TEConomy/BIO

The Value of Bioscience Innovation in Growing Jobs and Improving Quality of Life

2016

TECONOMY PARTNERS LLC
Innovating Tomorrow's Economic Landscape

Bio
Biotechnology Innovation Organization

Presenting Sponsor:
VWR
We Enable Science

Bio Biotechnology Innovation Organization

BIO is the world's largest trade association representing biotechnology companies, academic institutions, state biotechnology centers and related organizations across the United States and in more than 30 other nations. BIO members are involved in the research and development of innovative healthcare, agricultural, industrial and environmental biotechnology products. BIO also produces the BIO International Convention, the world's largest gathering of the biotechnology industry, along with industry-leading investor and partnering meetings held around the world. BIOtechNOW is BIO's blog chronicling "innovations transforming our world."

TECONOMY PARTNERS LLC
Innovating Tomorrow's Economic Landscape

TEConomy Partners, LLC is a global leader in research, analysis, and strategy for innovation-based economic development. Today we're helping nations, states, regions, universities, and industries blueprint their future and translate knowledge into prosperity. The principals of TEConomy Partners include the authors of the prior Battelle/BIO State Bioscience Development reports, published since 2004. For further information, please visit www.teconomypartners.com.

PMP
Public Affairs Consultants

PMP Public Affairs Consulting, Inc.—PMP— is an independent consulting firm serving the public and constituent relations needs of bioscience-related companies and associations.

TEConomy Partners, LLC (TEConomy) endeavors at all times to produce work of the highest quality, consistent with our contract commitments. However, because of the research and/or experimental nature of this work, the client undertakes the sole responsibility for the consequence of any use or misuse of, or inability to use, any information or result obtained from TEConomy, and TEConomy, its partners, or employees have no legal liability for the accuracy, adequacy, or efficacy thereof.

TABLE OF CONTENTS

INTRODUCTION 1

THE ECONOMIC VALUE OF BIOSCIENCE INNOVATION 2

THE VALUE OF BIOSCIENCE INNOVATION TO PATIENTS 3
The Value to Patients: Lung Cancer 3
The Value to Patients: Type 2 Diabetes 5
Supporting Bioscience Innovation Activity that Drives Value: A National Effort 5

AN INNOVATION ECOSYSTEM REBOUNDING BUT WITH MIXED RESULTS 8

U.S. BIOSCIENCE INDUSTRY PERFORMANCE: RESILIENT SECTOR RETURNS TO A GROWTH PATH 9
Bioscience Industry Subsectors: Strength in Diversity 12
Bioscience Industry Wages: Generating High-Quality Jobs 13
Employment Multipliers: Even Broader Economic Value of the Bioscience Industry 14
State-by-State and Metropolitan Area Bioscience Industry Key Findings & Highlights 15
Metropolitan Area Industry Performance 17

THE INNOVATION ECOSYSTEM FOR THE U.S. BIOSCIENCE INDUSTRY 21
Continuing Strength in Bioscience Innovation: Bioscience-Related Patents 21
Capital Support for Innovation Grows: Bioscience-Related Venture Capital 22
Potential Obstacles to Further Development: Bioscience-Related R&D Investments 24

STATE AND METROPOLITAN AREA PERFORMANCE 25
Agriculture Feedstock & Chemicals 27
Drugs & Pharmaceuticals 31
Medical Devices & Equipment 35
Research, Testing, & Medical Laboratories 39
Bioscience-Related Distribution 43

THE INNOVATION ECOSYSTEM: STATE PERFORMANCE MEASURES 47
Academic Bioscience R&D Expenditures 47
NIH Funding 49
Bioscience Venture Capital Investments 50
Bioscience-Related Patents 52

APPENDIX: DATA & METHODOLOGY 55
Industry Employment, Establishments, and Wages 55
Industry Employment Multipliers 57
Additional Bioscience Performance Metrics Data 57
Bioscience Academic R&D Expenditures 57
National Institutes of Health (NIH) Funding 57
Bioscience Venture Capital Investments 57
Bioscience Patents 58

TABLES

Table 1: U.S. Bioscience Establishment and Employment Data, 2014, and Percent Change, 2001-2014 and 2012-2014 **12**
Table 2: Average Annual Wages for Selected Industries in the U.S., 2014 **14**
Table 3: State Specializations and Job Growth by Bioscience Subsector, 2014 **18**
Table 4: U.S. Bioscience Venture Capital Investments by Stage, 2012-2015 **23**
Table 5: States with Large and Specialized Employment in Agricultural Feedstock and Chemicals, 2014 **28**
Table 6: Metropolitan Statistical Areas with the Largest Employment Levels in Agricultural Feedstock and Chemicals, 2014 **28**
Table 7: Metropolitan Statistical Areas with the Highest Location Quotients in Agricultural Feedstock and Chemicals, 2014 **29**
Table 8: States with Large and Specialized Employment in Drugs and Pharmaceuticals, 2014 **32**
Table 9: Metropolitan Statistical Areas with the Largest Employment Levels in Drugs and Pharmaceuticals, 2014 **32**
Table 10: Metropolitan Statistical Areas with the Highest Location Quotients in Drugs and Pharmaceuticals, 2014 **33**
Table 11: States with Large and Specialized Employment in Medical Devices and Equipment, 2014 **36**
Table 12: Metropolitan Statistical Areas with the Largest Employment Levels in Medical Devices and Equipment, 2014 **36**
Table 13: Metropolitan Statistical Areas with the Highest Location Quotients in Medical Devices and Equipment, 2014 **37**
Table 14: States with Large and Specialized Employment in Research, Testing, and Medical Laboratories, 2014 **40**
Table 15: Metropolitan Statistical Areas with the Largest Employment Levels in Research, Testing, and Medical Laboratories, 2014 **40**
Table 16: Metropolitan Statistical Areas with the Highest Location Quotients in Research, Testing, and Medical Laboratories, 2014 **41**
Table 17: States with Large and Specialized Employment in Bioscience-Related Distribution, 2014 **44**
Table 18: Metropolitan Statistical Areas with the Largest Employment Levels in Bioscience-Related Distribution, 2014 **44**
Table 19: Metropolitan Statistical Areas with the Highest Location Quotients in Bioscience-Related Distribution, 2014 **45**
Table 20: Leading States—Academic Bioscience R&D Expenditures & Growth, 2014 **48**
Table 21: Leading States—Per Capita and Concentration of Academic Bioscience R&D Expenditures, 2014 **48**
Table 22: Leading States—NIH Funding, 2015 **49**
Table 23: Leading States in Bioscience Venture Capital Investments, 2012-2015 **50**
Table 24: Leading States in Bioscience Venture Capital Investments by Segment, 2012-2015 **51**
Table 25: Leading States—Bioscience-Related Patents **52**
Table 26: Leading States—Bioscience-Related Patents by Class Group **53**
Table A-1: The Bioscience Industry, NAICS Definition **56**
Table A-2: Bioscience-Related Patents—Classes and Groups **60**

FIGURES

Figure 1: U.S. Lung Cancer Age-Adjusted Mortality Rates, 2000-2012 **4**
Figure 2: Geographic Distribution of Currently Recruiting and Active U.S. Clinical Trials in Lung Cancer and Type 2 Diabetes **6**
Figure 3: Employment Trends, 2001-2014 **9**
Figure 4: Percent Employment Change, 2001-2014 **10**
Figure 5: Change in Real Average Annual Wages in the Biosciences, 2001-2014 **14**
Figure 6: Change in Bioscience Employment by State, 2001-2014 and 2012-2014 **16**
Figure 7: Bioscience-Related U.S. Patents, 2012-2015 **21**
Figure 8: Bioscience-Related U.S. Patents by Segment, 2012-2015 **21**
Figure 9: Bioscience-Related Venture Capital Investments, 2012-2015 **22**
Figure 10: Bioscience-Related Venture Capital Investments by Segment, 2012-2015 **22**
Figure 11: NIH Awards, 2012-2015 **24**
Figure 12: University Bioscience R&D Expenditures, 2012-2014 **24**

INTRODUCTION

Innovation is the foundation of the 21st Century bioscience industry. It is an industry borne from scientific innovations involving techniques to understand and manage the machinery of living things. The advent of biotechnology in the 1970s, enabled work at the molecular and cellular level including moving genetic information from one living cell to another and tracing the pathways of disease. Over the last 40 years, bioscience innovation has advanced at an astonishing speed.

Advances in the biosciences have reshaped all aspects of biomedical development from the way we study medicine, discover and develop therapeutics, and diagnose and treat diseases and medical conditions. Looking ahead, bioscience innovation will continue to shape two important medical revolutions. The first is the rise of genomic-based medicine in which medicine is moving from being an inexact art of detection and treatment to a science of prediction, prevention and strategic intervention or what is more popularly referred to as "personalized" medicine. The second revolution is regenerative medicine which refers to the use of biotechnology to restore bodily functions, replace failing body components and organs and address many currently incurable diseases with cell-based therapies.

Advances in biotechnology innovation have also had an enormous transformative impact on many sectors of the economy — from improving and protecting plants that are key to feeding the world to industrial biotechnology applications that are leading to bio-based fuels, chemicals and products that can protect our environment and herald a new age of sustainable development.

What stands out about bioscience innovation is its proven value in creating jobs and in improving the quality of life. The 2016 biennial report on State Biosciences Development takes stock of this value of bioscience innovation by considering the economic value that is found across the fast paced and ever changing world of bioscience industries. This year we also seek to put a human face on the value of bioscience innovation by considering how biotechnology is improving the quality of lives.

THE ECONOMIC VALUE OF BIOSCIENCE INNOVATION

As an innovative industry and national economic driver, the biosciences have shown both impressive strength and resilience over the last decade and a half. The industry, spanning five major subsectors with varied activities but common underlying technology, grew at a steep rate through the early and mid-2000s before seeing a modest employment decline during the deep national recession when the overall private sector plunged and most industries fared much worse.

The view from the other side of this challenging period reveals an industry back on track, recovering the lost jobs from the recession and each subsector contributing to job growth. It is the innovative nature of the biosciences that has allowed it to be so resilient, and why so many nations, states, and regions, are pursuing the industry as a driver of economic growth and innovative solutions to today's global challenges.

Key findings from the latest TEConomy/BIO assessment of the industry's performance include:

- The bioscience industry employed 1.66 million in 2014 across more than 77,000 U.S. business establishments.
- Overall industry employment has increased for four consecutive years, and in 2014 all five of the major industry subsectors grew.
- The industry continues to pay high wages, reflecting the high skills and education requirements of an innovative workforce, with the average U.S. bioscience worker earning nearly $95,000 per year, or 85% greater than the private sector average. Since 2001, bioscience wages have grown substantially faster than overall private sector wages.
- From 2012 through 2014, the focal period of this edition of the report, 35 states experienced net job growth in the biosciences.
- The bioscience industry is well distributed geographically, and diverse in the niche strengths that span the nation's states and cities. Among all U.S. states, 32 states and Puerto Rico have an employment specialization in at least one bioscience subsector. For U.S. metropolitan areas, also featured in this report, 222 of 381 have at least one specialization.
- The broader employment impact of the 1.66 million U.S. bioscience jobs via significant multiplier effects is an additional 7.53 million jobs throughout the rest of the economy. Taken together, these direct, indirect, and induced bioscience jobs account for a total employment impact of 9.2 million jobs.

THE VALUE OF BIOSCIENCE INNOVATION TO PATIENTS

The bioscience industry stands not only as an engine of economic prosperity, but more importantly, it is delivering improved health outcomes and giving individuals who suffer from medical conditions the hope of living a fuller, healthier life.

Innovations made by the bioscience industry are transforming the way we treat patients. Today, many diagnoses that were once devastating can now be treated as a manageable chronic condition, including:

- Hepatitis C, which was once an incurable disease, now has cure rates above 90%;[1]
- The death rate for cancer has fallen by 20% since its peak in 1991, due in large part to medicines;[2]
- Among children born during the last 20 years, it is estimated that vaccination and advances in vaccines will prevent more than 730,000 early deaths in the U.S.[3]
- The five-year survival rate for acute lymphocytic leukemia has increased from 41% in the mid-1970s to 70% between 2005 and 2011.

In addition, life expectancy in the U.S. has risen steadily from 76.8 years in 2000 to nearly 78.8 years in 2013, while death rates from conditions such as heart disease, stroke, cancer, influenza and pneumonia are steadily declining.[4] The contributions from the bioscience industry to increasing life expectancy are directly linked – it is estimated that 73% of the increase in recent years is attributable to the use of innovative medical products.[5]

These advances are more than just statistics; to patients, their loved ones and caregivers, they are the measure of a fuller life. As BIO's *Time is Precious* campaign explains: "Today's breakthroughs in biopharmaceutical medicines are delivering more than stunning outcomes. More than cures. They are giving us hope. They are giving us time."[6]

Today, lung cancer and diabetes are two of the most pressing health challenges facing Americans. While there is not yet a cure for either condition, recent advancements offer hope that one day there will be.

The Value to Patients: Lung Cancer

Lung Cancer is not only one of the most commonly diagnosed cancers, it is also the leading cause of cancer-related death in the United States. It is the second most commonly diagnosed cancer in both men and women, with over 224,000 new cases expected in 2016, accounting for about 14% of all cancer diagnoses. Unfortunately, lung cancer is responsible for more deaths than any other cancer, with an estimated 158,000 deaths expected in 2016 – or about 1 in 4 cancer deaths. The five-year survival rate for lung cancer stands at a mere 17%.[7]

Using the tools of modern bioscience, we are learning that there are many different types of lung cancer and that they each behave differently and need to be treated differently. New molecular targeted therapies are being introduced in the fight against lung cancer to treat specific genetic abnormalities in the tumor based on its genetic profile. This new ability is helping to create new targeted therapies and provide hope for a cure for one of the most deadly cancers.

Other novel biotechnology-related approaches to tackling lung cancer include the use of angiogenesis inhibitors to slow the growth of new blood vessels through the use of a recombinant humanized monoclonal antibody. When combined with chemotherapy, these approaches are having a demonstrable effect in reducing lung cancer progression. In 2015, the U.S. Food and

1 U.S. Food and Drug Administration, see: http://www.fda.gov/ForConsumers/ ConsumerUpdates/ucm405642.htm
2 National Cancer Institute, Surveillance Epidemiology and End Results, (accessed 13 May 2014)
3 See: http://www.nytimes.com/2015/09/15/science/732000-american-lives-saved-by-vaccination.html
4 Centers for Disease Control, Health, United States, 2014
5 Frank Lichtenberg, Columbia University. "Pharmaceutical Innovation and Longevity Growth in 30 Developing and High-income Countries, 2000-2009," *Health Policy and Technology*, published online 12 October 2013. This study examined broad factors shaping the rise in life expectancy from 2000 to 2009 across 30 nations, including the U.S.
6 See BIO web site -- http://timeisprecious.life/
7 American Cancer Society, Cancer Facts and Figures, 2016

Drug Administration (FDA) also approved new immunotherapy drugs for the treatment of certain advanced lung cancers.

The value of these targeted drugs is well recognized by lung cancer patients. One lung cancer patient participating at an FDA public meeting explained, “You do see people who have been through multiple lines of therapy and then all of a sudden they were tested for a mutation [to be a candidate for targeted treatment] and now their lives have transformed.”[8] The American Cancer Network reports on one such individual who was diagnosed with stage IV non-small cell lung cancer and enrolled in an aggressive six-month trial of a drug that shrank the tumor on her lung and eliminated all cancer in her lymph nodes. Today, tests reveal no evidence of disease. “I feel healthy… and the clinical trial gave me back some of the control that cancer had taken from me,” the individual says. “If that clinical trial hadn’t been available, I would not be here right now.”[9]

Today there are 592 new experimental drugs and 100 biologics advancing through clinical trials for lung cancer, with the majority of trials progressing to Phase 2 or later and numerous other trials investigating new procedures, devices, and diagnostics designed to improve a patient's quality of life.[10] Industry is working together with patient advocates, the FDA, and academic medical centers in novel ways to advance these targeted therapies.

The Lung Cancer Master Protocol (Lung-MAP) is a unique public private partnership among the federal government, the patient advocacy community, and the biopharmaceutical industry that is a multi-drug, biomarker driven clinical trial for patients with advanced lung cancer. The trial uses genomic profiling to match patients to an investigational treatment that is designed specifically to target the genomic driver of their specific cancer.

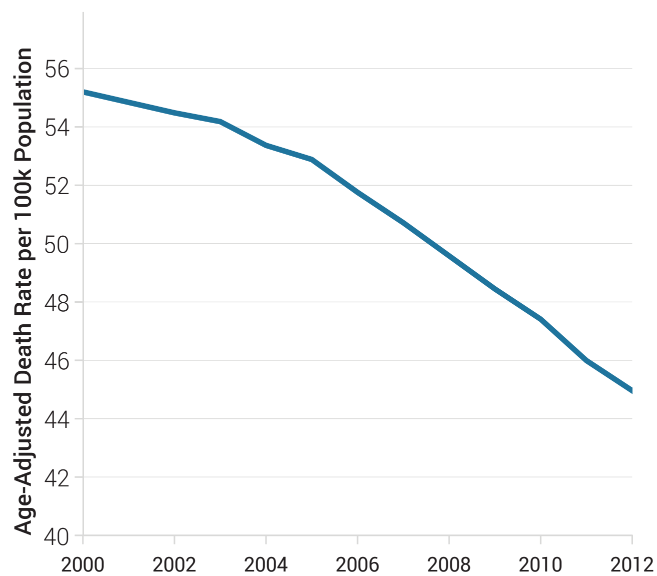
Project Transform, launched by LUNGevity in collaboration with a researcher at Johns Hopkins University, is a program designed to engage patients and integrate their experiences into the policy, treatment, and research of lung cancer. The goal is to develop evidence-based conclusions about patient desires to ensure that their preferences are understood.

By integrating the patient perspective early on, these diverse, collaborative partnerships are helping to not only advance the innovation happening in the labs, but also to speed the process, resulting in treatments getting to patients faster than ever before.

The effect of the increased focus on research and experimental drug treatment options across the spectrum of lung cancer types led to a dramatic impact on U.S. mortality rates over the past 10 years. The age-adjusted mortality rate for lung cancer has dropped from 55 per 100,000 population in 2000 to 45 in 2012 (Figure 1).[11] The reduction in deaths associated with a lung cancer diagnosis can be largely attributed to the ongoing deployment of next generation therapeutics and advancements in oncology diagnostics.

FIGURE 1

U.S. Lung Cancer Age-Adjusted Mortality Rates
2000-2012



Source: U.S. Cancer Statistics: WONDER Online Database; U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute.

8 FDA Voice of the Patient, Public Meeting on Lung Cancer, June 28, 2013, page 11.
9 Cancer Action Network, Catalyst for Cures, page 20.
10 Based on TEConomy Partners analysis of clinicaltrials.gov database, accessed May 2016.
11 Centers for Disease Control and Prevention and National Cancer Institute, United States Cancer Statistics 2015.

The Value to Patients: Type 2 Diabetes

Diabetes is one of the most common chronic diseases in the U.S., affecting an estimated 29 million Americans, and is a growing health crisis. Today, diabetes is the seventh leading cause of death in the nation. The most common form of diabetes is Type 2, accounting for about 90 to 95% of the diagnosed cases in the U.S. What makes Type 2 diabetes of grave concern is that an estimated 86 million adults have "prediabetes," making them high at risk of developing the disease. When considering the number of Americans who either have Type 2 diabetes or prediabetes, nearly one in three Americans is affected – a staggering figure that has far-reaching consequences for patients and our healthcare system.

Bioscience advances have not cured Type 2 diabetes yet, but the industry has made significant progress in bringing forward new classes of drugs to manage the disease. We've made great strides in treating patients with Type 2 diabetes. There's no magic pill yet, but there are more options than ever before to manage the condition.

In recent years, the FDA has approved numerous classes of Type 2 diabetes medicines, giving patients and their doctors more options to treat and manage the disease.[12] For example, DPP-4 inhibitor drugs lower blood glucose levels by allowing more insulin to be released in the body by inhibiting certain hormones that limit the production of insulin. Since its approval in 2006, there have been three additional DPP-4 inhibitors brought to market, all with similar efficacy in lowering sugar levels, but distinctive in how they are metabolized and excreted in the body.

What is particularly exciting is that these new classes of drugs are offering patients and their physicians a multitude of options to manage the condition. As one patient and marathon runner explained at an FDA-Patient Dialogue on unmet needs in diabetes: "I have to make compromises because I have diabetes. I wouldn't need to do these things if it wasn't a literal matter of life and death … But as I started out on my journey as a diabetic, the first thing I realized is that I'm dependent on a drug. Very difficult. I convinced my doctor that I was going to be the patient that was cured from diabetes through sheer force of will … that didn't work out so well. So I started on multiple therapies. That was my second realization, that this is something I have to do every day for the rest of my life if I intended to actually have a life."[13]

Building on the progress already made, the biopharmaceutical industry continue to work toward the development of new and better treatments for Type 2 diabetes and its related conditions.

Supporting Bioscience Innovation Activity that Drives Value: A National Effort

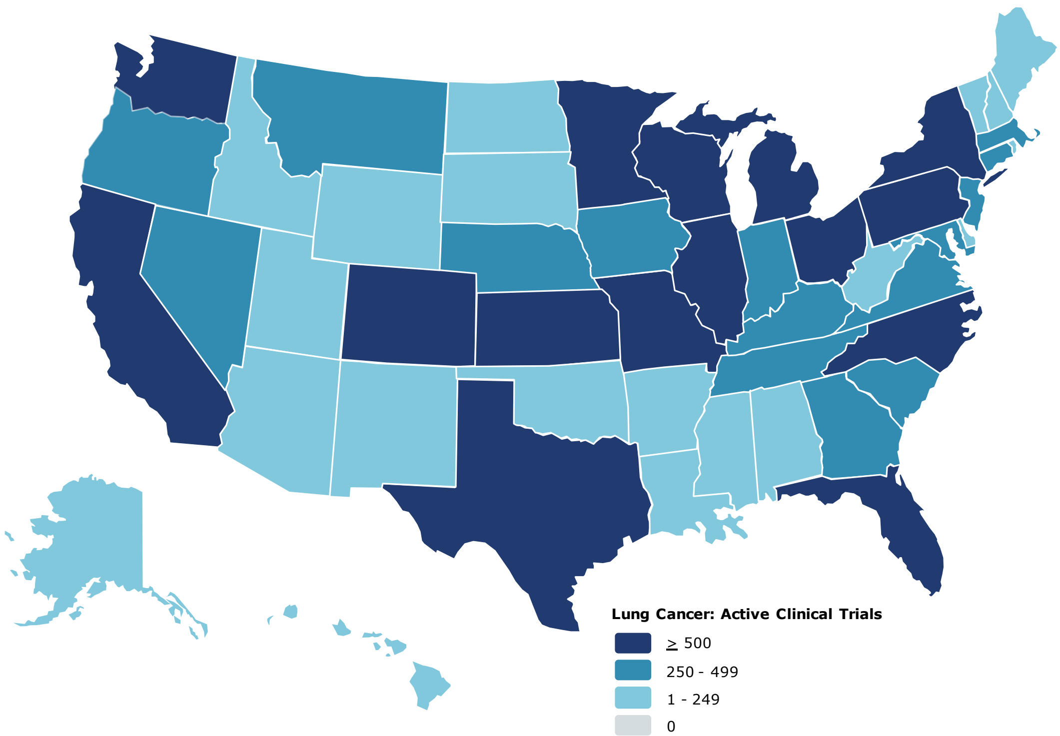
Every state across the country is contributing to the advancement of bioscience research, generating intellectual property that is bringing new treatments to market. Over the last five years, 101 patents detailing new therapeutics and treatments for lung cancer were granted that span 24 states across the U.S. and 169 patents for new compounds, delivery mechanisms, and devices were granted for Type 2 diabetes during that same time from inventors across 31 states. Additionally, in every state, clinical trials are being conducted to bring access to new therapeutics and treatment regimens. Today, there are 1,198 currently active or recruiting clinical trials for lung cancer and 489 currently active or recruiting clinical trials for Type 2 diabetes. The maps in figure 2 show how these activities are distributed geographically across the nation.

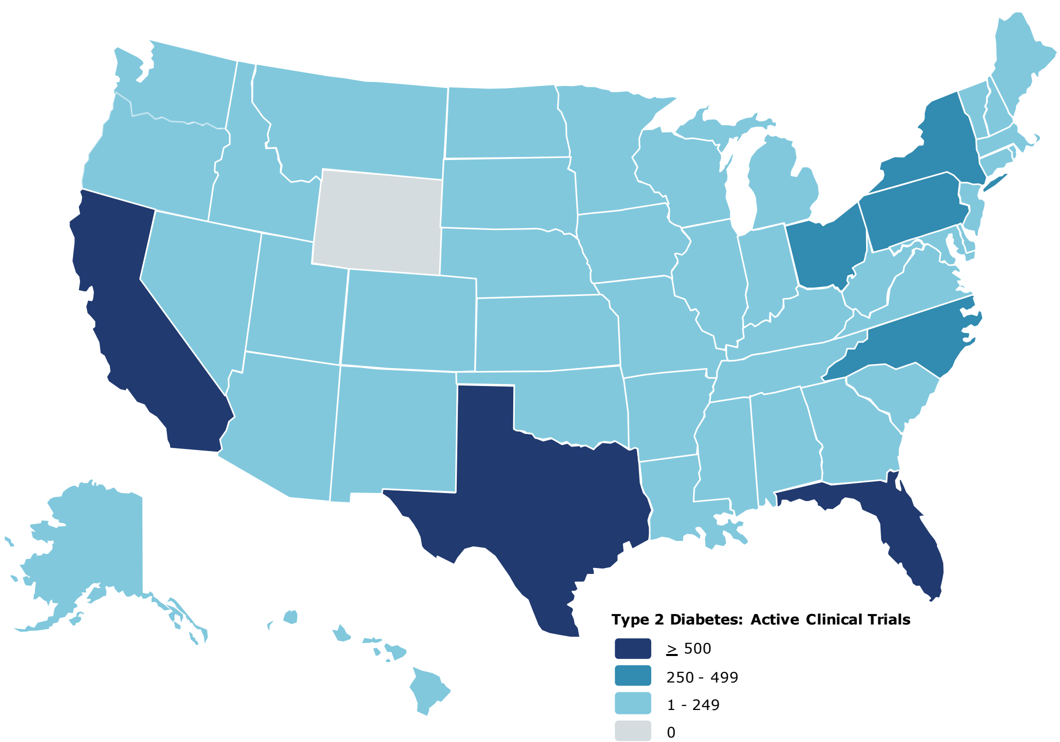
Similar to improving health, other quality of life improvements from bioscience advances are found in agriculture and food and industrial biotechnology. The BIO report on "Healing, Fueling, Feeding: How Biotech is Enriching Your Life" offers some key insights:

12 For more details on recent developments see articles: Lisa Leontis and Amy Hess-Fischl, "New Medications for Type 2 Diabetes," Endocrineweb.com, accessed May 2016 and Sarah Lewis, Treatment Advances in Type 2 Diabetes, Healthgrades, August 2015.
13 FDA-Patient Dialogue on the Unmet Needs in Diabetes, November 3, 2014.

FIGURE 2

Geographic Distribution of Currently Recruiting and Active U.S. Clinical Trials in Lung Cancer and Type 2 Diabetes





Source: TEConomy Partners analysis of clinicaltrials.gov database, accessed May 2016.

- In agriculture and food, advances in bioscience are dealing with the global challenge of how to feed a fast growing population in the midst of global climate change. By addressing harmful pests, increasing agricultural yields, reducing environmental impacts from agricultural production and improving food safety, advances in biosciences are making a major difference in food production.
- In industrial biotechnology, a shift towards bio-based products is underway that is critical for environmentally sustainable development. These bio-based products are biodegradable and non-polluting, and can also be applied to use in environmental remediation to clean up the legacy of our non-sustainable industrial past.

The value of bioscience innovation is evident in the advances in quality of life achieved over the last three decades. But these advances cannot be taken for granted. A high-quality innovation ecosystem has emerged over the years to include strong investment and incentives for research and development, strong intellectual property protections, a progressive approach to technology transfer, a highly developed venture financing market for innovation-led emerging companies and a transparent payment system that rewards innovation and encourages free market competition.

Tackling Cystic Fibrosis: How Orphan Diseases Can Be Addressed Through Biotechnology Innovations

Cystic Fibrosis (CF) is a life threatening disease that affects 30,000 children and adults in the United States. It is primarily a lung disease caused by a defective gene that makes the body produce mucus that clogs the lungs and leads to serious infections.

Advancements in biotechnology are helping Cystic Fibrosis patients live longer and more active lives. These advancements includes more effective pancreatic enzyme replacement therapies (PERT) to ensure Cystic Fibrosis patients get the nutrients they need, as well as new inhaled antibiotics to aid in the treatment of infections. In the 1980s, life expectancy of people with cystic fibrosis was 14 years. By 2000, the life expectancy of a person with cystic fibrosis was around 18 years. By 2010, it reached 35 years. If the trends between 2000 and 2010 continue, it is likely that the life expectancy will reach 50 years or more.[14]

Of particular note are the significant steps made in recent years to go beyond simply treating the symptoms of Cystic Fibrosis, but instead, to target the underlying causes of the disease by identifying and narrowing in on the mutations in the CFTR gene that cause CF. These advancements are the result of cross-sector collaborations that are now driving the discovery and development of new biopharmaceutical products. By pioneering the "venture philanthropy model," the Cystic Fibrosis Foundation partnered with industry and others to build a drug pipeline for CF that eventually led to a breakthrough therapy. As Robert J. Beall, President and CEO of the Cystic Fibrosis Foundation explains: "As genetically-targeted treatments move through the CF drug pipeline and on to patients, this disease is at the forefront of a new era in personalized medicine and is a model for what can be achieved when stakeholders collaborate on the development of treatments for a rare disease … The main focus of the CF model is collaboration across sectors, as the Foundation, academia, industry, government, patients and the medical community work together to develop treatments."[15]

14 Mackenzie, T, et al. "Longevity of Patients with Cystic Fibrosis in 2000 to 2010 and Beyond: Survival Analysis of the Cystic Fibrosis Foundation Patient Registry." Annals of Internal Medicine. 2014. 161(4):233-241. http://annals.org/article.aspx?articleid=1897099.
15 Robert Beall, Written Testimony for House Committee on Energy, Commerce, Subcommittee on Health," July 11, 2014.

AN INNOVATION ECOSYSTEM REBOUNDING BUT WITH MIXED RESULTS

In 2014, we began to see some troubling signs on the robustness of the nation's innovation ecosystem for biosciences development. These "signs of stress" included declining research funding from the National Institutes of Health (NIH) and relatively moderate gains in venture capital investments.

A fresh examination of recent trends finds similar concerns with respect to NIH funding, as well as a corresponding slowdown in bioscience-related academic R&D expenditures. Countering these trends, however, are strong gains in venture capital funding and patents generated.

- Overall funding from NIH has declined by 3% from 2012 through 2015, despite an uptick in this latest year.
- Across America's colleges and universities, the pace of R&D spending in bioscience-related research areas has slowed considerably. From 2012 through 2014, the average annual increase in bioscience-related university R&D was 0.6%, while during the preceding 10-year period annual increases averaged 7%.
- A bright spot in the ecosystem has been a strengthening pool of innovation capital to fuel bioscience firms at all stages. Venture capital investments in bioscience-related companies have increased significantly from a $10.0 billion per year average in 2012-13 to a $14.4 billion per year average in 2014-15. The investment levels reached in the last two years represent new highs for bioscience-related venture capital, exceeding the prior investment peaks reached in 2007-08. While the increase in venture funding is welcome news, growth in total VC funding since 2012 has been double that for the biosciences, due to rapid growth in investments made to IT-related companies. This has caused the bioscience-related share of overall venture funding to decline during this period.
- Innovation continues to drive the biosciences, with more than 100,000 U.S. bioscience patents awarded from 2012 through 2015. During this period, patent volumes continue to trend upward, rising 15% from 2012 through 2015, though it declined slightly in 2015.

These mixed results suggest that we must continue to strive to improve our innovation ecosystem. The U.S. has earned its position as a global leader in biopharmaceutical and other applications of biotechnology through its efforts to advance innovation. The fruits of that leadership are strong economic and health dividends. Without continued national and state support for bioscience innovation initiatives, the U.S. risks squandering that leadership position.

U.S. BIOSCIENCE INDUSTRY PERFORMANCE: RESILIENT SECTOR RETURNS TO A GROWTH PATH

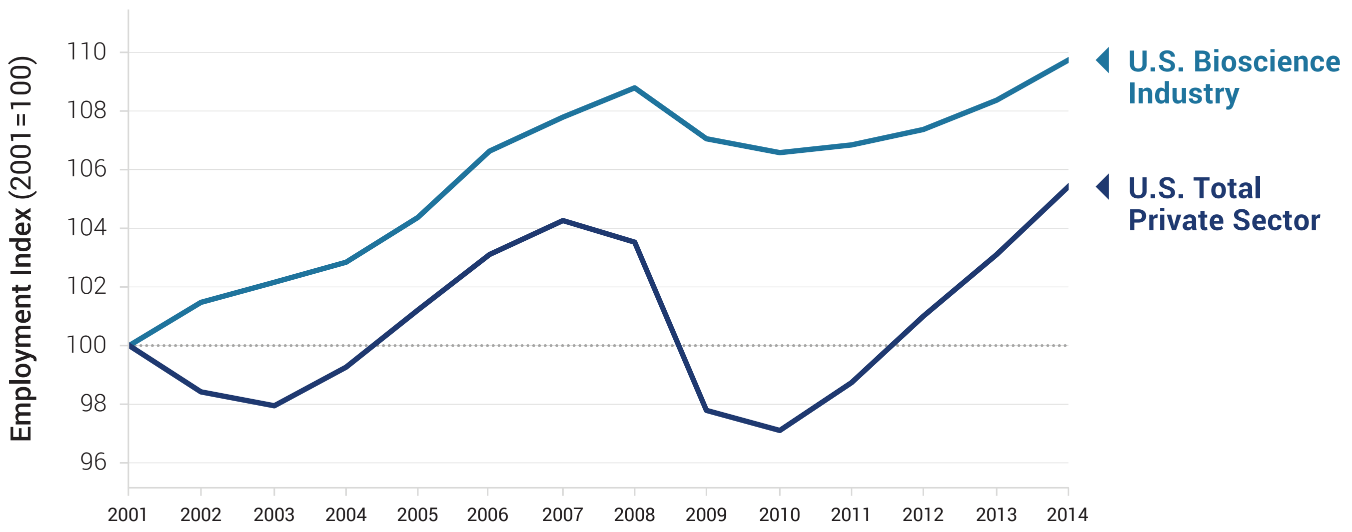
The nation's bioscience industry is continuing its long track record of creating high-quality jobs, with a base of innovation activity that spans every U.S. state. The industry has grown its employment base for four consecutive years following small employment losses as the nation emerged from the deep recession that ended in 2009. Today the industry employs 1.66 million in more than 77,000 U.S. business establishments.

The emergence of the bioscience industry from the recession has taken a different track from that of the overall private sector (Figure 3). The bioscience industry did not slide as deeply into the recession as the rest of the economy, with employment declining in 2009 and 2010 by just 2%. The bioscience industry also recovered its lost jobs and exceeded its previous employment peak earlier than the overall private sector. What is most impressive as shown in Figure 3 is the strong track record of success of the biosciences at the outset of the 21st Century.

This edition of the TEConomy/BIO biennial report has as its primary focus the recent experience of the industry and broader innovation ecosystem from 2012 through 2014 (and in several cases 2015 where data are available). Since 2012, the bioscience industry has increased employment by 2.2%.

FIGURE 3

Employment Trends
2001-2014



Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

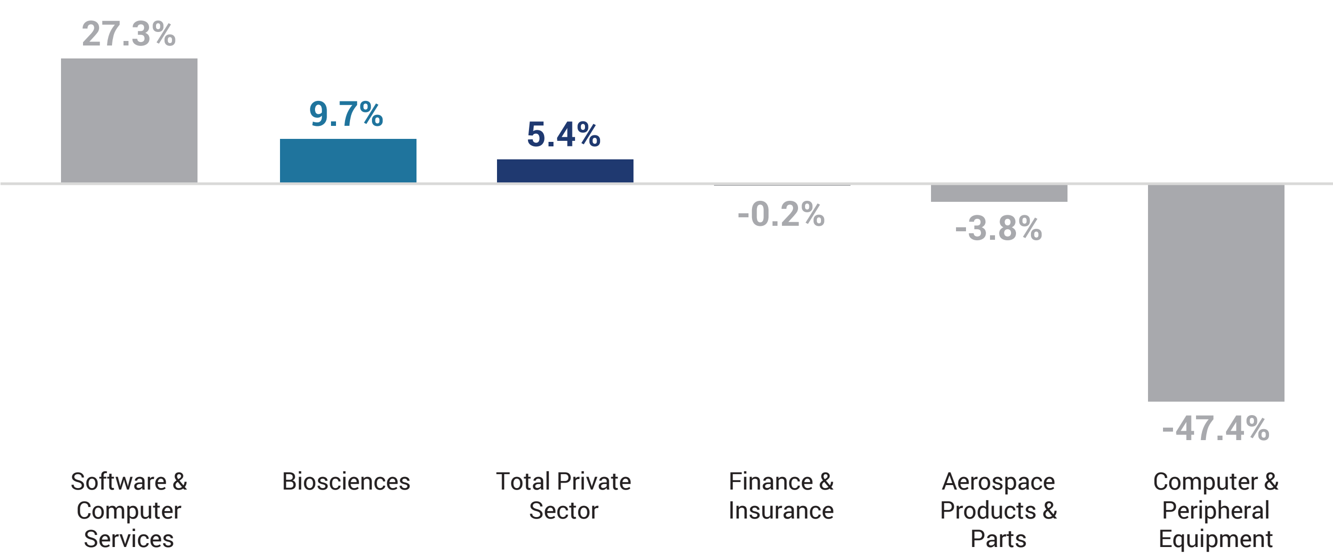
U.S. BIOSCIENCE INDUSTRY PERFORMANCE: RESILIENT SECTOR RETURNS TO A GROWTH PATH

For a decade and a half, the bioscience industry has been a leading performer for the U.S. economy. The industry has grown its employment base by nearly 10% or 147,000 jobs since 2001. Bioscience job growth has been more rapid compared not only against the overall private sector, but also against other U.S. knowledge-driven, technology-based sectors such as finance and insurance, aerospace, and computer hardware (Figure 4). It has not, however, matched the pace of growth in software and computer services, though the two sectors are increasingly tied with the rise of applied computing technologies and applications such as bioinformatics, health information technology and precision agriculture.

The physical footprint of the industry, measured by the number of individual establishments owned and operated by bioscience firms, has expanded by nearly 25% since 2001 and by 5.7% or nearly 4,200 since 2012. The average bioscience establishment employs just over 21 workers, significantly larger than the employment for an average private sector establishment of 13.

FIGURE 4

Percent Employment Change
2001-2014



Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

Industry Employment Data and Analysis

To measure the size, relative concentration, and overall employment impacts of the biosciences in the United States, TEConomy 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 five bioscience industry subsectors for 2001 through 2014 (though for MSA data just 2014 data are included), the most current, detailed, 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 for detailed industries at the sub-national level. The data represent a virtual "census" of workers covered under the Unemployment Insurance system, as reported by employers.

Metropolitan area data that measure employment and the 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 more information on the industry definition and data used in this employment analysis, please see the Data and Methodology appendix.

Defining the Biosciences

Defining the biosciences is challenging due to its diverse mix of technologies, products, R&D focus, and companies themselves. The industry includes companies engaged in advanced manufacturing, research activities, and technology services but has a common thread or link in their application of knowledge in the life sciences and how living organisms function. At a practical level, federal industry classifications don't provide for one over-arching industry code that encompasses the biosciences. Instead, more than two dozen detailed industries must be combined and grouped to best organize and track the industry in its primary activities.

The TEConomy/BIO State Initiatives reports have developed an evolving set of major aggregated subsectors that group the bioscience industry into five key components, including:

Agricultural feedstock and chemicals—Firms engaged in agricultural production and processing, organic chemical manufacturing, and fertilizer manufacturing. The subsector includes industry activity in the production of ethanol and other biofuels.

Bioscience-related distribution—Firms that coordinate the delivery of bioscience-related products spanning pharmaceuticals, medical devices, and agbiosciences. Distribution in the biosciences is unique in its deployment of specialized technologies including cold storage, highly regulated monitoring, and automated drug distribution systems.

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.

Research, testing, and medical laboratories—Firms engaged in research and development in biotechnology and other life sciences, life science testing laboratories, and medical laboratories.

Bioscience Industry Subsectors: Strength in Diversity

To truly understand the economic and innovation dynamics of the bioscience industry, one must dig deeper and appreciate its diversity. This report, part of an ongoing series completed every two years since 2004, has established an industry definition that recognizes the varied nature of the industry as well as its common threads. Five major subsectors, each of which shares a common link in the applications of biological knowledge and related technologies, represent this diversity in their unique commercial applications and marketplaces. These include:

- Agricultural Feedstock & Chemicals
- Bioscience-related Distribution
- Drugs & Pharmaceuticals
- Medical Devices & Equipment
- Research, Testing & Medical Laboratories

The major bioscience subsectors do not move in lock-step but rather have their own employment trends, establishment footprints, wages, and dispersion across the country. Recent bioscience job growth has been fueled largely by growth in research, testing, and medical labs and drugs and pharmaceuticals, where the former has steadily grown every year since 2001 and the latter is rebounding from five years of job declines. Additional growth has been generated in bioscience-related distribution and in agricultural feedstock and chemicals, while employment in medical devices has been flat.

TABLE 1

U.S. Bioscience Establishment and Employment Data, **2014** and Percent Change, **2001-2014 and 2012-2014**

	Establishment Data			Employment Data		
Bioscience Industry & Subsectors	**Count, 2014**	**Change, 2001-2014**	**Change, 2012-2014**	**Count, 2014**	**Change, 2001-2014**	**Change, 2012-2014**
Agricultural Feedstock & Chemicals	1,811	5.2%	2.2%	77,545	0.0%	1.5%
Bioscience-related Distribution	37,833	3.4%	2.8%	452,325	8.8%	2.3%
Drugs & Pharmaceuticals	3,301	26.4%	8.0%	293,353	-4.2%	3.2%
Medical Devices & Equipment	7,636	22.6%	5.5%	349,045	1.3%	-0.1%
Research, Testing, & Medical Laboratories	26,702	79.0%	10.2%	483,412	32.4%	3.4%
Total Biosciences	**77,283**	**24.5%**	**5.7%**	**1,655,680**	**9.7%**	**2.2%**

Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

Research, testing, and medical labs, which is unique in its focus on service and solutions offerings such as contract R&D and clinical research expertise, continues to represent the largest and fastest growing subsector of the U.S. bioscience industry. The subsector employs more than 483,000 or almost three in ten bioscience workers, and has experienced an impressive run of consistent growth—adding to its jobs base every year since 2001.

Bioscience-related distribution has three distinct focus areas—coordinating the delivery of drugs and pharmaceuticals; medical, dental, and hospital equipment and supplies; and agricultural seeds and chemicals. Combined the subsector employs more than 452,000 across nearly 38,000 U.S. business establishments. The subsector accounts for 27% of bioscience jobs nationally, and has grown employment by 2.3% since 2012.

Medical devices and equipment, U.S. companies operated more than 7,600 establishments in 2014 with just over 349,000 employees manufacturing a variety of biomedical devices, supplies, and equipment. Employment among medical device manufacturers has increased in three of the last four years, however a decline in 2013 offset those recent gains resulting in a minimal net change (-0.1%).

Drugs and pharmaceutical companies in the U.S. have rebounded with two consecutive years of net hiring increases following five difficult years of job losses that began with the national recession. Since 2012, when the subsector reached a new employment low, firms have increased employment by 3.2% or just over 9,000 jobs. In 2014, direct employment in drug and pharmaceutical firms accounted for 18% of U.S. bioscience jobs, but are also closely connected to the research, testing and medical lab subsector as well as bioscience-related distribution.

Agricultural feedstock and chemicals employs more than 77,000 across the U.S., representing 5% of all bioscience jobs. The subsector, which has two major focus areas—bio-based processing of corn, soybeans, and other oilseeds; and manufacturing organic and agricultural chemicals including biofuels—has increased employment each year since 2012 for an overall increase since 2012 of 1.5%.

Bioscience Industry Wages: Generating High-Quality Jobs

What makes the bioscience industry a highly sought-after economic driver for states, regions, and increasingly nations, is its creation of high-quality jobs. This is evident in the wages paid to bioscience workers which are consistently higher and increasing faster, on average, than the private sector and many other major industries.

Higher wages in the biosciences reveal the demand for a workforce that is highly educated and skilled to drive innovation. There is a broad recognition in today's knowledge-driven economy of the increasing importance of a workforce well versed in the "STEM" related fields of science, technology, engineering and mathematics. Innovative industries such as the biosciences must compete for talent with other sectors to maintain and ensure this talent base. Skilled professionals are in demand across a whole host of occupations in the biosciences with varied educational requirements including lab technicians, IT professionals, engineers, scientists, management, sales, and skilled production workers.

The average annual wage for a U.S. bioscience worker reached $94,543 in 2014 (Table 2). These earnings are $43,000 greater, on average, than the wages for the overall U.S. private sector ($51,148). This represents an 85% premium paid to bioscience workers, a premium which has steadily widened since 2001 when it was 65%. Bioscience earnings compare well against other major technology-driven industries such as finance and insurance, information, and professional and technical services.

With an average annual wage of more than $117,000, workers in drugs and pharmaceuticals earn the highest wages, followed by those employed in research, testing, and medical labs ($97,485). Each of the five major bioscience subsectors has average wages well above those for the overall private sector.

TABLE 2

Average Annual Wages for Selected Industries in the U.S.

2014

Employment Sector	Average Annual Wage
Drugs & Pharmaceuticals	$117,524
Research, Testing, & Medical Labs	$97,485
Finance & Insurance	$97,373
Total Biosciences	**$94,543**
Information	$90,804
Bioscience-Related Distribution	$90,458
Professional & Technical Services	$86,391
Agricultural Feedstock & Chemicals	$80,640
Medical Devices & Equipment	$79,537
Manufacturing	$62,977
Construction	$55,040
Real Estate & Rental & Leasing	$51,808
Total Private Sector	**$51,148**
Transportation & Warehousing	$48,720
Health Care & Social Assistance	$45,859
Retail Trade	$28,743

Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

Bioscience wages are not only higher than the private sector average but have consistently grown at a much higher rate since 2001. Over a decade and a half, real (inflation-adjusted) average wages in the biosciences have grown by 19% compared with 6% growth for the overall private sector (Figure 5). Each of the major subsectors has outpaced the private sector wage growth over this period.

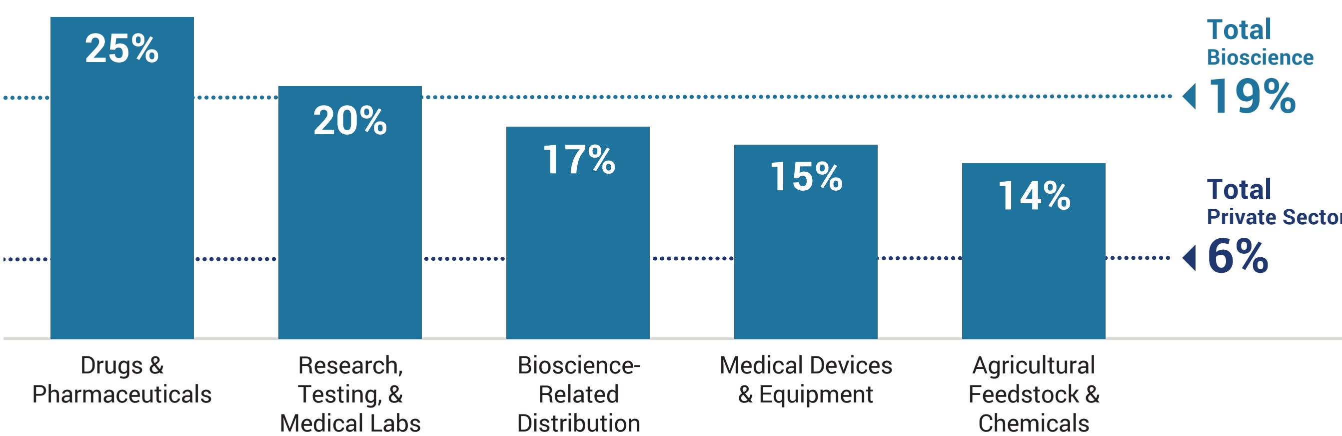
Employment Multipliers: Even Broader Economic Value of the Bioscience Industry

The bioscience industry, with 1.66 million jobs employing highly-skilled workers earning high-wages across every U.S. state, directly accounts for a substantial economic impact. When one takes into account the extensive, interdependent national supply chain required by the industry, these impacts extend even further. Bioscience firms depend upon other regional and national companies to supply everything from marketing, legal, and other business services to commodity inputs to facilities maintenance. As a result, the bioscience industry has a regional and national economic value and impact that is greater than its total direct employment or earnings suggest.

FIGURE 5

Change in Real Average Annual Wages in the Biosciences

2001-2014



Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

State-specific employment multipliers are used to measure this extended economic value of adding bioscience jobs. Multipliers quantify the broad ripple effects noted above where on industry creates and supports additional economic activities across others.

TEConomy has calculated state and national employment impact factors for each bioscience subsector, and the industry as a whole, using the direct-effect employment multipliers provided by IMPLAN Group, LLC. The multipliers represent the total change in the 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 employment multipliers for each major subsector are:

- Agricultural Feedstock & Chemicals: 18.4
- Drugs & Pharmaceuticals: 11.0
- Medical Devices & Equipment: 4.6
- Research, Testing & Medical Laboratories: 3.1
- Bioscience-related Distribution: 3.0
- Total Bioscience Industry: 5.5

The total indirect and induced employment impact of the 1.66 million U.S. bioscience jobs is an additional 7.53 million jobs throughout the rest of the economy. Taken together, these direct, indirect, and induced bioscience jobs account for a total employment impact of 9.2 million. This amounts to an overall bioscience direct-effect employment multiplier of 5.5.

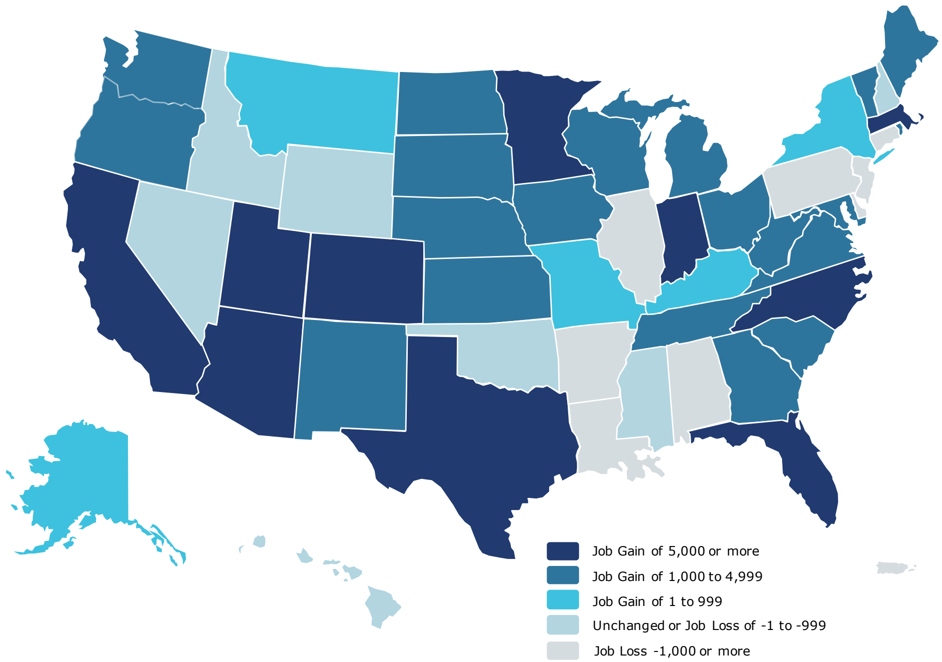
State-by-State and Metropolitan Area Bioscience Industry Key Findings & Highlights

The bioscience industry has a footprint in every state in the U.S., and in most states it is a significant economic driver, evident by the high number of states with specializations in at least one bioscience subsector and its widespread growth across states.

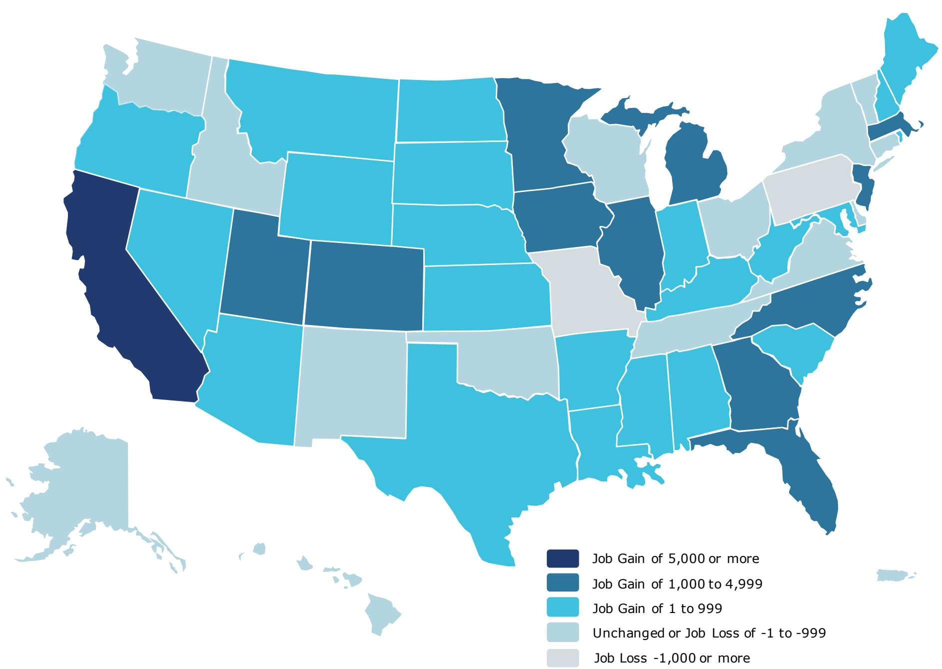
- Thirty-two States and Puerto Rico have a specialization in at least one of the five bioscience subsectors in 2014. These include:
  - 15 states specialized in Agricultural Feedstock & Chemicals
  - 10 states and Puerto Rico specialized in Bioscience-related Distribution
  - 13 states and Puerto Rico specialized in Drugs & Pharmaceuticals
  - 14 states and Puerto Rico specialized in Medical Devices & Equipment
  - 10 states and Puerto Rico specialized in Research, Testing & Medical Laboratories
- As was the case in the 2014 report, New Jersey and Puerto Rico stand out as the only states that are specialized in 4 of the 5 bioscience subsectors.
- Over the 2012 to 2014 period, 35 states experienced job growth in the bioscience industry.
- Looking over a longer time period, 35 states grew their bioscience industry employment from 2001 to 2014, with national bioscience employment growing by 9.7% over the same period.

FIGURE 6

Change in Bioscience Employment by State
2001-2014



Change in Bioscience Employment by State
2012-2014



Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

Metropolitan Area Industry Performance

The bioscience industry is well represented in the majority of the nation's metropolitan areas, with 222 out of 381 (58%) having an employment specialization in at least one bioscience subsector in 2014. This figure has increased from 216 metros reported two years ago.

Of the 222 specialized metro areas, 32 (14%) have a specialization in at least 3 bioscience subsectors, with Kalamazoo-Portage, MI metro area being the only to have a specialization in all five of the bioscience subsectors. These 32 metro areas span every region of the country and include (number of specializations in parentheses):

- Kalamazoo-Portage, MI Metropolitan Statistical Area (5)
- Boulder, CO Metropolitan Statistical Area (4)
- Durham-Chapel Hill, NC Metropolitan Statistical Area (4)
- Greensboro-High Point, NC Metropolitan Statistical Area (4)
- Indianapolis-Carmel-Anderson, IN Metropolitan Statistical Area (4)
- Lafayette-West Lafayette, IN Metropolitan Statistical Area (4)
- Madison, WI Metropolitan Statistical Area (4)
- Albany-Schenectady-Troy, NY Metropolitan Statistical Area (3)
- Ames, IA Metropolitan Statistical Area (3)
- Auburn-Opelika, AL Metropolitan Statistical Area (3)
- Bloomington, IN Metropolitan Statistical Area (3)
- Boston-Cambridge-Newton, MA-NH Metropolitan Statistical Area (3)
- Danville, IL Metropolitan Statistical Area (3)
- Fort Collins, CO Metropolitan Statistical Area (3)
- Greeley, CO Metropolitan Statistical Area (3)
- Idaho Falls, ID Metropolitan Statistical Area (3)
- Iowa City, IA Metropolitan Statistical Area (3)
- Knoxville, TN Metropolitan Statistical Area (3)
- Lebanon, PA Metropolitan Statistical Area (3)
- Lincoln, NE Metropolitan Statistical Area (3)
- Logan, UT-ID Metropolitan Statistical Area (3)
- Manhattan, KS Metropolitan Statistical Area (3)
- Memphis, TN-MS-AR Metropolitan Statistical Area (3)
- Oxnard-Thousand Oaks-Ventura, CA Metropolitan Statistical Area (3)
- Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metropolitan Statistical Area (3)
- Raleigh, NC Metropolitan Statistical Area (3)
- Salt Lake City, UT Metropolitan Statistical Area (3)
- San Diego-Carlsbad, CA Metropolitan Statistical Area (3)
- San Francisco-Oakland-Hayward, CA Metropolitan Statistical Area (3)
- South Bend-Mishawaka, IN-MI Metropolitan Statistical Area (3)
- Trenton, NJ Metropolitan Statistical Area (3)
- Worcester, MA-CT Metropolitan Statistical Area (3)

TABLE 3

State Specializations and Job Growth by Bioscience Subsector

2014

State	Agricultural Feedstock & Chemicals		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research, Testing, & Medical Laboratories		Bioscience-Related Distribution	
	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014
AL	●			●		●		●		
AK										●
AZ		●		●		●		●		
AR		●		●		●		●		
CA		●	●	●	●		●	●		●
CO				●	●			●		●
CT		●	●		●			●		
DE		●			●		●	●	●	
DC								●		●
FL				●		●		●	●	●
GA				●		●		●		●
HI		●								
ID	●			●		●	●		●	●
IL	●	●	●	●				●	●	●
IN	●		●	●	●			●		●
IA	●	●		●		●			●	●
KS	●	●		●				●		
KY				●				●		●
LA	●	●				●		●		●
ME			●	●				●		●
MD		●	●			●	●	●		
MA			●	●	●	●	●	●		●
MI				●		●		●		●
MN		●			●			●		●
MS	●	●		●		●		●		●
MO	●			●		●				●
MT		●		●		●				●
NE	●	●			●				●	●
NV		●		●		●				
NH				●	●			●		●
NJ		●	●	●	●		●		●	●
NM		●					●			

Note: Solid dots represent either a specialization >= 1.20 or employment growth > 0%.
Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

TABLE 3 (CONTINUED)

State Specializations and Job Growth by Bioscience Subsector

2014

State	Agricultural Feedstock & Chemicals		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research, Testing, & Medical Laboratories		Bioscience-Related Distribution	
	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014	Special-ization, 2014	Growth, 2012-2014
NY		•								•
NC	•		•	•			•	•		•
ND	•	•				•		•	•	•
OH								•		•
OK		•		•						
OR		•				•		•		•
PA		•	•				•	•		•
PR		•	•		•	•	•	•	•	
RI		•	•	•	•	•		•		•
SC		•		•						•
SD	•			•	•	•		•	•	•
TN	•	•				•		•	•	
TX		•		•		•		•		
UT			•	•	•	•	•	•		•
VT		•		•				•		
VA						•				•
WA		•								
WV		•	•					•		•
WI				•	•			•		
WY	•	•		•						•

Note: Solid dots represent either a specialization >= 1.20 or employment growth > 0%.
Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN Group.

THE INNOVATION ECOSYSTEM FOR THE U.S. BIOSCIENCE INDUSTRY

Continuing Strength in Bioscience Innovation: Bioscience-Related Patents

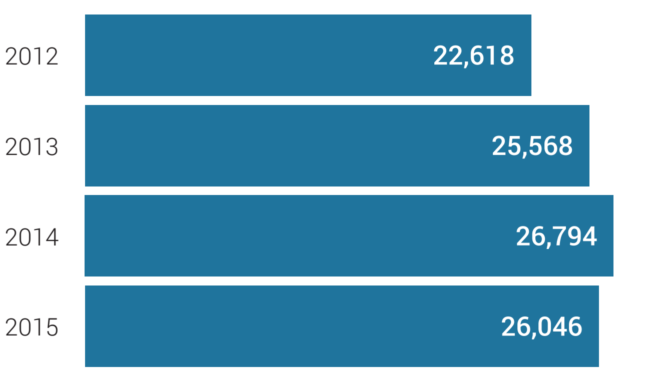
Traversing the pathway from basic science research to an on-the-market medicine, medical device, or bio-based product can require a decade or more of R&D and product testing before the first dollar of commercial sales is realized. A crucial step in the innovation process for new bioscience products is the creation of intellectual property in the form of a patent, which provides the predictable legal protection necessary to ensure private investment for further technology development of a bioscience invention. As *Scientific American* explains in its 2014 Worldview Scorecard on Biotechnology: “Biotechnology innovation – like that of many other businesses – relies on strong IP protection. In short, fewer innovators would take the risk of time and investment without some hope of capturing a return.”[16] The bioscience inventions that generate patents must still be developed into viable technology solutions with much additional applied research and development as well as testing for many medical and agricultural applications.

From 2012 to 2015, the U.S. continued its upward trend in bioscience patenting, with 101,026 bioscience-related patents granted with at least one U.S. inventor (Figure 7).[17] Even with a slight downtick in patents in 2015 compared to the previous year, bioscience-related patents have grown by 15% since 2012.

Patents related to medical and surgical devices represent the largest group of U.S. bioscience patents, making up 47% from 2012 to 2015 (Figure 8). Of the eight bioscience patent segments analyzed, five grew at double-digit rates over the 2012 to 2015 period. The largest growth occurring in patents related to drugs and pharmaceutical development, up 44%. Biomedical design patents, while comprising a small share of total bioscience patents, had the second highest growth rate, increasing by 43% to 954 patents in 2015.

FIGURE 7

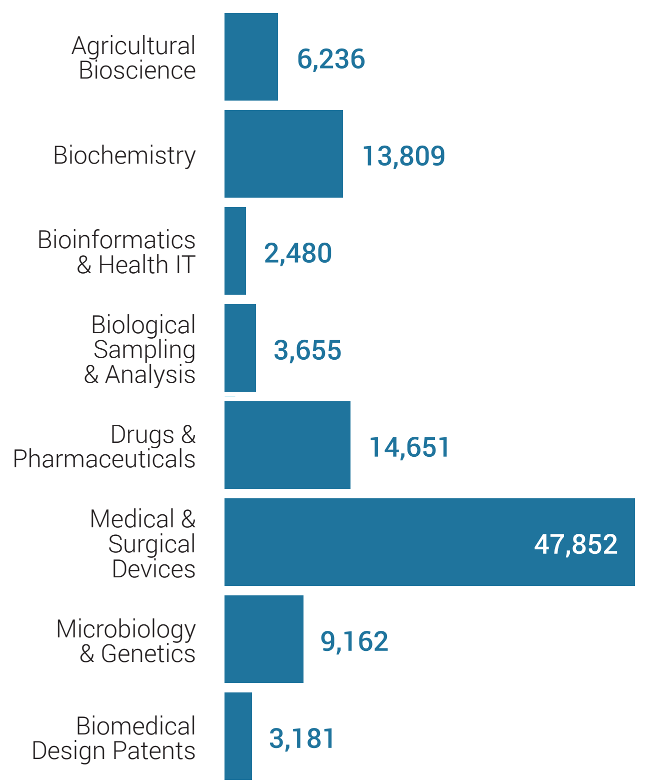
Bioscience-Related U.S. Patents
2012-2015



Source: TEConomy Partners analysis of Thomson Reuters Thomson Innovation patent analysis database.

FIGURE 8

Bioscience-Related U.S. Patents by Segment
2012-2015



Source: TEConomy Partners analysis of Thomson Reuters Thomson Innovation patent analysis database.

16 *Scientific American*, Worldview Scorecard: A Global Biotechnology Perspective, Special Report, 2014, page 36.
17 Patent data have been updated and newly categorized in bioscience-related technologies to reflect the shift that the U.S. Patent and Trademark Office has made to the new CPC system. For more information, see the Data & Methodology Appendix to this report.

Capital Support for Innovation Grows: Bioscience-Related Venture Capital

Risk capital is a critical source of funding to bring a bioscience innovation to market. This is especially true for nascent, early-stage companies that need capital not only to further the research and development of their product, but to conduct the rigorous pre-clinical and clinical testing required.

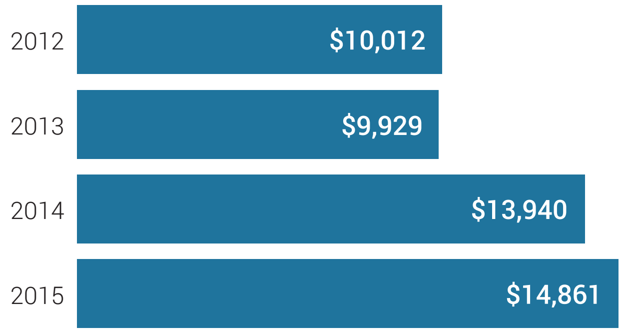
The 2014 report found the trend in bioscience-related venture capital investments had been on the decline, and could impact the health of the industry going forward. Recent data, however, show a strong resurgence in bioscience-related venture capital funding over the last two years (Figure 9), with investments in 2015 reaching a new high for the industry. In fact, both 2014 and 2015 were hallmark years for VC investments in the bioscience industry. Investments in 2014 reached $13.9 billion, and 2015 overtook that at $14.9 billion, the highest level over the 2001 to 2015 period. From 2012 to 2015, VC investments grew by 48%.

While the increase in venture funding is welcome news, it is important to put this new peak in context with the rest of the market for VC investments. Total VC funding, across all industries, grew by 97%, double the 48% growth recorded in biosciences venture capital from 2012 to 2015. This strong overall growth in venture funding was led by rapid growth in investments in IT-related firms, which increased by more than two and a half times (162%). Bioscience-related VC investments made up 25% of total U.S. VC funding, on average, from 2012 to 2015. However, while VC investments have increased in bioscience companies, its share of overall venture investing has actually declined since 2012 from 28% to 22% of the total. While the biosciences' share of VC was declining, that for IT grew by 16 percentage points to 63% of the total in 2015.

Figure 10 shows the breakdown of VC investments by industry segment over the 2012 to 2015 period. Investments in human biotechnology companies make up the largest share of funding at $21.7 billion, almost 45% of total investment in the bioscience industry.

FIGURE 9

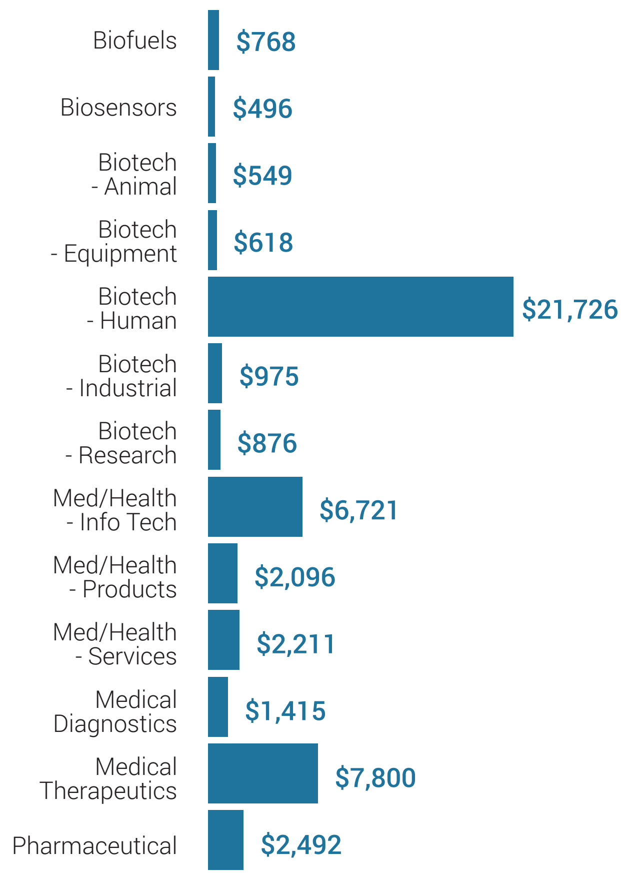
Bioscience-Related Venture Capital Investments
$ Millions
2012-2015



Source: TEConomy Partners analysis of Thomson Reuters Thomson ONE database.

FIGURE 10

Bioscience-Related Venture Capital Investments by Segment
$ Millions
2012-2015



Source: TEConomy Partners analysis of Thomson Reuters Thomson ONE database.

Breaking down venture capital investments by company stage shows that while investments span the corporate timeline, the majority have gone to companies in the early and later stages of development (Table 4). Of the $48.7 billion in VC invested in the bioscience industry from 2012 to 2015, 41% went to combined seed and early stage companies and 32% went to later stage companies.

Compared with investments made across all industries, the biosciences receive a strong share of dollars invested at the seed and early stages combined, but the share of deal activity in these critical earliest stages is lower with bioscience-related companies in seed and early stages making up 37% of all deals compared with 43% of deals across all industries. In addition, for the biosciences there is evidence that the threshold for the "early" stage of a company has moved further into the development process where investors are waiting for products to move into clinical trials before investing, a trend that should be monitored as this industry requires substantial capital prior to these clinical milestones.[18]

TABLE 4

U.S. Bioscience Venture Capital Investments by Stage

2012-2015

Stage	Number of Deals	Number of Companies	Total VC Investments ($ Millions)	Average Per Deal ($ Millions)	Average Investment Per Company in ($ Millions)
Start-Up/Seed	388	308	$1,919	$4.95	$6.23
Early Stage	1,974	1,114	$17,799	$9.02	$15.98
Expansion	803	477	$7,270	$9.05	$15.24
Later Stage	2,427	1,167	$15,485	$6.38	$13.27
Buyout or Acquisition	157	121	$2,223	$14.16	$18.37
Other	202	153	$4,046	$20.03	$26.44
Grand Total	**5,951**	**3,340**	**$48,742**	**$8.19**	**$14.59**

Source: TEConomy Partners analysis of Thomson Reuters Thomson ONE Venture Capital database.

18 For more information on these recent investment trends see: http://www.cnbc.com/2015/03/13/biotech-investing-trends-may-be-hurting-innovation.html.

Potential Obstacles to Further Development: Bioscience-Related R&D Investments

Funding for R&D efforts is vital to the sustained health of an innovation-intensive, science-based industry such as the biosciences. Several federal agencies fund bioscience-related research, including much of the R&D in medical sciences accounted for by colleges and universities, yet funding from NIH is considered to be the "gold standard" for biomedical research. Beyond funding university research, NIH also awards research funding to hospitals and other biomedical research institutions, often with a focus on translating research activities into commercially available treatments that enhance and even save lives.

The 2014 report found that funding from the National Institutes of Health (NIH) had declined over the 2009 to 2013 period. This downward trend generally persists in recent data though there was an uptick in funding in 2015. NIH awards have declined overall from 2012 to 2015 by 3%. The most recent peak in funding over the past 10 years occurred in 2009 when NIH funding reached $24.2 billion (not including funding from the American Recovery and Reinvestment Act). The U.S. has not seen that level of funding since, with 2015 funding reaching $22.9 billion (see Figure 11).

The slowdown in funding from the NIH is a factor in the slowing of growth in R&D expenditure levels across the nation's academic institutions. From 2012 to 2014, bioscience-related academic R&D increased by only 2% to reach $38.9 billion in 2014 (Figure 12). During this recent period, the average annual increase in bioscience-related university R&D was a meager 0.6%, while during the preceding 10-year period annual increases averaged 7%. While current data shows positive, though limited growth in this area, the slower pace indicates waning financial support for much needed academic research in the biosciences.

While the Federal government is the largest single source of funds for academic bioscience-related R&D, and its funding for research in these fields has declined since 2012, funding from other sources has increased to help maintain current R&D expenditure levels. The largest of these, as a share of bioscience-related funding, is from the academic institutions themselves (currently making up 20-30% of funding in bioscience fields) and funding from these institutions has increased substantially since 2012. In addition, funding from industry, state and local governments, and other sources has increased as well, though they each represent a much smaller share of R&D funding compared with federal and institutional dollars.

FIGURE 11

NIH Awards
$ Billions
FY 2012-2015

Source: TEConomy Partners analysis of NIH data.

FIGURE 12

University Bioscience R&D Expenditures
$ Millions
FY 2012-2014

Source: TEConomy Partners analysis of National Science Foundation Higher Education Research and Development Survey.

STATE AND METROPOLITAN AREA PERFORMANCE

This section provides an in-depth examination of employment trends for states among each of the five major bioscience subsectors. Data were tabulated for each state, the District of Columbia, and Puerto Rico, and for every U.S. Metropolitan Statistical Area (MSA) to determine the size and relative job concentration within each subsector. In addition, employment growth and loss were calculated to highlight recent trends.

The key metrics used in this section include:

- **Employment size** measures the absolute level of jobs within each region.
    - To allow for meaningful comparisons, each region's share of total U.S. subsector employment was analyzed. States with more than 5% of national employment are designated "large"; states with more than 3% but less than 5% are referred to as "sizable."
    - For metropolitan regions, two listings are given for each subsector: one table lists the top 25 metropolitan regions in employment, and the other lists the top 15 metropolitan areas based on the size of the region (either small, medium or large).
- **Employment concentration** is a useful way in which to gauge the relative size of a region's subsectors relative to the national average. While employment size reveals the largest geographic components, employment concentration can reveal the relative importance of the subsectors to a regional or state economy.
    - State and regional location quotients (LQs) measure the degree of job concentration within the region relative to the nation. 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 subsector.
    - The level of **employment growth or loss** over the 2012 to 2014 period provides a way to measure the health of a state's bioscience sector. In this analysis, job growth or loss was measured by absolute employment gains or losses, as percentage changes may overstate trends in those states with a smaller subsector employment base.

Agriculture Feedstock & Chemicals

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

Examples of Products

- Fertilizers, pesticides, herbicides, and fungicides
- Corn and soybean oil
- Ethanol and biodiesel fuels
- Biodegradable materials synthesized from plant-based feedstock
- Biocatalysts

Examples of Companies

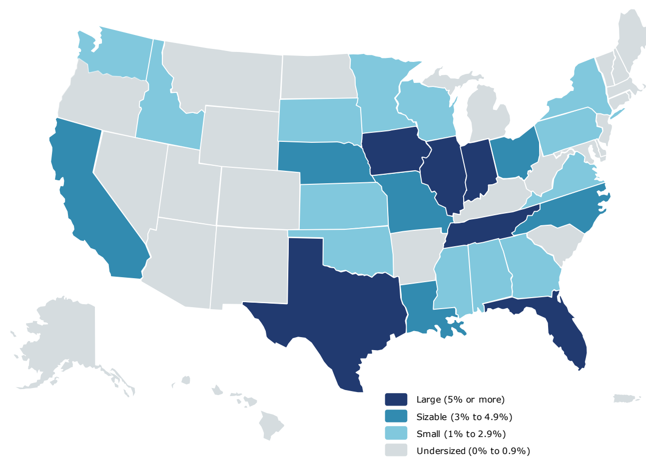
- Amyris
- Archer Daniels Midland
- BASF Plant Science
- Bayer CropScience
- Bunge
- Coca-Cola
- DSM
- Dow AgroSciences
- DuPont
- Monsanto
- Novozymes
- POET
- Scotts Miracle-Gro
- Simplot Plant Sciences
- Syngenta
- TerraVia

States that are Both Large and Specialized*

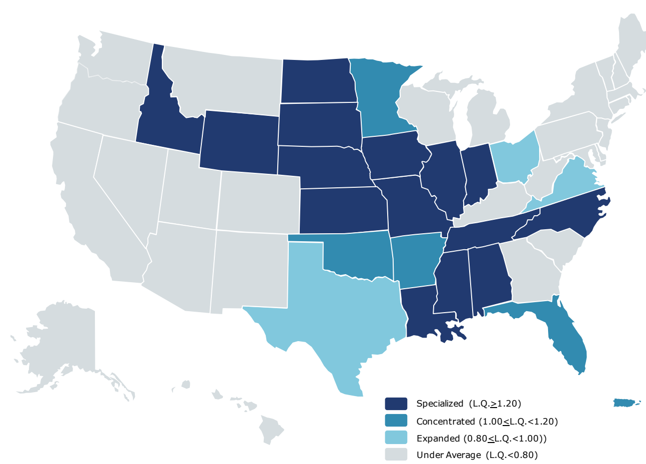
- Illinois
- Iowa
- Tennessee
- Indiana

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

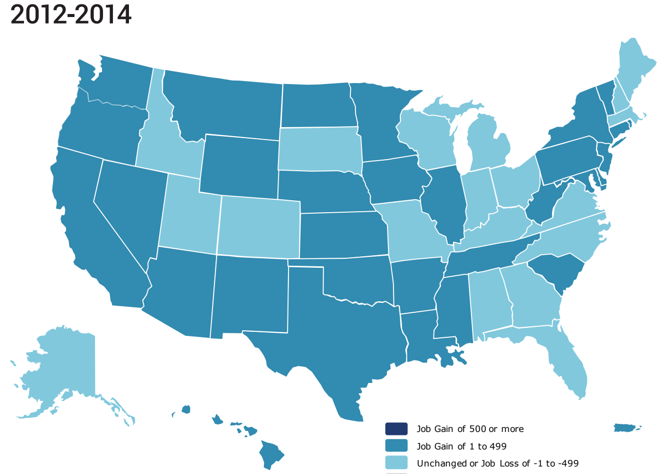
State Share of Total U.S. Employment
2014



Employment Concentration Relative to the U.S.
2014



Employment Gains and Losses
2012-2014



Agricultural Feedstock & Chemicals

State Leaders & Highlights

Employment Size: Agbioscience employment is relatively concentrated in the top 12 states, which account for 69% of employment in this subsector. Those 12 states are:

- Large States: Illinois, Iowa, Tennessee, Texas, Florida, Indiana
- Sizable States: California, North Carolina, Ohio, Louisiana, Nebraska, Missouri

Employment Concentration: Fifteen states have a specialized concentration of jobs in the agricultural feedstock and chemicals subsector, more than for any other subsector. These concentrations are in the Midwest and South.

- Specialized States: Iowa, Nebraska, Tennessee, South Dakota, Indiana, Idaho, Louisiana, Illinois, Wyoming, North Dakota, Mississippi, Alabama, Missouri, Kansas, North Carolina
- Concentrated States: Arkansas, Minnesota, Florida, Oklahoma, Puerto Rico

Employment Growth: Over the 2012 to 2014 period, 32 states experienced some increase in subsector employment, with Iowa, New York and Illinois experiencing the largest gains.

Large and Specialized States: Four states have both high employment and a specialized concentration of jobs in agricultural feedstock and chemicals (Table 5).

TABLE 6

Metropolitan Statistical Areas with the Largest Employment Levels in Agricultural Feedstock and Chemicals, **2014**

Metropolitan Statistical Area	2014 Employment
Decatur, IL	4,756
Indianapolis-Carmel-Anderson, IN	2,319
Memphis, TN-MS-AR	2,049
Houston-The Woodlands-Sugar Land, TX	1,928
Lakeland-Winter Haven, FL	1,774
Kingsport-Bristol-Bristol, TN-VA	1,559
Chicago-Naperville-Elgin, IL-IN-WI	1,381
New York-Newark-Jersey City, NY-NJ-PA	1,244
Tampa-St. Petersburg-Clearwater, FL	1,162
Baton Rouge, LA	1,160
New Orleans-Metairie, LA	1,141
Blacksburg-Christiansburg-Radford, VA	1,138
Cedar Rapids, IA	1,097
Kansas City, MO-KS	941
Omaha-Council Bluffs, NE-IA	870
Sioux City, IA-NE-SD	822
Greensboro-High Point, NC	752
Peoria, IL	721
Knoxville, TN	666
St. Louis, MO-IL	643
Dallas-Fort Worth-Arlington, TX	609
Oxnard-Thousand Oaks-Ventura, CA	542
Lafayette-West Lafayette, IN	540
Phoenix-Mesa-Scottsdale, AZ	493
St. Joseph, MO-KS	478

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 5

States with Large and Specialized Employment in Agricultural Feedstock and Chemicals
2014

State	Establishments, 2014	Employment, 2014	Location Quotient, 2014	Share of U.S. Employment
Illinois	96	8,424	2.54	10.9%
Iowa	127	7,759	9.07	10.0%
Tennessee	33	5,634	3.60	7.3%
Indiana	47	4,774	2.86	6.2%

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 7

Metropolitan Statistical Areas with the Highest Location Quotients in Agricultural Feedstock and Chemicals, by Size of MSA, **2014**

Metropolitan Statistical Area	Location Quotient	2014 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Memphis, TN-MS-AR	5.89	2,049
Baton Rouge, LA	5.51	1,160
Indianapolis-Carmel-Anderson, IN	4.13	2,319
Greensboro-High Point, NC	3.67	752
New Orleans-Metairie, LA	3.63	1,141
Omaha-Council Bluffs, NE-IA	3.22	870
Knoxville, TN	3.20	666
Oxnard-Thousand Oaks-Ventura, CA	2.91	542
Des Moines-West Des Moines, IA	2.25	449
Dayton, OH	2.01	409
Albany-Schenectady-Troy, NY	1.86	419
Madison, WI	1.75	337
Toledo, OH	1.73	291
Tampa-St. Petersburg-Clearwater, FL	1.65	1,162
Kansas City, MO-KS	1.65	941
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Kingsport-Bristol-Bristol, TN-VA	22.86	1,559
Sioux City, IA-NE-SD	16.08	822
Lakeland-Winter Haven, FL	14.98	1,774
Cedar Rapids, IA	13.23	1,097
Peoria, IL	6.84	721
Mobile, AL	4.57	445
Lubbock, TX	4.56	330
Gulfport-Biloxi-Pascagoula, MS	4.22	335
Fayetteville, NC	4.14	246
Salisbury, MD-DE	3.60	305
Greeley, CO	3.29	187
Spartanburg, SC	3.24	244
Charleston, WV	3.12	193
Stockton-Lodi, CA	2.57	320
Evansville, IN-KY	2.43	222
Small MSAs (Total Private Employment Less than 75,000)		
Decatur, IL	159.04	4,756
Blacksburg-Christiansburg-Radford, VA	34.24	1,138
Cleveland, TN	17.18	451
Morristown, TN	16.31	401
St. Joseph, MO-KS	15.28	478
Mankato-North Mankato, MN	11.94	366
Lafayette-West Lafayette, IN	11.43	540
Kankakee, IL	9.77	245
Decatur, AL	9.07	269
Valdosta, GA	8.00	223
Lima, OH	7.95	238
Grand Island, NE	7.58	185
Hanford-Corcoran, CA	7.40	152
Ames, IA	6.91	142
Danville, IL	6.36	98

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

Drugs & 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 R&D and manufacturing activities to bring drugs to market.

Examples of Products

- Biopharmaceuticals
- Vaccines
- Targeted disease therapeutics
- Tissue and cell culture media
- Dermatological/topical treatments
- Diagnostic substances
- Animal vaccines and therapeutics

Examples of Companies

- AbbVie
- Amgen
- Biogen Idec
- Bristol-Myers Squibb
- Celgene
- Eli Lilly & Co.
- Gilead
- Johnson & Johnson
- Merck & Co.
- Novartis
- OncoMed Pharmaceuticals
- Pfizer
- Regeneron
- Roche Group – Genentech

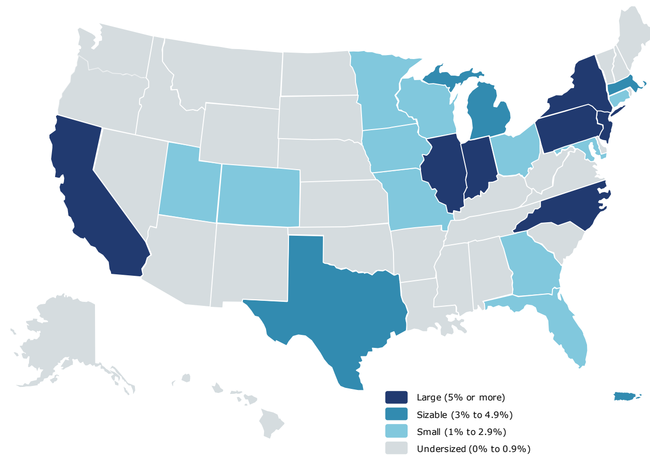
States that are Both Large and Specialized*

- California
- New Jersey
- North Carolina
- Illinois
- Pennsylvania
- Indiana

States are listed in descending order by subsector employment levels.

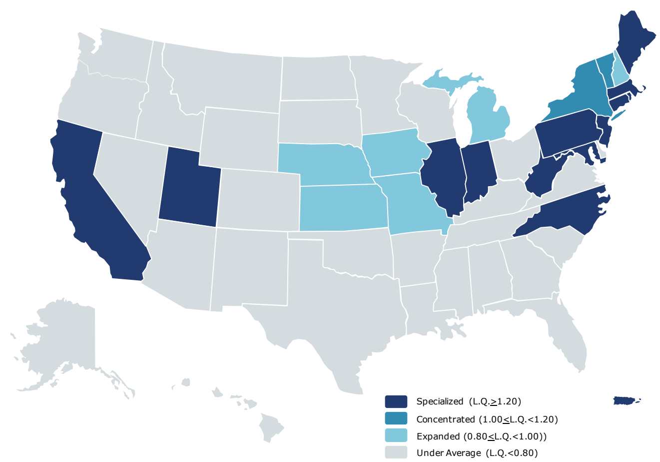
State Share of Total U.S. Employment

2014



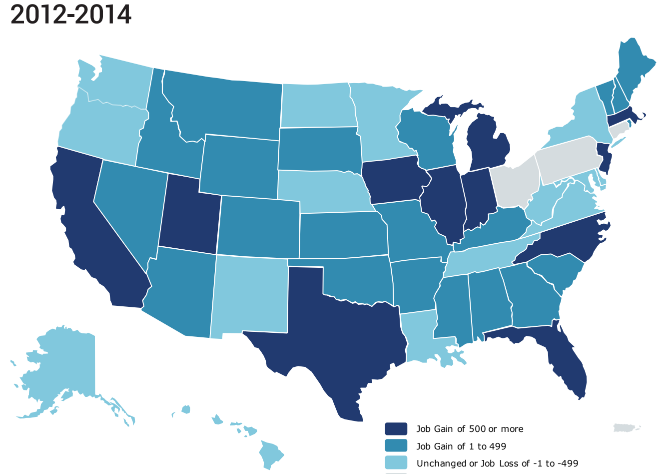
Employment Concentration Relative to the U.S.

2014



Employment Gains and Losses

2012-2014



Drugs & Pharmaceuticals

State Leaders & Highlights

Employment Size: In terms of geography, drugs and pharmaceuticals manufacturing is highly concentrated among fewer states. The top 5 employer states in this subsector make up almost 46% of U.S. employment.

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

Employment Concentration: Thirteen states and Puerto Rico have a specialized concentration of jobs in the drugs and pharmaceuticals subsector.

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

Employment Growth: Over the 2012 to 2014 period, 32 states experienced some increase in subsector employment. Of those states, California, Indiana, Massachusetts, Michigan, Texas, New Jersey, Utah, North Carolina, Illinois, Iowa and Florida saw substantial job increases.

Large and Specialized States: Six states have both high employment and a specialized concentration of jobs in drugs & pharmaceuticals (Table 8).

TABLE 9

Metropolitan Statistical Areas with the Largest Employment Levels in Drugs and Pharmaceuticals, **2014**

Metropolitan Statistical Area	2014 Employment
New York-Newark-Jersey City, NY-NJ-PA	37,446
Chicago-Naperville-Elgin, IL-IN-WI	17,397
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	14,441
San Francisco-Oakland-Hayward, CA	14,044
Indianapolis-Carmel-Anderson, IN	12,677
Los Angeles-Long Beach-Anaheim, CA	11,677
Boston-Cambridge-Newton, MA-NH	9,513
Durham-Chapel Hill, NC	6,734
San Diego-Carlsbad, CA	6,502
Oxnard-Thousand Oaks-Ventura, CA	6,334
Dallas-Fort Worth-Arlington, TX	4,658
Washington-Arlington-Alexandria, DC-VA-MD-WV	4,362
Bridgeport-Stamford-Norwalk, CT	3,463
St. Louis, MO-IL	3,189
Vallejo-Fairfield, CA	3,053
Raleigh, NC	2,871
Minneapolis-St. Paul-Bloomington, MN-WI	2,741
Morgantown, WV	2,646
Miami-Fort Lauderdale-West Palm Beach, FL	2,525
Rocky Mount, NC	2,453
Kalamazoo-Portage, MI	2,429
Baltimore-Columbia-Towson, MD	2,289
Trenton, NJ	2,270
Cincinnati, OH-KY-IN	2,205
Salt Lake City, UT	2,086

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 8

States with Large and Specialized Employment in Drugs and Pharmaceuticals
2014

State	Establishments, 2014	Employment, 2014	Location Quotient, 2014	Share of U.S. Employment
California	481	47,163	1.39	16.1%
New Jersey	248	27,459	3.35	9.4%
North Carolina	118	21,658	2.54	7.4%
Illinois	151	18,436	1.47	6.3%
Pennsylvania	111	17,570	1.40	6.0%
Indiana	42	17,414	2.76	5.9%

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 10

Metropolitan Statistical Areas with the Highest Location Quotients in Drugs and Pharmaceuticals, by Size of MSA, **2014**

Metropolitan Statistical Area	Location Quotient	2014 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Oxnard-Thousand Oaks-Ventura, CA	9.38	6,334
Indianapolis-Carmel-Anderson, IN	6.23	12,677
Bridgeport-Stamford-Norwalk, CT	3.72	3,463
San Francisco-Oakland-Hayward, CA	3.01	14,044
Madison, WI	2.65	1,847
Raleigh, NC	2.52	2,871
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	2.50	14,441
San Diego-Carlsbad, CA	2.35	6,502
New York-Newark-Jersey City, NY-NJ-PA	2.02	37,446
Chicago-Naperville-Elgin, IL-IN-WI	1.85	17,397
Boston-Cambridge-Newton, MA-NH	1.75	9,513
Worcester, MA-CT	1.73	1,332
Greenville-Anderson-Mauldin, SC	1.59	1,231
Salt Lake City, UT	1.59	2,086
Buffalo-Cheektowaga-Niagara Falls, NY	1.56	1,709
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Durham-Chapel Hill, NC	12.21	6,734
Vallejo-Fairfield, CA	11.81	3,053
Kalamazoo-Portage, MI	8.36	2,429
Trenton, NJ	5.42	2,270
Santa Cruz-Watsonville, CA	3.99	806
Boulder, CO	3.43	1,191
Lincoln, NE	3.42	1,150
Waco, TX	3.29	735
Provo-Orem, UT	3.13	1,293
Ogden-Clearfield, UT	2.88	1,261
Huntsville, AL	2.61	1,022
Salisbury, MD-DE	2.44	749
Portland-South Portland, ME	2.42	1,322
Norwich-New London, CT	2.28	510
Lansing-East Lansing, MI	2.18	828
Small MSAs (Total Private Employment Less than 75,000)		
Morgantown, WV	21.73	2,646
Rocky Mount, NC	20.98	2,453
East Stroudsburg, PA	19.54	2,065
Bloomington, IN	10.74	1,315
Kankakee, IL	10.51	955
Greenville, NC	10.15	1,310
St. Joseph, MO-KS	9.98	1,131
Midland, MI	8.11	678
Logan, UT-ID	7.71	807
Athens-Clarke County, GA	7.22	1,036
Lebanon, PA	6.54	666
Harrisonburg, VA	4.49	561
Terre Haute, IN	3.81	527
Iowa City, IA	3.50	517
Carson City, NV	2.87	130

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

Medical Devices & 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/prosthetic implants and devices
- Genomic sequencing equipment
- Automated external defibrillators (AEDs)
- Vascular stents and other implantable devices
- Dental instruments and orthodontics

Examples of Companies

- 3M Health Care
- Baxter International
- Becton, Dickinson and Co.
- Boston Scientific Corp.
- Cook Medical
- DuPuy Synthes
- GE Healthcare
- Fluke Biomedical
- Illumina
- Medtronic
- Philips Healthcare
- Regenesis Biomedical
- Siemens Medical Solutions
- Stryker
- Thermo Fisher Scientific
- Zimmer

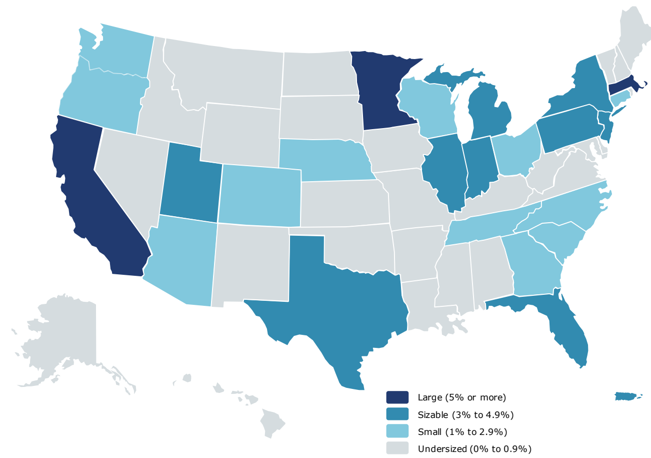
States that are Both Large and Specialized*

- California
- Minnesota
- Massachusetts

States are listed in descending order by subsector employment levels.

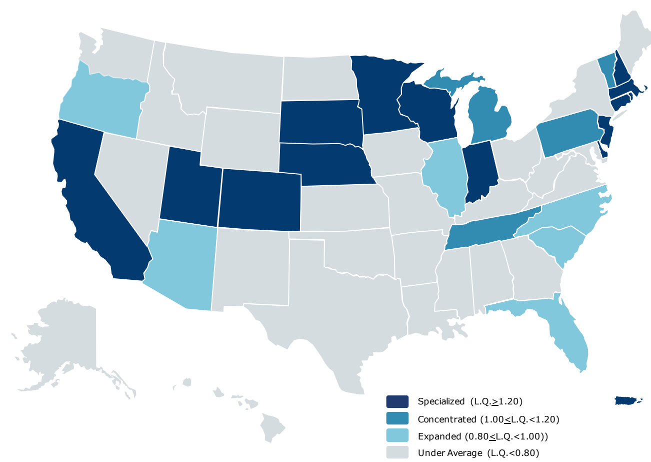
State Share of Total U.S. Employment

2014



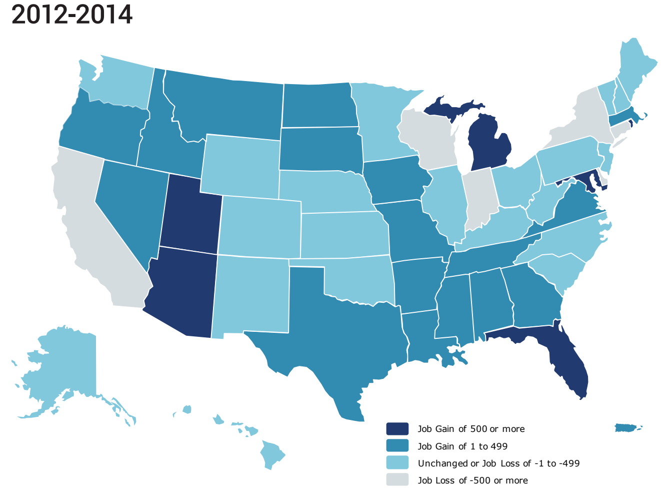
Employment Concentration Relative to the U.S.

2014



Employment Gains and Losses

2012-2014



Medical Devices & Equipment

State Leaders & Highlights

Employment Size: Every state is represented in this high employing subsector, including D.C. and Puerto Rico. The top ten employing states continue to account for almost 60% of employment in this subsector.

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

Employment Concentration: Fourteen states and Puerto Rico have a specialized concentration of jobs in the medical device and equipment subsector.

- Specialized States: Puerto Rico, Minnesota, Utah, Massachusetts, Indiana, Connecticut, Delaware, South Dakota, Nebraska, Colorado, California, Wisconsin, Rhode Island, New Hampshire, New Jersey
- Concentrated States: Tennessee, Michigan, Pennsylvania, Vermont

Employment Growth: Over the 2012 to 2014 period, 24 states experienced some increase in subsector employment with 6 states having substantial increases led by Florida, Utah and Michigan.

Large and Specialized States: Three states have both high employment and a specialized concentration of jobs in medical devices and equipment (Table 11).

TABLE 12

Metropolitan Statistical Areas with the Largest Employment Levels in Medical Devices and Equipment, **2014**

Metropolitan Statistical Area	2014 Employment
Los Angeles-Long Beach-Anaheim, CA	27,777
Minneapolis-St. Paul-Bloomington, MN-WI	25,267
Boston-Cambridge-Newton, MA-NH	15,879
New York-Newark-Jersey City, NY-NJ-PA	15,351
Chicago-Naperville-Elgin, IL-IN-WI	11,658
San Francisco-Oakland-Hayward, CA	8,308
San Jose-Sunnyvale-Santa Clara, CA	8,307
Salt Lake City, UT	8,169
San Diego-Carlsbad, CA	6,689
Milwaukee-Waukesha-West Allis, WI	6,471
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	6,032
Memphis, TN-MS-AR	5,811
Miami-Fort Lauderdale-West Palm Beach, FL	4,823
Pittsburgh, PA	4,753
Denver-Aurora-Lakewood, CO	4,443
Dallas-Fort Worth-Arlington, TX	4,338
Providence-Warwick, RI-MA	4,326
Seattle-Tacoma-Bellevue, WA	4,053
Cleveland-Elyria, OH	3,996
Portland-Vancouver-Hillsboro, OR-WA	3,801
Bloomington, IN	3,713
New Haven-Milford, CT	3,515
Riverside-San Bernardino-Ontario, CA	3,274
Boulder, CO	3,063
Houston-The Woodlands-Sugar Land, TX	2,929

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 11

States with Large and Specialized Employment in Medical Devices and Equipment **2014**

State	Establishments, 2014	Employment, 2014	Location Quotient, 2014	Share of U.S. Employment
California	1,149	60,669	1.50	17.4%
Minnesota	321	26,455	3.73	7.6%
Massachusetts	291	20,903	2.37	6.0%

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 13

Metropolitan Statistical Areas with the Highest Location Quotients in Medical Devices and Equipment, by Size of MSA, 2014

Metropolitan Statistical Area	Location Quotient	2014 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Minneapolis-St. Paul-Bloomington, MN-WI	5.36	25,267
Salt Lake City, UT	5.16	8,169
Memphis, TN-MS-AR	3.82	5,811
New Haven-Milford, CT	3.75	3,515
San Jose-Sunnyvale-Santa Clara, CA	3.08	8,307
Milwaukee-Waukesha-West Allis, WI	3.01	6,471
Providence-Warwick, RI-MA	2.47	4,326
Boston-Cambridge-Newton, MA-NH	2.43	15,879
Bridgeport-Stamford-Norwalk, CT	2.14	2,396
Worcester, MA-CT	2.09	1,936
San Diego-Carlsbad, CA	2.01	6,689
Greensboro-High Point, NC	1.89	1,693
Los Angeles-Long Beach-Anaheim, CA	1.88	27,777
Madison, WI	1.71	1,437
Jacksonville, FL	1.70	2,677
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Kalamazoo-Portage, MI	7.78	2,725
Boulder, CO	7.33	3,063
Utica-Rome, NY	3.83	1,019
Gainesville, FL	3.62	956
Ogden-Clearfield, UT	3.26	1,721
Reading, PA	3.12	1,376
Ann Arbor, MI	2.94	1,095
Naples-Immokalee-Marco Island, FL	2.78	978
Santa Maria-Santa Barbara, CA	2.70	1,279
Ocala, FL	2.58	623
Santa Rosa, CA	2.47	1,221
Colorado Springs, CO	2.38	1,458
Scranton--Wilkes-Barre--Hazleton, PA	2.04	1,345
Huntington-Ashland, WV-KY-OH	2.04	665
Saginaw, MI	2.04	447
Small MSAs (Total Private Employment Less than 75,000)		
Bloomington, IN	25.16	3,713
Flagstaff, AZ	17.94	2,321
Niles-Benton Harbor, MI	13.59	2,117
Glens Falls, NY	12.73	1,657
Sumter, SC	7.83	702
State College, PA	6.88	907
Corvallis, OR	4.84	370
Staunton-Waynesboro, VA	4.17	474
Sheboygan, WI	2.86	451
Michigan City-La Porte, IN	2.48	254
Lebanon, PA	2.42	297
Jackson, MI	2.42	353
Logan, UT-ID	2.35	297
Cleveland, TN	1.81	208
Florence, SC	1.62	314

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

Research, Testing, & 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 industrial biotechnologies, 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

- Contract and clinical research (CRO)
- Stem cell/regenerative research
- Molecular diagnostics and testing
- Preclinical drug development
- Drug delivery systems
- DNA synthesis
- Research/laboratory support services

Examples of Companies

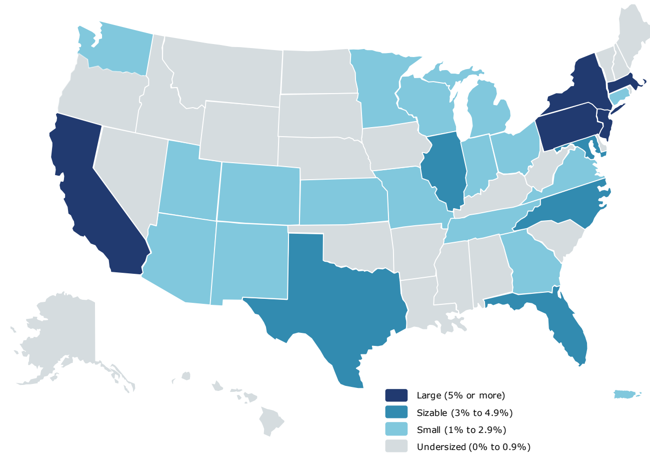
- Albany Molecular Research
- Algenol
- Charles River Laboratories
- Genomatica
- InCyte
- Intrexon
- Laboratory Corp. of America
- NeoGenomics
- Pacific Biomarkers
- Pathway Genomics
- PPD (Pharmaceutical Product Development)
- Quest Diagnostics
- Quintiles
- Synthetic Genomics

States that are Both Large and Specialized*

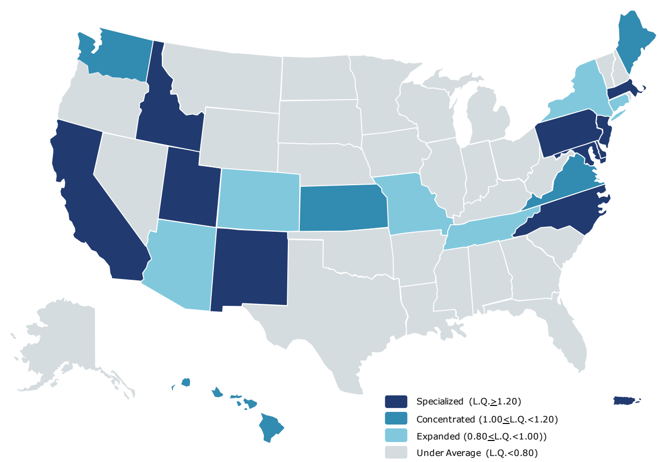
- California
- Massachusetts
- Pennsylvania
- New Jersey

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

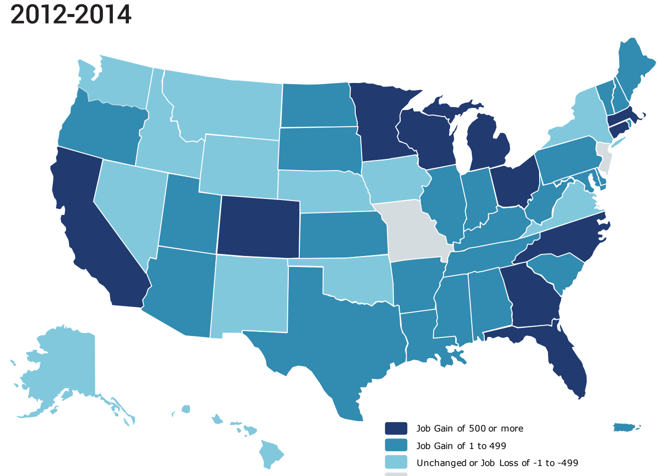
State Share of Total U.S. Employment
2014



Employment Concentration Relative to the U.S.
2014



Employment Gains and Losses
2012-2014



Research, Testing, & Medical Laboratories

State Leaders & Highlights

Employment Size: With the largest 2014 employment level and the highest overall growth rate among the five subsectors, the research, testing, and medical labs subsector has a significant presence in most states. The top ten employer states make up 62% of all employment.

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

Employment Concentration: Ten states and Puerto Rico have a specialized concentration of jobs in the research, testing, and medical laboratories subsector.

- Specialized States: Massachusetts, Maryland, New Mexico, Delaware, New Jersey, Puerto Rico, North Carolina, California, Utah, Pennsylvania, Idaho
- Concentrated States: Washington, Kansas, Maine, Hawaii

Employment Growth: Over the 2012 to 2014 period, 37 states experienced some increase in subsector employment. 11 states experienced substantial increases led by North Carolina, Massachusetts, California and Florida.

Large and Specialized States: Four states have both high employment and a specialized concentration of jobs in research, testing, and medical laboratories (Table 14).

TABLE 15

Metropolitan Statistical Areas with the Largest Employment Levels in Research, Testing, and Medical Laboratories, **2014**

Metropolitan Statistical Area	2014 Employment
Boston-Cambridge-Newton, MA-NH	37,339
New York-Newark-Jersey City, NY-NJ-PA	36,073
Los Angeles-Long Beach-Anaheim, CA	22,365
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	19,219
San Diego-Carlsbad, CA	19,177
San Francisco-Oakland-Hayward, CA	18,385
Washington-Arlington-Alexandria, DC-VA-MD-WV	16,513
Chicago-Naperville-Elgin, IL-IN-WI	13,132
San Jose-Sunnyvale-Santa Clara, CA	11,447
Baltimore-Columbia-Towson, MD	9,231
Durham-Chapel Hill, NC	7,563
Detroit-Warren-Dearborn, MI	7,465
Seattle-Tacoma-Bellevue, WA	7,278
Miami-Fort Lauderdale-West Palm Beach, FL	7,007
Pittsburgh, PA	6,563
Minneapolis-St. Paul-Bloomington, MN-WI	6,359
Atlanta-Sandy Springs-Roswell, GA	6,246
Dallas-Fort Worth-Arlington, TX	5,976
Phoenix-Mesa-Scottsdale, AZ	5,974
Kansas City, MO-KS	5,926
Houston-The Woodlands-Sugar Land, TX	5,734
Salt Lake City, UT	4,811
Columbus, OH	4,793
St. Louis, MO-IL	4,498
Indianapolis-Carmel-Anderson, IN	4,380

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 14

States with Large and Specialized Employment in Research, Testing, and Medical Laboratories **2014**

State	Establishments, 2014	Employment, 2014	Location Quotient, 2014	Share of U.S. Employment
California	3,517	81,336	1.45	16.8%
Massachusetts	1,361	41,917	3.43	8.7%
Pennsylvania	1,114	26,670	1.29	5.5%
New Jersey	903	25,733	1.90	5.3%

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 16

Metropolitan Statistical Areas with the Highest Location Quotients in Research, Testing, and Medical Laboratories, by Size of MSA, 2014

Metropolitan Statistical Area	Location Quotient	2014 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
San Diego-Carlsbad, CA	3.96	19,177
Boston-Cambridge-Newton, MA-NH	3.93	37,339
San Jose-Sunnyvale-Santa Clara, CA	2.92	11,447
Knoxville, TN	2.77	3,649
Albuquerque, NM	2.53	3,138
Madison, WI	2.33	2,839
San Francisco-Oakland-Hayward, CA	2.26	18,385
Albany-Schenectady-Troy, NY	2.15	3,059
Salt Lake City, UT	2.09	4,811
Baltimore-Columbia-Towson, MD	2.01	9,231
Greensboro-High Point, NC	1.91	2,477
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	1.90	19,219
Worcester, MA-CT	1.86	2,498
Raleigh, NC	1.68	3,355
Washington-Arlington-Alexandria, DC-VA-MD-WV	1.66	16,513
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Durham-Chapel Hill, NC	7.84	7,563
Kennewick-Richland, WA	5.48	2,190
Trenton, NJ	4.94	3,622
Wilmington, NC	4.14	1,669
Boulder, CO	3.49	2,120
Barnstable Town, MA	2.93	999
Ann Arbor, MI	2.37	1,282
Huntsville, AL	2.16	1,481
Peoria, IL	1.85	1,233
Spokane-Spokane Valley, WA	1.83	1,404
Syracuse, NY	1.75	1,830
Bloomington, IL	1.60	533
Norwich-New London, CT	1.49	587
Fort Collins, CO	1.46	701
Kalamazoo-Portage, MI	1.36	693
Small MSAs (Total Private Employment Less than 75,000)		
Burlington, NC	16.30	3,623
Idaho Falls, ID	9.68	2,140
California-Lexington Park, MD	5.87	742
Logan, UT-ID	2.93	536
Morgantown, WV	2.12	451
Johnstown, PA	1.96	396
Mount Vernon-Anacortes, WA	1.81	290
Battle Creek, MI	1.81	357
Ames, IA	1.78	231
Corvallis, OR	1.69	188
Manhattan, KS	1.66	201
Columbia, MO	1.59	448
Lafayette-West Lafayette, IN	1.50	448
Sebring, FL	1.49	147
Bangor, ME	1.46	356

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

Bioscience-Related Distribution

The bioscience-related distribution subsector coordinates the delivery of bioscience-related products spanning pharmaceuticals, medical devices, and agbioscience products. The subsector increasingly deploys specialized technologies such as cold storage, highly regulated product monitoring, RFID technologies, and automated drug distribution systems.

Examples of Products

Distribution of:

- Pharmaceuticals
- Vaccines
- Plasma/blood
- Veterinary medicines
- Surgical instruments/appliances
- Diagnostic and bioimaging equipment
- Dental equipment/supplies
- Plant seeds
- Agricultural chemicals

Examples of Companies

- AmerisourceBergen
- Cardinal Health
- Dekalb Seeds
- DuPont Pioneer
- Henry Schein
- McKesson
- Omnicare
- Owens & Minor
- Park Seed
- Patterson Companies
- PharMerica Corporation
- Seminis Vegetable Seeds
- Van Diest Supply Company
- Wilbur-Ellis

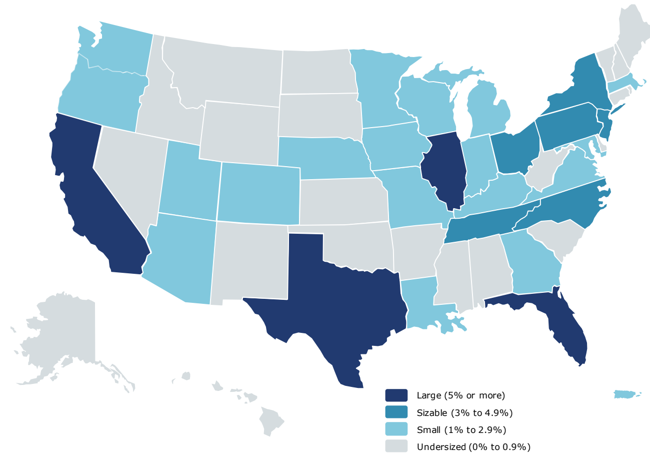
States that are Both Large and Specialized*

- Florida
- Illinois

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

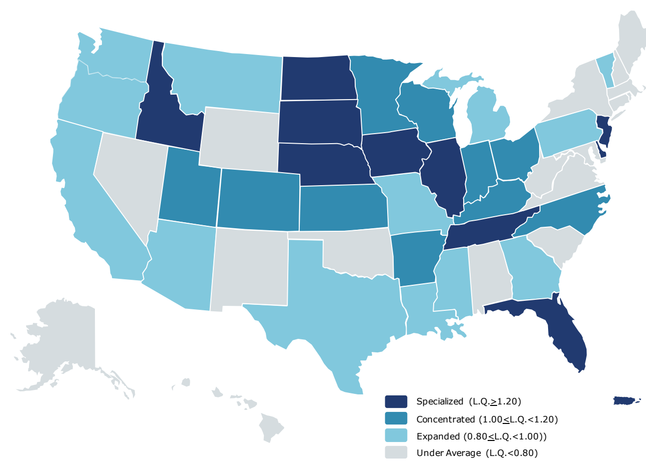
State Share of Total U.S. Employment

2014



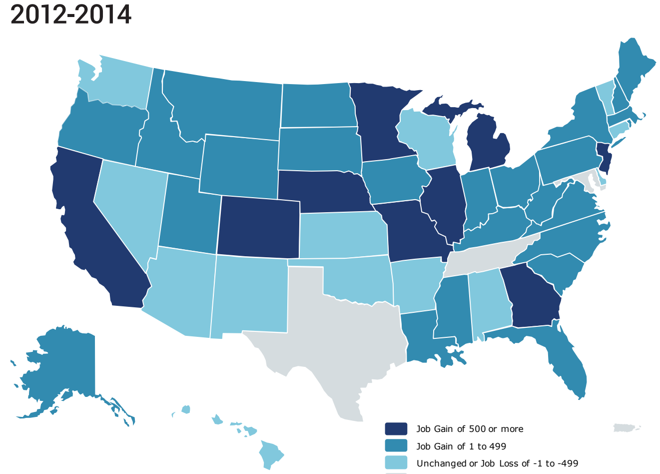
Employment Concentration Relative to the U.S.

2014



Employment Gains and Losses

2012-2014



Bioscience-Related Distribution

State Leaders & Highlights

Employment Size: Although this subsector has the second largest employment level in 2014, employment is not as concentrated among the leading states as in other subsectors, with the top 10 employing states making up only 55% of all employment.

- Large States: California, Florida, Texas, Illinois
- Sizable States: New Jersey, Ohio, New York, Pennsylvania, Tennessee, North Carolina

Employment Concentration: Ten states and Puerto Rico have a specialized concentration of jobs in the bioscience-related distribution subsector.

- Specialized States: Puerto Rico, Iowa, South Dakota, Nebraska, North Dakota, Tennessee, New Jersey, Idaho, Illinois, Florida, Delaware
- Concentrated States: Minnesota, Indiana, Utah, Colorado, Wisconsin, Kentucky, North Carolina, Kansas, Ohio, Arkansas

Employment Growth: Over the 2012 to 2014 period, 35 states experienced some increase in subsector employment with 9 states having substantial increases led by California, New Jersey, Illinois and Minnesota.

Large and Specialized States: Two states have both high employment and a specialized concentration of jobs in bioscience-related distribution (Table 17).

TABLE 18

Metropolitan Statistical Areas with the Largest Employment Levels in Bioscience-Related Distribution, **2014**

Metropolitan Statistical Area	2014 Employment
New York-Newark-Jersey City, NY-NJ-PA	29,951
Los Angeles-Long Beach-Anaheim, CA	22,749
Chicago-Naperville-Elgin, IL-IN-WI	20,035
Miami-Fort Lauderdale-West Palm Beach, FL	16,813
Dallas-Fort Worth-Arlington, TX	14,167
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	11,559
Atlanta-Sandy Springs-Roswell, GA	9,297
Houston-The Woodlands-Sugar Land, TX	7,155
Minneapolis-St. Paul-Bloomington, MN-WI	7,134
Phoenix-Mesa-Scottsdale, AZ	6,913
Boston-Cambridge-Newton, MA-NH	6,718
Detroit-Warren-Dearborn, MI	6,694
Columbus, OH	6,128
Denver-Aurora-Lakewood, CO	5,775
Memphis, TN-MS-AR	5,774
Riverside-San Bernardino-Ontario, CA	5,737
Seattle-Tacoma-Bellevue, WA	4,915
Tampa-St. Petersburg-Clearwater, FL	4,618
San Diego-Carlsbad, CA	4,579
Indianapolis-Carmel-Anderson, IN	4,559
Nashville-Davidson--Murfreesboro--Franklin, TN	4,534
St. Louis, MO-IL	4,514
Orlando-Kissimmee-Sanford, FL	3,975
Cincinnati, OH-KY-IN	3,882
Baltimore-Columbia-Towson, MD	3,808

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 17

States with Large and Specialized Employment in Bioscience-Related Distribution **2014**

State	Establishments, 2014	Employment, 2014	Location Quotient, 2014	Share of U.S. Employment
Florida	3,162	35,978	1.37	8.0%
Illinois	2,092	27,118	1.40	6.0%

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

TABLE 19

Metropolitan Statistical Areas with the Highest Location Quotients in Bioscience-Related Distribution, by Size of MSA, 2014

Metropolitan Statistical Area	Location Quotient	2014 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Memphis, TN-MS-AR	2.86	5,774
Des Moines-West Des Moines, IA	2.41	2,794
Miami-Fort Lauderdale-West Palm Beach, FL	2.06	16,813
Columbus, OH	1.91	6,128
Raleigh, NC	1.67	3,058
Nashville-Davidson--Murfreesboro--Franklin, TN	1.56	4,534
Oxnard-Thousand Oaks-Ventura, CA	1.49	1,612
Louisville/Jefferson County, KY-IN	1.44	2,989
Indianapolis-Carmel-Anderson, IN	1.40	4,559
Knoxville, TN	1.40	1,684
Riverside-San Bernardino-Ontario, CA	1.37	5,737
Jacksonville, FL	1.35	2,814
Columbia, SC	1.33	1,467
Chicago-Naperville-Elgin, IL-IN-WI	1.33	20,035
Omaha-Council Bluffs, NE-IA	1.32	2,074
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Port St. Lucie, FL	3.48	1,534
Springfield, IL	2.80	885
Naples-Immokalee-Marco Island, FL	2.72	1,270
Provo-Orem, UT	2.63	1,743
Trenton, NJ	1.95	1,311
Lakeland-Winter Haven, FL	1.82	1,254
Kalamazoo-Portage, MI	1.81	842
Visalia-Porterville, CA	1.71	807
Sioux Falls, SD	1.67	851
Fargo, ND-MN	1.62	735
Durham-Chapel Hill, NC	1.49	1,316
Lubbock, TX	1.40	590
Greeley, CO	1.36	449
Hickory-Lenoir-Morganton, NC	1.32	633
Shreveport-Bossier City, LA	1.30	757
Small MSAs (Total Private Employment Less than 75,000)		
Albany, OR	5.19	717
Jackson, TN	5.12	1,007
Idaho Falls, ID	4.99	1,011
El Centro, CA	3.13	571
Jonesboro, AR	3.11	534
Ames, IA	2.05	244
Hammond, LA	1.91	237
Yuma, AZ	1.88	364
Manhattan, KS	1.86	207
Bloomington, IN	1.83	359
Texarkana, TX-AR	1.82	319
Danville, IL	1.80	161
Champaign-Urbana, IL	1.73	480
Dubuque, IA	1.69	345
Hanford-Corcoran, CA	1.54	183

Source: TEConomy Partners analysis of Bureau of Labor Statistics QCEW data; enhanced file from IMPLAN.

THE INNOVATION ECOSYSTEM: STATE PERFORMANCE MEASURES

A thriving bioscience industry requires a high-performing innovation ecosystem that facilitates fundamental basic and applied research, access to capital, and protection of intellectual property. This section profiles leading states—both overall and on a per capita basis[19]—across the following measures:

- Academic bioscience R&D expenditures
- National Institutes of Health funding
- Venture capital investments in bioscience companies
- Bioscience-related patents

Academic Bioscience R&D Expenditures

As an industry rooted in science and propelled by scientific breakthroughs, the biosciences must leverage a robust and fundamental relationship with the university R&D community. These bioscience innovations or inventions often have close connections to academic research, either directly relating to discoveries from research efforts or to insights from research that can lead to new discoveries and technology breakthroughs. In drug discovery, for instance, basic research into disease processes can help in identifying possible targets for novel therapeutic development, which then requires considerable effort in drug discovery before a novel therapeutic is advanced.

U.S. colleges and universities are a significant driver of bioscience-related R&D in most regions, accounting for $38.9 billion in R&D spending in 2014. Leading states in academic R&D tend to be larger, with multiple research institutions such as California, New York, Texas, Pennsylvania, and North Carolina, each with university R&D spending totals that exceed $2 billion.

High-growth states include some of the smaller states with R&D spending growing from a more modest base amount. Seven states had 2-year growth rates in the double-digits despite slower growth in academic R&D nationally.

Measuring R&D spending on a per-capita basis highlights other states as leaders relative to their overall size. The District of Columbia, with two major research universities conducting bioscience-related R&D, leads, followed by other states with highly concentrated bioscience research—Maryland, Massachusetts, Connecticut, and North Carolina. These latter two states are especially bioscience-focused relative to other science and engineering research fields, as they are also among the top 10 states in their bioscience share of total R&D.

19 For comparability, the various metrics are converted into a per-capita measure (or into a "per 1 million population" metric) in the tables in this section. 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.

TABLE 20

Leading States—Academic Bioscience R&D Expenditures & Growth

FY 2014

Academic Bioscience R&D Expenditure, 2014	
Leading States	Total R&D Expenditure ($ Thousands)
California	$5,119,062
New York	$3,634,138
Texas	$3,011,942
Pennsylvania	$2,061,958
North Carolina	$2,049,435
Maryland	$1,668,335
Massachusetts	$1,515,537
Illinois	$1,396,626
Ohio	$1,318,183
Michigan	$1,214,255

Academic Bioscience R&D Growth, 2012-14	
Leading States	Growth Rate, %
Nevada	36.0%
Tennessee	17.0%
Utah	16.9%
Georgia	16.1%
Rhode Island	16.1%
Maine	14.0%
Connecticut	10.3%
Washington	9.5%
Delaware	9.3%
North Dakota	8.7%

Source: TEConomy Partners analysis of National Science Foundation Higher Education Research and Development Survey.

TABLE 21

Leading States—Per Capita and Concentration of Academic Bioscience R&D Expenditures

FY 2014

Academic Bioscience R&D Per Capita, 2014	
Leading States	$ Per Capita
District of Columbia	$488.55
Maryland	$279.20
Massachusetts	$224.35
Connecticut	$223.23
North Carolina	$206.17
New York	$184.02
Rhode Island	$162.53
Pennsylvania	$161.17
Iowa	$159.12
Nebraska	$158.13

Bioscience Share of Total Science and Engineering R&D, 2014	
Leading States	% Share
Missouri	83.3%
Arkansas	82.9%
Vermont	79.1%
Connecticut	77.7%
Kentucky	75.7%
North Carolina	74.8%
South Carolina	71.3%
Minnesota	70.1%
Alabama	70.0%
Wisconsin	69.8%

Source: TEConomy Partners analysis of National Science Foundation Higher Education Research and Development Survey.

NIH Funding

The top recipients of the $22.9 billion in NIH funding awarded in FY 2015 are shown in table 22, with institutional totals in seven states exceeding the $1 billion threshold. Massachusetts is well ahead of other leading states in its funding levels on a per capita basis at $357 in 2015, more than 5 times the national average ($71 per capita).

TABLE 22

Leading States—NIH Funding

FY 2015

Total NIH Funding, 2015		Per Capita NIH Funding, 2015		NIH Funding Growth, 2012-15	
Leading States	**Total Funding ($ Thousands)**	**Leading States**	**$ Per Capita**	**Leading States**	**Growth Rate, 2012-15**
California	$3,474,161	Massachusetts	$357	Alaska	56.0%
Massachusetts	$2,424,537	District of Columbia	$288	Wyoming	46.1%
New York	$2,046,828	Maryland	$215	Mississippi	38.9%
Pennsylvania	$1,500,310	Connecticut	$128	Nevada	16.3%
Maryland	$1,292,800	Rhode Island	$125	New Hampshire	12.4%
North Carolina	$1,055,163	Washington	$123	South Carolina	12.1%
Texas	$1,004,412	Pennsylvania	$117	Maine	11.6%
Washington	$885,340	North Carolina	$105	Delaware	11.5%
Illinois	$735,888	New York	$103	Idaho	10.9%
Ohio	$670,052	Minnesota	$90	Alabama	10.7%

Source: TEConomy Partners analysis of NIH data.

Bioscience Venture Capital Investments

Beyond funding that specifically targets research, venture capital represents a critical source of funding for companies, often at their earliest stages, to advance promising or even proven ideas toward commercial viability. While venture capital is on an upward trend, and reaching new highs in the biosciences, it remains highly concentrated in two leading bioscience states—California and Massachusetts, which combined account for 59% of the 2012-15 cumulative U.S. funding total of $48.7 million. Nine states had total VC funding that exceeded $1 billion during the 4-year period—the eight states listed in table 23 and Colorado.

The strength of VC investments in California and Massachusetts keep them among the leaders in per capita funding. Smaller states including Rhode Island, New Hampshire, and the District of Columbia appear in this group based on their high concentrations relative to population.

Table 24 shows the top 5 states receiving VC funding across each of the major bioscience-related technology areas/segments. California companies are among the largest recipients across all 13 segments, and Massachusetts is well diversified as a leader in 11 areas. Maryland, Pennsylvania, and Texas each are among the leading states in 4 areas.

TABLE 23

Leading States in Bioscience Venture Capital Investments
2012-2015

Total Bioscience Venture Capital Investment, 2012-15	
Leading States	**Total ($ Millions)**
California	$19,161
Massachusetts	$9,476
Texas	$1,664
Pennsylvania	$1,564
Washington	$1,523
New York	$1,308
Maryland	$1,292
North Carolina	$1,262
New Jersey	$1,214
Illinois	$1,139

Bioscience Venture Capital Distributions	
Leading States	**$ Per 1M Population**
Massachusetts	$1,395
California	$489
Connecticut	$273
Maryland	$215
Washington	$212
Rhode Island	$204
Colorado	$187
Minnesota	$177
New Hampshire	$142
District of Columbia	$136

Source: TEConomy Partners analysis of Thomson Reuters Thomson ONE database.

TABLE 24

Leading States in Bioscience Venture Capital Investments by Segment

2012-2015

State	Biofuels	Biosensors	Biotech					Med/Health			Medical Diagnostics	Medical Therapeutics	Pharmaceutical
			Animal	Equipment	Human	Industrial	Research	Info Tech	Products	Services			
CA	•	•	•	•	•	•	•	•	•	•	•	•	•
CO	•	•				•							
CT				•	•						•		
FL								•					
IL	•		•			•							
KS			•										
MA	•	•	•	•	•	•		•	•		•	•	•
MD				•			•		•				•
MN									•			•	
NC			•		•							•	
NJ						•						•	•
NY							•	•					
OH							•			•	•		
PA	•			•							•		•
TN		•								•			
TX							•	•	•	•			
VA										•			
WA					•								
WI		•											

Source: TEConomy Partners analysis of Thomson Reuters Thomson One Venture Capital database.

Bioscience-Related Patents

Patents awarded to U.S. inventors reveal the focus areas of technology and innovation in areas most closely aligned with the biosciences. Patents with at least one U.S. inventor totaled more than 100,000 over the 2012-15 period, and have been on the rise. In bioscience-related patent classes, California has led during this 4-year period with nearly 30,000 (Table 25). The four leading states in overall patent activity are also among the state leaders on a per-capita basis—California, Massachusetts, Minnesota, and New Jersey, reflecting the highly-concentrated strength of their recent innovation activities. Other states show innovation strengths relative to their size including Delaware, Connecticut, New Hampshire, Indiana, Maryland, and Rhode Island.

Table 26 presents the top 10 states across each of the bioscience-related class groups.

TABLE 25

Leading States—Bioscience-Related Patents
2012-2015

Bioscience-Related Patent Totals, 2012-15		Bioscience-Related Patent Distributions	
Leading States	**Count**	**Leading States**	**Per 1M Population**
California	29,992	Massachusetts	1,586
Massachusetts	10,777	Minnesota	1,287
Minnesota	7,064	Delaware	1,056
New Jersey	7,052	Connecticut	981
Pennsylvania	6,754	New Hampshire	891
New York	6,520	New Jersey	787
Florida	4,904	California	766
Texas	4,521	Indiana	606
Ohio	4,438	Maryland	588
Illinois	4,414	Rhode Island	568

Source: TEConomy Partners analysis of Thomson Reuters Thomson Innovation patent analysis database.

TABLE 26

Leading States—Bioscience-Related Patents by Class Group

2012-2015

State	Agricultural Bioscience	Biochemistry	Bioinformatics & Health IT	Biological Sampling & Analysis	Drugs & Pharmaceuticals	Medical & Surgical Devices	Microbiology & genetics	Biomedical Design Patents
CA	●	●	●	●	●	●	●	●
CT		○			○			
DE							○	
FL	○		○		○	●		●
IA	●							
IL	●	○	●	○				○
IN	●	○				○		
MA		●	●	●	●	●	●	●
MD		○		●	○		●	
MN	●		○			●		○
MO	○		●					
NC		○		○	○		○	
NJ		●	○	○	●	○	○	○
NY		●	●	●	●	○	●	●
OH	○			○		●		●
PA	○	●	○	●	●	○	●	○
TX				○	○	○	○	○
WA			○					
WI	○						○	

Note: A shaded circle signifies the state ranks in the top 5 and an open circle signifies the state ranks in the next 5 for that particular patent class.

Source: TEConomy Partners analysis of Thomson Reuters Thomson Innovation patent analysis database.

APPENDIX: DATA & METHODOLOGY

Industry Employment, Establishments, and Wages

The bioscience industry employment analysis in this report examines national, state, and metropolitan area data and corresponding trends in the biosciences from 2001 through 2014. For employment analysis, TEConomy Partners used the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) data. The QCEW data provide the most current, detailed industry employment, establishment, and wage figures available at both a national and subnational level. TEConomy utilizes an enhanced version of these data from a private vendor, the IMPLAN Group LLC.

The QCEW program is a cooperative program involving BLS and the State Employment Security Agencies. 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]).

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 data produced by the QCEW program for 2001 to present are not comparable with SIC-based industry data from prior years. This limits the ability to construct a longer time series for data analysis; however, 14 years of NAICS-based data (2001-2014) are now available.

Twenty-five NAICS industries at the most detailed (6-digit) level make up the TEConomy definition of the biosciences and its subsectors. These detailed industries are aggregated up to five major subsectors of the bioscience industry. Four of the detailed NAICS industries, Testing Laboratories (NAICS 541380); R&D in the Physical, Engineering, and Life Sciences (NAICS 54171); Drug and Druggists' Sundries Merchant Wholesalers (NAICS 424210); and Farm Supplies Merchant Wholesalers (NAICS 424910) are adjusted in this analysis by TEConomy to include only the share of these industries directly involved in biological or other life science activities. To isolate these relevant life science components, TEConomy used information and data from the U.S. Census Bureau's Economic Census.

The definition of the bioscience industry is presented in Figure A-1.

National and state 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, DC and Puerto Rico data are from the IMPLAN Group LLC.

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

FIGURE A-1

The Bioscience Industry, NAICS Definition

NAICS Code	NAICS Description
Agricultural Feedstock & Chemicals	
311221	Wet Corn Milling
311222	Soybean Processing
311223	Other Oilseed Processing
325193	Ethyl Alcohol 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	Biological Product (except Diagnostic) Manufacturing
Medical Devices & Equipment	
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334517	Irradiation Apparatus Manufacturing
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
339114	Dental Equipment and Supplies Manufacturing
Research, Testing, & Medical Laboratories	
541380*	Testing Laboratories
54171*	Research and Development in the Physical, Engineering, and Life Sciences
621511	Medical Laboratories
Bioscience-Related Distribution	
423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
424210*	Drugs and Druggists' Sundries Merchant Wholesalers
424910*	Farm Supplies Merchant Wholesalers

*Includes only the portion of these industries engaged in relevant life science activities.

Industry Employment Multipliers

Employment multipliers from the IMPLAN Group's state level Input/Output models were used to estimate the employment impact on all other industries of adding bioscience jobs at both the state and national levels. It is important to note that, like all impact models, Input/Output models provide an approximate order-of-magnitude estimate of impacts.

Multipliers and the resulting employment impacts are shown in each state profile table for each major bioscience subsector. This is the first report in which multipliers and employment impacts are provided for Puerto Rico.

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 innovation ecosystem. 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's (NSF) ***Higher Education Research and Development Survey*** (and its predecessor the ***Survey of R&D Expenditures at Universities and Colleges***), national and state totals (summation of all state's responding institutions) are calculated for FY 2014 (most current year available) as well as the previous two years (FY 2012 – FY 2013). 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 ***Higher Education Research and Development*** Survey, see http://www.nsf.gov/statistics/srvyherd/.

National Institutes of Health (NIH) Funding

NIH funding data for FY 2015 (the most current full year available) and for the previous three years (FY 2012 – FY 2014) were obtained using the ***NIH Awards by Location & Organization*** section within the NIH ***Research Portfolio Online Reporting Tool (RePORT)*** database. Data are provided for total NIH funding, growth from FY 2012 through FY 2015 and FY 2015 per capita measures are also calculated.

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

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 were collected using the Thomson Reuters Thomson ONE venture capital database and include all venture capital deals from January 1, 2012 through December 31, 2015. The analysis includes all investments categorized in Thomson ONE in the Medical/Health/Life Sciences major category and five subcategories within the Information Technology major category that capture medical/health-related information technology applications. Additionally, investments in venture capital deals related to ethanol/biofuel/biodiesel-related companies were included from the Other Renewable Energy category maintained in Thomson ONE.

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. Patents provide some measure of comparability among regions in one facet of innovation in terms of activity levels within distinct technology areas. Furthermore, examining recent patent activity provides some insight into firms' recent R&D investment areas and strategies, 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.

Each patent document references at least two distinct entities who are associated with the intellectual property (IP) that was generated—the inventor(s) of the patent, or the person(s) who generated the IP disclosed in the patent, and the assignee(s) of the patent, or the entity(ies) which current have ownership of the IP outlined in the patent. Each patent can have multiple inventors and assignees, and multiple inventors are very common. For this analysis TEConomy used the address location of the named inventor(s) in the analysis of geographic distribution of bioscience patent areas across states, with the credit for invention being "shared" across all the unique states represented by the set of listed inventors in the patent document. Hence, if a bioscience patent is invented by individuals in two states, each state will receive "credit" for generating 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.

It is important to note that this analysis uses only the inventors of the patent as a measure of bioscience innovation activity levels. As companies acquire ownership of IP being generated by others, patents can be assigned to different geographies without any addition of significant innovative value to the original patent. As a result, tracking patent innovation levels by inventor allows for a more consistent and accurate assessment of the places where innovative bioscience IP is being generated by researchers as opposed to being retained or licensed by companies which may or may not align with the same geographic context.

USPTO assigns each patent with a specific numeric major patent "class" as well as supplemental secondary patent classes which detail the primary technology areas being documented by the patented IP. These classes are assigned to patents by dedicated classification staff who examine the documented IP's key focus and end uses. For example, a patent for a new biopharmaceutical may have a main patent class detailing the therapeutic activity or formulation of the drug with supplemental classes documenting any novel synthesizing or manufacturing processes critically tied to creation of the drug. The major patent class and supplemental patent classes are chosen by the USPTO classification staff during the process of reviewing patent applications. By combining relevant patent classes across the wide array of bioscience-related activity, these class designations allow for an aggregation scheme that focuses around broad technology themes that are specific to the biosciences. TEConomy has grouped US-invented patents into broader bioscience patent class groups for the purposes of bioscience innovation trends analysis.

Beginning in 2010, the USPTO and the European Patent Office (EPO) began the process of moving towards a Cooperative Patent Classification (CPC) system enacted as a harmonization and compatibility effort to provide consistent technology class documentation of disclosed IP across international borders. The new class system uses a structure that is similar to and complies with the International Patent Classification (IPC) system, but expands on it in documenting detailed new technology areas. As the USPTO transitions to this new system, the legacy US Patent Classification (USPC) will eventually migrate towards the new CPC scheme. To this end, the CPC scheme was used to create the bioscience patent theme groupings for this effort in order to harmonize reporting of state bioscience patenting trends with the anticipated future shift to CPC as the main US patent classification scheme.

Patent data were collected using the Thomson Reuters Thomson Innovation patent analysis database and includes all granted patents from January 1, 2012 through December 31, 2015 as documented by USPTO. Table A-2 provides a listing of the patent classes and class groups that were used in this analysis to determine the set of bioscience-related patents as well as how they are grouped into major areas of bioscience-related technologies.

TABLE A-2

Bioscience-Related Patents—Classes and Groups

Patent Class	Patent Class Name
Agricultural Bioscience	
A01H	New plant varieties, cultivars, genotypes, and processes for engineering them
A01N	Preservation of human or animal bodies and plants, biocides/pesticides, and plant growth regulators
C05B	Phosphatic fertilizers
C05C	Nitrogenous fertilizers
C05D	Inorganic fertilizers
C05F	Organic fertilizers
C05G	Fertilizer mixtures
Biochemistry	
C07D	Organic chemistry (heterocyclic compounds)
C07H	Sugars and derivatives thereof; nucleosides; nucleotides; nucleic acids
C07J	Steroids
C07K	Peptides
Bioinformatics & Health IT	
G06F 19/1, 19/2	Bioinformatics
G06F 19/3	Medical informatics and clinician decision support tools
G06Q 50/22	General health IT systems and software
G06Q 50/24	Patient record data management
Biological Sampling & Analysis	
G01N24	Assays (e.g. immunoassays or enzyme assays)
G01N25	Screening methods for compounds of potential therapeutic value
G01N26	Assays involving molecular polymers
G01N28	Detection or diagnosis of specific diseases
G01N 33 (partial)	Investigation and analysis techniques pertaining to specific biological substances
G01R 33 (partial)	NMR spectroscopy analysis of biological material (e.g. in vitro testing) and NMR imaging systems
Drugs & Pharmaceuticals	
A61K	Pharmaceuticals, biopharmaceuticals, and biologics
Medical & Surgical Devices	
G06K 9 (partial)	Microscopic inspection of biological structures
G06T 7 (partial)	Biomedical image processing and analysis
A61B	Surgical and diagnostic devices
A61C	Dental instruments, implements, tools or methods
A61D	Veterinary instruments, implements, tools or methods
A61F	Orthopedic and prosthetic equipment, implantable devices (e.g. stents), bandages and first aid devices, and other medical supplies
A61G	Medical transport devices, operating chairs and tables for medical/dental patient applications
A61H	Physical therapy apparatus, artificial respiration
A61J	Containers and devices for administering pharmaceuticals, medicine and food and other medical materials; baby comforters
A61L	Sterilising/deodorization of materials; chemical materials for bandages, dressings and other surgical articles
A61M	Devices for introducing or removing media from the body; devices for producing or ending sleep/stupor
A61N	Electrotherapy; magnetotherapy; radiation therapy; ultrasound therapy
Microbiology & Genetics	
C12M	Enzymology or microbiology equipment and devices
C12N	Genetic engineering, culture media, and other microbiology methods or compositions
C12P	Fermentation or enzyme-related synthesis of chemical compounds
C12Q	Measuring or testing processes involving enzymes or microbiology