Venture Funds	Investors in Bioscience Early-Stage Venture Funds
AZ	●	●		
HI	●			
IN	●			
IA	●		●	
KS	●	●		
KY	●		●	
LA	●			
ME	●		●	
MD	●	●		
MI	●			
MT	●		●	
NM	●			
NY	●			
NC	●	●	●	●
ND	●		●	
OH	●		●	
OK	●		●	
OR			●	
VA	●			
WI	●	●	●	●

Venture Capital

States use a variety of mechanisms to increase the availability of venture capital. They can create funds that make investments directly in companies; invest in privately managed funds that agree to invest in state companies; or create a fund that, in turn, invests in private venture-capital funds, which is referred to as a “fund of funds”if it involves more than one fund. During the past 2 years, 9 states invested in funds of funds, and nine reported investing in private venture-capital companies—in addition to states that may have made such investments prior to 2006 and may still be investing those resources. Thirteen states reported that they made direct investments in bioscience firms between 2006 and 2008. Table 36 summarizes Sstates that invested in funds of funds, private venture-capital firms, bioscience companies, or others.

The Oregon Investment Fund is an example of a fund of funds. Managed by Credit Suisse with funding from the Oregon Investment Council, it has made investments in two California-based venture-capital firms. To date, one of the venture funds has invested in a life-science start-up company that is a spin-out of the Oregon Health and Science University. In 2008, the Oregon Growth Account made a $3 million investment in the Oregon Angel Fund, which will be required to invest at least $1 million annually in Oregon start-up technology companies.

Table 36. State Investments to Increase the Availability of Locally Managed, Later-Stage Venture Capital, 2006–2008

State	Invested in Fund of Funds	Invested in Private VC Firms	Invested in Bioscience Companies	Other
DE	●	●	●	
HI				Appropriated funds for contract with private nonprofit to provide funding for companies
IL	●	●	●	●
KS			●	
KY	●	●	●	
MA			●	Through Massachusetts Technology Development Corporation
MI	●			
MT	●			
NJ	●	●	●	
NM		●	●	
NC		●		
OH	●	●	●	
OK	●		●	
OR	●			
PA		●		
RI			●	
SD			●	Provides financing for feasibility studies in the form of a forgivable loan
VA			●	
WI		●	●	

California and New Jersey reported that their state pension funds have made investments in venture funds. The California Biotechnology Program administered by the California Public Employees' Retirement System committed $1.5 billion to bioscience-focused investment funds. New Jersey's State pension fund allocated $100 million to alternative asset investments.

Facilities Financing

Facility costs are among the most significant expenses for bioscience companies as firms need access to wet-lab space and specialized facilities and equipment. Three states—Connecticut, Georgia, and Kansas—have created dedicated bioscience facilities funds. Table 37 lists the specifics of these funds. The Connecticut BioFacilities Fund provides funding to qualified biotechnology companies for the construction of wet-lab and related space. Since its inception in 1998, the program has committed more than $37 million, translating into more than 350,000 square feet of lab and support space throughout the state. The Kansas Bioscience Expansion and Attraction Fund offers direct financial assistance in the form of low-interest loans, grants, and bonds to qualifying companies.

California, Indiana, Kentucky, Maryland, Massachusetts, and Virginia have economic development programs that provide financing by means of loans, tax-exempt financing, tax credits, and credit enhancements that are used to provide assistance for fit-out for bioscience companies. These programs are available to technology companies in a variety of sectors, rather than being limited to the biosciences.

Table 37. Bioscience Companies Facilities Financing

State	Fund	Total Size of Fund	Average Size of Loan	Average Term of Loan
CT	BioFacilities Fund	$54 million	$3 million	5 years
GA	Life Sciences Facilities Fund	$14 million	$2 million	10 years
	Strategic Industries Loan Fund	NA	$2 million	10 years
KS	Kansas Bioscience Expansion and Attraction Fund	$5 million in 2008	$1 million	5 years

Wet-Lab Space: Incubators and Research Parks

Wet-lab–equipped incubators have become widespread, with many states having multiple facilities. More than 100 bioscience incubators were identified in the 2006 report. Twenty-seven states indicated that they continue to have a shortage of wet-lab space in the 2008 survey; but, there were also indications that the private market is beginning to address this need. Twenty-one respondents indicated that they thought developers were more willing to build wet-lab space today than in the past. Of the incubators reported to have wet-lab space, only 25 percent were reported to have wet-lab space currently available. Of the 78 research parks reported to include public or university-built wet-lab space, 35 were reported to have wet-lab space available.

Supportive Tax Policies

Not only do states use their tax policies to encourage investment in early-stage companies and both early- and late-stage investment funds, they also enact policies aimed at easing the cash flow demands that bioscience companies face as they seek to navigate the long process of bringing a new technology or product to the market. Thirty-six states reported that they offer R&D tax credits. In six states, the R&D tax credit is refundable meaning that the business can exchange unused R&D tax credits with the state for a percent age of the value of the credit. Two states, New Jersey and Pennsylvania, allow the tax credit to be transferred to another firm. See Table 38.

Table 38. State R&D Tax Credits

State	R&D Tax Credit	Transferable	Refundable	Comments
AR	●			
AZ	●			
CA	●			
CT	●		●	
DE	●			
GA	●			
HI	●		●	
IL	●			
IN	●			
IA	●		●	The refundable tax credit is equal to 6.5% of qualified expenditures, and it may be doubled up to 13% with participation in a state tax credit program.
ID	●			
KS	●			
KY	●			
LA	●			
ME	●			
MD	●			
MA	●			
MI	●			
MN	●			
MS	●			R&D Jobs Credit
MT	●			
NE	●		●	
NH	●			
NJ	●	●		
NC	●			
ND	●			
NM	●			
NY	●		●	
OH	●			
OR	●			
PA	●	●		
RI	●			The R & D tax credit has a carry forward of 14 years
SC	●			
UT	●			
WA	●			Washington State has no state income tax. Instead a Business & Operating (B&O) tax is levied against businesses. The R&D tax credit can be taken against the levied B&O tax.

Thirty-one states reported exempting sales tax for equipment used in R&D, including equipment purchased for biomanufacturing. Four states, Colorado, Missouri, New Jersey and Rhode Island offer sales tax exemptions specifically targeted to bioscience firms. Thirty-nine states allow firms to carry forward net operating losses (NOLs) for periods ranging from 5 years to 20 years, with the one exception being Puerto Rico that allows carry forward for an unlimited number of years. The NOL carry forward is transferable in four states: Kentucky, New Jersey, Ohio and Tennessee. See Table 39.

Table 39. Sales Tax Exemptions and Net Operating Loss (NOL) Carry Forward

State	Sales tax exemption for equipment used in R&D	Specifically targeted to bioscience	Sales tax on equipment purchased for biomanufacturing	NOL Carryover Allowed	Years of Carryover	Transferable
AL				●	15	
AR				●	5	
CA				●	10	
CO	●	●	●	●	10	
CT	●		●	●	20	
DE	●		●	●	20	
FL	●		●	●	20	
GA	●		●	●	10	
HI	●		●	●	20	
ID				●	20	
IL	●		●	●	12	
IN	●		●	●	10	
IA	●		●	●	20	
KS	●		●	●	5	
KY	●		●	●	20	●
LA	●		●	●	10	
ME	●		●			
MD	●		●			
MA	●		●	●	5	
MI	●		●	●	10	
MN	●		●	●	15	
MS	●		●	●	5	
MO	●	●	●	●	5	
MT				●	15	
NE	●		●	●	7	
NV	●		●			
NH				●	10	
NJ	●	●	●	●	7	●
NM				●	5	
NY	●		●	●	10	
NC				●	15	
ND	●		●	●	5	
OH	●		●	●	15	●
OK				●	15	
OR				●	15	
PA	●		●	●	20	
PR				●	Unlimited	
RI	●	●	●	●	5	
SC	●		●	●	15	
SD	●		●			
TN				●	15	●
UT				●	5	
VA	●		●	●	15	
WA	●		●			

Addressing Talent Needs

States and regions have become very active in working with the biosciences industry sector to identify skill needs and to develop programs and initiatives to develop a workforce prepared to pursue careers in the biosciences. Of the 45 states that responded to the 2008 survey,

- 34 indicated a shortage of serial bioscience entrepreneurs
- 27 indicated a shortage of technical bioscience workers
- 25 indicated a shortage of bioscience scientists
- 24 indicated a shortage of regulatory workers
- 14 indicated a shortage of bioscience sales workers.

Twenty-seven States have either conducted or are conducting studies analyzing bioscience workforce needs.

States also indicated shortages in allied health care, nursing, clinical trials, advanced manufacturing technology, biomedical engineering, and biostatistics.

States are responding to these shortages by developing new curricula, adding new programs, retraining workers from other industries to pursue opportunities in the biosciences, conducting outreach to encourage more people to pursue training in the biosciences, and, in some cases, recruiting people to the state to fill bioscience positions. The following section outlines examples of these activities.

Attracting and Retaining Talent

Lack of people with experience in launching and growing a bioscience company is a challenge for any region seeking to grow its biosciences industry base. Some states are trying to address this by growing their own entrepreneurs; others are trying to attract people who have left the state to return. The Kansas Technology Enterprise Corporation's (KTEC) **KTEC Pipeline** program is designed to identify talented and entrepreneurial Kansans; match them with best-in-class training, resources, and mentors; and encourage them to pursue a career as a technology entrepreneur in Kansas. Delaware's Office of Economic Development Workforce Center of Excellence has hired a recruiter who focuses on recruiting science, technology, engineering, and math (STEM) graduates to locate in the State. The Illinois Department of Commerce and Economic Opportunity has awarded $860,000 to support experienced and young entrepreneurs in creating new, high-impact companies through the Entrepreneur in Residence Program, administered by the Chicagoland Entrepreneurial Center. Mississippi and South Dakota operate Web sites, the **Executive Talent Exchange** and **Dakota Roots**, respectively, posting both job openings and resumes of people interested in returning to the State. In its first year, Dakota Roots assisted 241 former South Dakotans in returning from 40 states and identified 1,400 individuals who have an interest in returning to South Dakota. Oklahoma is planning a similar effort.

Many states use internship programs to try to retain graduates of their educational institutions. The **Iowa Student Internship Program** links college students from Iowa schools to internship opportunities in small and medium-sized firms in the biosciences and advanced manufacturing and information technology industries with the goal of transitioning the interns to full-time employment in the state upon graduation.

New Directions in Bioscience Education

Biotechnology certificate and degree programs are becoming extremely widespread; and new programs are being created to address specific industry needs, particularly in the areas of regulatory affairs and clinical trials. Examples of the new programs that have been created in the past 2 years include the following:

- The University of Georgia's College of Pharmacy established a clinical trials design and management certificate program and a pharmaceutical and biomedical regulatory affairs graduate certificate program.

- Northwestern University will offer a graduate certificate in clinical research and regulatory administration and a master of science in quality assurance and regulatory science.
- The University of Medicine and Dentistry of New Jersey now offers a postgraduate certificate in stem cell research, and the Robert Woods Johnson Medical School has launched a master's degree program in clinical and translational science.
- A master's degree in regulatory affairs is now offered by the University of Washington.

The number of programs combining business and bioscience programs has also increased. San Jose State offers a master of biotechnology program that integrates advanced, hands-on training in laboratory-based core biotechnologies from the Department of Biological Sciences with MBA-level business courses in management/marketing from the College of Business. The University of Central Florida offers a master's in biotechnology with an MBA option. Indiana University's Kelley School of Business offers a Business for Life Science Executives program. The University of Kansas and Washington State University both offer animal health MBAs.

A number of new multi-institutional institutes have been created to offer specialized bioscience programs, including the following:

- Georgia Bioscience Technology Institute, a joint program of the Athens and Gwinnet Technical Colleges, was formed in 2007 to train a broad range of bioscience employees, including those who will work in biomanufacturing facilities.
- A new Graduate School of Biomedical Sciences has been launched in Maine. The School is a multi-institutional program that includes the University of Maine, Orono, the Jackson Laboratory, and the Maine Institute for Human Health and Genetics.
- A joint bioengineering research and research training program was established based on a formal agreement between Clemson University (CU) and the Medical University of South Carolina (MUSC). The partnership provides comprehensive translational and clinical research opportunities for CU bioengineering faculty and students and expanded research and graduate degree opportunities at MUSC.

Feeding the Bioscience Pipeline

Numerous activities are underway in the states to encourage students to consider careers in the biosciences, to ensure that teachers are knowledgeable about the biosciences, and to prepare students to pursue bioscience degrees. In addition, programs are being put in place to upgrade the skills of bioscience workers and to retrain workers from other industries to enable them to pursue opportunities in the biosciences.

Delaware, Ohio, Nevada, Tennessee, and South Dakota have opened specialized science and math high schools, while schools focused specifically on the biosciences have been created in Louisiana and Minnesota, including the following:

- A Biotechnology Magnet Academy, an academically gifted high school program (grades 9 through 12), was instituted at Southwood High School in Shreveport, Louisiana. Partners include the Caddo Parish School Board, the Biomedical Research Foundation of NW Louisiana, and Louisiana State University Health Sciences Center at Shreveport.
- Arlington High School in St. Paul was awarded a 3-year, $6 million grant from the U.S. Department of Education in 2007 to transform itself into a bioscience high school through a program it calls BioSMART (Science, Math, Academic Rigor, Technology). All students at the school will choose one of three tracks: Biomedical and Health Sciences, Bioengineering and Technology, or Biobusiness and Marketing. As part of this effort, the school is actively cultivating partnerships with bioscience companies in the area. The school is working with the nonprofit National Consortium on Health Science and Technology in the development of its model and is utilizing the national Project Lead the Way curriculum in its Bioengineering and Technology track.

In addition to creating special programs, states are working to integrate bioscience curricula into K-12 schools. Many activities are underway to provide teachers with the training they need to incorporate these subjects.

- The Illinois Department of Commerce and Economic Opportunity, iBIO Institute, and the National Biotechnology Institute work collaboratively to train a cadre of teachers (K-16) on integrating biotechnology into their lessons and classrooms. These trained teachers are expected to inculcate awareness and knowledge of biotechnology to their students as well as train them in related skills. Teachers take part in conferences and training sessions and will then go on to train other teachers in their local area and across the nation.
- MassBioEd supports students and K-12 teachers through internship/externship programs, curriculum support, career education guidance, and grants. MassBioEd's BioTeach Program is working to outfit school science labs with lab equipment and supplies to teach biotechnology, provide professional development for biology teachers in biotechnology science, help teachers to access and use engaging biotech curricula, and develop sustainable plans for replenishing supplies and ongoing professional development.
- The University of Oklahoma's K20 Center's Advancing Biotechnology and Climatology (ABC): Educating for Economic Growth in Oklahoma project, established by the National Science Foundation's Partnerships for Innovation program, partners education, government, and biotechnology research and industry communities to design and support model secondary schools. ABC, with support from the Presbyterian Health and Inasmuch Foundations, currently involves six schools across the State of Oklahoma, impacting 15 science teachers and more than 1,000 students with year-round bioscience professional development opportunities for teachers, authentic and inquiry-based biotechnology lesson integration into current science curriculum, and opportunities for research and industry connections through real and videoconferencing field trips.

Another area in which states are becoming more involved is in providing skills upgrade training and retraining for workers interested in opportunities in the biosciences.

- The Department of Community and Economic Opportunity (DCEO) in Illinois is now offering the Biotech Training Investment Program (bio-TIP) to help advance the skills of employees working in biotech/bioscience industries. bio-TIP reimburses employers up to 50 percent of the costs of training, not to exceed $5,000, to help train graduate students seeking biotech industry experience who find part-time employment as lab technicians/engineers. bio-TIP also helps cover training costs for existing full-time employees who are interested in upgrading their skills.
- The Pittsburgh Life Sciences Greenhouse (PLSG) received a $2.43 million grant to provide employed and unemployed trainees with skills for employment/advancement in bioscience companies. As part of the grant, PLSG trained 5,000 people, had more than 30 participating companies, and had more than $1 million in leveraged resources.
- Rhode Island used funding from the Federal H-1B visa program, funding typically used to bring workers from other countries to the United States to fill positions for which there are not enough U.S. workers, to create the Biotechnology/Biomanufacturing Training Initiative Grant program. Concordia Fibers utilized the funding to train and retain its original textile workers to become part of the company's transformation to the biomedical manufacturing industry. Instead of possibly losing their jobs, these workers were given the opportunity to learn new skills in a high-tech/high-growth industry, along with the potential to increase their income and opportunity for promotion.

CONCLUSION

BIOSCIENCE 08

The biosciences sector is truly coming of age. New discoveries are increasingly finding their way into new applications and products leading to new medical treatments, new sources of energy, and new industrial products made out of biobased materials. The impact of the progress in the biosciences is being felt across the United States, as demonstrated by bioscience job growth, up 5.7 percent between 2001 and 2006, and the number of bioscience establishments, up 15.7 percent nationwide during the same time period. This growth is spread across the United States with clusters of bioscience firms focused on specialized niches of the biosciences found in states and regions. Thirty-five states, the District of Columbia, and Puerto Rico have an employment specialization in at least one of the four biosciences subsectors: agricultural feedstock and chemicals; drugs and pharmaceuticals; medical devices and equipment; and research, testing, and medical laboratories.

State and regional economic development organizations throughout the United States are becoming increasingly sophisticated in their understanding of the biosciences and of building the biosciences sector and are adopting and implementing policies and programs that support its growth.

States are supporting the development and commercialization of bioscience discoveries by investing in bioscience R&D and in R&D facilities and infrastructure, supporting programs aimed at attracting and retaining world-class academic researchers, creating and maintaining mechanisms to encourage collaborations between bioscience companies and academic researchers, and facilitating the commercialization of university intellectual property.

Key Indicators of the Growth of the Biosciences in the United States

- The total employment impact, including direct, indirect, and induced jobs, of the biosciences sector is 7.5 million jobs
- Academic bioscience R&D expenditures totaled $29 billion in FY 2006
- Approximately 589,000 workers were employed in bioscience occupations in 2006
- U.S. higher education institutions awarded bioscience-related degrees to more than 143,000 students in the 2006 academic year
- Venture capital investments in bioscience companies reached $11.6 billion in 2007
- More than 82,000 bioscience-related patents were awarded between 2002 and 2007 in the United States

State governments are also undertaking initiatives to help grow and prosper bioscience companies, recognizing that their needs vary depending on the stage of development. Early-stage companies often need help in assessing the market for new products, putting together management teams, determining commercialization routes, protecting intellectual property, and finding space. More mature companies require links to strategic partners; information on market, industry, and economic trends; and funding for growth and continued new product development. States have in place an array of business assistance programs that provide such services to entrepreneurs and growing bioscience companies.

One of the greatest challenges for bioscience firms is the need for capital. While all technology companies need substantial capital to take a new technology to the marketplace, many bioscience companies, at least those involved in biomedicine, need to access larger amounts of capital for longer time periods to cover the long development process for products that must go through clinical trials and obtain regulatory approval before they can be introduced into the market. Increasingly, state governments are trying to address capital needs by providing funding for precommercialization/proof-of-concept activities, creating seed funds, implementing policies that encourage private investment in early-stage and later-stage venture capital, and supplying capital for facilities financing.

Finding talent is another challenge for bioscience firms. States and regions are working closely with their biosciences industries to identify skill needs and establish programs and initiatives to develop a workforce that is prepared to pursue careers in the biosciences. To create a pipeline of talent for the biosciences, states are developing new curricula, adding new program offerings at their institutions of higher education, retraining workers from other industries, conducting outreach to encourage more people to pursue training in the biosciences, and, in some cases, recruiting people to the state to fill bioscience positions.

The biosciences industry sector continues to evolve, and states must continue to examine and revamp their policies in view of these changes. During the past 4 years, states have made substantial investments in creating a strong bioscience infrastructure. A challenge for state policymakers will be to continue to support this level of investment in light of decreases in federal funding in some areas and continued fiscal pressure facing state governments as the U.S. economy weakens. But, doing so will result in significant benefits: better healthcare for citizens, alternative fuels that can decrease U.S. dependence on oil and improve environmental quality, and economic opportunities that can lead to an improved quality of life.

Employment & Establishments

The economic analysis in this report examines national, state, and metropolitan area data and corresponding trends in the biosciences from 2001 to 2006. For employment analysis, Battelle used the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) data. The QCEW data (formerly known as the ES-202 program) provide the most current, detailed industry employment, establishment, and wage figures available at both a national and subnational level.[10] Battelle receives an enhanced version of these state and county data from a private vendor, the Minnesota IMPLAN Group, Inc.

The QCEW program is a cooperative program involving BLS and the State Employment Security Agencies (SESAs). The QCEW program produces a comprehensive tabulation of employment and wage information for workers covered by state unemployment insurance (UI) laws and federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. Publicly available files include data on the number of establishments, monthly employment, and quarterly wages, by NAICS (North American Industry Classification System) industry, by county, and by ownership sector, for the entire United States. These data are aggregated to annual levels, to higher industry levels (NAICS industry groups, sectors, and supersectors), and to higher geographic levels (national, state, and metropolitan statistical area [MSA]).[11]

Since 2001, the QCEW has been producing and publishing data according to the NAICS. Federal statistical agencies have a mandate to publish industry data according to this improved classification system. Compared with the prior classification system—the 1987 Standard Industrial Classification (SIC) system, NAICS better incorporates new and emerging industries. Employment, establishment, and wage estimates produced by the QCEW program for 2001 to present are not comparable with SIC-based industry estimates from prior years. This limits the ability to construct a longer time series for data analysis; however, 6 years of NAICS-based data (2001-2006) are now available.

Twenty-seven NAICS industries at the most detailed (6-digit) level make up the Battelle definition of the biosciences and its subsectors (Figure A-1). These detailed industries are aggregated up to four major subsectors of the bioscience industry. Two of the detailed NAICS industries, Testing Laboratories (NAICS 541380) and Physical, Engineering, and Biological Research (NAICS 541710), are adjusted in this analysis to include only the share of these industries directly involved in biological or other life

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[10] In general, QCEW monthly employment data represent the number of covered workers who worked during, or received pay for, the pay period that included the 12th day of the month. Virtually all workers are reported in the state in which their jobs are located. Covered private-industry employment includes most corporate officials, executives, supervisory personnel, professionals, clerical workers, wage earners, piece workers, and part-time workers. It excludes proprietors, the unincorporated self-employed, unpaid family members, and certain farm and domestic workers. An establishment is an economic unit such as a farm, mine, factory, or store that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Total wages: Covered employers in most states report total compensation paid during the calendar quarter, regardless of when the services were performed. A few state laws, however, specify that wages be reported for or be based on the period during which services are performed, rather than for the period during which compensation is paid. Under most state laws or regulations, wages include bonuses, stock options, severance pay, the cash value of meals and lodging, tips and other gratuities, and—in some states—employer contributions to certain deferred compensation plans such as 401(k) plans.

[11] Major exclusions from UI coverage, and thus from the QCEW data, include self-employed workers, some wage and salary agricultural workers, unpaid family workers, railroad workers, and some state and local government workers.

science activities. To isolate these relevant life science components, Battelle used information and data from the U.S. Census Bureau's Economic Census.

Figure A-1. The Bioscience Subsector Industries

NAICS Code	NAICS Description
AGRICULTURAL FEEDSTOCK & CHEMICALS	
311221	Wet corn milling
311222	Soybean processing
311223	Other oilseed processing
325193	Ethyl alcohol manufacturing
325199	All other basic organic chemical manufacturing
325221	Cellulosic organic fiber manufacturing
325311	Nitrogenous fertilizer manufacturing
325312	Phosphatic fertilizer manufacturing
325314	Fertilizer (mixing only) manufacturing
325320	Pesticide and other agricultural chemical manufacturing
DRUGS & PHARMACEUTICALS	
325411	Medicinal and botanical manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Other biological product manufacturing
MEDICAL DEVICES & EQUIPMENT	
334510	Electromedical apparatus manufacturing
334516	Analytical laboratory instrument manufacturing
334517	Irradiation apparatus manufacturing
339111	Laboratory apparatus and furniture manufacturing
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
RESEARCH, TESTING, & MEDICAL LABORATORIES	
541380*	Testing laboratories
541710*	R&D in the physical, engineering, and life sciences
621511	Medical laboratories
621512	Diagnostic imaging centers

*Includes only the portion of these industries engaged in biological or other life sciences activities.

National, state, and MSA data were tabulated and presented in both summary analytical and state profile tables. Data for Puerto Rico and the District of Columbia are included in this report at both the "state" and national level. U.S. employment, establishment, and wage totals in this report reflect the sum of all state data and include both Puerto Rico and DC. All state and DC data are from the Minnesota IMPLAN Group; data for Puerto Rico are directly from BLS. Metropolitan area data do not include estimates for Puerto Rico as they are generally not disclosed at the 6-digit NAICS level of detail by BLS.

Data for 361 U.S. MSAs with bioscience employment activity were tabulated for this report. To best analyze location quotients (LQs) for MSAs, the areas were sorted by their total private-sector employment base and designated as either large, medium, or small metro areas. A "large" MSA has total employment at or above 250,000. A "medium" MSA has employment greater than or equal to 75,000, but less than 250,000. A "small" MSA has employment less than 75,000. Within each size classification, the metropolitan areas are then ranked by their LQ. Employment growth rates for MSAs were not included in this analysis because the relatively small bioscience employment bases in most metropolitan areas tend to result in large percentage changes in either direction that appear to overstate gains or losses among smaller MSAs and understate gains or losses among larger MSAs.

For more information on the BLS Quarterly Census of Employment and Wages, see http://www.bls.gov/cew/home.htm.

Employment multipliers from the Bureau of Economic Analysis (BEA) were used to estimate the employment impact on all other industries of adding bioscience jobs at both the state and national levels. BEA's Regional Input-Output Modeling System (RIMS II) is based on an Input-Output (I-O) table in an accounting framework. I-O tables are calculated for each industry and show the distribution of inputs purchased and outputs sold. These tables are derived from two major data sources: BEA's national I-O table for almost 500 U.S. industries and BEA's regional economic accounts used to adjust the data for a region's industrial structure and trading patterns. It is important to note that, like all impact models, RIMS provides an approximate order-of-magnitude estimate of impacts, and the multipliers are best used to estimate impacts of small changes on a regional economy.

Multipliers and the resulting employment impacts are shown in each state profile table, for each major bioscience subsector. BEA does not provide employment multipliers for Puerto Rico.

For more information on the Bureau of Economic Analysis RIMS II Multipliers, see http://www.bea.gov/bea/regional/rims/.

In the time series analysis of earnings estimates in this report, the Consumer Price Index for All Urban Consumers (CPI-U) was used to adjust for inflation. The Consumer Price Index is a measure of the average change in prices over time of goods and services purchased by households.

Additional Bioscience Performance Metrics Data

At the national level and for each of the state profiles, additional key bioscience performance metrics provide further insights into the current structure, recent performance, and capacity of the state's bioscience infrastructure. These metrics and their data sources are briefly described in the following paragraphs.

Bioscience Academic R&D Expenditures

Based upon data from the *National Science Foundation (NSF) Survey of R&D Expenditures at Universities and Colleges*, national and state totals (summation of all state's responding institutions) are calculated for FY 2006 (most current year available). Data are provided for total R&D expenditures (including per capita measures) as well as in chart form for the bioscience fields including Medical Sciences, Biological Sciences, Agricultural Sciences, Bio/Biomedical Engineering, and Other Life Sciences.

For more information on the NSF Survey of R&D Expenditures at Universities and Colleges, see http://www.nsf.gov/statistics/nsf08300/.

National Institutes of Health (NIH) Support to Institutions

Using data from the *NIH Awards to Institutions and Higher Education* (NIH Office of Extramural Research—http://grants1.nih.gov/grants/award/awardtr.htm), total and per capital measures are calculated for FY 2007 (most current year available).

For more information on the NIH Awards data, see http://report.nih.gov/award/trends/State_Congressional/StateOverview.cfm.

Bioscience-related Occupational Employment

The Bureau of Labor Statistics Occupational Employment Statistics (OES) program produces employment and wage estimates for more than 800 occupations.[12] From these specific occupations, OES data from May 2006 were used to construct and calculate occupational employment totals for four bioscience-related occupational groupings: Agricultural, Food, and Nutrition Scientists and Technicians; Biological Scientists and Technicians; Biomedical and Biochemical Scientists and Engineers; and Medical and Clinical Laboratory Technicians. The specific occupational categories (and Standard Occupational Classification [SOC] Code) included in each of these groups is shown in Table A-2.

For more information on the BLS Occupational Employment Statistics program, see http://www.bls.gov/oes/home.htm.

Table A-2. Bioscience-Related Occupations and Groups and SOC Codes

Bioscience Occupations and Groups	SOC Code
Agricultural, Food and Nutrition Scientists and Technicians	
Agricultural and Food Scientists	19-1010
Soil and Plant Scientists	19-1013
Animal Scientists	19-1011
Agricultural and Food Science Technicians	19-4011
Biological Scientists and Technicians	
Microbiologists	19-1022
Epidemiologists	19-1041
Medical Scientists, Except Epidemiologists	19-1042
Biological Scientists, all other	19-1029
Biological Technicians	19-4021
Biomedical and Biochemical Scientists and Engineers	
Biomedical Engineers	17-2031
Biochemists and Biophysicists	19-1021
Medical and Clinical Laboratory Technicians	
Medical and Clinical Laboratory Technologists	29-2011
Medical and Clinical Laboratory Technicians	29-2012
Dental Laboratory Technicians	51-9081
Medical Appliance Technicians	51-9082
Ophthalmic Laboratory Technicians	51-9083

Bioscience-related Degrees from Academic Institutions

Data from the U.S. Department of Education's National Center for Educational Statistics (NCES) were used to construct and calculate five bioscience-related degree categories, each consisting of a number of individual Classification of Instructional Program codes (CIP codes). These categories include the following: Agricultural, Food, and Nutrition Science; Biological Science; Biomedical Sciences and Engineering; Medical and Veterinary Sciences; and Other Life Science Clinical/Technical Fields. Charts are provided that examine the numbers of associate's, bachelor's, master's, and doctorate (Ph.D.) degrees by each degree category.

Given the emphasis on bioscience-related research and development activities, educational programs primarily designed to develop clinical practitioners (e.g., doctors, dentists, nurses) are not included in these categories. However, some instructional areas that provide degrees used in both clinical and research settings are included.

The data come from the Integrated Postsecondary Education Data System (IPEDS) and are described on the NCES website (http://nces.ed.gov/IPEDS/about/):

[12] The OES survey covers all full-time and part-time wage and salary workers in nonfarm industries. Surveys collect data for the payroll period including the 12th day of May. The survey does not cover the self-employed, owners and partners in unincorporated firms, household workers, or unpaid family workers.

"IPEDS is the core postsecondary education data collection program for NCES. Data are collected from all primary providers of postsecondary education in the country in areas including enrollments, program completions, graduation rates, faculty, staff, finances, institutional prices, and student financial aid. These data are made available on our website to students, researchers and others."

Graduate data for Academic Year (AY) 2006 were used as the most recent year available.

Bioscience Venture Capital Investments

Venture capital investments, while not the only source of equity capital for bioscience firms, is often the largest and is typically the most publicly known and reported source of investment funds allowing for comparability among states.

Venture capital data was collected using the Thomson Reuters VentureXpert venture capital database and includes all venture capital deals from January 1, 2002 through December 31, 2007 (as reported to Thomson Reuters as of May 1, 2008). The analysis includes all investments categorized in VentureXpert in the Medical/Health/Life Sciences major category and four subcategories within the Information Technology major category that capture medical/health-related information technology applications (e.g., software, e-commerce, internet content, and internet services).

Bioscience Patents

The use of patent data provides a surrogate (though not perfect) approach to understanding those innovations that bioscience-related industrial organizations, research institutions, and general inventors deem significant enough to register and protect and provides some measure of comparability among regions in one facet of innovation. Furthermore, examining recent patent activity provides some insight into firms' recent R&D areas, and hence, potential future lines of business. Three types of patents are defined by the U.S. Patent and Trademark Office (USPTO):

- ***Utility*** patents, which may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof.
- ***Design*** patents, which may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture.
- ***Plant*** patents, which may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.

Additionally, patents have two geographic bases—the location of the inventors and the location of the assignee. For this analysis Battelle uses the location of the named inventor(s) as the geography of record. Hence, if a bioscience patent is invented by individuals in two states, each state will receive "credit" for the patent, but at a national level the patent is counted only once. Similarly, when two or more named inventors are from the same state the patent only gets counted once.

USPTO assigns each patent with a specific numeric major patent "class" as well as supplemental secondary patent classes. By combining relevant patent classes across the wide array of bioscience-related activity, these class designations allow for an aggregation specific to the biosciences. Battelle has grouped these relevant patents into broader patent class groups for this analysis.

Patent data was collected using the Thomson Reuters Delphion patent analysis tool and includes all published patents from January 1, 2002 through December 31, 2007. Table A-3 provides a listing of the patent classes and class groups were used in this analysis.

Table A-3. Bioscience-Related Patents—Classes and Groups

BIO Patent Class Group	Major Patent Class	Patent Class Name
Agricultural Bioscience	71	Chemistry: fertilizers
Agricultural Bioscience	504	Plant protecting and regulating compositions
Agricultural Bioscience	PLT	Plants
Biochemistry	435	Chemistry: molecular biology and microbiology
Biochemistry	436	Chemistry: analytical and immunological testing
Biochemistry	530	Chemistry: natural resins or derivatives; peptides or proteins; lignins or reaction products
Biochemistry	536	Organic compounds: Carbohydrates and related
Biotechnology	800	Multicellular living organisms and unmodified parts and related processes
Biotechnology	930	Peptide or protein sequence
Drugs & Pharmaceuticals	424	Drug, bio-affecting and body treating compositions
Drugs & Pharmaceuticals	514	Drug, bio-affecting and body treating compositions
Surgical and Medical Instruments	128	Surgery: in vitro devices and respiratory devices
Surgical and Medical Instruments	600	Surgery: diagnostic/therapy testing, techniques, or devices
Surgical and Medical Instruments	601	Surgery: kinesitherapy
Surgical and Medical Instruments	602	Surgery: splint, brace, or bandage
Surgical and Medical Instruments	604	Surgery: blood/fluid-related devices
Surgical and Medical Instruments	606	Surgery: surgical instruments and devices
Surgical and Medical Instruments	607	Surgery: light, thermal, and electrical application
Other Medical Devices and Equipment	351	Optics: eye examining, vision testing and correcting
Other Medical Devices and Equipment	433	Dentistry
Other Medical Devices and Equipment	623	Prosthesis (i.e., artificial body members), parts, or aids and accessories
Other Medical Devices and Equipment	D24	Medical and laboratory equipment
Other Bioscience-Related	Various	Includes patents whose main patent class is not one of the above, but have one of the above as a secondary patent class reference.

Comparability with the 2006 BIO Report

Data used in this report are, in general, completely comparable with those presented in the previous BIO/Battelle publication *Growing the Nation's Bioscience Sector: State Bioscience Initiatives 2006*.

Both the industry and occupational employment data in this report are derived from the same data sources and methodology and incorporate the same definitions as those presented in the 2006 report. It is important to be aware, however, that industry employment data from the QCEW program are subject to revision. Some data presented in the 2006 report were ultimately revised and therefore may not match updated estimates from the same data source.

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