TEConomy/BIO

The Bioscience Economy:

Propelling Life-Saving Treatments, Supporting State & Local Communities

2020

TECONOMY PARTNERS LLC

Bio Biotechnology Innovation Organization

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-driven 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.

Table of Contents

The Bioscience Industry is in a Strong Position to Meet the Medical and Economic Challenges of a Global Pandemic 1

Introduction: An Industry Built for this Moment 1

The Bioscience Industry's Pandemic Response 1

Highlights and Key Findings of the Latest Bioscience Industry and Ecosystem Assessment 3

The U.S. Bioscience Industry: A Strong Growth Trajectory Entering a Period of Global Economic Uncertainty 5

Bioscience Industry Wages Reach Nearly Two Times the U.S. Average 10

Bioscience Industry Economic Impacts: A $2.6 Trillion Contribution to the U.S. Economy 11

The Role Small- and Mid-Sized Firms Play in the U.S. Biopharmaceutical Sector and Innovation Pipeline Biopharmaceutical Sector and Innovation Pipeline 13

The Bioscience Industry in U.S. States and Metropolitan Areas: Highlights and Key Findings 15

The Innovation Ecosystem for the Biosciences: National Highlights and Leading States 21

University Bioscience R&D Activity: Rapid Recent Growth Fueling Innovation and Discovery 21

NIH Research Funding Returns to Steady Growth 24

Patent Activity Signals Increasing Bioscience Innovation 26

Bioscience Venture Capital Investments Reach New Highs, Funding Shifts Towards Earlier Stages 30

State and Metropolitan Area Performance Across the Bioscience Industry Subsectors 35

Agricultural Feedstock & Industrial Biosciences 36

Drugs & Pharmaceuticals 39

Medical Devices & Equipment 42

Research, Testing, & Medical Laboratories 45

Bioscience-Related Distribution 48

Appendix: Data & Methodology 51

Industry Employment, Establishments and Wages 51

Industry Economic Impacts and Employment Multipliers 53

Bioscience Academic R&D Expenditures 53

National Institutes of Health (NIH) Funding 53

Bioscience Venture Capital Investments 54

Bioscience Patents 54

Tables

Table 1: U.S. Bioscience Establishment and Employment Summary, 2018 and Recent Trends 9
Table 2: Average Annual Wages for the Biosciences and Other Major U.S. Industries, 2018 10
Table 3: Economic Impacts of the U.S. Bioscience Industry, 2018 ($ in millions) 12
Table 4: State Specializations and Job Growth by Bioscience Subsector, 2018 17
Table 5: Leading States in Academic Bioscience R&D Expenditures and Growth 22
Table 6: Leading States in Per Capita and Concentration of Academic Bioscience R&D Expenditures, 2018 23
Table 7: Leading States in NIH Funding, FY 2019 25
Table 8: Leading States-Bioscience-Related Patents 28
Table 9: Leading States in Bioscience-related Patents by Class Group, 2016-19 29
Table 10: U.S. Bioscience Venture Capital Investments by Stage, 2016-2019 31
Table 11: Leading States in Bioscience Venture Capital Investments 32
Table 12: Leading States in Bioscience Venture Capital Investments by Segment, 2016-19 33
Table 13: States with Large and Specialized Employment in Agricultural Feedstock and Industrial Biosciences, 2018 37
Table 14: Metropolitan Statistical Areas with the Largest Employment Levels in Agricultural 37
Table 15: Metropolitan Statistical Areas with the Highest Location Quotients
in Agricultural Feedstock and Industrial Biosciences, by Size of MSA, 2018 38
Table 16: States with Large and Specialized Employment in Drugs and Pharmaceuticals, 2018 40
Table 17: Metropolitan Statistical Areas with the Largest Employment Levels in Drugs and Pharmaceuticals, 2018 40
Table 18: Metropolitan Statistical Areas with the Highest Location Quotients
in Drugs and Pharmaceuticals, by Size of MSA, 2018 41
Table 19: States with Large and Specialized Employment in Medical Devices and Equipment, 2018 43
Table 20: Metropolitan Statistical Areas with the Largest Employment Levels in Medical Devices and Equipment, 2018 43
Table 21: Metropolitan Statistical Areas with the Highest Location Quotients
in Medical Devices and Equipment, by Size of MSA, 2018 44
Table 22: States with Large and Specialized Employment in Research, Testing, and Medical Labs, 2018 46
Table 23: Metropolitan Statistical Areas with the Largest Employment Levels in Research, Testing, and Medical Labs, 2018 46
Table 24: Metropolitan Statistical Areas with the Highest Location Quotients
in Research, Testing, and Medical Labs, by Size of MSA, 2018 47
Table 25: States with Large and Specialized Employment in Bioscience-Related Distribution, 2018 49
Table 26: Metropolitan Statistical Areas with the Largest Employment Levels in Bioscience-Related Distribution, 2018 49
Table 27: Metropolitan Statistical Areas with the Highest Location Quotients
in Bioscience-Related Distribution, by Size of MSA, 2018 50
Table A-1. Bioscience Industry Definition 52
Table A-2. Bioscience-Related Patents—Classes and Groups 55

Figures

Figure 1: Economic Impacts of the U.S. Bioscience Industry, 2018 3
Figure 2: Employment, Establishment, and Wage Trends for the U.S. Bioscience Industry 5
Figure 3: U.S. Bioscience Industry and Private Sector Employment Trends, 2001-18 6
Figure 4: Bioscience and Major Industry Subsector Employment Growth Trends, 2016-18 8
Figure 5: Economic Impacts of the U.S. Bioscience Industry, 2018 12
Figure 6: Summarizing the Importance of Small and Mid-Sized Firms in the U.S. 14
Figure 7: Change in Bioscience Industry Employment by State, 2010-18 and 2016-18 16
Figure 8: University Bioscience R&D Expenditures, FY 2010-18 ($ in Billions) 22
Figure 9: National Institutes of Health Awards, FY 2013-19 ($ in billions) 24
Figure 10: Bioscience-related U.S. Patents, 2016-19 26
Figure 11: Bioscience-related U.S. Patents by Segment, Cumulative 2016-19 27
Figure 12: Bioscience-related Venture Capital Investments, 2016-19 ($ in Billions) 30
Figure 13: Bioscience-related Venture Capital Investments by Segment, 2016-19 ($ in Millions) 32

The Bioscience Industry is in a Strong Position to Meet the Medical and Economic Challenges of a Global Pandemic

Introduction: An Industry Built for this Moment

2020 has seen the rapid progression of the COVID-19 global pandemic caused by the spread of the novel coronavirus SARS-CoV-2.[1] While this global health emergency is alarming and tragic, a strong public health response, combined with smart science and innovative solutions, will enable us to win the fight. As this biennial report on our nation's bioscience industry has documented, two key characteristics of the industry set it apart and make it vital in meeting the challenges of the pandemic:

- The innovative capacity of the bioscience industry to address global challenges from human health to food production and security, to clean energy, and sustainability; and
- The bioscience industry's role as a consistent economic stalwart, with a track record of generating high-quality jobs and near continuous growth that has acted as a key buffer during prior economic recessions.

The bioscience industry is well-positioned to respond to the imperative for new medical treatments to help end the health crisis posed by the COVID-19 pandemic, as well as to contribute to the expected post-pandemic economic recovery.

Since 2004, this report has assessed the state of the U.S. bioscience industry and its associated innovation ecosystem at the national, state, and metropolitan area levels. This year, it also analyzes the important role of small- and mid-sized biopharmaceutical companies within the innovation pipeline of new treatments. And while this report primarily documents the state of the industry leading up to the global pandemic, it begins by recognizing the rapid mobilization of the industry and key partners to respond.

The Bioscience Industry's Pandemic Response

America's bioscience industry is mobilizing in an unprecedented manner to address the pandemic. Since the novel coronavirus was first detected, the industry has stepped forward to develop diagnostics, antiviral therapies, and vaccines to contain and treat the rapidly spreading illness. Dedicated scientists and researchers from across the bioscience industry have begun or accelerated development of vaccines and antiviral therapies. Numerous antiviral drugs, such as HIV medicines, have entered clinical trials to test whether they can be used safely and effectively against the virus. Medicines previously developed as medical countermeasures against other coronaviruses, including SARS and MERS, are also being tested as potential treatments for COVID-19. According to BIO's own pipeline tracker for COVID-19, as of mid-May 2020, there were more than 400 drug programs in development aimed at eradicating the disease, including 100 vaccine programs and 135 antiviral drug programs.[2]

1 *Note: COVID-19 stands for the coronavirus disease 2019.*
2 *To access BIO's COVID-19 Therapeutic Development Tracker, visit: https://www.bio.org/policy/human-health/vaccines-biodefense/coronavirus/covid-19-pipeline-tracker.*

Containing an outbreak such as the novel coronavirus requires an all-hands-on-deck effort with strategic collaborations. Numerous large biopharmaceutical companies such as Pfizer, Johnson & Johnson, AbbVie and Gilead, as well as smaller biotech firms like Inovio, Moderna, and Novavax, are working closely with U.S. government agencies to identify and develop vaccines and therapies to counter the deadly virus. Collaboration between the public and private sectors is vital to translating science into solutions to combat the virus. For these reasons, BIO is leading an effort that will connect innovators with partners across both the industry and government. The BIO Coronavirus Collaboration Initiative is sharing information and best practices, as well as leveraging the expertise of leaders with experience responding to past public health emergencies.[3] It includes researchers and executives from BIO member companies and is overseen by experienced industry leadership.

The pandemic has placed a spotlight on the importance of nurturing bioscience R&D and innovation ecosystems. The current situation illustrates the importance of proactive investment in these ecosystems and the underlying infrastructure and talent that powers them—resources that can be directed toward innovating solutions when a global challenge arises. The capacity of the global biopharmaceutical community to develop and produce diagnostic tests, vaccine candidates, and potential antiviral agents, and to then scale-up their clinical trials, manufacturing, and distribution, is the direct result of investments in the science, technologies, and skilled people that drive innovation. This report has long documented these investments and the corresponding ecosystem dynamics across the U.S. and sets out to do the same in this ninth edition.

There is no doubt that the bioscience industry will not be immune to the devastating economic impact caused by the pandemic. Of particular concern is the impact of the coronavirus on the ability of bioscience firms to conduct clinical trials, which are critical to bringing medical innovations forward and scaling up bioscience company activities. A survey by BIO and BioCentury of bioscience companies finds that 81 percent were facing challenges in conducting clinical trials because of the coronavirus outbreak.[4]

In addition, there are concerns about how the economic downturn caused by the COVID-19 pandemic will affect the formation and scale-up of emerging high-growth potential bioscience companies. The most recent Venture Monitor, a publication prepared by the National Venture Capital Association and PitchBook covering the first quarter of 2020, voices this concern that “investment pace will likely slow down if shelter-in-place orders are still in effect once deals that were already in progress or in the pipeline are completed, since VC is a business that revolves around in-person meetings with founding teams before making an investment … And just like startups in other sectors, life science companies are in cost-cutting mode.”[5]

Still, once the economy re-opens, history suggests the bioscience industry will serve as an economic stabilizer since the demand for medical treatments are not dependent upon economic conditions. During and just after the “Great Recession” of late 2007 through mid-2009, overall U.S. private sector employment declined by 6.9 percent compared with a decline of just 1.4 percent for the biosciences. Following the 2001 recession, all industry employment fell by 2 percent while the bioscience industry rose by 2 percent.

The bioscience industry as an innovation and economic driver has never been more important, both for our health and our economic recovery.

3 *For more information visit BIO's Coronavirus Hub at: https://hub.bio.org/.*

4 *BIO/BioCentury Survey: COVID-19 Impact on Clinical Trials: A joint survey from BIO and BioCentury at: https://www.bio.org/sites/default/files/2020-03/2020-03-25%20Survey%20and%20Citleine%20data%20v3.pdf.*

5 *NVCA and PitchBook, Venture Monitor: Q1 2020.*

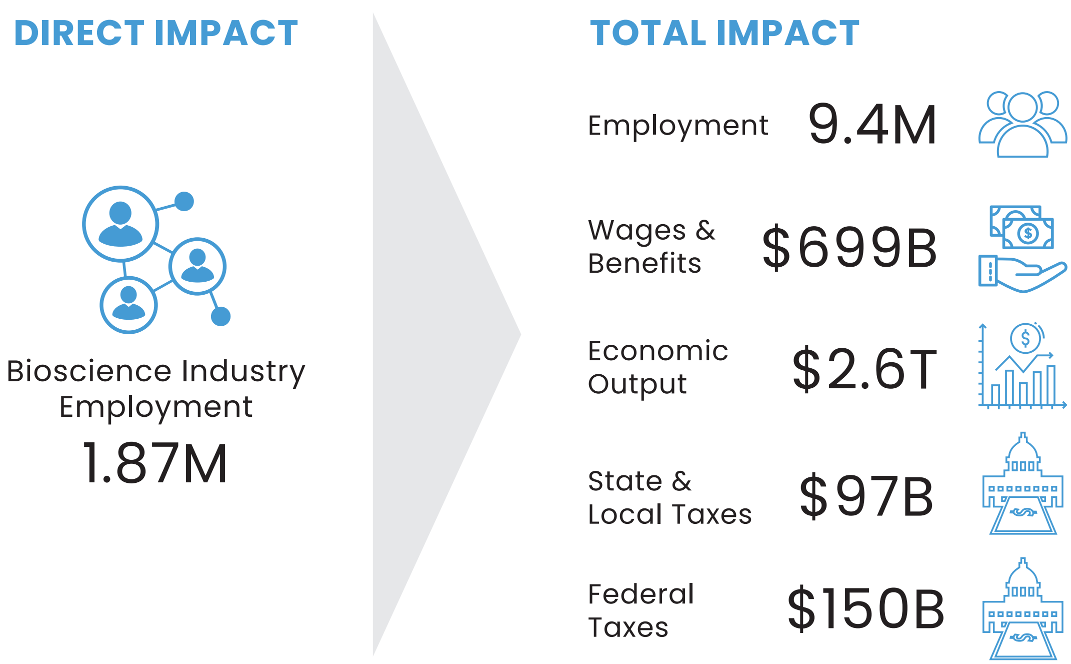
Highlights and Key Findings of the Latest Bioscience Industry and Ecosystem Assessment

National Industry Highlights:

The U.S. bioscience industry has continued its impressive growth trend, generating high-paying, quality jobs and significant economic impacts for the nation.

- The nation's bioscience industry employs 1.87 million across more than 101,000 U.S. business establishments.
- Since 2016, the industry has grown its employment base by 7.2 percent, which is more than twice the growth rate for the overall private sector.
- Bioscience industry establishments and average wages grew as well; and the industry continues to stand out as a major job generator among knowledge- and technology-driven sectors for the U.S. economy.
- All five of the industry's major subsectors have grown their employment base since 2016.
- Bioscience industry wages now reach nearly two times the overall U.S. average—the average bioscience worker earns more than $107,000, or $50,000 more than the nation's private sector average.
- The bioscience industry's total economic impact on the U.S. economy totaled $2.6 trillion dollars in 2018, as measured by overall output (Figure 1).

Figure 1: Economic Impacts of the U.S. Bioscience Industry, 2018



Source: TEConomy Partners data, analysis of U.S. IMPLAN Input/Output Model.

- The industry's 1.87 million employees and associated economic output support nearly 7.5 million additional jobs throughout the economy through indirect and induced effects.

State and Metropolitan Area Industry Highlights

The nation's bioscience industry has a vast geographic footprint—extending to every U.S. state and region. A majority of states have a "specialized" concentration of employment in at least one of the five bioscience subsectors, and the vast majority have contributed to national growth.

- Thirty-five states and Puerto Rico have a specialization in at least one of the five bioscience subsectors in 2018.

- Over the 2016 to 2018 period, 41 states experienced job growth in the bioscience industry.

Likewise, a majority of U.S. metropolitan areas also have a niche bioscience specialization.

- Of the nation's 384 metro regions, 217 (57 percent) have a specialized employment concentration in at least one bioscience subsector.

Innovation Ecosystem Highlights

The assessment of the industry's innovation ecosystem finds it performing well, trending upward, and reaching new heights. Highlights from the ecosystem assessment include:

- **University Bioscience R&D Activity: Rapid Recent Growth Fueling Innovation and Discovery.** Academic R&D expenditures in bioscience-related fields reached $47.2 billion in 2018. After stagnating for several years in the early part of the decade, U.S. universities have significantly increased bioscience research activity since 2015. Where expenditure growth averaged just 0.7 percent annually over the 2011-14 period, the pace has accelerated to average 5.8 percent growth annually since 2015.

- **NIH Research Funding Returns to Steady Growth Path.** In 2019, NIH awarded nearly $31 billion in extramural research funding. This continues a steady growth trend over the last 4 years following flat or declining research funding in the early part of the decade. Since 2015, annual growth in NIH funding has averaged 7.8 percent.

- **Patent Activity Signals Increasing Bioscience Innovation.** American inventors were associated with more than 108,000 U.S. patents awarded in bioscience-related classes and categories from 2016 through 2019. Despite a dip in totals in 2018, patent awards have grown by 17 percent since 2016, or 5.6 percent annual growth, to reach nearly 30,000 in 2019.

- **Bioscience Venture Capital Investments Reach New Highs, Funding Shifts Toward Key Earlier Stages.** Over the latest 4-year period, cumulative venture capital investments in U.S. bioscience companies exceeded $102 billion, reflecting an increasing trendline and new highs. In both 2018 and 2019, bioscience-related investments exceeded $30 billion. In the latest 4-year period, the pre-seed through early-stage investment dollars directed toward the biosciences matched the level of those invested in later-stage companies, a 50-50 split. This proportion of funding in earlier-stage companies is above the two-decade average of 45 percent, representing a positive shift toward the key earlier stage investments.

While the bioscience industry has continued with strong growth and a thriving ecosystem, its success cannot be taken for granted. This is particularly true as it addresses the global pandemic and challenges of a post-pandemic recovery. There is an acute need in the near-term for federal and private investments in R&D and both public and private investment need to scale-up production of vaccines and therapies for COVID-19.

The U.S. Bioscience Industry: A Strong Growth Trajectory Entering a Period of Global Economic Uncertainty

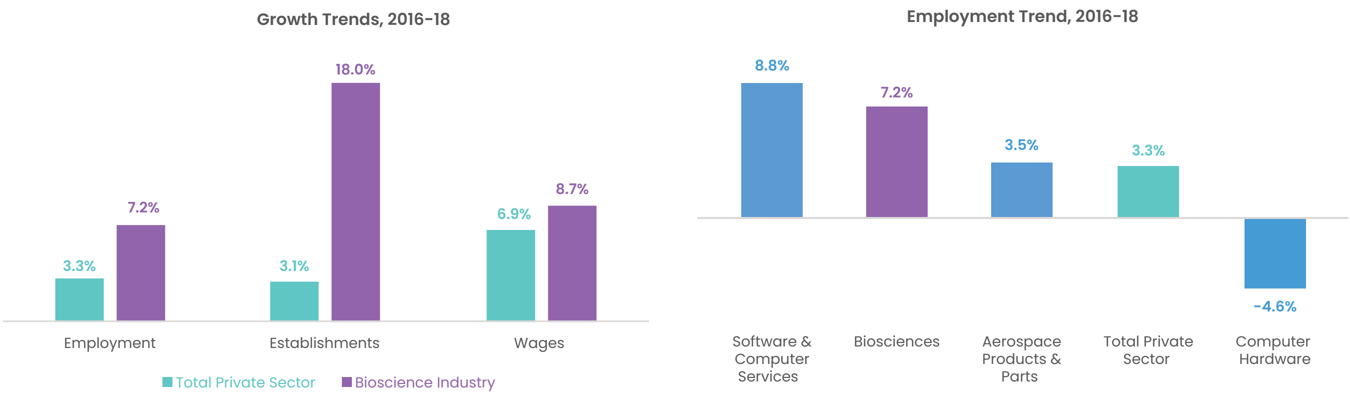
Leading up to the 2020 COVID-19 global pandemic, the U.S. bioscience industry continued its impressive growth trend, generating quality jobs and significantly impacting the national economy. Since 2016, the industry has grown by 7.2 percent or more than twice the growth rate for the overall private sector (3.3 percent).[6] Bioscience industry establishments and average wages were up as well and the industry continues to stand out as a major job generator among knowledge- and technology-driven sectors for the U.S. economy (see Figure 2).

These latest trends reflect sustained industry growth over an economic expansion that by 2019 had reached record-setting length. Since the "Great Recession" that began in late 2007, and bottomed-out in mid-2009, the bioscience industry has grown its employment base by 18 percent compared with 17 percent for all industries (Figure 3). Bioscience job growth accelerated from 2017 to 2018, even accounting for differences due to sector re-classification by the federal government (see the Technical Note on page 8).

What stands out about the long-term trend is the industry's near continuous growth and its resiliency during the last two recessions. The biosciences have provided a much-needed buffer during

Figure 2: Employment, Establishment, and Wage Trends for the U.S. Bioscience Industry

Bioscience Industry Growth Outpacing Overall Private Sector and Other Technology Industries

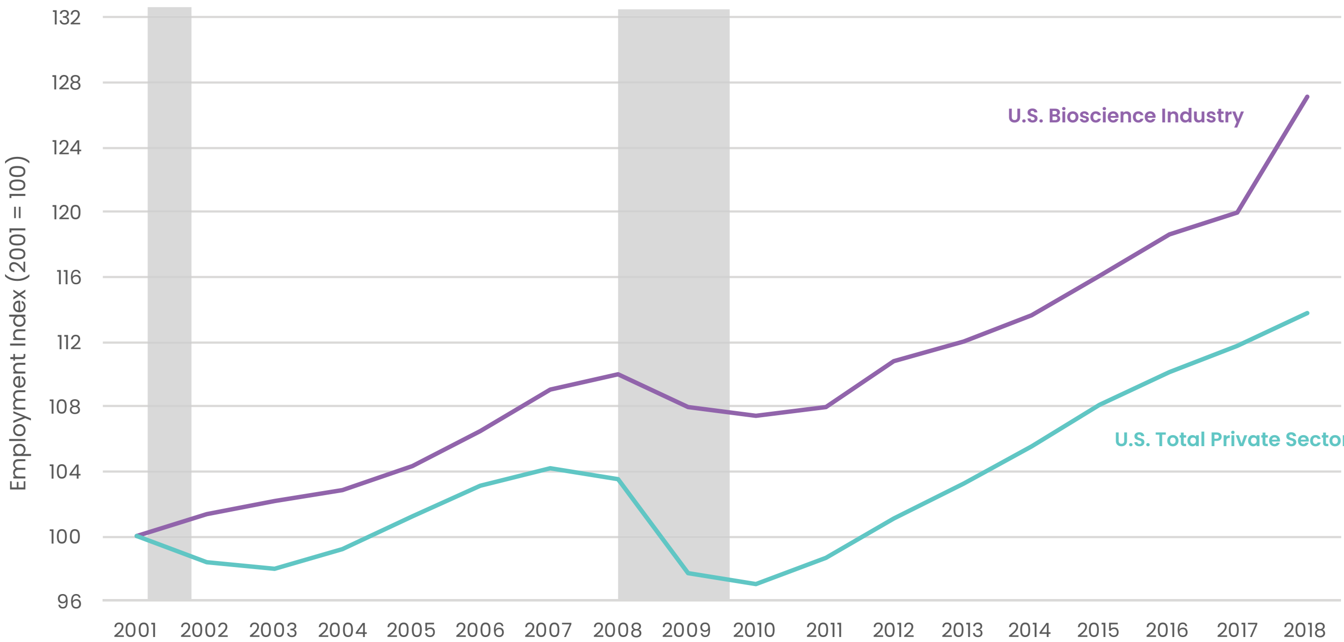


Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

6 *The bioscience industry growth trend has been impacted by a shift in the federal industry classifications in one of its five major subsectors—bioscience-related distribution. For a discussion on this, please see the Technical Note on page 8 of this report.*

Figure 3: U.S. Bioscience Industry and Private Sector Employment Trends, 2001-18

The industry's near continuous long-term growth and its resiliency during the last two recessions.



Note: Shaded areas represent recessions.
Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

What stands out about the long-term industry trend is the industry's near continuous growth and its resiliency during the last two recessions—the biosciences have provided a much-needed buffer during economic downturns, a key characteristic amid the current pandemic-induced global downturn.

economic downturns, a key characteristic amid the current pandemic-induced global downturn. In the Great Recession, overall U.S. private sector employment declined by 6.9 percent compared with a decline of just 1.4 percent for the biosciences. Following the 2001 recession, all industry employment fell by 2 percent while the bioscience industry rose by 2 percent.

The biosciences are not monolithic. The breadth of industry activity translates into a series of unique products and markets, each with their own economic and business dynamics (see "Defining the Bioscience Industry"). With that acknowledged, all five of the industry's major subsectors have grown since 2016 (see Figure 4 and Table 1).

- Research, testing, and medical laboratories represents the largest subsector of the bioscience industry. The subsector, which employs nearly 570,000 (30 percent of total industry jobs), grew by 4 percent from 2016-18.

That is an annual pace slightly lower than its average during the full economic expansion. Biotechnology and other commercial life sciences R&D and testing labs employ about two-thirds of the bioscience workers within the subsector. The remainder are employed in medical laboratories. Both major components of the subsector have grown since 2016.

- Medical devices and equipment employ one in five U.S. bioscience workers and saw its hiring accelerate in the last two years—growing by 5.3 percent overall since 2016. The subsector's average annual employment growth of 2.6 percent since 2016 was more than twice as fast as that for the overall expansion period (1.2 percent growth annually since 2010). Each component of the medical device subsector has contributed to growth in recent years. Manufacturers of surgical and medical equipment and of electromedical equipment have seen particularly strong growth.

- The drugs and pharmaceuticals subsector employs more than 308,000 U.S. workers and also experienced accelerated hiring since 2016, growing its employment base by 3.1 percent, up from 2.0 percent growth in the prior 2-year period. After several years of net job declines for the subsector during and immediately following the Great Recession, pharmaceutical manufacturers have now increased employment in six consecutive years. While accounting for 16 percent of U.S. bioscience jobs, the subsector is closely tied to commercial R&D firms and establishments, including biotechnology R&D, that are included within research, testing, and medical labs. Within the drugs and pharmaceuticals subsector, each component industry has grown since 2016, with the strongest growth coming from companies manufacturing biological products, which includes vaccines.

- Agricultural feedstock and industrial biosciences returned to a growth path in the last two years, growing its employment base by 0.9 percent following two years of modest job declines. The subsectors' nearly 69,000 jobs represent 4 percent of U.S. bioscience jobs. Job gains were spread across the subsector components, with modest growth in both agricultural feedstocks and in agricultural chemicals manufacturing.

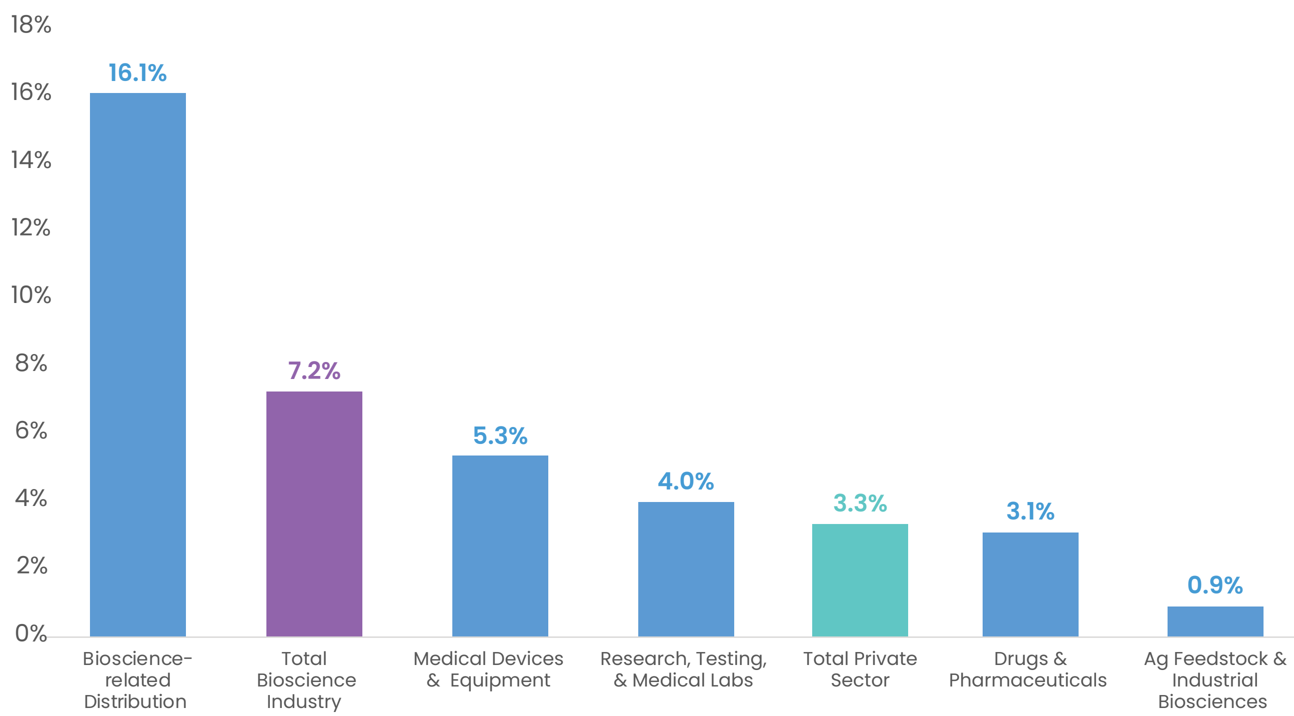
- Bioscience-related distribution operations employ 545,000 in key activities across the industry value chain, accounting for 29 percent of industry employment. A significant classification adjustment to the federal data by the Bureau of Labor Statistics (see Technical Note sidebar) boosted in 2018 what was a more modest growth trend. Subsector growth, and the impact of the adjustment, was concentrated in two of the wholesale components—medical, dental, and hospital equipment and drugs distribution.

Technical Note on the Growth Trend in Bioscience-related Distribution

Changes in the federal classification approach within the wholesale trade industry have impacted the growth trend for bioscience-related distribution and warrant a discussion in this report. Periodically, the federal statistical system updates its industry classification scheme (the North American Industry Classification Scheme or "NAICS"). Following the 2017 NAICS update, the U.S. Bureau of Labor Statistics (BLS) revisited the way in which it classifies certain distribution establishments. In doing so, BLS has shifted away from classifying many individual establishments in a relatively general "Wholesale Trade Agents and Brokers" industry sector and instead placed more establishments into distribution sectors specifically aligned with their wholesale products. In doing so, a disproportionate number of establishments (and their associated employment) ended up reclassified into the bioscience-related distribution sectors (particularly drugs and medical equipment) and had the effect of creating a significant, yet immaterial, increase in the employment, establishment and wage level within the bioscience-related distribution subsector in 2018. This reclassification, while providing a more accurate count of the true size and scale of bioscience-related distribution, has impacted the overall bioscience industry trends. And while it is not possible to fully adjust for this, the growth trend in distribution is consistent with growth across the biosciences during this period and toward the end of a record-setting economic expansion.

Figure 4: Bioscience and Major Industry Subsector Employment Growth Trends, 2016-18

All five bioscience industry subsectors grew during the 2016-18 period



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

Table 1: U.S. Bioscience Establishment and Employment Summary, 2018 and Recent Trends

Bioscience Industry & Major Subsectors	Establishments			Employment		
	Count, 2018	Change, 2010-18	Change, 2016-18	Count, 2018	Change, 2010-18	Change, 2016-18
Agricultural Feedstock & Industrial Biosciences	1,785	4.6%	4.4%	68,642	3.8%	0.9%
Bioscience-related Distribution	51,582	42.6%	31.8%	545,055	23.9%	16.1%
Drugs & Pharmaceuticals	4,451	53.1%	18.6%	308,357	4.2%	3.1%
Medical Devices & Equipment	8,753	25.8%	8.3%	378,431	10.2%	5.3%
Research, Testing, & Medical Laboratories	34,572	47.5%	4.7%	569,470	30.9%	4.0%
Total Biosciences	101,143	42.1%	18.0%	1,869,955	18.3%	7.2%

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

Defining the Bioscience Industry

Defining the biosciences is challenging due to its diverse mix of technologies, products and markets, 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 do not provide for one over-arching industry code that encompasses the biosciences. Instead, two dozen detailed industries must be combined and grouped to best organize and track the industry in its primary activities.

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

Agricultural feedstock and industrial biosciences —Firms engaged in agricultural 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 ag biotech. Distribution in the biosciences is unique in its deployment of specialized technologies including cold storage, highly regulated monitoring and tracking, 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 (pre-market) and other life sciences, life science testing laboratories, and medical laboratories. Includes contract and clinical R&D organizations.

Bioscience Industry Wages Reach Nearly Two Times the U.S. Average

The importance of the bioscience industry as an economic engine for the U.S. is further illustrated by its wage levels. Bioscience workers earn wages well above those for their counterparts in other major industries, reflecting the highly innovative, value-adding nature of the industry and the skills it requires.

In 2018, the average U.S. bioscience worker earned more than $107,000, which is $50,000 more than the private sector national average (Table 2). This 89 percent wage premium reflects the demand for a skilled workforce throughout the industry performing scientific R&D, designing and engineering complex products and production processes, leveraging information technologies and advanced data analytics, manufacturing and distributing products, largely under highly-regulated oversight regimes.

Average wages for each of the five major subsectors far exceed those for the overall private sector, and three of the five exceed $100,000 annually. The biosciences pay wages that are competitive relative to other knowledge-intensive sectors such as information technology, finance and insurance, and professional services.

Table 2: Average Annual Wages for the Biosciences and Other Major U.S. Industries, 2018

Major U.S. Industries	Average Annual Wages
Research, Testing, & Medical Laboratories	$120,320
Information	$113,795
Drugs & Pharmaceuticals	$113,544
Finance and Insurance	$109,247
Total Biosciences	$107,610
Bioscience-related Distribution	$105,905
Professional, Scientific, and Technical Services	$97,114
Medical Devices & Equipment	$90,541
Agricultural Feedstock & Industrial Biosciences	$83,151
Manufacturing	$68,528
Construction	$62,732
Real Estate and Rental and Leasing	$59,125
Total Private Sector	$57,043
Transportation and Warehousing	$53,215
Health Care and Social Assistance	$50,328
Retail Trade	$32,357

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

Bioscience Industry Economic Impacts: A $2.6 Trillion Contribution to the U.S. Economy

The 1.87 million U.S. bioscience industry workers are employed across every U.S. state, create a substantial national economic impact. The biosciences have an extensive, interdependent supply chain for its research, production, and distribution activities. The industry both supports and depends upon other sectors to supply everything from business services to commodity inputs. In addition, industry employees who earn high average wages generate demand for goods and services through their own personal spending. As a result, the biosciences have a national economic impact that extends and multiplies well beyond the industry's direct employment and earnings.

Economic impact analysis measures these types of impacts and effects described, including:

- *Direct effects*: *the direct employment and other economic activity generated by the bioscience industry's operations and expenditures;*
- *Indirect effects*: *the economic activity generated by supplier firms to the bioscience industry; and*
- *Induced effects*: *the additional economic activity generated by the personal spending of the direct bioscience employees and the employees of the supplier firms in the overall economy.*

The sum of these three effects is referred to as the *total economic impact*. TEConomy estimated the total economic impact of the U.S. bioscience industry in 2018 based on employment values for each detailed industry sector within the biosciences and evaluated the impacts across several key economic measures:

- *Employment.* The total number of full- and part-time jobs in all industries;
- *Personal Income.* The wages and salaries, including benefits, earned by the workers holding the jobs created;
- *Value-Added.* The difference between an industry's total output and the cost of its labor and other inputs; and
- *Output.* The total value of production or sales in all industries.[7]

Additionally, the model allows for a high-level estimation of tax revenues generated by the economic activity at a combined state/local level and at a federal level. These tax revenues include estimates of a variety of corporate and personal tax payments, including both the employer and employee portions of social insurance taxes.

The total economic impact of the bioscience industry on the U.S. economy, as measured by overall output, totaled $2.6 trillion dollars in 2018 (Figure 5 and Table 3). This impact is generated by the direct industry output ($1.1 trillion) combined with the indirect and induced impacts, which total nearly $1.5 trillion. It means that for every $1 in industry output, an additional $1.27 in output is generated throughout the rest of the national economy. This is an industry output "multiplier" of 2.27. This substantial industry output represents 7.1 percent of all U.S. economic activity.

The 1.87 million bioscience employees, and their associated economic output, support nearly 7.5 million additional jobs throughout the entire economy through both indirect and induced effects. These additional jobs span numerous other industries including real estate, consulting, legal services, transportation, information technology, and utilities, just to name some. The industry's employment multiplier is 5.0, which means that for every one bioscience job an additional four jobs are supported throughout the rest of the economy.

7 *The total output impacts are often referred to as the "economic impact" of an industry, project or investment.*

Additional economic impacts of the industry extend to local, state, and federal tax revenues through the corporate, personal income, and other taxes paid by bioscience firms, their suppliers, and their workers.

These total taxes, through combined direct and multiplier effects, are estimated to have contributed nearly $97 billion to state and local governments and almost $150 billion to the federal government in 2018.

Figure 5: Economic Impacts of the U.S. Bioscience Industry, 2018

DIRECT IMPACT

Bioscience Industry Employment

1.87M

TOTAL IMPACT

Employment 9.4M

Wages & Benefits $699B

Economic Output $2.6T

State & Local Taxes $97B

Federal Taxes $150B

Source: TEConomy Partners data, analysis of U.S. IMPLAN Input/Output Model.

Table 3: Economic Impacts of the U.S. Bioscience Industry, 2018 ($ in millions)

Impact Type	Employment	Labor Income	Value Added	Output	State/Local Tax Revenue	Federal Tax Revenue
Direct Effect	1,869,955	$228,022	$537,976	$1,147,179	$32,455	$52,387
Indirect Effect	3,496,978	$253,877	$397,365	$781,598	$27,817	$50,935
Induced Effect	3,984,387	$217,588	$381,999	$678,212	$36,331	$46,255
Total Impacts	**9,351,320**	**$699,486**	**$1,317,340**	**$2,606,989**	**$96,603**	**$149,578**
Multiplier	5.00	3.07	2.45	2.27		

Source: TEConomy Partners data, analysis of U.S. IMPLAN Input/Output Model.

The Role Small- and Mid-Sized Firms Play in the U.S. Biopharmaceutical Sector and Innovation Pipeline

The most well-recognized segment of the biopharmaceutical industry are large multinational firms. These firms are typically household names, publicly traded, and with substantial employment, R&D investments, and revenues. Yet, a major segment of research, innovation, and economic activity is also occurring among small and mid-sized biopharmaceutical firms that are much less recognized.[8]

Who are these small and mid-sized biopharmaceutical firms? One metric used by BIO and others, small and mid-sized biopharmaceutical firms are those generating less than $1 billion in revenues. From a federal procurement perspective, they include companies with fewer than 1,000 employees for biopharmaceutical R&D companies, and fewer than 1,250 employees for biopharmaceutical manufacturing firms.[9]

While the largest firms are indeed the most well-known and play an essential role in helping to drive the overall biopharmaceutical ecosystem, smaller and mid-sized biopharmaceutical firms account for a significant majority of the industry's employment and establishments. Small and mid-sized biopharmaceutical companies comprise 71 percent of total biopharmaceutical industry employment and 99 percent of the business establishments.[10]

While it is not surprising within a major industry cluster to have small and mid-sized firms comprise a large share of business establishments and employment, what does stand out for small- and mid-sized biopharmaceutical companies is the important role they play in advancing innovation. Often small- and mid-sized biopharmaceutical companies are an important means for commercializing novel therapies associated with research discoveries generated at universities, non-profit research institutes, and federal laboratories.

BIO estimates that there are nearly 6,700 therapies in the clinical stage pipeline (from Phase 1 trials through new drug or biologics application), with more than 5,000 (76 percent) either led by small and mid-sized emerging (primarily pre-revenue) companies, or where smaller firms are in partnered research programs with large biopharmaceutical firms. This pipeline covers the broad spectrum of disease areas with 5 percent or more of the activities in five areas: oncology (42 percent), neurology (12 percent), infectious (8 percent), immunology (7 percent) and endocrine-related diseases (5 percent).

Often these smaller firms bring forward a specific research niche or focus for development. As they continue to develop these technologies and related therapies, there comes an increased need for clinical research-related skills and employees, which leads to significant employment growth. Some examples of small-firm growth and expansion include:

- Alnylam Pharmaceuticals, with a cutting-edge research program in RNAi therapeutics, grew from 60 employees during its early funding rounds to a free-standing public company with 1,323 employees at the end of 2019.
- Esperion Therapeutics, with a research program dedicated to approaches for reducing cholesterol, has had two distinct growth periods. Initially in the early 2000s, Esperion grew to 65 employees, while at the

8 *For these purposes, the biopharmaceutical industry consists of NAICS 3254 Pharmaceutical Manufacturing and NAICS 541714 R&D in Biotechnology (formerly NAICS 541711).*

9 *SBA Table of Size Standards. See: https://www.sba.gov/document/support--table-size-standards*

10 *U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Q1 Data by Size of Firm, 2018. While the data presented in the text refers to the combined biopharmaceutical industry, the size distribution of establishments for NAICS 3254 Pharmaceutical Manufacturing are fairly similar. establishments with 1,000 or more employees account for 1 percent of all establishments and 32 percent of total employment.*

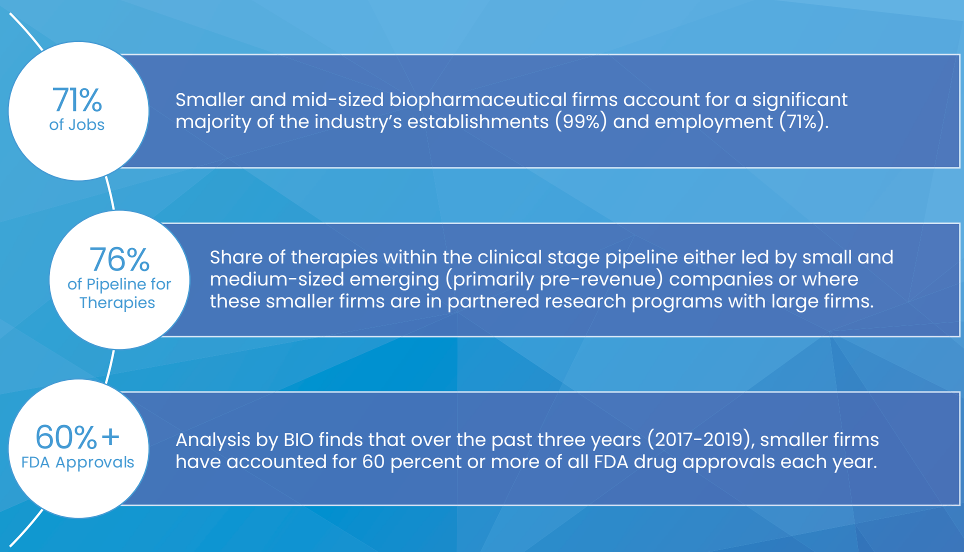
time being acquired by Pfizer. Operating as a separate unit within Pfizer, it became an independent enterprise once again in 2008. Esperion has since grown to more than 190 employees by the end of 2019.

- Moderna Therapeutics, a leader in mRNA-based development, received its Series A funding with approximately 25 employees in 2010, and has grown through significant venture and shareholder investments to 830 employees at the end of 2019.
- Spark Therapeutics, with a leading gene therapy research program, grew from 50 employees in 2015 to 450 employees in 2019 as they were being acquired by Genentech.
- Vertex Pharmaceuticals, a leading firm in the development of Cystic Fibrosis therapies, started in 1989 and grew from nearly 70 employees at its IPO in 1991 to approximately 3,000 employees generating $4.2 billion in revenue in 2019.

While there are inherent research risks in any biopharmaceutical research pipeline, small and mid-sized firms have experienced their share of success. Analysis by BIO finds that over the past three years (2017-2019), smaller firms have accounted for 60 percent or more of all FDA drug approvals each year, accounting for nearly 100 new drugs and therapies over this period. These results provide concrete evidence that smaller biopharmaceutical firms, though perhaps less well known as their larger colleagues, are an active and significant component of the biopharmaceutical industry and its innovation pipeline.

Within the biopharmaceutical ecosystem, small and mid-sized companies are a critical driver of innovation. They must often take on extensive research costs needed to bring drug and pharmaceutical innovations to market, well before earning revenue. While these investments in research are the financial risks borne by the biopharmaceutical industry regardless of the size of firm, the ability of small and mid-sized companies to realize success depends upon having access to risk capital, strategic partnerships with larger biopharmaceutical companies, and federal sources of innovation funding, such as the Small Business Innovation Research (SBIR) grants.

Figure 6: Summarizing the Importance of Small and Mid-Sized Firms in the U.S. Biopharmaceutical Sector and Innovation Pipeline



Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Q1 Data by Size of Firm, 2018; BIO analysis of clinical stage pipeline and FDA drug approvals.

The Bioscience Industry in U.S. States and Metropolitan Areas: Highlights and Key Findings

The nation's bioscience industry has a vast geographic footprint—extending to every U.S. state and region. The industry's breadth and diversity translates into significant market and economic development opportunities for most states; in fact, a majority of states have a "specialized" concentration of employment in at least one of the five bioscience subsectors.

Highlights of State Industry Performance

- Thirty-five states and Puerto Rico have a specialization in at least one of the five bioscience subsectors in 2018. These include:
    - 19 states specialized in Agricultural Feedstock & Industrial Biosciences
    - 10 states and Puerto Rico specialized in Bioscience-related Distribution
    - 11 states and Puerto Rico specialized in Drugs & Pharmaceuticals
    - 13 states and Puerto Rico specialized in Medical Devices & Equipment
    - 11 states and Puerto Rico specialized in Research, Testing & Medical Laboratories
- New Jersey and Puerto Rico stand out as the only states that are specialized in four of the five bioscience subsectors. While nine states have a specialization in three subsectors, no state has a specialization in all five subsectors.
- Over the 2016 to 2018 period, 41 states experienced job growth in the bioscience industry.

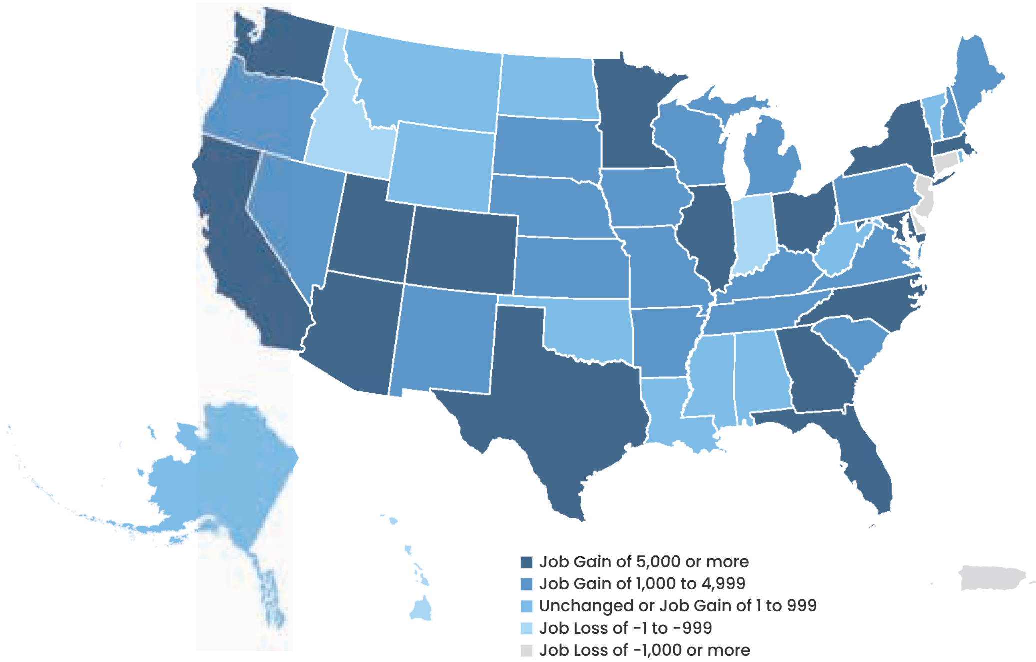
Measuring Industry Concentration and "Specialization"

Employment concentration is a useful way to gauge the relative importance of an industry to a state or regional economy.

State location quotients (LQs) measure the degree of job concentration within the state relative to the national average. States or regions with an LQ greater than 1.0 are said to have a concentration in the sector. When the LQ is significantly above average, 1.20 or greater, the state is said to have a "specialization" in the industry.

Figure 7: Change in Bioscience Industry Employment by State, 2010-18 and 2016-18

2010-18: Economic Expansion Period



2016-18: Latest Period

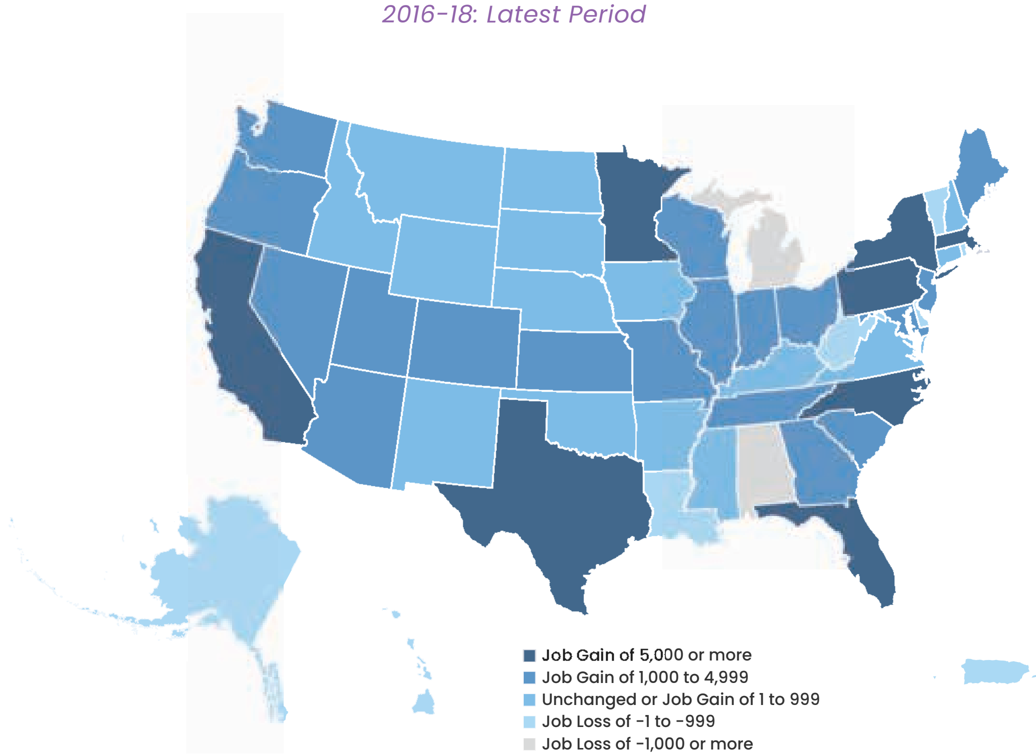


Table 4: State Specializations and Job Growth by Bioscience Subsector, 2018

State	Agricultural Feedstock & Industrial Biosciences		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research, Testing, & Medical Laboratories		Bioscience-related Distribution	
	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18
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		●		●	●	●		●		●

State	Agricultural Feedstock & Industrial Biosciences		Drugs & Pharmaceuticals		Medical Devices & Equipment		Research, Testing, & Medical Laboratories		Bioscience-related Distribution	
	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18	Specialization, 2018	Growth, 2016-18
NJ			●		●	●	●		●	●
NM		●		●		●	●			●
NY		●		●				●		●
NC	●	●	●	●		●	●	●		●
ND	●	●				●			●	●
OH				●		●			●	●
OK	●	●		●		●		●		●
OR		●		●		●				●
PA		●	●	●		●	●	●		●
PR			●	●	●	●	●		●	
RI						●				●
SC		●		●		●				
SD	●	●		●	●	●			●	●
TN		●				●		●	●	●
TX		●		●		●		●		●
UT			●	●	●	●	●	●		●
VT										●
VA		●		●		●				●
WA		●		●		●	●	●		●
WV	●		●	●		●				
WI	●	●		●	●	●				●
WY	●	●		●		●		●		●

Note: Dots represent either a "specialized" employment concentration (LQ >= 1.20) or employment growth (> 0%).
Source: TEConomy Partners analysis of U.S. Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

Highlights of Metropolitan Area Industry Performance

A majority of U.S. metropolitan areas also have a niche bioscience specialization. Of the nation's 384 metropolitan regions, 217 (57 percent) have a specialized employment concentration in at least one bioscience subsector.

Thirty metro areas have an especially diverse set of bioscience industry strengths, with specializations in at least three of the five industry subsectors. These metros span all regions of the U.S. and reflect the broad distribution of the industry nationally. These include (number of specializations in parentheses):

- Ames, IA (4)
- Boulder, CO (4)
- Durham-Chapel Hill, NC (4)
- Lafayette-West Lafayette, IN (4)
- Lincoln, NE (4)
- Madison, WI (4)
- Raleigh-Cary, NC (4)
- Albany-Schenectady-Troy, NY (3)
- Allentown-Bethlehem-Easton, PA-NJ (3)
- Bloomington, IN (3)
- Boston-Cambridge-Newton, MA-NH (3)
- Gainesville, FL (3)
- Grants Pass, OR (3)
- Greensboro-High Point, NC (3)
- Indianapolis-Carmel-Anderson, IN (3)
- Iowa City, IA (3)
- Lebanon, PA (3)
- Logan, UT-ID (3)
- Memphis, TN-MS-AR (3)
- Morgantown, WV (3)
- Salt Lake City, UT (3)
- San Diego-Chula Vista-Carlsbad, CA (3)
- San Francisco-Oakland-Berkeley, CA (3)
- San Jose-Sunnyvale-Santa Clara, CA (3)
- Santa Cruz-Watsonville, CA (3)
- St. Joseph, MO-KS (3)
- Syracuse, NY (3)
- Texarkana, TX-AR (3)
- Trenton-Princeton, NJ (3)
- Worcester, MA-CT (3)

The Innovation Ecosystem for the Biosciences: National Highlights and Leading States

The innovation-intensive biosciences industry requires a robust, supportive ecosystem in which to thrive. The type of long-term growth achieved in the nation's bioscience sector is rooted in, and enabled by, basic and applied research and development activities; development of, and access to, a qualified and highly skilled workforce; investment capital allocated to innovative emerging and existing firms; and strong and enforced legal protections of intellectual property. Nations, regions, states, and localities compete fiercely to develop, attract, and retain bioscience industry "clusters" by nurturing each of these elements of a thriving innovation ecosystem.

While the bioscience industry has continued to see strong growth, its success cannot be taken for granted, particularly as it addresses the global pandemic and the challenges of post-pandemic economic recovery. There will be an acute need in the near-term for federal and private investments in R&D, as well as federal and private investment to enable scale-up production for therapies and vaccines for COVID-19.

This section of the report takes stock of the nation's overall position and performance, as well as highlighting leading states, across several key elements of the U.S. ecosystem, specifically:

- University Bioscience R&D Expenditures
- NIH Funding
- Bioscience-related Patents
- Venture Capital and Angel Investments in Bioscience Companies

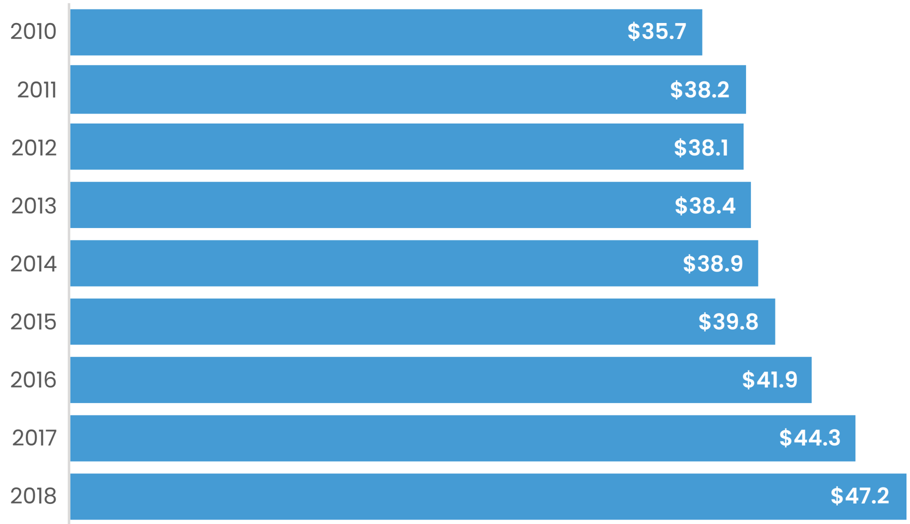
University Bioscience R&D Activity: Rapid Recent Growth Fueling Innovation and Discovery

University-led R&D in the biosciences plays a central role in scientific discovery and innovation by helping fuel the industry's innovation ecosystem. Bioscience-related research activities span numerous academic disciplines and contribute to a firm foundation in fundamental, basic scientific inquiry.

National academic R&D expenditures in bioscience-related fields reached $47.2 billion in 2018, following strong, consistent growth in recent years (Figure 8). After stagnating for several years in the early part of the decade, universities in the United States significantly increased bioscience research activity since 2015. Where expenditure growth averaged just 0.7 percent annually over the 2011-14 period, growth has risen to a 5.8 percent average pace annually since 2015.

Bioscience disciplines represent a majority of all academic research activity, and that share is growing. The diverse bioscience-related fields categorized by the National Science Foundation (NSF) include agricultural, biological, health, and other life sciences in addition to biomedical engineering, and natural resources and conservation. Combined, they account for 63 percent of all U.S. university R&D expenditures today. This share has risen from 61 percent for much of the decade, as growth in biosciences R&D in recent years has outpaced growth for overall science and engineering disciplines.

Figure 8: University Bioscience R&D Expenditures, FY 2010-18 ($ in Billions)



Source: TEConomy Partners analysis of National Science Foundation (NSF), National Center for Science and Engineering Statistics, Higher Education Research and Development (HERD) Survey.

Biomedical research is the primary driver of university bioscience R&D, with health sciences research accounting for 55 percent of research activities, followed by biological and biomedical sciences at 31 percent. Both shares have risen slightly during the strong growth period since 2015.

Leading states in university bioscience R&D tend to be larger and have multiple research universities Each of the five states with the most R&D activity exceeded $2 billion in expenditures in 2018 (Table 5). California is not only the leading state in university research, but is also among the fastest growing since 2016. Utah led all states in its percentage increase since 2016 at 61 percent growth.

Table 5: Leading States in Academic Bioscience R&D Expenditures and Growth

Academic Bioscience R&D Expenditures, 2018	
Leading States	**Total R&D Expenditures ($ Billions)**
California	$6.644
New York	$4.409
Texas	$3.550
Pennsylvania	$2.767
North Carolina	$2.352
Maryland	$1.932
Massachusetts	$1.813
Illinois	$1.561
Michigan	$1.536
Florida	$1.530

Academic Bioscience R&D Growth, 2016-18	
Leading States	**Growth Rate, %**
Utah	61.4%
Nevada	32.1%
New Jersey	32.0%
Maine	28.6%
Montana	27.2%
Arizona	26.1%
California	19.9%
Alaska	18.5%
South Dakota	18.0%
Rhode Island	17.3%

Source: TEConomy Partners analysis of National Science Foundation (NSF), National Center for Science and Engineering Statistics, Higher Education Research and Development (HERD) Survey.

There are other states which stand out in the intensiveness of university bioscience R&D relative to the size of their populations, and as a component of their overall science and engineering research complex. Per capita expenditures in Washington, DC reflect the presence of two major research institutions while smaller states like Connecticut, Nebraska, Vermont, and New Hampshire lead relative to their size (Table 6). For several other states, the biosciences account for the vast majority of overall expenditures, which can be as high as 80 percent or greater in several cases.

Table 6: Leading States in Per Capita and Concentration of Academic Bioscience R&D Expenditures, 2018

Per Capita Expenditures		Share of Total Science & Engineering R&D	
Leading States	$ Per Capita	Leading States	% Share
District of Columbia	$507	Missouri	84.4%
Maryland	$320	Vermont	83.9%
Connecticut	$282	Connecticut	80.6%
Massachusetts	$263	Arkansas	80.3%
North Carolina	$227	Kentucky	79.9%
New York	$226	North Carolina	75.8%
Pennsylvania	$216	Nebraska	75.0%
Nebraska	$194	Oregon	73.5%
Vermont	$179	Minnesota	71.9%
New Hampshire	$179	Wisconsin	70.4%

Source: TEConomy Partners analysis of National Science Foundation (NSF), National Center for Science and Engineering Statistics, Higher Education Research and Development (HERD) Survey.

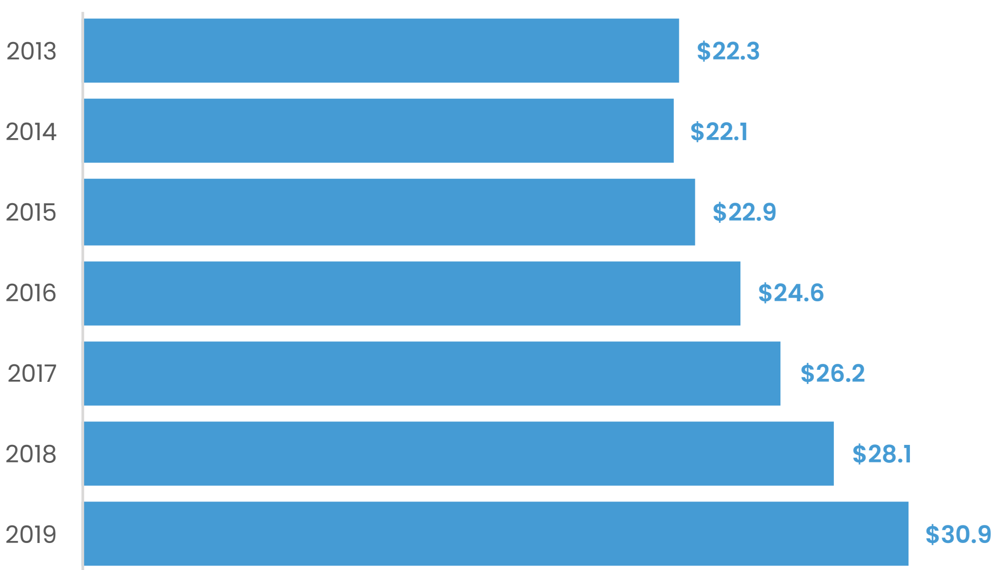
NIH Research Funding Returns to Steady Growth

Funding for university R&D originates from several major sources including the federal government, non-profit organizations, internal institutional funds, business, state and local governments, and others. University research funding in biosciences is relatively evenly split between federal (52 percent) and non-federal sources (48 percent). The vast majority of the federal funding is allocated through the Department of Health and Human Services, and within that, originates from the National Institutes of Health (NIH).

In 2019, NIH awarded nearly $31 billion in extramural research and related funding to universities, hospitals, medical research institutes, and industry (Figure 9). This continues a steady growth trend over the last 4 years following flat or declining research funding in the early part of the decade. Since 2015, annual growth in NIH funding has averaged 7.8 percent.

Nine states had institutions and researchers with combined NIH awards exceeding $1 billion in 2019 (Table 7). Among these states, Massachusetts and Maryland are smaller states with very high per capita concentrations of funding that reach levels three to four times higher than the national average ($94 per capita). While national NIH funding grew by 25 percent from 2016-19, a number of states far exceeded that growth rate including Maine, West Virginia, and Rhode Island, where each grew nearly 50 percent. Arizona had growth just over 60 per-cent. While these gains are impressive in their own right, high percentage growth can reflect a modest base from which it grew. This makes North Caroli-na's growth particularly impressive given it is both a leading state and among the highest growth states.

Figure 9: National Institutes of Health Awards, FY 2013-19 ($ in billions)



Source: TEConomy Partners analysis of National Institutes of Health RePORT data.

Table 7: Leading States in NIH Funding, FY 2019

Total NIH Funding, 2019		Per Capita NIH Funding		NIH Funding Growth, 2016-19	
Leading States	Total Funding ($ Billions)	Leading States	$ Per Capita	Leading States	Growth Rate, %
California	$4.592	Massachusetts	$439	Arizona	60.9%
Massachusetts	$3.024	District of Columbia	$349	Maine	48.0%
New York	$2.892	Maryland	$318	West Virginia	48.0%
Pennsylvania	$1.944	Rhode Island	$207	Rhode Island	45.7%
Maryland	$1.920	Connecticut	$169	Oregon	45.4%
North Carolina	$1.590	Pennsylvania	$152	Virginia	44.8%
Texas	$1.370	North Carolina	$152	Indiana	44.0%
Washington	$1.135	Washington	$149	Puerto Rico	40.2%
Illinois	$1.012	New York	$149	Kentucky	39.8%
Ohio	$0.883	California	$116	North Carolina	37.7%

Source: TEConomy Partners analysis of National Institutes of Health RePORT data.

Patent Activity Signals Increasing Bioscience Innovation

Inventing and successfully commercializing a biomedical therapy or medical device is uniquely challenging. Scientific rigor is challenging in its own right; but one must also consider the sensitive and complex nature of biomedical therapies and patient interactions with those therapies. This requires meeting and fulfilling staunch regulatory requirements for clinical trials and manufacturing that in-turn require a lengthy time horizon unlike any other product category. At the end of this risky and costly process, a firm must be confident that its intellectual property will be protected.

Patents offer a legal framework for protecting valuable intellectual property (IP), which in the biopharmaceutical sector can represent significant time and resources invested in development of a novel therapeutic. Patent analysis provides a window into those areas in which major investments are concentrated and where innovation is emerging.

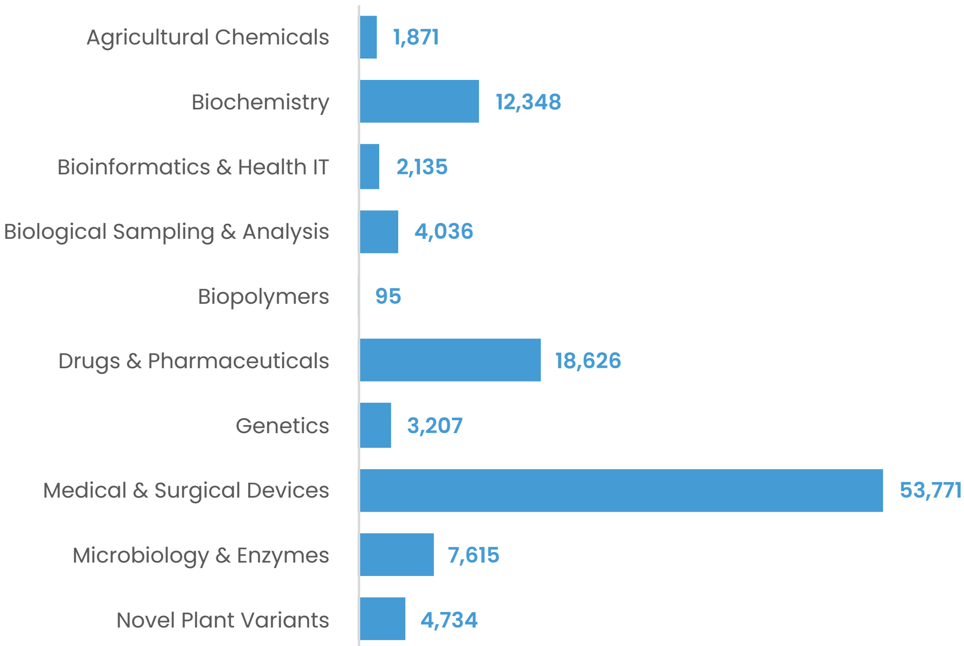
American inventors, from 2016 through 2019, were associated with more than 108,000 U.S. patents awarded in bioscience-related classes and categories (Figure 10). Despite a dip in 2018, patent awards have grown by 17 percent since 2016, or 5.6 percent annually, to reach nearly 30,000 patents in 2019.

The impressive breadth of bioscience innovation is illustrated in Figure 11. It shows the cumulative patent totals for medical devices and drugs and pharmaceuticals as clear leaders, and it also shows innovation taking place in bioinformatics, genetics, and ag biotech. Since 2016, nearly one in two U.S. bioscience patents were in medical and surgical device classes. This includes a very wide range of products from biomedical imaging and ultrasound

Figure 10: Bioscience-related U.S. Patents, 2016-19

Source: TEConomy Partners analysis of U.S. Patent & Trademark Office data from Clarivate Analytics' Derwent Innovation patent analysis database.

Figure 11: Bioscience-related U.S. Patents by Segment, Cumulative 2016-19



Source: TEConomy Partners analysis of U.S. Patent & Trademark Office data from Clarivate Analytics' Derwent Innovation patent analysis database.

therapies, to dental, veterinary, and surgical instruments, and orthopedic equipment and implantable devices. Emerging areas of bioscience patenting include areas with fewer, but rapidly rising, patent awards such as bioinformatics and health IT, biological sampling and analysis, and genetics.

California is a well-established state leader in bioscience patenting accounting for 30 percent of all patent awards during the 4-year period (Table 8). Massachusetts also stands out for its overall level of patents, as well as its high concentration of award activity relative to its size. Several other states have a strong per capita innovation basis including Minnesota, New Hampshire, Connecticut, Rhode Island, Delaware, and Maryland.

Table 8: Leading States-Bioscience-Related Patents

Patent Totals, 2016-19	
Leading States	**Total Patents**
California	32,299
Massachusetts	13,003
New York	7,592
New Jersey	7,374
Pennsylvania	7,222
Minnesota	6,603
Florida	5,459
Ohio	5,208
Texas	4,950
Illinois	4,292

Patents Per 1M Population	
Leading States	**Per 1M Population**
Massachusetts	532
Minnesota	307
New Hampshire	276
Connecticut	267
California	229
Rhode Island	218
New Jersey	215
Delaware	193
District of Columbia	171
Maryland	171

Source: TEConomy Partners analysis of U.S. Patent & Trademark Office data from Clarivate Analytics' Derwent Innovation patent analysis database.

Table 9 shows the breadth of bioscience innovation and specific niche strengths among states. Several states are leaders in many innovation segments, including: California, Florida, Illinois, Massachusetts, New Jersey, New York, Pennsylvania, and Texas.

Other states demonstrate more focused strengths such as: Indiana in agricultural chemicals, Iowa in novel plant variants, Michigan in biopolymers, Minnesota in medical devices, or Missouri in genetics.

Table 9: Leading States in Bioscience-related Patents by Class Group, 2016-19

State	Total Bio-sciences	Agri-cultural Chemicals	Biochem-istry	Bioinfor-matics & Health IT	Biological Sampling & Analysis	Biopoly-mers	Drugs & Pharma-ceuticals	Genetics	Medical & Surgical Devices	Microbi-ology & Enzymes	Novel Plant Variants
AZ						●					
CA	●	●	●	●	●		●	●	●	●	●
CT			○								
FL	○	○		○	○	●	○		●		○
GA						○					
IL	○	●	○	●		○				○	●
IN		●						○	○		○
IA								○			●
MD			○		●		○	●		●	
MA	●		●	●	●	○	●	●	●	●	
MI						●					○
MN	○	○				●			●		●
MO								●			○
NE											○
NJ	●	○	●	○	●		●		○	○	
NY	●	○	●	●	●	●	●	●	○	●	
NC		●	○	○			○	○		○	
OH	○				○	○	○		●		
PA	●	●	●	○	○		●	○	○	●	
TX	○	○		●	○	○	○	○	○	○	
WA			○	○	○						
WI										○	●

Note: a shaded circle signifies the state ranks in the top 5 and an open circle signifies a ranking in the next 5 for that particular patent class group.
Source: TEConomy Partners analysis of U.S. Patent & Trademark Office data from Clarivate Analytics' Derwent Innovation patent analysis database.

Bioscience Venture Capital Investments Reach New Highs, Funding Shifts Towards Earlier Stages

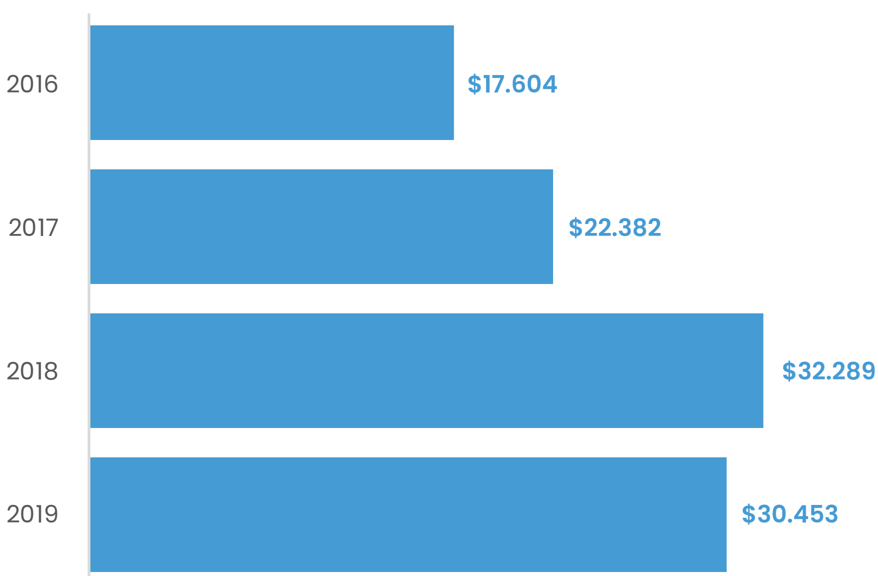
The availability of investment capital is critical for advancing and sustaining industry development; and for an innovation-intensive and science-driven industry such as the biosciences, it is especially important for companies navigating lengthy time horizons to achieve commercial viability. Access to seed- and early-stage capital is especially important to sustain product development and where relevant, to conduct and meet rigorous pre-clinical and clinical testing requirements.

Venture capital (VC) investments in U.S. bioscience companies exceeded $102 billion over the latest four-year period, reflecting an increasing trendline and new highs. This is despite year-to-year variability in investment totals that is common (Figure 12). In both 2018 and 2019, bioscience-related investments reached new heights, exceeding $30 billion in both years.

The bioscience industry share of total U.S. VC funding remained relatively constant in recent years, averaging 25 percent of investment funding since 2016. This matches the average bioscience share over the last two decades. A similar consistency exists with respect to deal volume, where the biosciences accounted for 20 percent of deal activity in the 2016-19 period, which is just slightly above the 19 percent average since 2001. The industry share of total VC deals has risen compared with the prior 4-year period (2012-15) where bioscience companies share of all VC deals averaged 17 percent.

In general, later-stage VC investments tend to be significantly larger compared with those at the earliest stages, though deal volume tends to be higher as investors fund smaller rounds often across several tranches. In the latest four-year period, pre-seed through early-stage investment dollars directed toward the biosciences matched the level

Figure 12: Bioscience-related Venture Capital Investments, 2016-19 ($ in Billions)



Source: TEConomy Partners analysis of PitchBook Data, Inc.

Table 10: U.S. Bioscience Venture Capital Investments by Stage, 2016-2019

Stage	Number of Deals	Number of Companies	Total VC Investments ($ Millions)	Average Investment Per Deal ($ Millions)	Average Investment Per Company ($ Millions)
Pre-Seed	2,782	2,039	$155	$0.06	$0.08
Angel	1,847	1,465	$3,025	$1.64	$2.06
Seed	1,465	1,231	$3,287	$2.24	$2.67
Early Stage	3,150	2,350	$44,797	$14.22	$19.06
Later Stage	2,312	1,555	$51,465	$22.26	$33.10
Total	**11,556**	**6,660**	**$102,728**	**$8.89**	**$15.42**

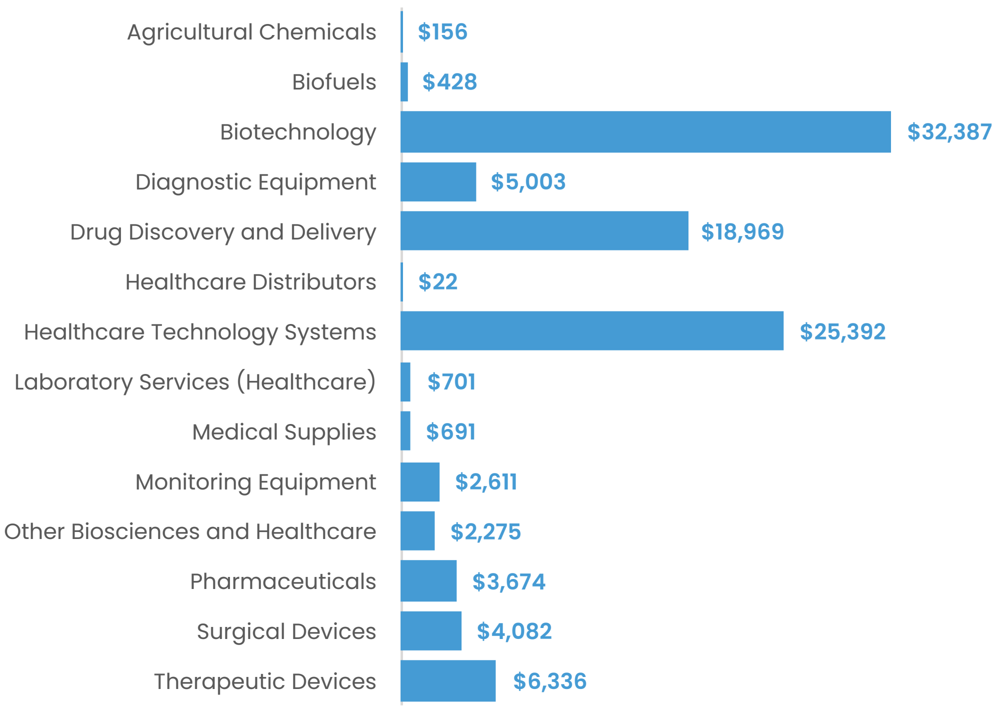
Note: Company totals by stage will not sum to the total as individual companies progress in their stage and often receive multiple investments during a multi-year time frame. Pre-Seed stage includes accelerator, incubator and even crowdfunding-based sources.
Source: TEConomy Partners analysis of PitchBook Data, Inc.

of those invested in later-stage companies, which is a 50-50 split (Table 10). This proportion of funding in earlier-stage companies in the last four years is above the two-decade average of 45 percent, representing a positive shift toward the key earlier stage investments.

Within bioscience VC investments, 54 percent of cumulative investment dollars since 2016 have been directed toward companies engaged in biopharmaceutical development spanning the biotechnology, drug discovery and delivery, and pharmaceuticals segments (Figure 13). One of every four investment dollars went to companies in healthcare technology solutions or to digital health firms.

Bioscience VC investments continue to be highly concentrated in two states—California and Massachusetts, which combined account for 63 percent of the national totals since 2016. Eight of the ten states with the largest VC funding totals exceeded $2 billion during this time period (Table 11). Several other, smaller states stand out for their per capita concentrations in VC investments including Connecticut, Utah, Delaware, and Maryland.

Figure 13: Bioscience-related Venture Capital Investments by Segment, 2016-19 ($ in Millions)



Source: TEConomy Partners analysis of PitchBook Data, Inc.

Table 11: Leading States in Bioscience Venture Capital Investments

Total VC Investments, 2016-19		Per Capita VC Investments	
Leading States	**Total ($ Billions)**	**Leading States**	**$ Per Capita**
California	$42.873	Massachusetts	$3,210
Massachusetts	$22.126	California	$1,085
New York	$6.862	Connecticut	$474
Pennsylvania	$3.476	New York	$353
Illinois	$2.739	Washington	$314
Washington	$2.393	Utah	$306
Texas	$2.337	Delaware	$300
New Jersey	$2.291	Pennsylvania	$272
Connecticut	$1.689	Maryland	$266
Maryland	$1.606	New Jersey	$258

Source: TEConomy Partners analysis of PitchBook Data, Inc.

Table 12 presents the leading states in bioscience VC investments by individual industry/technology segment.

Table 12: Leading States in Bioscience Venture Capital Investments by Segment, 2016-19

State	Agricultural Chemicals	Biofuels	Biotechnology	Diagnostic Equipment	Drug Discovery and Delivery	Healthcare Distributors	Healthcare Technology Systems	Laboratory Services	Medical Supplies	Monitoring Equipment	Other Biosciences and Healthcare	Pharmaceuticals	Surgical Devices	Therapeutic Devices
CA	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CO	●	●							●					
CT				●				●						
FL													●	
GA											●			
IL		●					●			●				
IN						●								
MD	●				●									
MA	●	●	●	●	●		●		●	●	●	●	●	●
MI	●			●		●								
MN													●	●
MO								●						
NJ							●					●		
NY		●	●		●		●	●	●	●				
NC			●											
OH											●	●		
PA			●	●	●	●			●				●	●
TX						●		●			●	●		
WA										●				●

Source: TEConomy Partners analysis of PitchBook Data, Inc.

State and Metropolitan Area Performance Across the Bioscience Industry Subsectors

This section provides an in-depth examination of the employment position and recent performance trends for states across each of the five major bioscience industry subsectors. To determine the size and relative employment concentration within each subsector, data were tabulated for each state, the District of Columbia, Puerto Rico, and every U.S. Metropolitan Statistical Area (MSA). In addition, employment gains and declines were calculated to highlight recent trends.

The key metrics used in this section include:

Employment size measuring 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 percent of national employment are designated "large"; states with more than 3 percent but less than 5 percent are referred to as "sizable."
- For metropolitan regions, a table is included for each subsector presenting the top 25 metropolitan regions in total employment.

Employment concentration is a useful way in which to gauge the concentration of a region's employment 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 1.00 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.
- For metropolitan regions, a table is provided presenting the top 15 metropolitan areas according to LQs, based on the size of the region (either small, medium or large).

The level of **employment growth or loss** over the 2016 to 2018 period provides a way to measure the performance of a state's bioscience industry. In this analysis, job growth or job loss was measured by absolute employment gains or losses, since percentage changes may overstate trends in those states with a smaller subsector employment base.

Agricultural Feedstock & Industrial Biosciences

The agricultural feedstock and industrial biosciences subsector applies life sciences knowledge, biochemistry, and biotechnologies to the processing and production of agricultural goods as well as organic and agricultural chemicals. The subsector also includes activities around the production of biofuels and feedstocks for biobased polymers.

Examples of Products

- Fertilizers, pesticides, herbicides, fungicides and agricultural microbials
- Corn and soybean oil
- Ethanol and biodiesel fuels
- Organic chemicals made from renewable resources or through biological processes
- Polymers, plastics and textiles synthesized from plant-based feedstock or through biological processes
- Biocatalysts
- Biobased ingredients for cosmetics, personal care products, flavors and fragrances

Examples of Companies

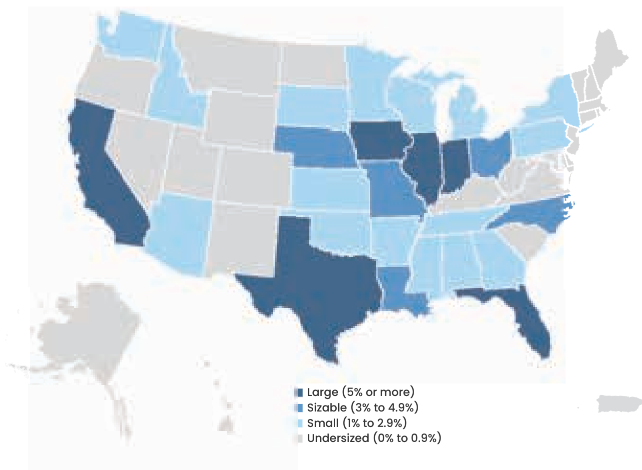
- Amyris
- BASF Enzymes
- Bayer CropScience
- Corteva Agriscience
- Evolva
- Genus
- Novozymes
- Poet
- Scotts Miracle-Gro
- Simplot Plant Sciences
- Syngenta

States that are Both Large and Specialized*

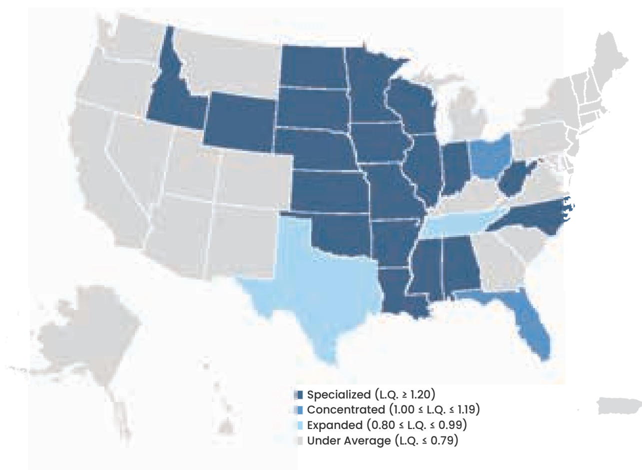
- Illinois
- Iowa
- Indiana

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

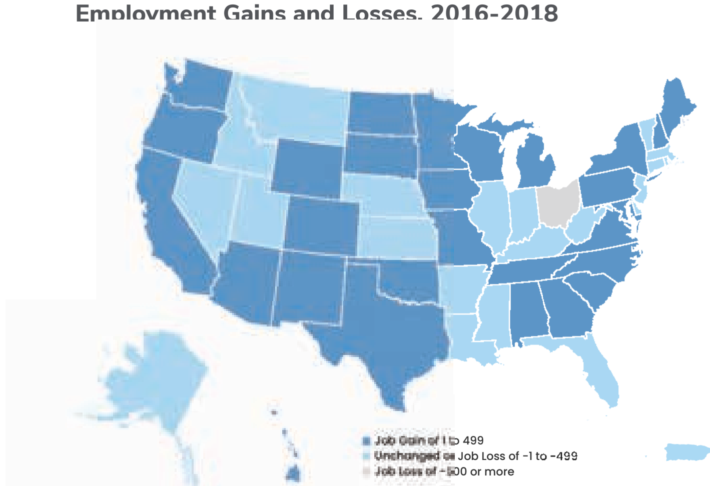
State Share of Total U.S. Employment, 2018



Employment Concentration Relative to the U.S., 2018



Employment Gains and Losses, 2016-2018



Agricultural Feedstock & Industrial Biosciences

State Leaders & Highlights

Employment Size: Employment is relatively concentrated in the top 11 states, which account for 67 percent of employment in this subsector. Those states are:

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

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

- **Specialized States:** Iowa, Nebraska, South Dakota, Illinois, Louisiana, North Dakota, Wyoming, Idaho, Indiana, Missouri, Kansas, Alabama, Oklahoma, Arkansas, Mississippi, Minnesota, Wisconsin, West Virginia, North Carolina
- **Concentrated States:** Florida, Ohio

Employment Growth: Over the 2016 to 2018 time period, 28 states experienced some increase in subsector employment, with California, New York, Wisconsin, and Georgia experiencing the largest gains.

Large and Specialized States: Three states have both large employment shares and a specialized concentration of jobs in agricultural feedstock and industrial biosciences (Table 13).

Table 14: Metropolitan Statistical Areas with the Largest Employment Levels in Agricultural Feedstock and Industrial Biosciences, 2018

Metropolitan Statistical Area	2018 Employment
Decatur, IL	5,246
Chicago-Naperville-Elgin, IL-IN-WI	1,984
Houston-The Woodlands-Sugar Land, TX	1,782
Lakeland-Winter Haven, FL	1,776
Baton Rouge, LA	1,311
Cedar Rapids, IA	1,181
Indianapolis-Carmel-Anderson, IN	914
Omaha-Council Bluffs, NE-IA	879
New Orleans-Metairie, LA	844
Tampa-St. Petersburg-Clearwater, FL	825
Memphis, TN-MS-AR	760
Kansas City, MO-KS	689
Sioux City, IA-NE-SD	679
New York-Newark-Jersey City, NY-NJ-PA	669
St. Louis, MO-IL	634
Des Moines-West Des Moines, IA	608
Columbus, OH	587
Lafayette-West Lafayette, IN	583
Madison, WI	524
Mobile, AL	487
St. Joseph, MO-KS	475
Dallas-Fort Worth-Arlington, TX	468
Orlando-Kissimmee-Sanford, FL	453
Fresno, CA	447
Sacramento-Roseville-Folsom, CA	446

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

Table 13: States with Large and Specialized Employment in Agricultural Feedstock and Industrial Biosciences, 2018

State	Establishments, 2018	Employment, 2018	Location Quotient, 2018	Share of U.S. Employment
Illinois	78	8,463	2.97	12.3%
Iowa	125	7,999	11.14	11.7%
Indiana	58	3,443	2.36	5.0%

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

Table 15: Metropolitan Statistical Areas with the Highest Location Quotients in Agricultural Feedstock and Industrial Biosciences, by Size of MSA, 2018

Metropolitan Statistical Area	Location Quotient	2018 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Baton Rouge, LA	7.26	1,311
Omaha-Council Bluffs, NE-IA	3.78	879
Des Moines-West Des Moines, IA	3.35	608
New Orleans-Metairie, LA	3.19	844
Madison, WI	3.04	524
Memphis, TN-MS-AR	2.52	760
Fresno, CA	2.49	447
Indianapolis-Carmel-Anderson, IN	1.83	914
Knoxville, TN	1.63	294
Albany-Schenectady-Troy, NY	1.61	317
Dayton-Kettering, OH	1.57	277
Kansas City, MO-KS	1.37	689
Tampa-St. Petersburg-Clearwater, FL	1.27	825
Tulsa, OK	1.23	261
Houston-The Woodlands-Sugar Land, TX	1.23	1,782
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Cedar Rapids, IA	17.05	1,181
Lakeland-Winter Haven, FL	16.17	1,776
Lafayette-West Lafayette, IN	13.74	583
Charleston, WV	6.08	329
Fayetteville, NC	5.83	359
Mobile, AL	5.73	487
Beaumont-Port Arthur, TX	5.56	424
Lubbock, TX	5.04	319
Peoria, IL	4.79	415
Bellingham, WA	4.33	183
Stockton, CA	3.63	430
Evansville, IN-KY	3.57	278
Jackson, MS	2.96	346
Santa Cruz-Watsonville, CA	2.67	130
Yakima, WA	2.63	142
Small MSAs (Total Private Employment Less than 75,000)		
Decatur, IL	209.73	5,246
Sioux City, IA-NE-SD	18.39	679
St. Joseph, MO-KS	18.22	475
Mankato, MN	16.04	426
Decatur, AL	14.36	367
Sierra Vista-Douglas, AZ	13.38	172
Hanford-Corcoran, CA	10.97	206
Enid, OK	10.68	124
Greenville, NC	7.68	229
Florence-Muscle Shoals, AL	7.28	183
Twin Falls, ID	7.03	170
Lima, OH	6.74	171
Grand Island, NE	6.21	115
Cheyenne, WY	5.84	106
Pine Bluff, AR	5.78	74

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

Drugs & Pharmaceuticals

The drugs and pharmaceuticals subsector produces commercially available medicinal and diagnostic substances. This 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

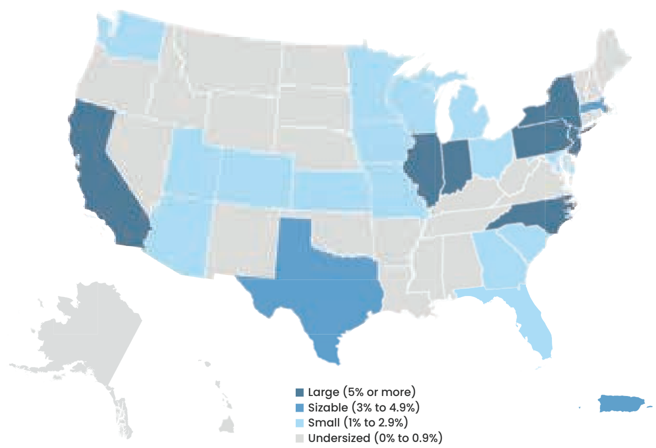
- Acorda Therapeutics
- Alkermes
- Alnylam Pharmaceuticals
- Amgen
- Bayer
- Biogen
- Eli Lilly and Company
- GlaxoSmithKline
- Novo Nordisk
- Pfizer
- Roche Group-Genentech
- Sangamo Therapeutics
- Vertex Pharmaceuticals

States that are Both Large and Specialized*

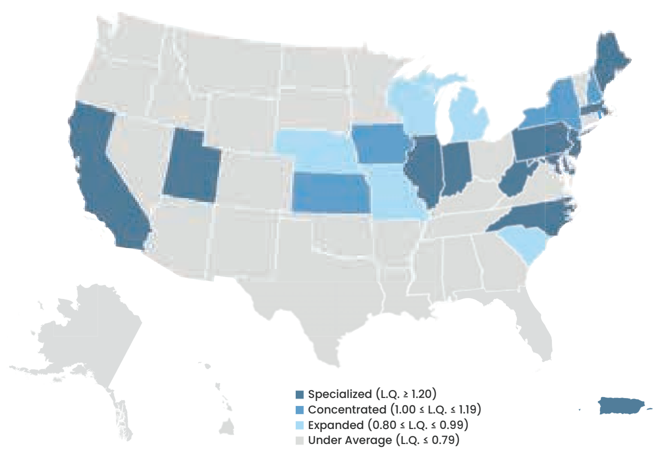
- California
- New Jersey
- North Carolina
- Illinois
- Pennsylvania
- Indiana

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

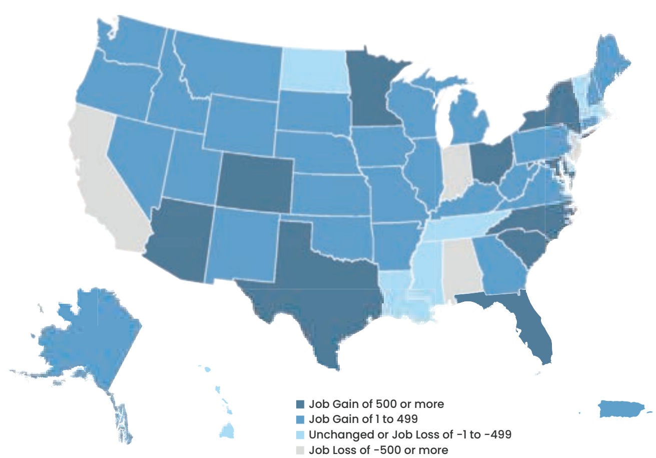
State Share of Total U.S. Employment, 2018



Employment Concentration Relative to the U.S., 2018



Employment Gains and Losses, 2016-2018



Drugs & Pharmaceuticals

State Leaders & Highlights

Employment Size: Drugs and pharmaceuticals manufacturing has a relatively high concentration among the leading states. The six largest employer states in this subsector account for about half of U.S. employment.

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

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

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

Employment Growth: Over the 2016 to 2018 time period, 37 states, DC and Puerto Rico experienced some increase in subsector employment. Of those states, New York, Maryland, South Carolina, North Carolina, and Colorado experienced substantial job increases.

Large and Specialized States: Six states have both a large employment share and a specialized concentration of jobs in drugs and pharmaceuticals (Table 16).

Table 17: Metropolitan Statistical Areas with the Largest Employment Levels in Drugs and Pharmaceuticals, 2018

Metropolitan Statistical Area	2018 Employment
New York-Newark-Jersey City, NY-NJ-PA	32,915
Chicago-Naperville-Elgin, IL-IN-WI	17,551
San Francisco-Oakland-Berkeley, CA	17,093
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	14,177
Los Angeles-Long Beach-Anaheim, CA	11,681
Indianapolis-Carmel-Anderson, IN	11,643
Boston-Cambridge-Newton, MA-NH	9,611
San Diego-Chula Vista-Carlsbad, CA	7,492
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,917
Durham-Chapel Hill, NC	5,713
Dallas-Fort Worth-Arlington, TX	4,614
St. Louis, MO-IL	3,907
Minneapolis-St. Paul-Bloomington, MN-WI	3,754
Vallejo, CA	3,437
Raleigh-Cary, NC	3,230
Kalamazoo-Portage, MI	3,211
San Jose-Sunnyvale-Santa Clara, CA	3,164
Phoenix-Mesa-Chandler, AZ	3,130
Houston-The Woodlands-Sugar Land, TX	2,970
Rocky Mount, NC	2,901
Miami-Fort Lauderdale-Pompano Beach, FL	2,732
Salt Lake City, UT	2,680
Morgantown, WV	2,645
Cincinnati, OH-KY-IN	2,506
Baltimore-Columbia-Towson, MD	2,505

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

Table 16: States with Large and Specialized Employment in Drugs and Pharmaceuticals, 2018

State	Establishments, 2018	Employment, 2018	Location Quotient, 2018	Share of U.S. Employment
California	632	46,694	1.27	15.1%
New Jersey	304	21,950	2.57	7.1%
North Carolina	122	21,705	2.38	7.0%
Illinois	202	20,297	1.59	6.6%
Pennsylvania	138	18,064	1.41	5.9%
Indiana	69	17,093	2.61	5.5%

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

Table 18: Metropolitan Statistical Areas with the Highest Location Quotients in Drugs and Pharmaceuticals, by Size of MSA, 2018

Metropolitan Statistical Area	Location Quotient	2018 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Durham-Chapel Hill, NC	8.82	5,713
Indianapolis-Carmel-Anderson, IN	5.20	11,643
San Francisco-Oakland-Berkeley, CA	3.20	17,093
Madison, WI	2.97	2,297
Albany-Schenectady-Troy, NY	2.48	2,185
San Diego-Chula Vista-Carlsbad, CA	2.41	7,492
Raleigh-Cary, NC	2.40	3,230
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	2.26	14,177
Greenville-Anderson, SC	2.04	1,781
Buffalo-Cheektowaga, NY	1.89	2,172
Worcester, MA-CT	1.85	1,527
Salt Lake City, UT	1.77	2,680
Chicago-Naperville-Elgin, IL-IN-WI	1.73	17,551
New York-Newark-Jersey City, NY-NJ-PA	1.65	32,915
Boston-Cambridge-Newton, MA-NH	1.61	9,611
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Kalamazoo-Portage, MI	11.78	3,211
Vallejo, CA	11.65	3,437
Lafayette-West Lafayette, IN	4.65	886
Trenton-Princeton, NJ	4.61	2,135
Boulder, CO	3.65	1,402
Waco, TX	3.28	817
Provo-Orem, UT	3.24	1,728
Portland-South Portland, ME	2.94	1,764
Lincoln, NE	2.90	1,047
Ogden-Clearfield, UT	2.87	1,477
Fort Collins, CO	2.31	738
Lexington-Fayette, KY	2.20	1,206
Gainesville, GA	2.02	402
Salisbury, MD-DE	1.87	637
Lynchburg, VA	1.86	414
Small MSAs (Total Private Employment Less than 75,000)		
Rocky Mount, NC	24.82	2,901
Morgantown, WV	20.20	2,645
East Stroudsburg, PA	19.12	2,245
Kankakee, IL	16.04	1,546
Bloomington, IN	14.26	1,833
Greenville, NC	12.74	1,708
Decatur, IL	9.34	1,050
St. Joseph, MO-KS	8.96	1,050
Ames, IA	5.88	564
Lebanon, PA	5.33	576
Athens-Clarke County, GA	5.08	851
Harrisonburg, VA	4.81	661
Logan, UT-ID	3.63	429
Terre Haute, IN	2.79	403
Winchester, VA-WV	2.05	270

Source: TEConomy Partners analysis of U.S. 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 healthcare 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

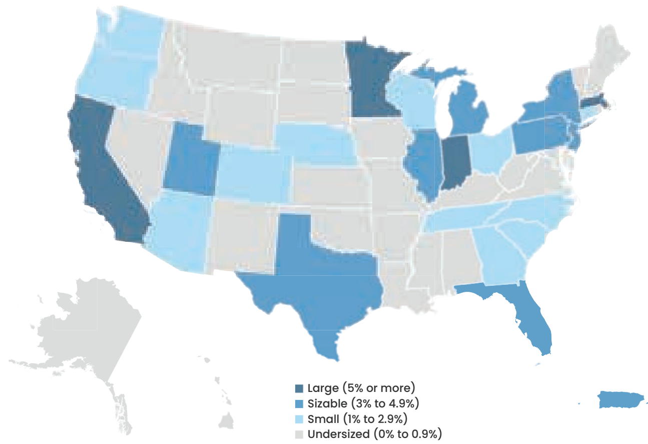
- 3M Health Care
- Auris Health
- Baxter
- Boston Scientific Corp.
- Cook Medical
- DuPuy Synthes
- GE Healthcare
- INSIGHTEC
- Medtronic
- Outset Medical
- Regenesis Biomedical
- Stryker
- Zimmer Biomet

States that are Both Large and Specialized*

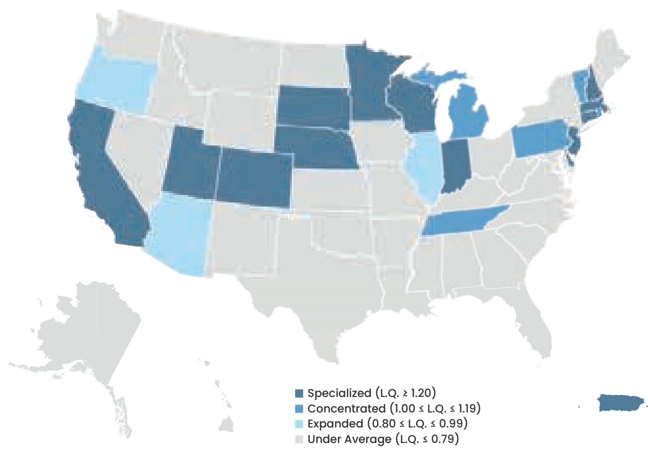
- California
- Minnesota
- Massachusetts
- Indiana

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

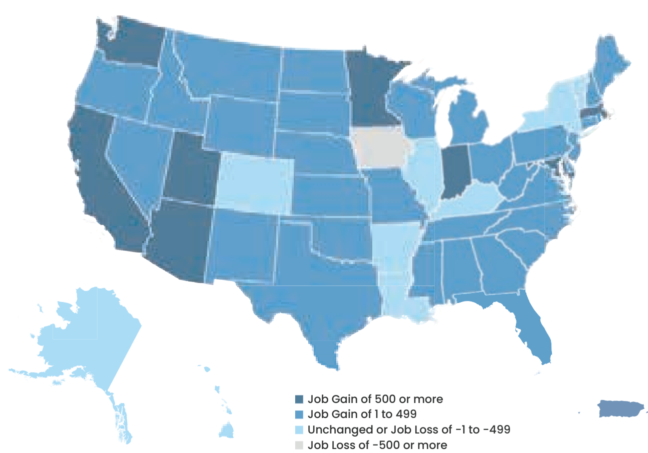
State Share of Total U.S. Employment, 2018



Employment Concentration Relative to the U.S., 2018



Employment Gains and Losses, 2016-2018



Medical Devices & Equipment

State Leaders & Highlights

Employment Size: The medical device subsector has a well-distributed geographic footprint, with large or sizable states from every region. The top ten employing states continue to account for almost 60 percent of employment in this subsector.

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

Employment Concentration: Thirteen 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, Delaware, South Dakota, Nebraska, Connecticut, California, Colorado, New Hampshire, Wisconsin, New Jersey
- **Concentrated States:** Tennessee, Rhode Island, Vermont, Michigan, Pennsylvania

Employment Growth: Over the 2016 to 2018 time period, 40 states and Puerto Rico experienced some increase in subsector employment with nine states having substantial increases led by California, Indiana, Massachusetts, and Utah.

Large and Specialized States: Four states have both a large employment share and a specialized concentration of jobs in medical devices and equipment (Table 19).

Table 20: Metropolitan Statistical Areas with the Largest Employment Levels in Medical Devices and Equipment, 2018

Metropolitan Statistical Area	2018 Employment
Los Angeles-Long Beach-Anaheim, CA	29,800
Minneapolis-St. Paul-Bloomington, MN-WI	27,486
Boston-Cambridge-Newton, MA-NH	17,752
New York-Newark-Jersey City, NY-NJ-PA	15,791
Chicago-Naperville-Elgin, IL-IN-WI	12,422
San Francisco-Oakland-Berkeley, CA	10,933
San Diego-Chula Vista-Carlsbad, CA	10,002
San Jose-Sunnyvale-Santa Clara, CA	9,685
Salt Lake City, UT	9,597
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	6,530
Milwaukee-Waukesha, WI	6,189
Memphis, TN-MS-AR	5,935
Seattle-Tacoma-Bellevue, WA	5,369
Pittsburgh, PA	5,334
Cleveland-Elyria, OH	4,433
Denver-Aurora-Lakewood, CO	4,187
Portland-Vancouver-Hillsboro, OR-WA	4,166
Dallas-Fort Worth-Arlington, TX	4,151
Providence-Warwick, RI-MA	3,965
Bloomington, IN	3,898
Raleigh-Cary, NC	3,788
Miami-Fort Lauderdale-Pompano Beach, FL	3,673
Boulder, CO	3,298
Phoenix-Mesa-Chandler, AZ	3,281
New Haven-Milford, CT	3,234

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

Table 19: States with Large and Specialized Employment in Medical Devices and Equipment, 2018

State	Establishments, 2018	Employment, 2018	Location Quotient, 2018	Share of U.S. Employment
California	1,384	70,355	1.56	18.6%
Minnesota	374	28,206	3.74	7.5%
Massachusetts	298	22,370	2.35	5.9%
Indiana	178	18,755	2.33	5.0%

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

Table 21: Metropolitan Statistical Areas with the Highest Location Quotients in Medical Devices and Equipment, by Size of MSA, 2018

Metropolitan Statistical Area	Location Quotient	2018 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Minneapolis-St. Paul-Bloomington, MN-WI	5.26	27,486
Salt Lake City, UT	5.17	9,597
Memphis, TN-MS-AR	3.57	5,935
New Haven-Milford, CT	3.25	3,234
San Jose-Sunnyvale-Santa Clara, CA	3.06	9,685
Milwaukee-Waukesha, WI	2.66	6,189
San Diego-Chula Vista-Carlsbad, CA	2.62	10,002
Boston-Cambridge-Newton, MA-NH	2.42	17,752
Raleigh-Cary, NC	2.30	3,788
Syracuse, NY	2.18	1,664
Providence-Warwick, RI-MA	2.10	3,965
Worcester, MA-CT	2.05	2,077
Bridgeport-Stamford-Norwalk, CT	1.95	2,284
Rochester, NY	1.86	2,501
Los Angeles-Long Beach-Anaheim, CA	1.80	29,800
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Kalamazoo-Portage, MI	9.40	3,146
Boulder, CO	7.00	3,298
Santa Rosa-Petaluma, CA	5.03	2,857
Ocala, FL	3.87	1,078
Naples-Marco Island, FL	3.57	1,504
Gainesville, FL	3.33	1,105
Ogden-Clearfield, UT	3.18	2,007
Reading, PA	2.65	1,271
Colorado Springs, CO	2.57	1,817
Santa Maria-Santa Barbara, CA	2.54	1,316
Saginaw, MI	2.17	499
Huntington-Ashland, WV-KY-OH	2.11	721
Ann Arbor, MI	2.11	875
Manchester-Nashua, NH	2.06	1,181
Utica-Rome, NY	1.89	538
Small MSAs (Total Private Employment Less than 75,000)		
Bloomington, IN	24.72	3,898
Flagstaff, AZ	19.11	2,763
Niles, MI	13.32	2,207
Glens Falls, NY	9.57	1,301
Sumter, SC	7.69	875
State College, PA	6.06	866
Staunton, VA	3.63	454
Corvallis, OR	3.61	315
Sheboygan, WI	2.88	496
Dover, DE	2.66	432
Auburn-Opelika, AL	2.58	351
Lebanon, PA	2.24	298
Logan, UT-ID	2.15	312
Michigan City-La Porte, IN	2.08	220
Grants Pass, OR	1.66	124

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

Research, Testing, & Medical Laboratories

The research, testing, and medical laboratories subsector includes firms performing a range of activities; from highly research-oriented companies working to develop 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. The subsector is closely tied to drugs and pharmaceuticals and unique in that some companies will “graduate” or shift out of the subsector and into drugs and pharmaceuticals when technologies or discoveries are successfully commercialized.

Examples of Products

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

Examples of Companies

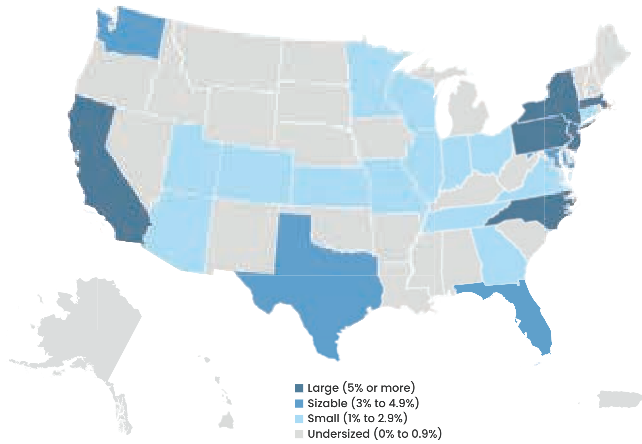
- Charles River Laboratories
- Covance
- IQVIA
- Laboratory Corp. of America
- PPD
- Quest Diagnostics
- Rallybio
- Sema4
- Virent

States that are Both Large and Specialized*

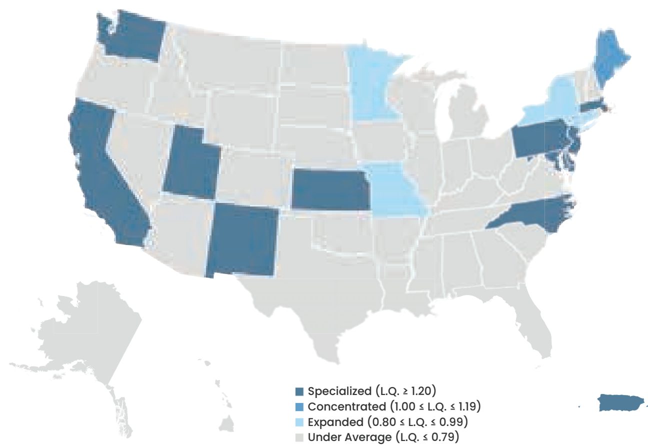
- California
- Massachusetts
- New Jersey
- North Carolina
- Pennsylvania

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

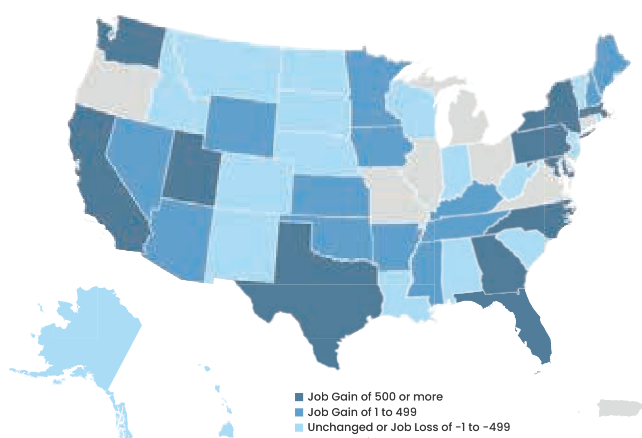
State Share of Total U.S. Employment, 2018



Employment Concentration Relative to the U.S., 2018



Employment Gains and Losses, 2016-2018



Research, Testing, & Medical Laboratories

State Leaders & Highlights

Employment Size: With the largest employment base 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 67 percent of national employment, and the top 14 all have more than 10,000 subsector jobs.

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

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

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

Employment Growth: Over the 2016 to 2018 time period, 24 states experienced some increase in subsector employment. Eleven states experienced substantial increases led by California, Massachusetts, North Carolina, New York, Pennsylvania, and Washington

Large and Specialized States: Five states have both a large employment share and a specialized concentration of jobs in research, testing, and medical laboratories (Table 22).

Table 23: Metropolitan Statistical Areas with the Largest Employment Levels in Research, Testing, and Medical Labs, 2018

Metropolitan Statistical Area	2018 Employment
Boston-Cambridge-Newton, MA-NH	54,677
New York-Newark-Jersey City, NY-NJ-PA	48,767
San Francisco-Oakland-Berkeley, CA	34,745
San Diego-Chula Vista-Carlsbad, CA	27,037
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	26,168
Los Angeles-Long Beach-Anaheim, CA	22,060
Washington-Arlington-Alexandria, DC-VA-MD-WV	21,142
Chicago-Naperville-Elgin, IL-IN-WI	16,008
Seattle-Tacoma-Bellevue, WA	12,467
Durham-Chapel Hill, NC	10,411
San Jose-Sunnyvale-Santa Clara, CA	9,940
Miami-Fort Lauderdale-Pompano Beach, FL	8,925
Minneapolis-St. Paul-Bloomington, MN-WI	7,999
Raleigh-Cary, NC	7,753
Houston-The Woodlands-Sugar Land, TX	7,633
Kansas City, MO-KS	7,320
Salt Lake City, UT	7,319
Baltimore-Columbia-Towson, MD	7,178
Phoenix-Mesa-Chandler, AZ	7,141
Atlanta-Sandy Springs-Alpharetta, GA	6,920
Dallas-Fort Worth-Arlington, TX	6,595
Pittsburgh, PA	5,851
Tampa-St. Petersburg-Clearwater, FL	5,257
St. Louis, MO-IL	5,159
Madison, WI	5,001

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

Table 22: States with Large and Specialized Employment in Research, Testing, and Medical Labs, 2018

State	Establishments, 2018	Employment, 2018	Location Quotient, 2018	Share of U.S. Employment
California	4,623	103,583	1.53	18.2%
Massachusetts	1,881	59,920	4.18	10.5%
New Jersey	1,111	35,324	2.24	6.2%
North Carolina	1,868	32,467	1.92	5.7%
Pennsylvania	1,378	32,260	1.37	5.7%

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

Table 24: Metropolitan Statistical Areas with the Highest Location Quotients in Research, Testing, and Medical Labs, by Size of MSA, 2018

Metropolitan Statistical Area	Location Quotient	2018 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Durham-Chapel Hill, NC	8.70	10,411
Boston-Cambridge-Newton, MA-NH	4.96	54,677
San Diego-Chula Vista-Carlsbad, CA	4.70	27,037
San Francisco-Oakland-Berkeley, CA	3.53	34,745
Madison, WI	3.50	5,001
Raleigh-Cary, NC	3.12	7,753
Salt Lake City, UT	2.62	7,319
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	2.26	26,168
Albuquerque, NM	2.15	3,040
San Jose-Sunnyvale-Santa Clara, CA	2.08	9,940
Greensboro-High Point, NC	1.95	2,855
Worcester, MA-CT	1.87	2,850
Washington-Arlington-Alexandria, DC-VA-MD-WV	1.83	21,142
Kansas City, MO-KS	1.75	7,320
Albany-Schenectady-Troy, NY	1.64	2,667
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Wilmington, NC	4.62	2,258
Kennewick-Richland, WA	4.31	2,075
Trenton-Princeton, NJ	4.29	3,668
Oshkosh-Neenah, WI	2.45	947
Barnstable Town, MA	2.34	895
Boulder, CO	2.29	1,626
St. Cloud, MN	2.10	891
Spokane-Spokane Valley, WA	1.55	1,392
Gainesville, FL	1.41	703
Lafayette-West Lafayette, IN	1.32	466
Lincoln, NE	1.31	875
Columbia, MO	1.30	446
Norwich-New London, CT	1.23	541
South Bend-Mishawaka, IN-MI	1.22	675
Santa Cruz-Watsonville, CA	1.16	470
Small MSAs (Total Private Employment Less than 75,000)		
Burlington, NC	13.03	3,322
California-Lexington Park, MD	2.56	362
Mount Vernon-Anacortes, WA	2.55	474
Logan, UT-ID	1.81	396
Dover, DE	1.74	423
Ithaca, NY	1.50	310
Ames, IA	1.48	262
Morgantown, WV	1.43	345
Lewiston, ID-WA	1.32	136
Brunswick, GA	1.28	209
Bangor, ME	1.08	290
Santa Fe, NM	1.05	227
St. Joseph, MO-KS	1.02	222
Terre Haute, IN	0.97	260
Pueblo, CO	0.95	214

Source: TEConomy Partners analysis of U.S. 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 equipment, and ag biotech products. The subsector leverages and 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
- Plant seeds
- Agricultural chemicals

Examples of Companies

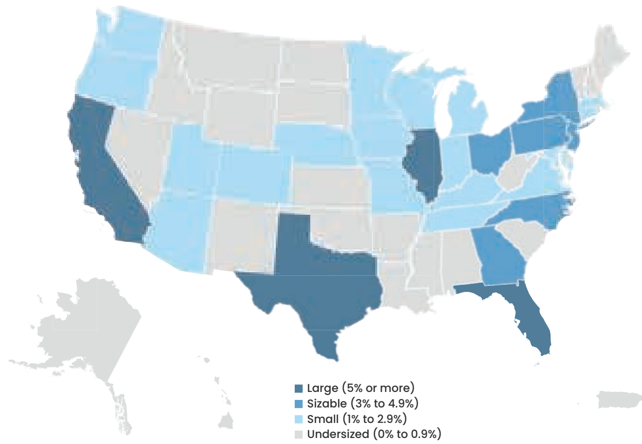
- AmerisourceBergen
- Apria Healthcare
- Cardinal Health
- CuraScript SD
- McKesson
- Omnicare
- Owens & Minor
- Park Seed
- Patterson Companies
- PharMerica Corporation
- Seminis Vegetable Seeds
- Wilbur-Ellis

States that are Both Large and Specialized*

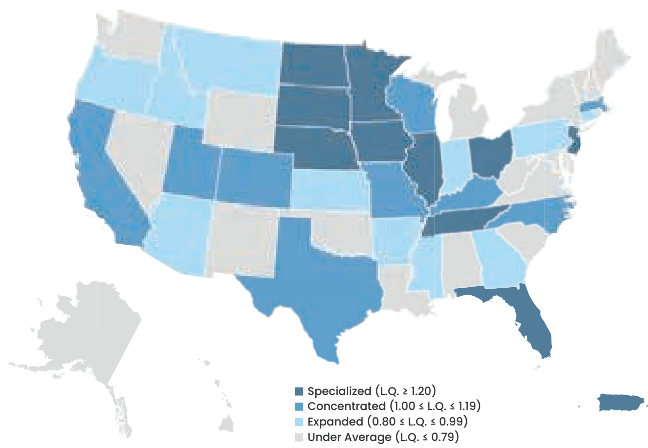
- Florida
- Illinois

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

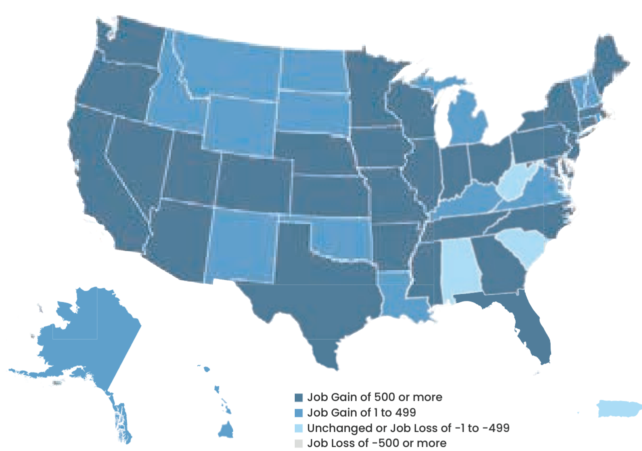
State Share of Total U.S. Employment, 2018



Employment Concentration Relative to the U.S., 2018



Employment Gains and Losses, 2016-2018



Bioscience-Related Distribution

State Leaders & Highlights

Employment Size: The distribution subsector's large employment base is well distributed across the U.S., with the top 10 employing states making up just 57 percent of all employment and every state having a presence to some degree.

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

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

- **Specialized States:** Nebraska, South Dakota, Iowa, North Dakota, Puerto Rico, New Jersey, Minnesota, Tennessee, Illinois, Florida, Ohio
- **Concentrated States:** Colorado, Kentucky, North Carolina, Missouri, Massachusetts, Utah, Wisconsin, California, Texas

Employment Growth: Over the 2016 to 2018 time period, 46 states and the District of Columbia experienced some increase in subsector employment with 21 states having substantial increases led by California, Texas, Ohio, New York, and Florida.

Large and Specialized States: Two states have both a large employment share and a specialized concentration of jobs in bioscience-related distribution (Table 25).

Table 26: Metropolitan Statistical Areas with the Largest Employment Levels in Bioscience-Related Distribution, 2018

Metropolitan Statistical Area	2018 Employment
New York-Newark-Jersey City, NY-NJ-PA	36,518
Los Angeles-Long Beach-Anaheim, CA	29,314
Chicago-Naperville-Elgin, IL-IN-WI	24,472
Dallas-Fort Worth-Arlington, TX	20,962
Miami-Fort Lauderdale-Pompano Beach, FL	19,118
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	12,637
Atlanta-Sandy Springs-Alpharetta, GA	12,445
Houston-The Woodlands-Sugar Land, TX	11,554
Boston-Cambridge-Newton, MA-NH	11,063
Minneapolis-St. Paul-Bloomington, MN-WI	10,851
Phoenix-Mesa-Chandler, AZ	8,871
Columbus, OH	8,176
Denver-Aurora-Lakewood, CO	7,458
St. Louis, MO-IL	7,056
Detroit-Warren-Dearborn, MI	6,534
Riverside-San Bernardino-Ontario, CA	6,210
Nashville-Davidson--Murfreesboro--Franklin, TN	5,917
Memphis, TN-MS-AR	5,822
San Francisco-Oakland-Berkeley, CA	5,731
Seattle-Tacoma-Bellevue, WA	5,627
Tampa-St. Petersburg-Clearwater, FL	5,521
San Diego-Chula Vista-Carlsbad, CA	5,490
Raleigh-Cary, NC	5,199
Cincinnati, OH-KY-IN	5,092
Charlotte-Concord-Gastonia, NC-SC	5,042

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

Table 25: States with Large and Specialized Employment in Bioscience-Related Distribution, 2018

State	Establishments, 2018	Employment, 2018	Location Quotient, 2018	Share of U.S. Employment
Florida	3,348	41,053	1.24	7.53%
Illinois	2,132	29,905	1.32	5.49%

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

Table 27: Metropolitan Statistical Areas with the Highest Location Quotients in Bioscience-Related Distribution, by Size of MSA, 2018

Metropolitan Statistical Area	Location Quotient	2018 Employment
Large MSAs (Total Private Employment Greater than 250,000)		
Memphis, TN-MS-AR	2.43	5,822
Des Moines-West Des Moines, IA	2.27	3,262
Raleigh-Cary, NC	2.19	5,199
Columbus, OH	2.09	8,176
Oxnard-Thousand Oaks-Ventura, CA	1.94	2,451
Miami-Fort Lauderdale-Pompano Beach, FL	1.87	19,118
Nashville-Davidson--Murfreesboro--Franklin, TN	1.57	5,917
Dallas-Fort Worth-Arlington, TX	1.51	20,962
Louisville/Jefferson County, KY-IN	1.45	3,622
Minneapolis-St. Paul-Bloomington, MN-WI	1.44	10,851
Greensboro-High Point, NC	1.43	2,004
Allentown-Bethlehem-Easton, PA-NJ	1.38	1,987
Chicago-Naperville-Elgin, IL-IN-WI	1.37	24,472
Toledo, OH	1.36	1,619
Durham-Chapel Hill, NC	1.36	1,555
Medium MSAs (Total Private Employment Between 75,000 and 250,000)		
Naples-Marco Island, FL	3.22	1,951
Springfield, IL	2.65	959
Port St. Lucie, FL	2.33	1,328
Poughkeepsie-Newburgh-Middletown, NY	2.03	1,919
Provo-Orem, UT	1.93	1,818
Fargo, ND-MN	1.76	930
Visalia, CA	1.71	1,008
Trenton-Princeton, NJ	1.69	1,386
Fort Collins, CO	1.64	925
Lakeland-Winter Haven, FL	1.57	1,366
Santa Cruz-Watsonville, CA	1.51	587
Sioux Falls, SD	1.50	912
Greeley, CO	1.47	608
Boulder, CO	1.44	979
Stockton, CA	1.42	1,337
Small MSAs (Total Private Employment Less than 75,000)		
Albany-Lebanon, OR	4.30	772
El Centro, CA	3.00	597
Morgantown, WV	2.70	624
Ames, IA	2.20	373
Jonesboro, AR	2.15	463
Hammond, LA	2.06	299
Texarkana, TX-AR	1.71	345
Bloomington, IN	1.65	375
Iowa City, IA	1.62	435
Hanford-Corcoran, CA	1.48	220
St. Joseph, MO-KS	1.43	296
Jackson, TN	1.39	394
Danville, IL	1.38	130
Yuma, AZ	1.25	294
Grand Island, NE	1.18	173

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

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 2018. 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, IMPLAN Group, LLC (IMPLAN).

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. 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, 18 years of NAICS-based data (2001-2018) 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. Five of the detailed NAICS industries, Testing Laboratories (NAICS 541380); Research and Development in Nanotechnology (541713); Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology) (541715); 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 the most current available data from the U.S. Census Bureau's Economic Census.

Table A-1. Bioscience Industry Definition

Bioscience Subsector	NAICS Code	NAICS Description
Agricultural Feedstock & Industrial Biosciences	311221	Wet Corn Milling
	311224	Soybean and Other Oilseed Processing
	325193	Ethyl Alcohol 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
	541713*	Research and Development in Nanotechnology
	541714	Research and Development in Biotechnology (except Nanobiotechnology)
	541715*	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
	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

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

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 most data for Puerto Rico are from TEConomy's enhanced QCEW file from IMPLAN.

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

Industry Economic Impacts and Employment Multipliers

The economic impact of the U.S. bioscience industry is estimated using national employment at a detailed industry sector level as inputs; and was developed using a custom national Input/Output (I/O) model from IMPLAN. The IMPLAN model's data matrices track the flow of commodities to industries from producers and institutional consumers within the nation. The data also model consumption activities by workers, owners of capital and imports. The inter-industry trade flows built into the model permit estimating the impacts of one sector on all other sectors with which it interacts. The model's outputs, which are the impacts typically measured in an economic impact study, are the expenditure impacts of the bioscience industry. They quantify direct and indirect job creation, associated personal incomes, business output and associated revenues to federal, state, and local taxing jurisdictions.

Separately, employment multipliers generated from IMPLAN's state level Input/Output models were used to estimate the employment effect on all other industries of adding bioscience jobs at the state level. It is important to note that, like all impact models, Input/Output models provide an approximate order-of-magnitude estimate of impacts. State level multipliers and the resulting estimated employment impacts are shown in each state profile table for each major bioscience subsector.

Bioscience Academic R&D Expenditures

Based upon data from the National Science Foundation's (NSF) Higher Education Research and Development Survey, national and state totals (summation of all state's responding institutions) are calculated for FY 2018 (most current year available) as well as the previous two years (FY 2016 – FY 2017). Data are provided for total R&D expenditures (including per capita measures) as well as in chart form for the bioscience fields including Health Sciences, Biological and Biomedical Sciences, Agricultural Sciences, Bio/Biomedical Engineering, Natural Resources and Conservation 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 extramural funding data for FY 2019 (the most current full year available) and for previous years 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 extramural funding, growth from FY 2016 through FY 2019 and FY 2019 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, are often the largest and typically the most publicly known and reported source of investment funds allowing for comparability among states.

Venture capital data were collected using the PitchBook venture capital database capturing all venture capital (including "Angel" and pre-seed investment activity) from January 1, 2016 through December 31, 2019. The analysis includes selected investments categorized in PitchBook in the Healthcare industry sector, including all companies in Healthcare Devices and Supplies, Healthcare Technology Systems, Pharmaceuticals and Biotechnology and Other Healthcare as well as all additional companies included in PitchBook's Digital Health and HealthTech industry verticals. Only Healthcare Distributors and Laboratory Services companies are included from PitchBook's Healthcare Services industry group; but the analysis excludes hospitals, clinics, elder care facilities and other healthcare service companies. Investments in Agricultural Chemicals within PitchBook's Materials and Resources industry sector were also included. Additionally, specific investments in venture capital deals related to ethanol/biofuel/biodiesel-related companies were included from the Alternative Energy Equipment and Energy Production industry codes located within the Energy sector in PitchBook.

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.

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 currently 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 uses 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.

The United States Patent and Trademark Office (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 UPSTO 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. TEConomy uses this CPC scheme to group US-invented patents into broader bioscience patent class groups for the purposes of bioscience innovation trends analysis.

Patent data were collected using the Clarivate Analytics' Derwent Innovation patent analysis database and includes all granted patents from January 1, 2016 through December 31, 2019 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

Bioscience Patent Class Group	Patent Class	Patent Class Description
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

Bioscience Patent Class Group	Patent Class	Patent Class Description
Bioinformatics & Health IT	G16B	Bioinformatics
	G06F 19/3	Medical informatics and clinician decision support tools
	G16H	General health IT systems and software
	G06Q 50/24	Patient record data management
Biological Sampling & Analysis	G01N 24	Assays (e.g. immunoassays or enzyme assays)
	G01N 25	Screening methods for compounds of potential therapeutic value
	G01N 26	Assays involving molecular polymers
	G01N 28	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	Sterilizing/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

TECONOMY

PARTNERS LLC