

WISCONSIN BIOHEALTH

Industry Landscape and Economic Impact Report

September 2020

Prepared for: BioForward Wisconsin
Prepared by: TEconomy Partners, LLC



TEconomy Partners, LLC is a global leader in research, analysis, and strategy for innovation-based economic development. Today, we're helping nations, states, regions, universities, and industries blueprint their future and translate knowledge into prosperity.

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EXECUTIVE SUMMARY

Wisconsin's biohealth industry represents a leading economic growth and innovation driver for the state, generating significant economic impacts and outperforming most major state industries in terms of job growth and wages. The dynamic biohealth industry and the broader biohealth economy, which represents an integrated network of biomedical and health solutions leaders spanning biotech and biopharmaceuticals; digital health; medical devices and diagnostics; and healthcare services, has both established strengths and considerable areas of emergence in Wisconsin. The state is a national leader in medical device manufacturing, and is emerging in its concentration, focus, and major investments in several biomanufacturing-related industries and markets spanning biologics and active pharmaceutical ingredient (API) manufacturing, contract research organizations, and sophisticated biohealth research tools and instrumentation.



Snapshot of Wisconsin's Biohealth Industry, Trends, and Impacts

Biohealth Industry Employment:

46,160

Employment Growth Since 2015:

8%

Outpacing Overall Job Growth in WI (3%)

Average Annual Wages:

\$87,294

79% Above Overall Industry Average in WI

Business Establishments:

1,709

Total State Economic Impact:

\$28.8 Billion

Total State Employment Impact:

118,605 Jobs

An Innovation Ecosystem that includes:

\$517M

in Risk Capital Investments since 2015;

Nearly \$934M

in Biohealth-related University R&D performed annually.

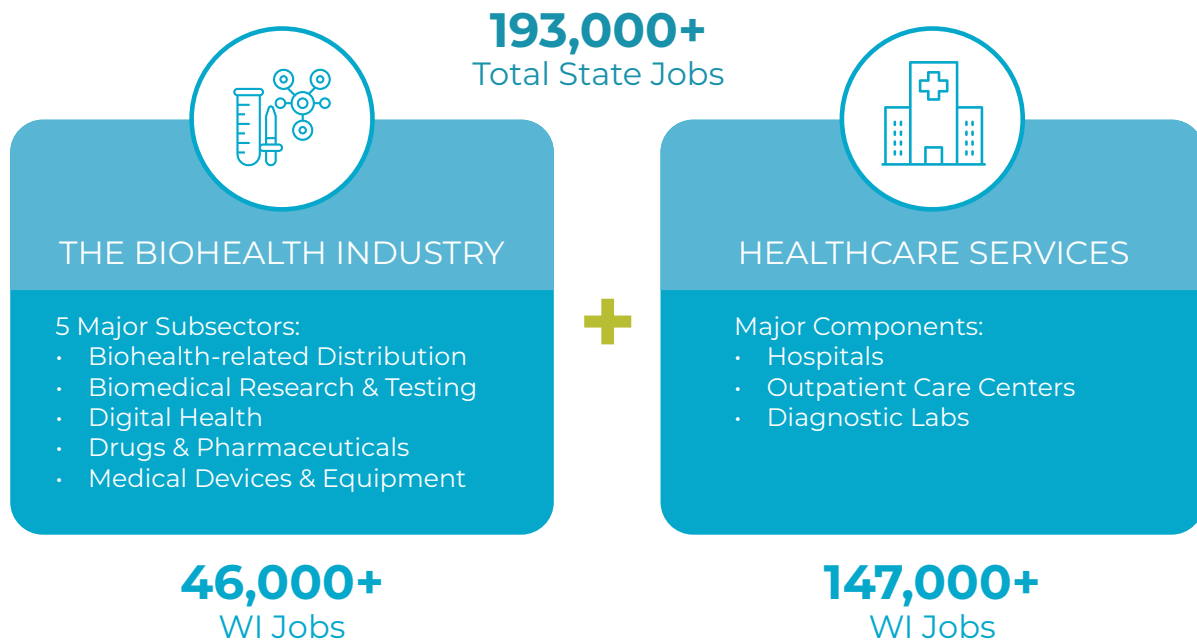
Wisconsin’s Biohealth Industry: A Leading Growth Driver for the State’s Economy

The biohealth industry can be segmented into two major components to reflect both the manufacturing, digital, and innovation activities at the center of life science and biohealth innovations and production as well as healthcare services where life-saving and quality-of-life improving biomedical advances are deployed for patients (Figure ES-1).

Taken altogether, Wisconsin’s biohealth companies and healthcare service providers—spanning both the biohealth industry and healthcare and clinical services segments—employed more than 193,000 in 2018 in 2,645 individual business establishments across the state. The combined industry has grown by 5.5 percent since 2015, well-outpacing growth for the overall state economy and many major industries.

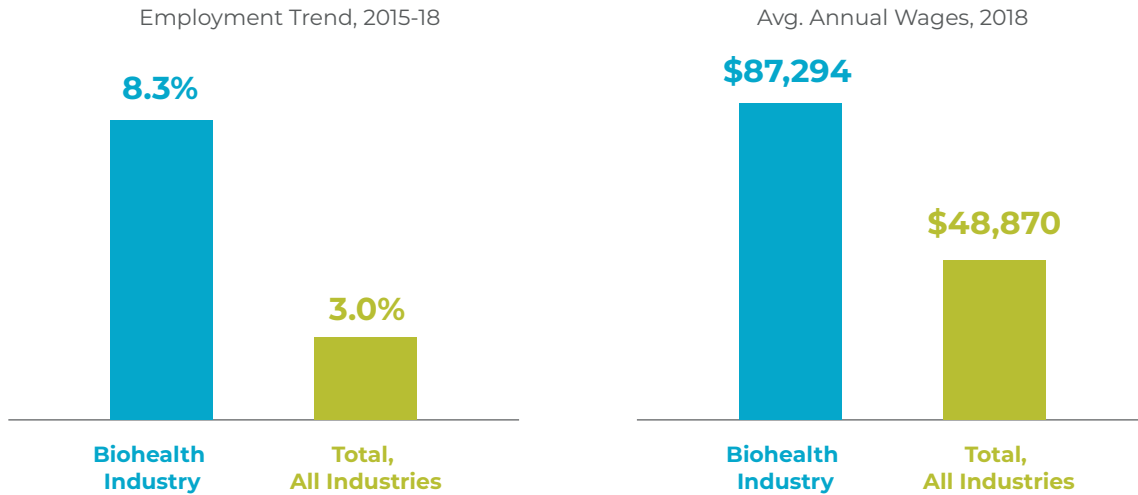
This report, however, narrows the focus primarily to the biohealth industry where the sector stands out as a leading Wisconsin industry for both job growth and wages (Figure ES-2). Wisconsin’s biohealth research organizations, manufacturers, digital health, and distribution companies employed 46,160 in 2018 following 8.3 percent job growth from 2015.¹ The high-quality jobs generated across the industry pay more than \$87,000, on average. This wage premium reflects the industry’s high value-adding activities and the skilled workforce it deploys across scientific R&D, manufacturing, sales, distribution, and other key roles.

Figure ES-1: Wisconsin’s Biohealth Economy, Major Segments, and Underlying Subsectors



1 The biohealth industry concept includes private sector biohealth-related research and development organizations but does not include the education sector, and therefore excludes research-related employment in the state’s colleges and universities.

Figure ES-2: Employment Trends and Average Wages – Wisconsin’s Biohealth Industry vs. All Industries Total



Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN; TEconomy’s identification of digital health firms and estimated employment and wages.

Total Economic Impacts of the Wisconsin Biohealth Industry Reach Nearly \$29 Billion

The biohealth industry’s size and the high-quality jobs it generates translate into significant economic impacts for Wisconsin. Key findings from the economic impact analysis include:

- In 2018, Wisconsin’s biohealth industry is estimated to have generated more than \$17.6 billion in direct annual economic output and more than \$28.8 billion in overall economic impact (output) from direct, indirect, and induced sources (Figure ES-3).
- The industry’s economic activities create major employment impacts, supporting more than 72,000 additional jobs—36,000 jobs through supply chain (indirect) and 36,000 jobs through

worker spending (induced) impacts. Combined with the more than 46,000 direct industry jobs, the biohealth industry supports nearly 119,000 jobs throughout the State of Wisconsin. This translates into an employment multiplier of 2.57.

- The biohealth industry generates an estimated \$4.6 billion in direct compensation (wages and benefits combined) to the industry’s 46,160 employees—equaling nearly \$99,500 per Wisconsin industry worker. Including the more than 72,000 supplier jobs and jobs generated by worker spending in the state, the overall compensation impact reaches \$8.5 billion.



Figure ES-3: Economic Impacts of Wisconsin's Biohealth Industry, 2018

DIRECT IMPACT





Biohealth Industry
Employment

46,160

TOTAL IMPACT

Employment **118,605** 

Wages & Benefits **\$8.5B** 

Economic Output **\$28.8B** 

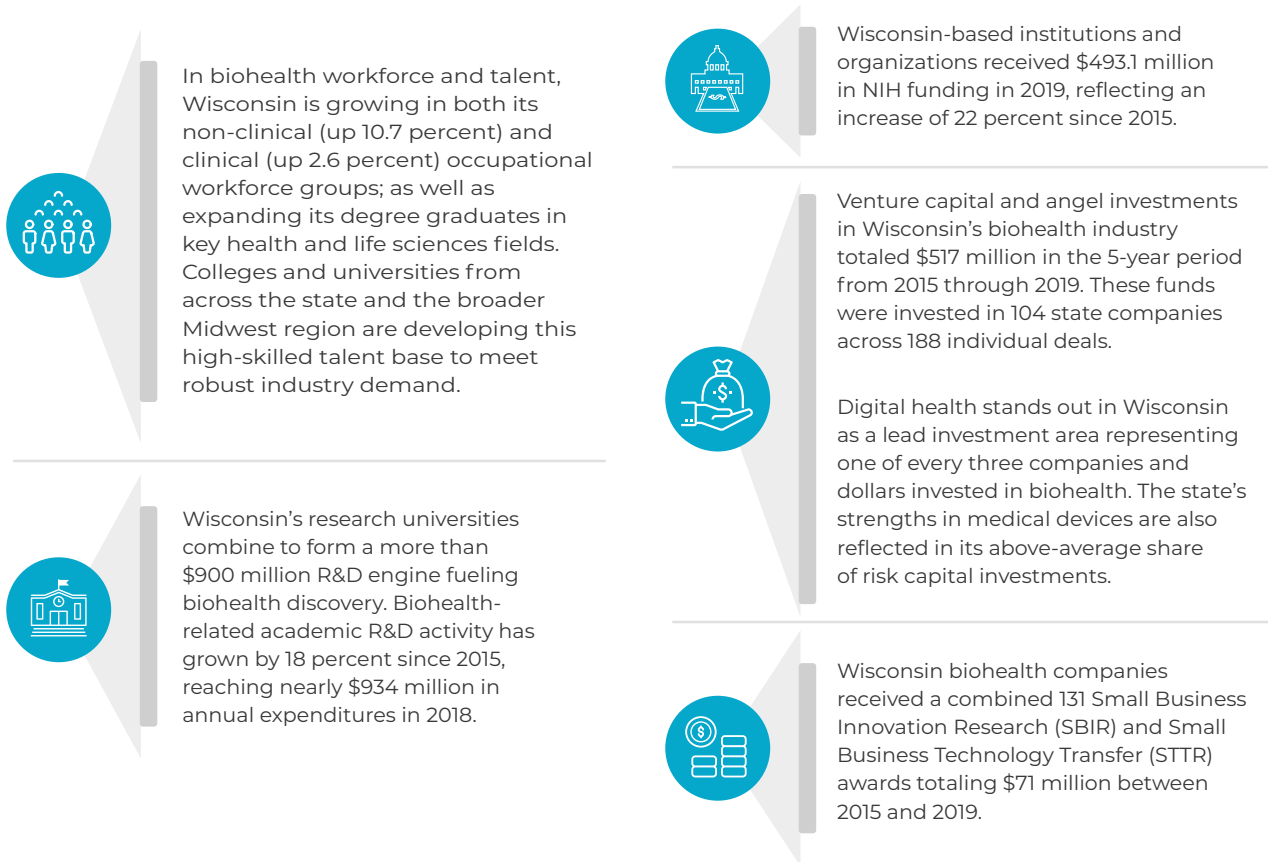
State & Local Taxes **\$1.0B** 

Federal Taxes **\$1.8B** 

Source: TEconomy Partners' analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

Biohealth Accounts for Significant Shares of Key Innovation Ecosystem Elements in Wisconsin

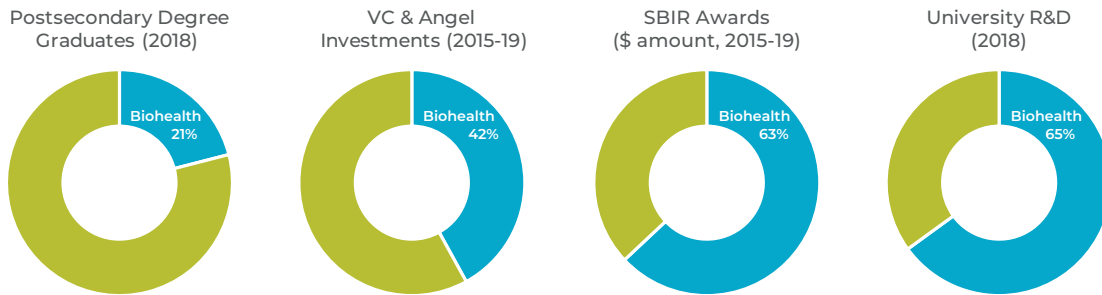
A vibrant and dynamic biohealth industry requires a robust and supportive ecosystem that fuels scientific discovery and technologies leading to innovative new products and services. An examination of key facets of Wisconsin’s ecosystem finds:



Biohealth is significantly represented across Wisconsin’s innovation ecosystem—from college and university graduates and research, to private equity investments and federal innovation grants for biohealth companies (Figure ES-4).

Partners across this ecosystem are initiating efforts to ensure the industry’s strong recent growth and continuing emergence are strongly rooted, specifically in the area of biomanufacturing where BioForward Wisconsin has partnered with UW-Madison and others to advance R&D, develop talent, support entrepreneurs, and commercialize technologies. Though still in its early stages, the Forward BIO Initiative is unique in connecting early technology development and training through large, established companies enhancing the ecosystem for biomanufacturing development.

Figure ES-4: Biohealth’s Share of Key Innovation Ecosystem Elements in Wisconsin



Source: TEconomy Partners’ analysis of data from National Center for Education Statistics, IPEDS database; PitchBook; sbir.gov database; and NSF, HERD survey.

Identified Industry and Ecosystem Challenges

This report validates the importance to Wisconsin of its biohealth industry and broader biohealth economy to growing high-quality jobs, advancing innovation, and bringing new biomedical treatments and capabilities to patients. The assessment finds, however, several notable areas where Wisconsin’s performance is lagging the nation and other states, and it could be at risk of seeing its share of industry and ecosystem elements erode unless action is taken to address these challenges.

Specific challenges identified through this assessment include:

	<p>The biohealth economy, while growing, is seeing its national share erode slightly with overall job growth that is lagging just behind the nation.</p>		<p>Meeting the workforce demand challenge is critical to maintaining industry growth. Wisconsin is lagging the nation in both the growth of its clinical and non-clinical biohealth workforce. It is also behind the U.S. growth rate in degree graduates in key biohealth and life sciences fields.</p>
	<p>Wisconsin’s biohealth workers earn less, in general, than their counterparts nationally. Although cost of living factors must be considered, this can still pose challenges for out-of-state talent recruitment, particularly among top talent in high-demand areas such as regulatory affairs, quality control, IT, engineering, and scientific expertise.</p>		<p>Wisconsin has consistently lagged behind the nation in receipt of federal SBIR and STTR awards for small, innovative biohealth companies, with the gap growing wider over time. At the same time, the state’s share of national biohealth VC funding has diminished since 2015.</p>
	<p>While growing, Wisconsin is lagging the nation in NIH funding and award growth, eroding its overall national share of key biohealth innovation funding.</p>		

In general, the biohealth industry challenges are not dire, as most all of these industry and ecosystem elements have been growing in Wisconsin, but the overarching theme is the state is “lagging” others in key areas, and competition for biohealth development among other states and nations is especially fierce.



Wisconsin should leverage this assessment to not only validate this industry is among its leading economic performers and more than worthy of targeted state development; but to further consider priorities and investments in areas such as talent development to meet the demands of a growing industry; ensuring it is receiving its share of federal funding in terms of small business innovation and NIH biohealth research funding.

INTRODUCTION

The biohealth industry has two unique characteristics that distinguish its value from other sectors—its role in delivering innovative, life-saving and quality-of-life improving treatments to society and its role as a steady economic growth driver, generating high-quality jobs and sizable economic impacts for local communities, states, and nations. Amidst the ongoing COVID-19 global pandemic, these characteristics have perhaps never been more important in meeting the dual health and economic challenges that have arisen. With the onset of the pandemic, the industry has rapidly mobilized to develop the diagnostics, anti-viral therapeutics, and vaccines needed to contain and treat the virus. With the deep recession generated by the pandemic-induced economic shutdowns, the industry will again be called upon as a vital buffer to offset job losses in other industries, as it has done in the prior two recessions. Wisconsin's biohealth industry is actively contributing on both fronts in the struggle against the novel coronavirus, emphasizing the breadth of sizable impacts the industry contributes to the overall state economy and innovation landscape.

While the pandemic shines an especially bright spotlight on the value of the biohealth industry, BioForward Wisconsin continues to be a steady advocate and leading voice for the industry across the state. BioForward Wisconsin is the collective voice of Wisconsin's robust and comprehensive biohealth cluster which represents more than 220 member organizations across an integrated network of health solution leaders including re-

search institutions, biotech and biopharma, digital health and medical devices and diagnostics. It is an action-oriented association which focuses on initiatives to strengthen the state's talent pipeline; collaborations to develop supply chain partnerships; educational and networking events to enhance professional development; and legislative advocacy to highlight the economic and social impact of the biohealth industry on the state, nation, and world.

BioForward has engaged TEconomy Partners, LLC (TEconomy) to develop this Industry Landscape and Economic Impact Report to once again document and highlight the economic position, performance, and impacts of the biohealth industry in the State of Wisconsin and to profile key facets of its unique innovation ecosystem. As one of our nation's leading technology-based economic development consulting organizations, TEconomy is recognized as a national leader in advancing life science strategies across basic and translational research enhancement, technology development, new venture development, talent development, business development, and for measuring the economic impacts of life science and related investments.

This report is segmented into five major sections. The first profiles Wisconsin's biohealth industry, its current position, recent trends, and performance relative to the nation. The second section details the economic impacts of the biohealth industry in Wisconsin and highlights the depth of the intra-state industry supply chain. The third section

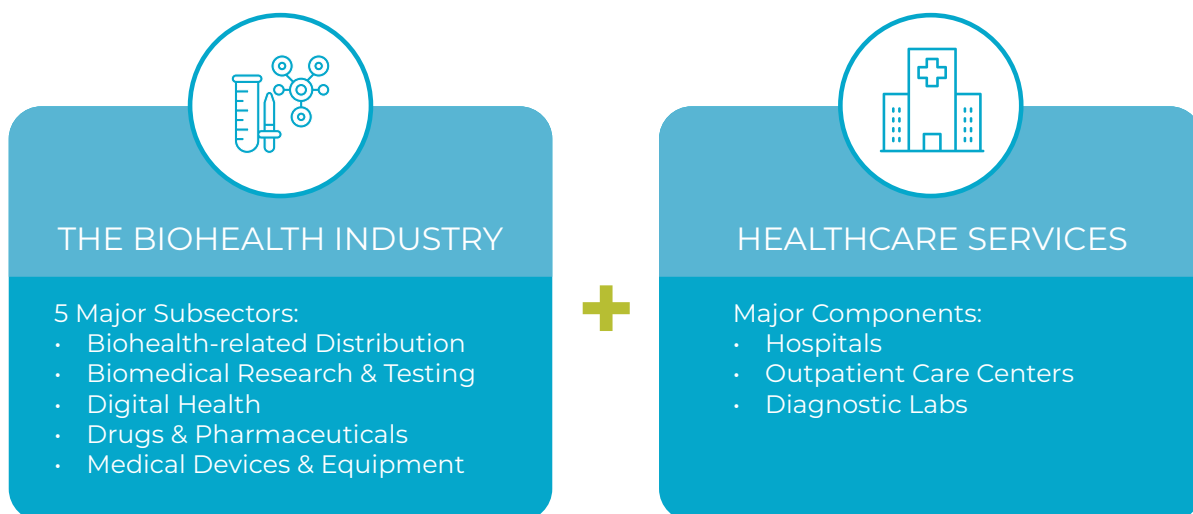


focuses on detailed biohealth industry strengths and includes several vignettes on clusters of key companies that represent concentrations of current and emerging industry strengths. The fourth section presents high-level performance and insights into key elements of Wisconsin’s biohealth innovation ecosystem. The report concludes with the identification of challenges seen throughout the assessment and raises areas to consider for further attention and investments going forward.

Defining the Biohealth Economy

BioForward Wisconsin plays a lead role in advancing the state’s biohealth economy, with a diverse membership that reflects an impressively varied set of industry activities across research and testing, manufacturing, digital health and related technologies, distribution, and healthcare services. Because of this diversity, biohealth can be challenging to define as one unified industry. To effectively capture the breadth of industry activity along a complex value chain and innovation ecosystem requires combining numerous industries into major segments and “subsectors” of the biohealth economy as shown in Figure 1 below. **While this report will cover key aspects of the entire biohealth economy, its primary focus will be on the biohealth industry and its major subsectors.**²

Figure 1: Defining Wisconsin’s Biohealth Economy, Major Segments, and Underlying Subsectors



2 For a description and a detailed listing of the federal industry NAICS codes that define each subsector of the biohealth economy, see the Appendix to this report.

I. WISCONSIN'S BIOHEALTH INDUSTRY: A Leading Economic Growth Driver Generating High-Quality Jobs

Wisconsin's biohealth industry is large and growing, representing both a significant innovation and economic growth driver for the state, outpacing Wisconsin's overall growth in recent years across all industries with wages far exceeding the state average.

Companies and organizations across Wisconsin's full biohealth economy employ more than 193,000 in 2,645 business establishments, a jobs figure that has grown by 5.5 percent since 2015, well outpacing growth for the overall state economy (3.0 percent, see Table 1). During the latter stages of a record-setting economic expansion, each of

the major biohealth subsectors contributed to the strong job growth.

Focusing in on the biohealth industry, the sector stands out as a leading growth driver for Wisconsin's economy, outpacing the growth of most major state "traded-sector" industries

Table 1: Wisconsin's Biohealth Economy—Business Establishments and Employment, 2018

Biohealth Economy & Major Subsectors	Establishments 2018	Employment 2018	Employment Growth, 2015-18
Total, All Industries*	175,270	2,876,297	3.0%
Total Biohealth Economy	2,645	193,453	5.5%
Biohealth Industry	1,709	46,160	8.3%
Digital Health	111	11,894	7.9%
Medical Devices and Equipment	280	11,748	0.7%
Biohealth-Related Distribution	960	9,655	23.3%
Biomedical Research and Testing	273	7,935	1.6%
Drugs & Pharmaceuticals	85	4,928	13.8%
Healthcare Services	936	147,293	4.6%

*Total, All Industries includes both private and government establishment and employment.

Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN; TEconomy's identification of digital health firms and estimated employment.

Measuring the Digital Health Subsector

Unlike the majority of the biohealth industry which can be delineated and defined by federal industrial classifications, isolating companies engaged in Digital Health requires building up a firm-level database with employment estimates derived from several sources. Because of this unique approach applied to Wisconsin, comparisons with the U.S. on any Digital Health metrics are not available.

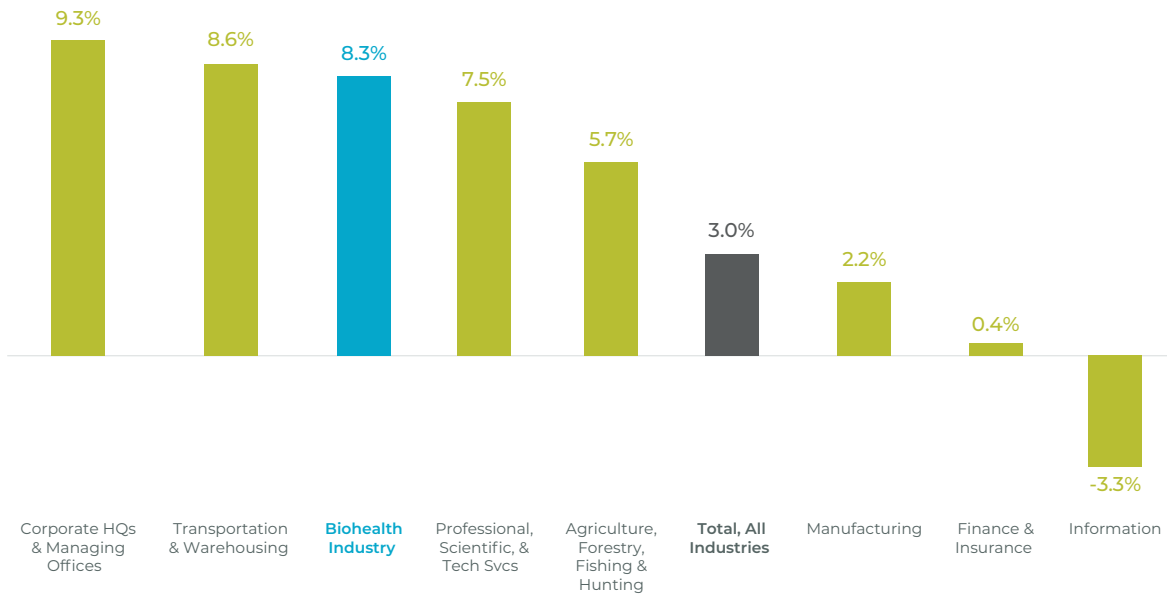
For more information on the approach to identifying state Digital Health firms, see the Appendix.



(Figure 2).³ Wisconsin’s commercial biomedical research firms, manufacturers, digital health companies, and distributors that make up the industry employed 46,160 in 2018 following 8.3 percent job growth from 2015. Within the biohealth industry, two major subsectors have

experienced double-digit job growth, outpacing the nation and clearly emerging in Wisconsin—biohealth-related distribution and drugs and pharmaceuticals.⁴ Employment in digital health has also grown at a rapid rate in recent years.

Figure 2: Employment Trends in Wisconsin’s Biohealth and Other Major Traded Sectors, 2015-18



*Total, All Industries includes both private and government establishment and employment.
Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

- 3 Traded sector industries are those within a state that export goods and services and therefore drive new wealth and job creation beyond local industries.
- 4 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, please see the Appendix.

Beyond the subsector growth measures, industry concentration measured by location quotients (LQ) highlight areas in which Wisconsin has a concentration of employment above that for the U.S. (a LQ greater than 1.0) and further highlights areas in which Wisconsin has a “specialized” concentration significantly greater than the national average (a LQ greater than 1.20).

- **Medical Devices & Equipment is a “specialized” subsector in Wisconsin, with an employment concentration 37 percent greater than the national average (LQ equals 1.37).**

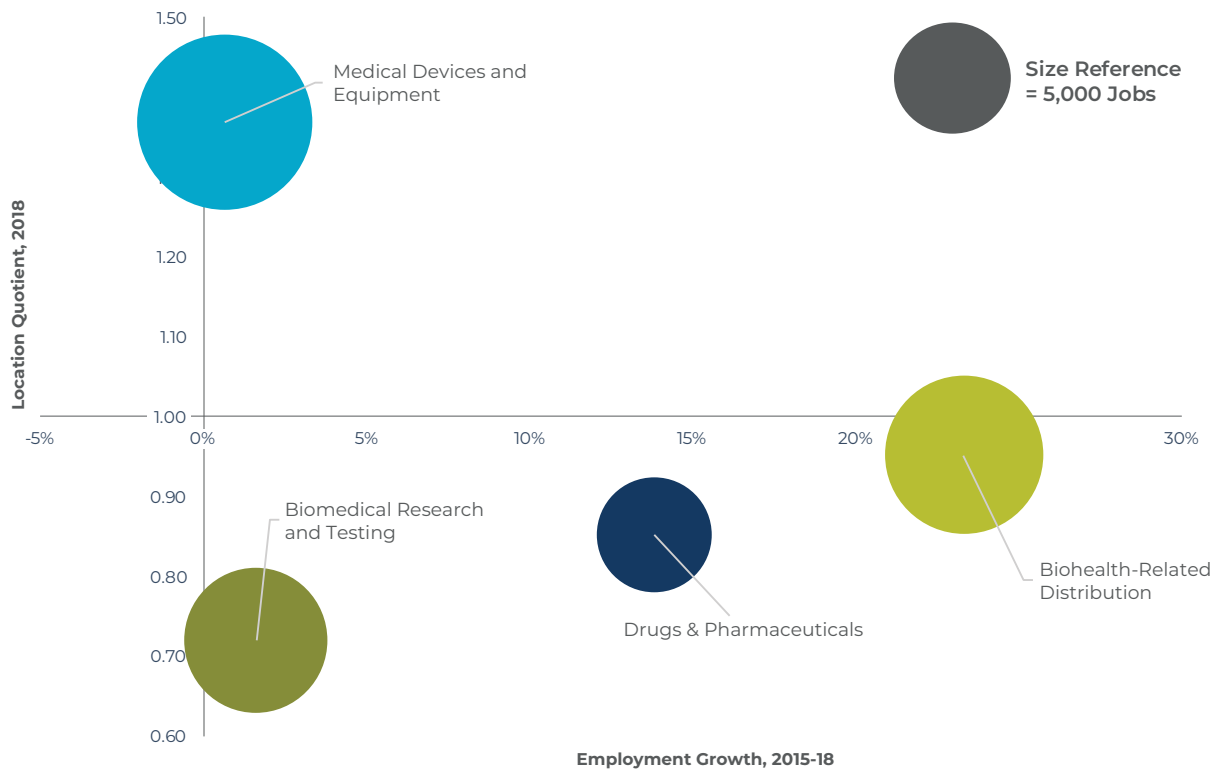
The “bubble” chart in Figure 3 plots for the major subsectors of the biohealth industry the three key position and performance variables of industry employment size (size of bubble), growth (horizon-

Measuring Industry Concentration & “Specialization” Using Location Quotients

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 3: Wisconsin’s Biohealth Industry: Current Position & Recent Performance Across Subsector Size, Concentration, and Growth



Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

tal axis) and relative concentration as measured by LQs (vertical axis).

- Each of the biohealth industry subsectors is positioned to the right of the vertical axis, indicating job growth since 2015.
- Medical devices' position high on the vertical axis indicates its high degree of specialization in the state.
- Other subsectors are clearly “emerging” – growing but not yet specialized in their concentration.

Biohealth represents a high-growth industry not only in Wisconsin, but nationally as well. And while the entire biohealth economy cannot be fully compared against U.S. trends due to an inability to estimate national digital health employment, comparisons across key subsectors are helpful to gauge Wisconsin's recent employment trends and whether it is keeping pace with national growth.

Challenge for Wisconsin:

The biohealth economy, while growing, is seeing its national share erode slightly with overall job growth that is lagging just behind the nation.

Excluding digital health, the total biohealth economy—inclusive of the biohealth industry and healthcare services—has grown at a rate just behind that for the U.S. (5 percent versus 8 percent, see Figure 4). Similarly, the biohealth industry alone has also lagged just behind national growth (8 percent versus 10 percent).

The biohealth industry's performance, compared against that for the nation overall is further summarized below in Table 2.

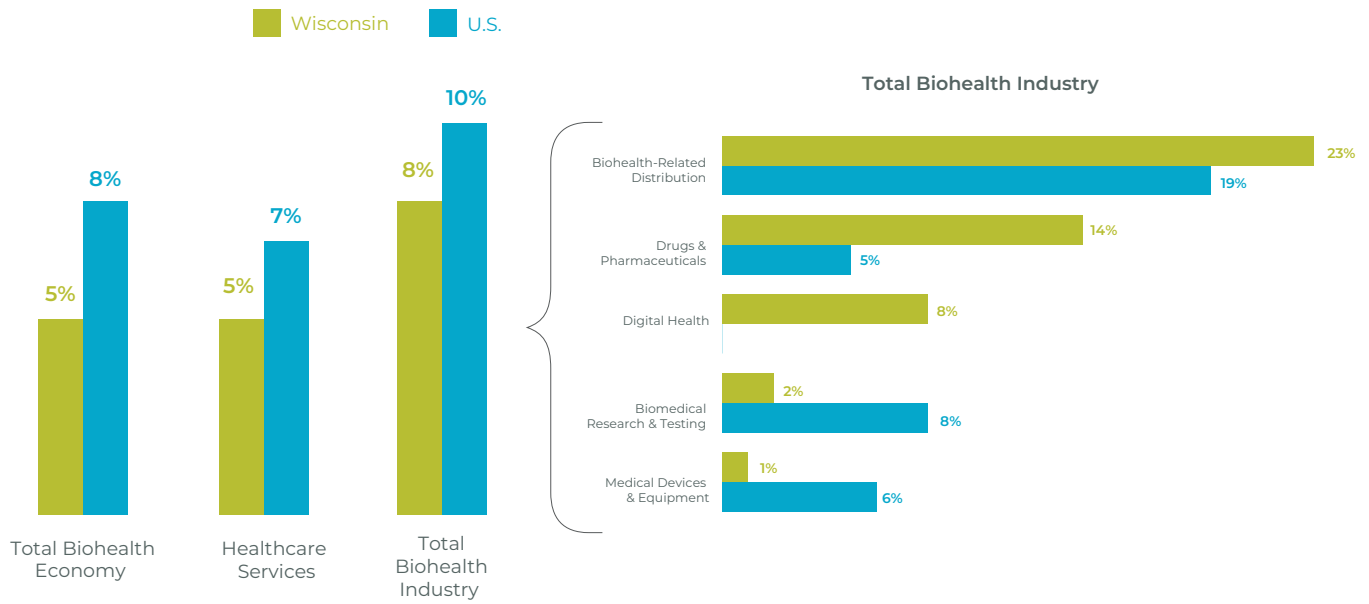
Wisconsin Among the National Leaders in Medical Device Manufacturing

Wisconsin's large and specialized medical device and equipment subsector is near the top tier of states in both its employment level and location quotient. Based on the industry employment analysis conducted by TEconomy and BIO in the most recent national bioscience industry report, Wisconsin ranks 14th among all states and Puerto Rico in medical device manufacturing size (employment level) and 13th in its relative concentration (LQ).*

Wisconsin's device manufacturing subsector is led by the very large footprint of companies such as GE Healthcare. With facilities across Wisconsin, GE Healthcare is a global leader in advanced healthcare technologies. Its offerings range from medical imaging (including radiography, fluorography, mammography, computed tomography, magnetic resonance, molecular imaging, and ultrasound), software and IT, patient monitoring, anesthesia delivery, and performance improvement solutions. With approximately 6,000 employees in Wisconsin and more than \$8 billion in economic output annually, GE Healthcare enables clinicians to make faster, more informed decisions through intelligent devices, data analytics, applications and services. Wisconsin continues to be an important hub for GE Healthcare, serving as the global headquarters of its imaging and clinical care solutions businesses, supporting a major hub for repair/recycling of devices, and demonstrating advanced manufacturing technologies.

*Source: TEconomy/BIO, "The Bioscience Economy: Propelling Life-Saving Treatments, Supporting State & Local Communities," 2020. Note that medical device industry definitions in the national report vary slightly from that used in this report, but the vast majority of the industry definition is the same.

Figure 4: Biohealth Economy and Subsector Growth Trends, Wisconsin and U.S., 2015-18



*Note: Industry totals for both the Biohealth Economy and Biohealth Industry exclude Digital Health.
 Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

Table 2: A Snapshot of Wisconsin’s Biohealth Industry Subsector Position

Biohealth Industry & Major Subsectors	Wisconsin Location Quotient	Specialized Industry Concentration	Employment Growth in WI	Outpacing U.S. Employment Growth
Biohealth Industry	0.96		✓	
Biohealth-Related Distribution	0.95		✓	✓
Biomedical Research & Testing	0.72		✓	
Drugs & Pharmaceuticals	0.85		✓	✓
Medical Devices & Equipment	1.37	✓	✓	
Digital Health	n/a	n/a	✓	n/a
Healthcare Services	0.98		✓	

Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

Biohealth Industry Wages

Average wages for Wisconsin's biohealth industry workers reached more than \$87,000 in 2018, which is \$38,000 or 79 percent greater than the state's private-sector average (Figure 5). This represents a significant wage premium and reflects the strong value-adding and innovation focus of the state's biohealth industry. It also reflects the high skills composition of the innovative industry and the fierce competition for talent. Compared with other traded sector industries across the Wisconsin economy, biohealth and its major subsectors exceed all in their average earnings.

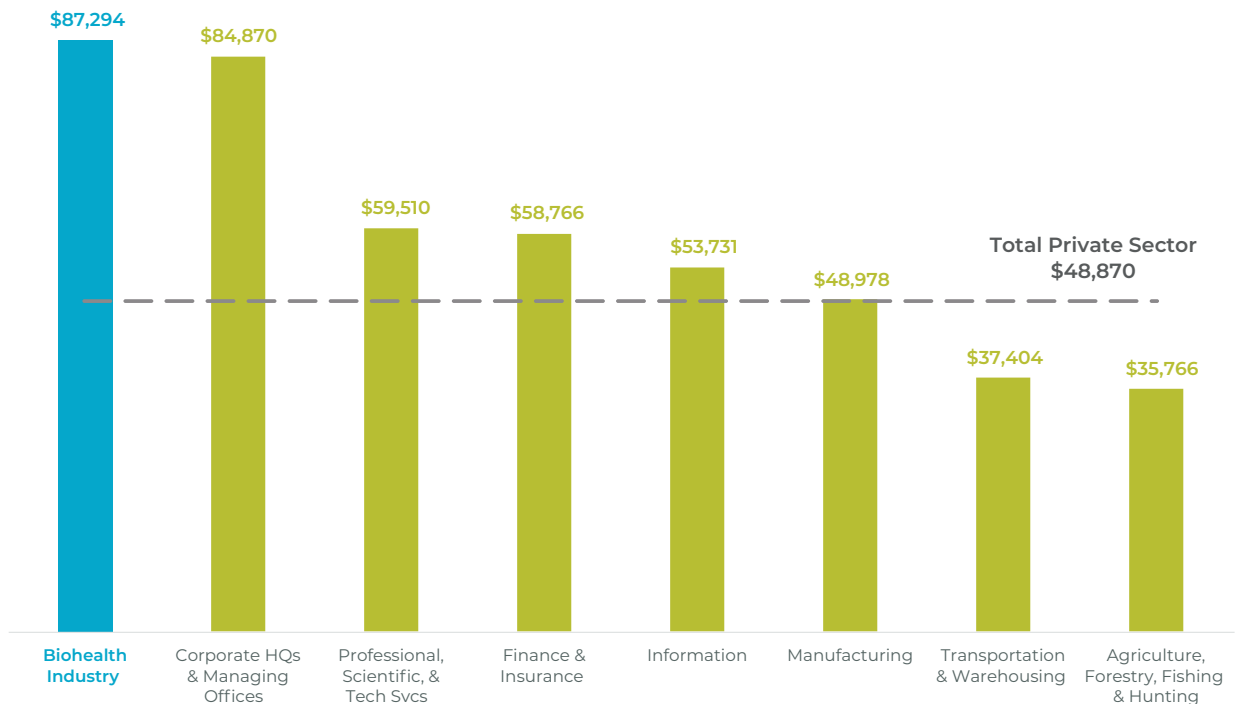
The high overall average wage in the biohealth industry reflects strong wage premiums across each

Challenge for Wisconsin:

Wisconsin's biohealth workers earn less, in general, than their counterparts nationally. This can pose challenges for out-of-state talent recruitment, particularly among top talent in high-demand areas such as regulatory affairs, quality control, IT, engineering, and scientific expertise.

of the individual subsectors, where each is well above the state private-sector average and most all major industries (Figure 6).

Figure 5: Average Annual Wages for Wisconsin's Biohealth and Other Traded Sector Industries, 2018



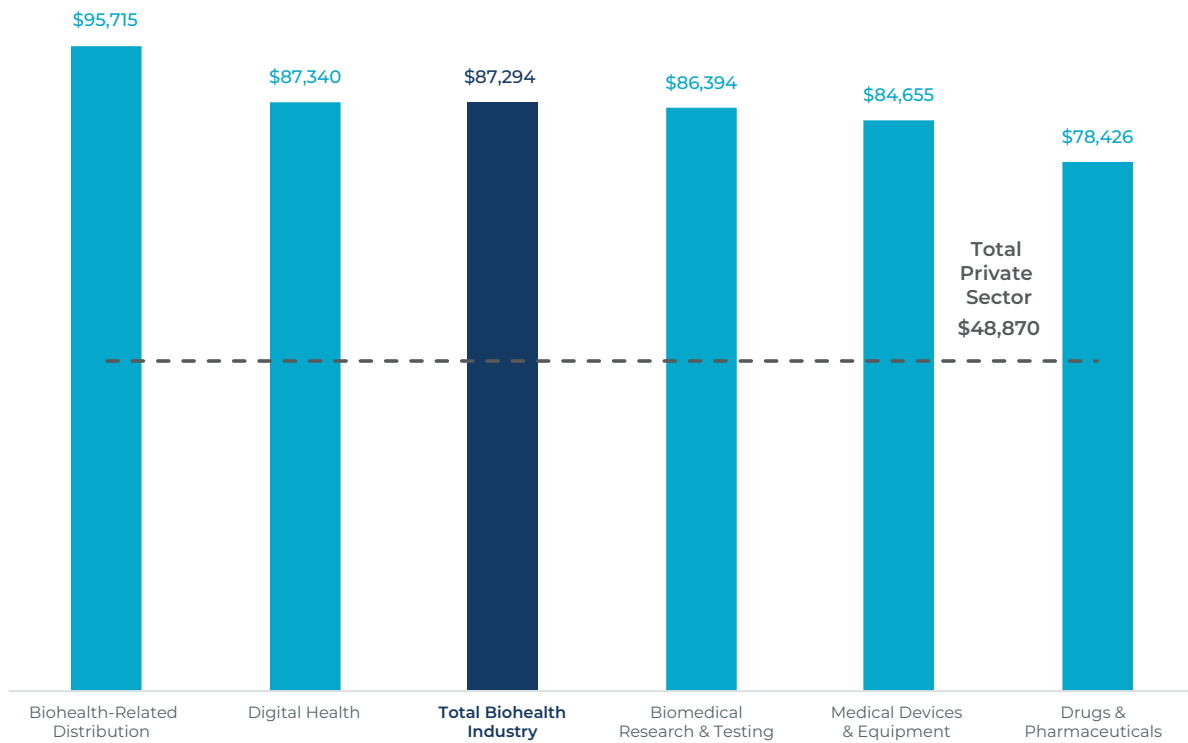
Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

While biohealth workers in Wisconsin earn wages well above their intra-state counterparts in other traded sectors, average industry and subsector wages are below that for the nation. Across the U.S., the average annual wage for biohealth industry workers is more than \$108,000.⁵ National wages significantly exceed those for Wisconsin in every major subsector, except for medical device manufacturing where the average is essentially the same.

In light of Wisconsin’s lower cost of living compared with the national average, these wage findings are not overly surprising; however, the cost of living in

the Madison metro region is the exception, where costs are higher than the U.S. average.⁶ In fact, Greater Madison is more costly than several other leading regional biohealth and life sciences hubs in the U.S., including Raleigh, Indianapolis, and Salt Lake City, just to name a few. The generally lower wages can pose a challenge for biohealth companies recruiting talent into Greater Madison and other parts of the state if they are not at levels commensurate with other competing industry hubs.

Figure 6: Average Annual Wages for Wisconsin’s Biohealth Industry and Major Subsectors, 2018



Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

5 This average U.S. wage rate does not include the Digital Health subsector.

6 Analysis is based on Cost of Living Index (COLI) calculated for U.S. metro regions by the Council for Community and Economic Research (C2ER) and estimate of state-level COLI for the State of Wisconsin.

II. THE ECONOMIC IMPACTS OF THE BIOHEALTH INDUSTRY IN WISCONSIN

Wisconsin’s large employment base and high average wages in the biohealth industry lead to outsized economic impacts for the state. This section of the report presents these impacts.

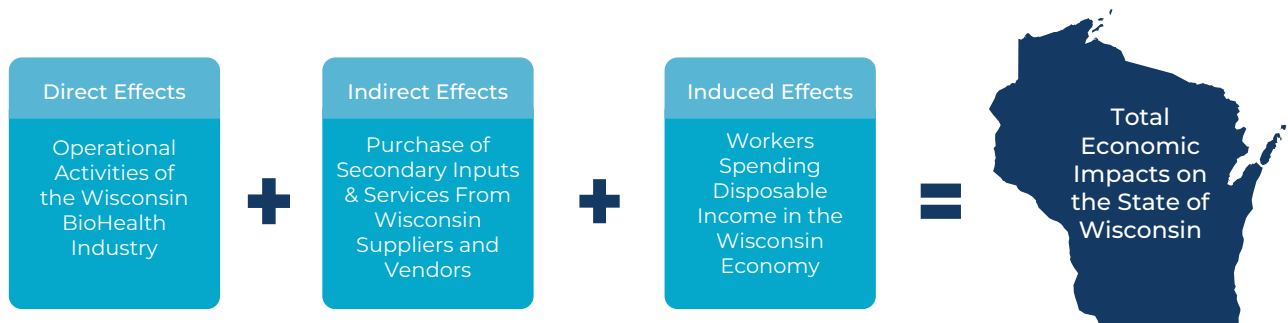
The economic impacts, or more precisely the revenue and expenditure impacts, of Wisconsin’s biohealth industry can be measured using the well-established regional economic analysis technique of input/output (I/O) analysis, which tracks the production activities of a sector and the related economic activity of suppliers to the sector and its personnel.

The following analysis is focused primarily on the biohealth industry segment of the broader biohealth economy—consisting of the manufacturers, digital health, and distribution subsectors

as defined in the prior section.⁷ The premise is that every dollar these firms spend within the state’s economy (the direct impact) is spent and re-spent on the purchase of inputs and additional goods or services by suppliers and workers generating additional economic activity and impact in the state as depicted in Figure 7.

The impact analysis captures and reports the following impact metrics, with detailed values reported in Table 3.

Figure 7: Components of the Wisconsin Biohealth Industry Economic Impacts



⁷ Two additional analyses are also provided to demonstrate the economic impact of university biohealth research expenditures and to provide a broader, significantly more inclusive set of economic impacts that represent the full biohealth economy combining the biohealth industry, biomedical university research, and healthcare services. Highlights of these two analyses are included in text boxes elsewhere in this report.

Output

Typically referred to as the “economic impact”, the Wisconsin biohealth industry is estimated to produce more than \$17.6 billion in output (sales or revenue) in 2018. This direct output generates \$6.1 billion in output from in-state suppliers and \$5.2 billion from the spending of worker wages within the state for a total economic impact of more than \$28.8 billion for the Wisconsin economy. This results in an output multiplier of 1.64 meaning every dollar generated by the Wisconsin biohealth industry generates an additional \$0.64 within the state economy.

Employment and Compensation

The economic activities of the Wisconsin biohealth industry directly employ more than 46,000 (workers and owners). In turn, through purchases of goods and services from supplier firms within the state an additional 36,000 workers are supported by the industry (*indirect effects*). Finally, as these industry and supplier firms’ employees spend their wages within the Wisconsin economy, an additional 36,000 employees are supported (*induced effects*). In total the Wisconsin biohealth industry

supports nearly 119,000 Wisconsin jobs, for an employment multiplier of 2.57—for every direct job in the Wisconsin biohealth industry, 1.57 additional Wisconsin jobs are supported.

Direct labor income, consisting of the value or cost of all wages and benefits paid to employees and owners, reaches \$4.6 billion in 2018 or an average of \$99,000 per industry worker. Through supplier and employee purchases the indirect and induced labor income generated by the industry reaches \$3.9 billion combined. Overall, the Wisconsin biohealth industry supports nearly \$8.5 billion in annual wages and benefits in the state.

Taxes

The biohealth industry in Wisconsin is estimated to have paid nearly \$500 million in state and local taxes. Including suppliers and worker income and spending, the industry generates an estimated \$1.0 billion in total state and local taxes. From a federal tax perspective, the industry generated nearly \$1.8 billion in federal tax revenues in 2018.

Table 3: Economic Impact of the Wisconsin Biohealth Industry, 2018

Impact Type	Employment	\$ in Billions			
		Labor Income	Output	State/Local Tax Revenue	Federal Tax Revenue
Direct Effect	46,160	\$4.593	\$17.616	\$0.484	\$0.979
Indirect Effect	36,190	\$2.281	\$6.067	\$0.224	\$0.455
Induced Effect	36,255	\$1.609	\$5.166	\$0.311	\$0.347
Total Effect	118,605	\$8.483	\$28.848	\$1.019	\$1.781
Multiplier	2.57	1.85	1.64		

Source: TEconomy Partners analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

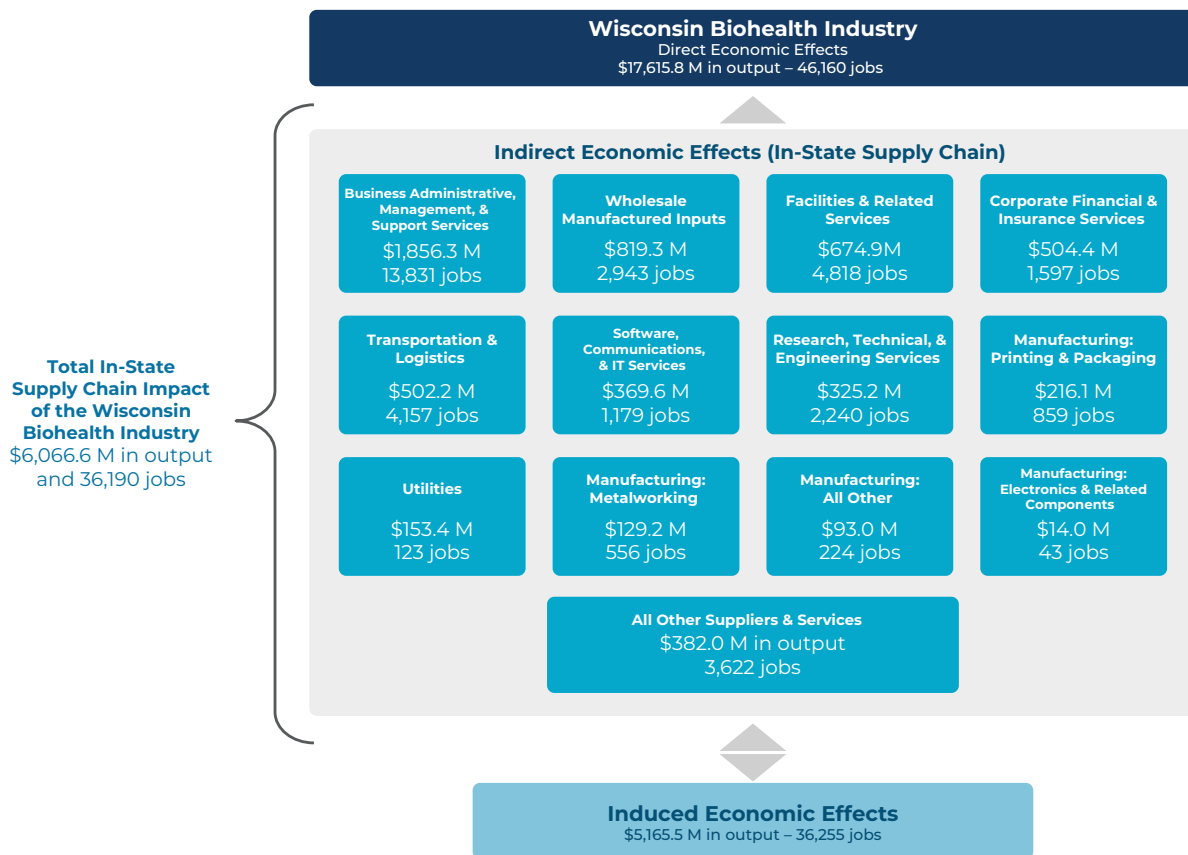
The Biohealth Industry Supply Chain

The biohealth industry is leveraging a deep and valuable supply chain across Wisconsin. Within the analysis of the economic impacts of the biohealth industry, some insights can be gleaned into the size and involvement of other sectors of the Wisconsin economy in supplying the nearly \$6.1 billion in products and services to the state’s biohealth industry. Figure 8 provides a visual perspective on the overall economic impact analysis and the important role played by 13 key in-state supplier input sectors to the Wisconsin biohealth industry.⁸

Output

The 13 “supply chain” sectors shown in Figure 8 represent the breadth of in-state inputs to the industry. Similar to many industry sectors the largest input sector, *business administrative, management, & support services* (which includes administrative and service support functions provided by corporate headquarters, regional, sales, or other corporate offices, legal, accounting, and management consulting services, employment and other administrative service businesses),

Figure 8: Key In-State Supplier Sectors to Wisconsin’s Biohealth Industry



Source: TEconomy Partners analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

8 Appendix Table A-2 provides data on key subcomponents of these 13 supply chain sectors.

accounts for 31 percent (\$1,856 million) of the total in-state supplier value. Likewise, the second largest sector, *wholesale manufactured inputs* (materials, components, and parts purchased from wholesale distributors) accounts for \$819 million. *Facilities & related services* account for \$675 million, while both *financial & insurance services* and *transportation & logistics* each account for slightly more than \$500 million. Combined, the four manufacturing supply chain sectors (*printing & packaging; metalworking; electronics & related components; all other manufacturing*), account for just over \$450 million, or 7 percent of total in-state supply chain value.

Employment

The 36,190 jobs among Wisconsin's suppliers to the biohealth industry are spread across the state economy in a somewhat different distribution than output impacts. *Business administrative, management, & support services*, parallel to its output effects, is the largest employer among the supply chain sectors accounting for more than 13,800 jobs or 38 percent of all supplier workers. The second-largest supply chain sector in terms of employment is *facilities & related services* capturing the more than 4,800 workers involved in the leasing, maintenance, and repair of facilities and equipment used by the biohealth industry. Supporting the biohealth industry with more than 4,150 workers, *transportation & logistics* is the third-largest supply chain sector, in terms of employment.

Economic Impacts of the “Extended” Biohealth Economy in Wisconsin

Results from a separate analysis are provided here, in part, to present a more holistic depiction of the full, broader biohealth economy in Wisconsin. This analysis combines the impacts of the biohealth industry and university biohealth-related research with the significantly larger economic base of both private and public hospitals and other healthcare-related services establishments, although it does not include the individual offices of physicians.

This biohealth economy accounts for more than 197,000 Wisconsin jobs (direct employment) across the various sectors included. They also represent a combined direct output of more than \$43 billion—larger than Wisconsin's agricultural production sector, construction industry, and machinery and equipment manufacturing industry.

The total economic impact of this extended biohealth economy and ecosystem in Wisconsin supports more than 422,000 workers and generates nearly \$77 billion in annual output. It is responsible for generating a total of more than \$2.4 billion in state and local taxes throughout the state and generates more than \$5.4 billion in federal tax revenues. Please see the Appendix to this report for more details.



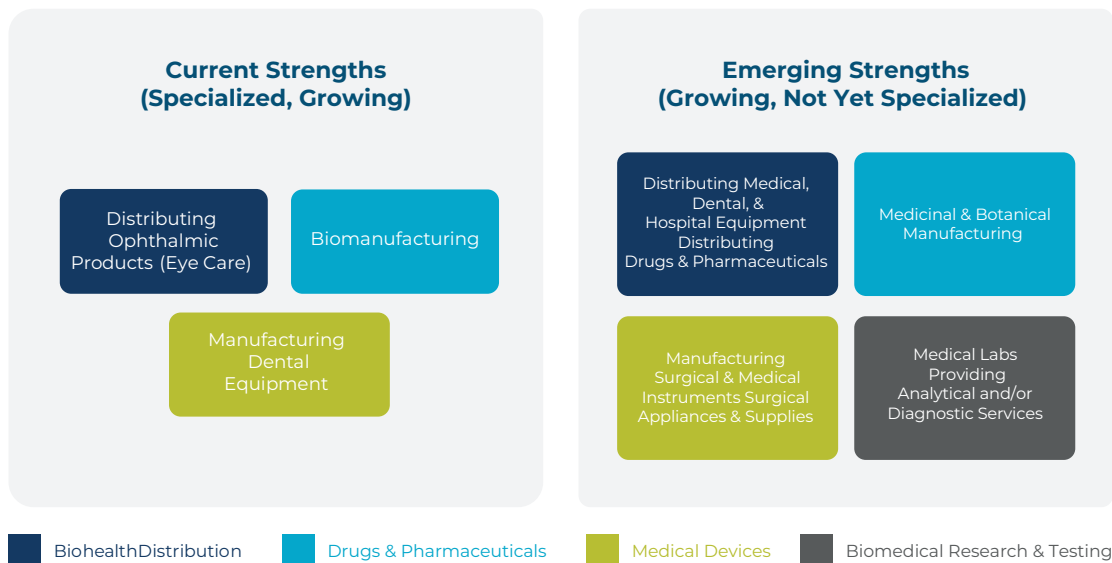
III. ASSESSING DETAILED BIOHEALTH STRENGTHS IN WISCONSIN

Wisconsin has a diversity of industry strengths that span each of the major biohealth industry subsectors.

Acknowledging the high-level existing and emerging biohealth industry strengths in Wisconsin established at the outset of the report, and establishing the broadly impactful nature of the industry on the state's economy, this section identifies those detailed industry strengths, including more specific markets and products, within the industry where Wisconsin stands out. It proceeds then to shine a spotlight on a few areas in which Wisconsin has concentrations of companies and recent investments that represent particular strengths and opportunities for the state going forward.

Wisconsin's detailed industry strengths are identified by going below the subsector level and examining the data and concentrations of companies that signify strengths at the individual product and service levels. The analysis reveals a host of detailed industries that are either a current, established strength for Wisconsin (where industries are both specialized in their concentrations and growing), or are an emerging area of strength (where they are not yet specialized but growing). Figure 9 summarizes these using the concepts of industry specialization and growth.

Figure 9: Identifying Wisconsin's Detailed Biohealth Economy Strengths



Source: TEconomy Partners LLC analysis of Bureau of Labor Statistics, QCEW data from IMPLAN Group LLC.

Seizing the Biomanufacturing Opportunity: A Breadth of Industry Strengths in Wisconsin Form a Cluster of Opportunity within Biohealth

Wisconsin's concentration of companies and exciting recent investments across several aligned application, product, and service areas combine to form a unique and strong cluster of innovative development and manufacturing in what can broadly be referred to as "biomanufacturing". These areas span biopharmaceutical manufacturing and commercial research and testing, and are rooted in, in some cases, historical scientific discovery and innovation strengths of Wisconsin.

Biomanufacturing uses living cells and biological systems to make commercial products, or to extract and utilize a particular molecule via the bioprocessing of tissues or cells. These products or biological molecules can be used across a varied set of applications and markets for medicines and vaccines; food and beverage ingredients and processing; and other industrial applications. Biomanufactured products can be harvested from animal or plant cells, from blood, or from microbes.

In the late 1990s Dr. James Thomson, a UW-Madison developmental biologist was the first to introduce lab-derived human embryonic stem cells, a major breakthrough that underlies the field of regenerative medicine. Further, these cells are used across the world to test drugs, develop treatments for diseases, and advance understanding of human biology. Today, UW-Madison remains a leader in stem cell research.

Biomanufacturing has come to play a critical role in the pharmaceutical and biological products manufacturing industry and represents an ongoing paradigm shift from traditional small-molecule therapeutic product manufacturing to products based on biomaterials and biomolecules. The role of this key segment of the biopharmaceutical manufacturing industry is expected to continue growing to meet the needs of new generations of biobased products, ranging from medical products like immunotherapeutics to food and beverage applications in enzymes to industrial uses in plastics and other commercial products.

The three areas of alignment in Wisconsin are depicted in Figure 10 and have resulted in an exciting new initiative to advance the biomanufacturing

Figure 10: Wisconsin's Biomanufacturing-related Strengths and Resulting Forward BIO Initiative to Support and Advance the Biomanufacturing Ecosystem

The Biomanufacturing Opportunity Leverages Several Strengths:



Wisconsin Biohealth Stakeholders Collaborating to Advance Key Facets of Ecosystem Development to Advance Biomanufacturing



ecosystem—Wisconsin’s Forward BIO Initiative. Each area and the resulting Forward BIO Initiative are discussed in turn in this section.

Wisconsin’s Established Strengths in Biologics, Active Pharmaceutical Ingredient (API), Cell & Tissue Manufacturing

Within the high-growth drugs and pharmaceuticals subsector, Wisconsin has a current strength in the manufacturing of biological products and a concentration of sizable companies actively manufacturing biologics. In addition, companies have established competencies in API development and production in the state. APIs are the component part of a drug or pharmaceutical that produce the intended effects. Drugs are made up of both APIs and excipients as the core components with the excipient substances designed to deliver the medicine to a patient’s system. Today, the manufacturing of APIs has largely been outsourced from traditional pharmaceutical operations in the U.S. and Europe to overseas operations in Asia, particularly India and China. As a result of supply chain challenges uncovered by the COVID-19 pandemic, there will likely be an increased emphasis on U.S. production of APIs.

Key companies in the biomanufacturing and API production space in Wisconsin are featured here.

Alcami Corporation in Germantown is home to the company’s Center of Excellence for API development, scale-up and commercialization. Alcami is a contract development and manufacturing organization headquartered in North Carolina. The Germantown site conducts API development and manufacturing in one location. By establishing a Center of Excellence, Alcami has invested in state-of-the-art capabilities, including a series of investments targeting workforce, infrastructure, tools, and technology. Investments have expanded capabilities for controlled substances and highly potent API’s.

Catalent Biologics in Madison is part of the multinational and publicly traded parent company, Catalent, focused on contract development and manufacturing. Catalent develops, manufactures, and analyzes pharmaceutical and consumer products. The Madison facility has state-of-the-art biologics capabilities including mammalian cell line engineering, process development, analytical services and biomanufacturing using single-use systems—equipment designed to be used once and then changed over before the next manufacturing batch, offering enhanced flexibility in production

Recent Investments Highlight Exciting Growth and Emergence in Biologics and API Manufacturing

“Alcami to Establish Active Pharmaceutical Ingredient Center of Excellence in Germantown”
-PR Newswire, September 6, 2017

“Madison biotech Catalent to expand, add more than 100 jobs in nearly \$100M local investment”
-Wisconsin State Journal, January 8, 2019

“FUJIFILM Cellular Dynamics to Establish New Facility for Production of Human iPS Cell Therapy Applications”

scale and space planning and eliminating significant cleaning costs in development and change over.

The company has made major investments to grow and expand its facility and operations in Madison, in 2019 announcing that it had commenced a 60,000 square-foot expansion and will increase its employment by more than 100 (from approximately 300 at the time) as part of a nearly \$100 million investment.

FUJIFILM Cellular Dynamics, Inc. (FCDI) is a leading developer and manufacturer of human cells used in drug discovery, toxicity testing, stem cell banking, and cell therapy development. In 2019, FCDI built a new cGMP-compliant production facility in Madison with the goal of industrializing iPS cell manufacturing for regenerative medicine therapies. The facility supports FCDI's internal cell therapeutics pipeline and also serves as a Contract Development and Manufacturing Organization for iPS cell products.

Scientific Protein Labs (SPL) in Waunakee has a greater than 4-decade history developing and manufacturing proprietary APIs functioning both as a supplier and contract manufacturer serving the pharmaceutical, veterinary, and food industries worldwide. SPL's APIs are from biologically-derived sources and include Heparin and Pancreatic Enzyme products produced in a state-of-the-art cGMP biomanufacturing facility.

SPL's other line of business is its biopharmaceutical contract manufacturing and process development operations. The company offers contract services across the biopharmaceutical development cycle, ranging from process development to manufacturing of preclinical and clinical supplies right through commercial scale-up and production of drug product for clients' proprietary products. To accommodate this service, the Waunakee facility is equipped with fully validated GMP suites, analytical labs, and process research labs and is staffed with experts in engineering, quality assurance, quality control, regulatory and other high-skilled professionals.

Stratatech, a Mallinckrodt plc owned regenerative medicine company in Madison, focuses on proprietary skin substitute products. Its StrataGraft technology, when approved, will be the first "off-the-shelf" skin substitute that could be used to treat severe burns. Stratatech uses proprietary tissue engineering technology which creates living tissue. That tissue mimics human skin and promotes tissue regeneration. In August 2020 it was announced that the U.S. Food and Drug Administration has accepted the Stratatech Biologics License Application for StrataGraft for review with a target date of February 2, 2021.

Wisconsin's Established Strengths in Biohealth Research Tools and Instrumentation

Clustered in and around Madison are several sizable and multinational firms developing and manufacturing research tools and instrumentation to serve the biotech, pharmaceutical, diagnostics, and other life science-related research sectors.

Aldevron, with a facility in Madison, serves the biotech industry as a leader in the production of plasmid DNA, proteins, mRNA, gene-editing enzymes, and antibodies. The custom products are used for a varied set of life science projects and applications ranging from discovery research to clinical trials to commercial applications. The products are key raw materials and components in drugs, gene and cell therapies, vaccinations, and others. The Madison facility recently increased its fermentation capacity and manufacturing space to produce plasma DNA and recombinant proteins.

Illumina is a multinational company with operations in Madison. The firm is a global leader in genomics sequencing, genotyping, and other integrated systems—developing, manufacturing, and applying innovative technologies to the analysis of genetic variations and functions, enabling groundbreaking advances in life sciences research, translational and consumer genomics, and molecular diagnostics and to ultimately move the world closer to the realization of personalized medicine. In

2019, Illumina expanded its Wisconsin operations with the opening of a new enzyme R&D, production lab, and office facility in Madison adjacent to the University of Wisconsin’s University Research Park.

Lucigen, part of LGC’s Biosearch Technologies’ portfolio, was originated in Middleton and has a more than 20-year history in developing and manufacturing products and services that enable life science professionals and researchers to conduct their research and testing more efficiently and effectively. The organization has competencies in enzyme evolution, protein expression, cloning, competent cells, next-gen sequencing, and molecular diagnostics, and has grown its offerings to manufacture and deliver biomedical research products to customers worldwide.

Promega is a global company headquartered in Madison that provides innovative solutions and technical support to the life sciences industry. The company’s portfolio of over 4,000 products support a range of life science work across areas such as cell biology; DNA, RNA and protein analysis; drug development; human identification and molecular diagnostics. For over 40 years these tools and technologies have grown in their application and are used today by scientists and technicians in labs for academic and government research, forensics, pharmaceuticals, clinical diagnostics and agricultural and environmental testing.

Contract Research Organizations: New Investments in Wisconsin Reflect a Large Concentration

One of the largest components of the biohealth industry is life science-related commercial R&D, which includes the concentration of several Contract Research Organizations (CROs).

CROs provide support for the R&D of pre-market pharmaceuticals, biotechnology, and medical devices. CROs enable companies to bring a drug to market by assisting with the development and testing of new products. By contracting external

help and valuable expertise for these processes, the company that owns the intellectual property under development can save time and money by not building these capabilities internally.

Covance’s Madison campus has a 50-year history of supporting the pharmaceutical, food, and agricultural industries as well as the local economy. Covering over 1 million square feet of nonclinical laboratory and clinical capacity, the Madison campus employs more than 2,000 providing a wide range of services including general toxicology, safety pharmacology, developmental and reproductive toxicology, immunotoxicology, ocular toxicology, metabolism, and bioanalytical chemistry. In addition, the Madison campus operates a Clinical Research Unit that provides clinical pharmacology services specializing in first-in-human and human AME studies in healthy volunteers, and early patient renal and hepatic studies.

Covance is a global leader in nonclinical safety assessment, clinical trial testing, and clinical trial management services. The firm’s unique perspectives are based on decades of scientific, medical, and regulatory expertise. Covance generates more safety and efficacy data to support drug approvals than any other company, supporting clients’ complete lifecycle management.

Eurofins operates two facilities in Wisconsin. The Food Integrity and Innovation facility in Madison was acquired in 2018, when Eurofins purchased the Covance Food Solutions business from LabCorp. In this facility, Eurofins develops testing strategies and performs tests on a wide variety of food products, ingredients, and supplements, including nutrition analyses and testing for contaminants. The facility develops testing strategies for new food products or ingredients, including nutritional analyses and testing for contaminants. In late 2019, Eurofins broke ground on a flagship 108,000 square-foot food testing lab, expected to be complete in 2021.

The Eurofins SF Analytical Laboratory in New Berlin was acquired in 2014 when Eurofins purchased SFA Laboratories. The SF Analytical Lab provides services covering a range of products, including pharmaceuticals, personal care products, and raw materials. Services include foreign material identification (e.g. extractions and filtration), chemical and ingredient verification (e.g. purity and safety), legal and insurance claims, and investigative and special projects.

a new 80,000 square-foot laboratory purpose-built to support the analytical testing of gene therapy products. The Middleton GMP Lab now covers nearly 450,000 square-feet of floor space with nearly 1,700 staff employed in the Dane County area. PPD also maintains a 100-person Bioanalytical Lab in Middleton that uses analytical chemistry instruments to measure levels of drug in patients taking part in clinical trials testing new therapeutic agents.

PPD's GMP (Good Manufacturing Practices) Lab in Middleton partners with global pharmaceutical companies to test the quality of drugs sold to patients worldwide or tested in patients in clinical trials. The GMP Lab uses various analytical chemistry, cellular, and molecular biology techniques to measure the identity, purity, potency, and stability of therapeutics, ensuring that they meet the manufacturer's specifications for safety and effectiveness. The Middleton GMP Lab has expanded multiple times since 2015, most recently opening



Seizing the Biomanufacturing Opportunity: Wisconsin’s Forward BIO Initiative



Wisconsin’s biohealth ecosystem has come together in a collaborative partnership to seize its opportunity, leverage its strengths, and ensure future opportunities in biomanufacturing. **The Forward BIO Initiative**, is a collaborative effort between Forward BIO Institute, Forward BIOLABS, and BioForward Wisconsin. It is committed to advancing Wisconsin as a national leader in biomanufacturing. A unique partnership, the Initiative offers comprehensive support for technological innovation and workforce development to effectively translate discoveries into commercial products and groundbreaking therapies.

Research discoveries cannot have transformative impact if they never leave the laboratory. The Forward BIO Institute is committed to establishing robust and effective public-private partnerships which seek to find innovative solutions for critical global biomanufacturing challenges.

The Forward BIO Institute leverages multi-disciplinary strengths and expertise at UW-Madison with the goal of “catapulting” technologies out of regional universities and into the private sector via supporting initiatives. The Catapult Program identifies high-value discoveries and technologies and develops preliminary business cases to connect research investigators with entrepreneurs and investors to accelerate commercialization and startup companies.

The Institute also is developing the biomanufacturing talent pipeline on several important levels. Its Innovators in Training Program targets doctoral candidates and postdoctoral trainees with business, legal, regulatory, and other training to facilitate their transition to entrepreneurial and technology development pursuits. The Career Enhancement Opportunity Program provides mentored career exploration for graduate students in biotechnology fields through internship opportunities in careers



based at UW-Madison, supports biomanufacturing innovations in workforce development, transformative R&D, and public-private partnerships.



a shared lab facility at the University Research Park, provides office and lab space and other supportive services for biotech startups to lower the barriers for entrepreneurs in launching new ventures.



representing Wisconsin’s biohealth industry, facilitates partnerships between government, academia and private industry, as well as marketing the economic and business impact of Wisconsin’s biohealth industry.

Technologies Being Developed as Part of the Forward BIO Institute’s “Catapult” Program:

- Efficient, inexpensive, and scalable technology for tissue repair
- Genome editing-based therapeutic for inherited retinal disease
- Exosome-mediated therapy for treatment of acute radiation syndrome
- A hydrogel device enabling efficient allogeneic tissue transfer
- Human tissue screening systems to advance neurodegenerative drug discovery
- Cancer therapy mediated via intratumoral protein delivery
- Coated microcarriers for serum-free human cell manufacturing
- Endogenous signal-based cell enrichment for immunotherapy applications

Source: Forward BIO Institute, UW-Madison.

outside of academia. The College of Engineering and School of Business have partnered to launch an Accelerated Master’s Program in Biomedical Innovation, Design, and Entrepreneurship.

Changing the ways life science companies are built

Forward BIOLABS extends the entrepreneurial ecosystem for the translational work of the Institute by providing valuable lab and office space for startups and early-stage companies—a significant enabling factor for startup biotech efforts to focus on the science and product development. The economic barriers to starting a life science company are especially high. Unlike an app developer or other

“There isn’t another shared life science laboratory like this in Wisconsin—or Minnesota, Illinois or Iowa for that matter.

The lab facilities, network and community that Forward BIOLABS provides are powerful tools enabling member startups to move faster than they otherwise would.”

– Forward BIOLABS’ cofounder
Jessica Martin Eckerly

tech ventures requiring little more than a laptop and a wireless connection, biotech startups require expensive lab space, facility maintenance, scientific equipment, safety protocols, security, and more. Forward BIOLABS is helping to lower these typically high barriers to entry for life sciences startups and at the same time, is creating an environment where startups are co-located which bolsters valuable interactions across companies, among investors and their valuable networks, and for talent attraction.

Early outcomes at Forward BIOLABS are promising—young companies that have taken space and even “graduated” from Forward BIOLABS have far exceeded projections, demonstrating the necessity of Forward BIOLABS in meeting the entrepreneurial demand for shared lab space and key services.

Taken together, the commitment to advancing biomanufacturing is clearly arising from both private industry and public-private partnerships. Private companies are increasing their investments in Wisconsin—as reflected by the investments of companies such as Catalent Biologics’ investment in its Center of Excellence, or Fujifilm Cellular Dynamics investing in a new facility for iPS manufacturing for regenerative medicine therapies in Madison. And the economic development, academic, and broader industry stakeholder communities are making smart investments to further enhance the ecosystem.

Wisconsin's Biohealth Industry Response to the COVID-19 Pandemic

The fast growth and widespread reach of the COVID-19 pandemic has caused significant strain on the healthcare sector and public health institutions. To meet the increasing demand for testing, treatment, and prevention of the novel coronavirus, several Wisconsin biohealth companies have pivoted their activity to focus on the virus. Whether increasing production of supplies to boost testing capacity within the state, developing vaccines and therapeutics to prevent and treat viral infection, or providing R&D or manufacturing support to other companies, Wisconsin's biohealth industry has worked to provide key resources in the fight against this deadly pandemic.

Catalent Biologics: Across its global network of 40+ locations, Catalent is working with over 40 customers on multiple COVID-related antivirals, vaccines, diagnostics and treatments for symptoms and effects of COVID-19, including Johnson & Johnson's lead vaccine candidate, the University of Oxford/AstraZeneca's vaccine candidate and Moderna's mRNA-based vaccine candidate. The Madison facility is working on several COVID-19 programs, including an mRNA-based vaccine candidate for Arcturus Therapeutics, a virus-like protein-based vaccine candidate for Spicona and a monoclonal antibody investigational therapy for Humanigen.

Exact Sciences in Madison is one of the world's leading providers of cancer screening and diagnostic tests. When the COVID-19 pandemic struck, what started as an effort to provide COVID-19 testing to its employees quickly evolved into a larger effort to support the overall public health response. The company has developed a test for detection of SARS-CoV-2, and received Emergency Use Authorization from the FDA in April 2020. In its first three months, Exact Sciences processed over 500,000 COVID-19 results—more than 400,000 for the State of Wisconsin. As of August 2020, Exact Sciences is providing the collection supplies and

laboratory capacity necessary to support tens of thousands of COVID-19 tests per week to support health officials and the ongoing need for testing.

FluGen in Madison is developing the M2SR influenza vaccine, which is currently in human trials. In collaboration with virologists at UW-Madison, FluGen is developing and testing a vaccine for COVID-19 called CoroFlu. By leveraging their work on influenza, FluGen hopes to create a unique vaccine that can provide immunity to both viruses through the insertion of SARS-CoV-2 gene sequences into M2SR. CoroFlu, which could be in clinical trials by Fall of 2020, will initially be manufactured by Bharat Biotech in India.

GE Healthcare in Wisconsin focused on ramping up the supply of medical equipment to those on the front lines, keeping that equipment in good working order and supporting the medical staff using it. In Madison, where GE Healthcare makes ventilators, it doubled capacity in early 2020 and aimed to double it again. GE also separately collaborated with Ford to quickly scale an Airon-designed ventilator for emergency use. Additionally, the company created a CT-in-a-Box solution for hospitals that needed a CT fast, deployed remote patient data monitoring technology to support critical COVID-19 patients, launched a new AI suite to detect chest X-ray abnormalities, and announced research to test how AI can help predict COVID-19 severity.

Gentueri is a developer of DNA swab testing and collection kits based in Verona, Wisconsin. To fulfill demand, Gentueri hired additional employees and pivoted production to Viral Transport Media Kits for COVID-19 oral testing. The kits include nasal or oral swabs and the Viral Transport Media used to keep the virus alive during storage and transportation. As of Sept 14, 2020, Gentueri has provided over 500,000 testing kits and 2,500,000 swabs to laboratories. The company is also developing a version

of its CollectEject Swab Kit that would allow individuals to collect an oral sample sent in themselves for automated processing.

Gilson in Middleton is a manufacturer of laboratory equipment and testing supplies including pipettes and automated liquid handling systems. A range of these products can be used to enable safe handling and accurate analysis of COVID-19 testing samples. Gilson also provides support services and guidance for use of their equipment in COVID-19 testing labs.

The **PPD** laboratories in Middleton are currently supporting over a dozen fast-track programs testing therapeutic agents for effectiveness against COVID-19 infection.

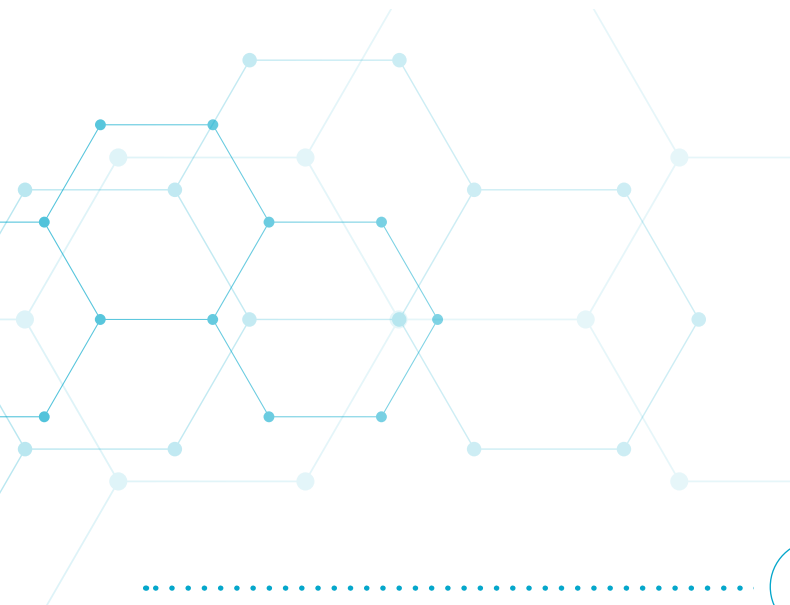
Promega in Madison is a manufacturer of enzymes and other products for biotechnology and molecular biology applications. Several of the company's RNA extraction and amplification products are approved by CDC for use in COVID-19 testing. Promega continues to develop new diagnostic methods for detecting both current COVID-19 infection and antibodies as evidence of past infection. The company has also partnered with Co-Diagnostics, Inc. of Utah to meet testing demand through manufacture of COVID-19 test kits.

“We are hearing the needs and concerns of our scientific colleagues and partners, and we are doing all that we can to help alleviate them.”

– Chuck York, VP of Manufacturing Operations, Promega

UW Health has worked to increase testing capacity for COVID-19 testing to improve turnaround time and enhance the state's testing capacity. UW Health and the University of Wisconsin School of Medicine and Public Health, its integrated academic medical and research institution, have also been a location for various COVID-19-related clinical trials including an antibody study and convalescent plasma investigation, leveraging the research and clinical expertise within the system. Additionally, UW Health has provided the state with medical advice and extended outreach directly to Wisconsinites through local media.

Versiti (Blood Center of Wisconsin) in Milwaukee is utilizing its blood donation capabilities to collect plasma from people who test positive for the SARS CoV-2 antibody as a result of recovering from COVID-19. With blood utilization temporarily down in April due to a decline in elective hospital procedures, Versiti committed resources to convalescent plasma collection and has been expanding their capabilities since. Plasma therapy from recovered COVID-19 patients is being studied at the Versiti Blood Research Institute as part of a nearly \$400,000 grant from the Advancing Healthier Wisconsin Endowment to be applied to research related to treating patients with COVID-19.



IV. THE BIOHEALTH INNOVATION ECOSYSTEM IN WISCONSIN

A vibrant and dynamic biohealth industry requires a robust and supportive ecosystem that fuels scientific discovery and technologies leading to innovative new products and services. The world’s leading biohealth and life science clusters are those that are anchored by research institutions such as leading universities and academic medical centers developing talent and advancing research and development, supported by access to research funding and risk capital for innovative companies, and connected to a robust talent pipeline to advance and implement innovations. Several facets of Wisconsin’s biohealth ecosystem and their recent performance are highlighted in this section of the report.

Workforce and Talent

Arguably the most critical ingredient to a thriving biohealth ecosystem is a statewide talent base equipped with the myriad blend of education, expertise, and hard skills required to advance scientific inquiry and R&D; translate discoveries into commercially-viable products; and ultimately produce, sell and distribute biohealth-related products and services. Presented here are high-level insights into the occupational demand and trends that underlie the broader industry dynamics, and a snapshot of the breadth of colleges and universities that are generating and “supplying” skilled biohealth talent.

Wisconsin’s “primary” biohealth workforce—those employed in occupations that are clearly and primarily life science-oriented—can be segmented into two major groups. First, the clinical workforce that play key roles across the state’s healthcare services industry and second, the non-clinical workforce that distinguishes the state’s industrial biohealth industry.

Wisconsin’s clinical workforce exceeds 240,000 and has grown by 2.6 percent since 2015, behind the

Challenge for Wisconsin:

Meeting the workforce demand challenge is critical to maintaining industry growth. Wisconsin is lagging the nation in both the growth of its clinical and non-clinical biohealth workforce. It is also behind the U.S. growth rate in degree graduates in key biohealth fields.

national pace (6.3 percent, see Table 4). Despite the slower growth compared to the nation, several clinical groups are growing faster than the overall occupational growth rate for Wisconsin, these include therapists, health techs, nursing, and health diagnosing and treating. As an occupational group, therapists have a strong concentration in Wisconsin, with a state location quotient reaching 1.14.

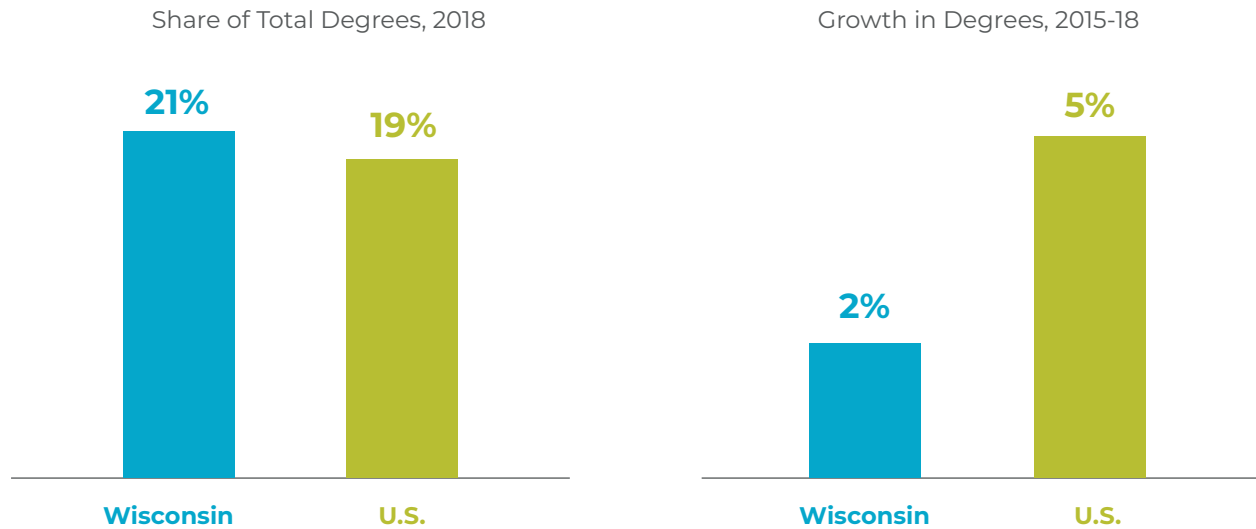
The non-clinical biohealth workforce totaled nearly 17,000 in 2019 and has experienced double-digit growth since 2015, though just behind the national growth rate. This segment of the biohealth workforce

Table 4: Primary Biohealth-related Occupational Employment Metrics, Wisconsin and U.S., 2019

Primary Biohealth Occupational Groups	Employment, 2019	Location Quotient	WI Empl. Change, 2015-19	U.S. Empl. Change, 2015-19
Total, All Occupations	2,992,930	1.00	3.10%	5.3%
Total, Clinical Workforce	243,114	0.97	2.60%	6.3%
Healthcare Assistants & Support	73,276	0.88	-3.40%	2.8%
Health Technologists & Technicians	65,407	1.04	6.10%	7.0%
Nursing	63,342	1.00	5.10%	9.2%
Health Diagnosing & Treating Practitioners	25,156	0.89	3.70%	7.2%
Therapists	15,932	1.14	6.90%	11.2%
Total, Non-Clinical Workforce	16,979	0.85	10.70%	12.2%
Biohealth Managers	7,166	0.82	13.00%	18.8%
Life & Biohealth Scientists	4,998	0.80	12.10%	11.8%
Life Science Technicians	4,554	1.02	7.00%	3.4%
Biomedical Engineers	260	0.65	-5.80%	-6.9%

Source: TEconomy Partners LLC analysis of EMSI 2020.Q1 Data Set.

Figure 11: Health and Life Science Degree Graduates—
Share of Total Degrees and Growth Trends (Associate’s and Higher)



Note major degree categories include: Biological and Biomedical Sciences; Health Professions and Related Clinical Sciences.
Source: TEconomy Partners analysis of National Center for Education Statistics, IPEDs Database.

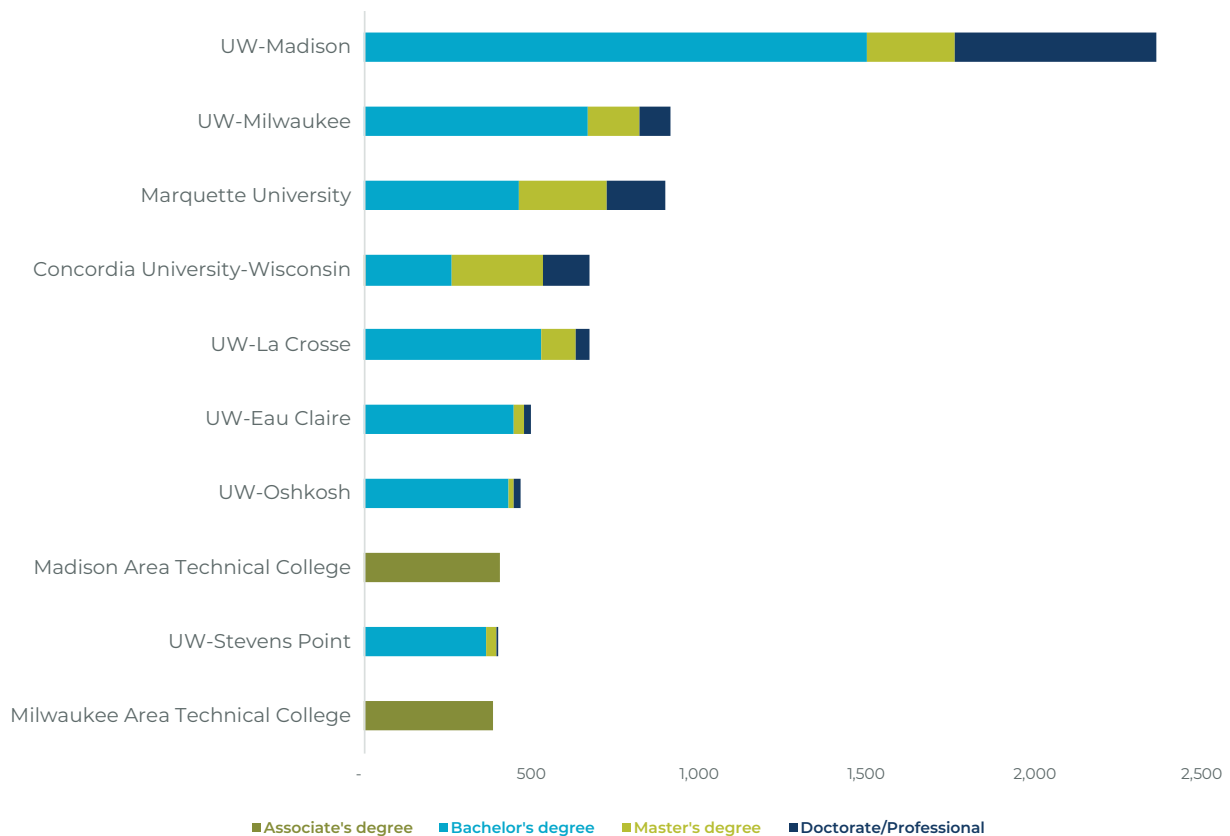
is primarily employed within the biohealth industry and includes biohealth-related management, scientists, technicians, and engineers. These occupations and employment totals also extend, however, into the public sector in government research functions and at public universities, though the occupations selected do not include collegiate teaching. Two groups in Wisconsin have outpaced the U.S. growth in recent years—life and biohealth scientists and life science technicians, reflecting the strong demand for scientific expertise in the industry.

Wisconsin’s colleges and universities have a strong concentration in health and life science degree fields, with more than one in five degrees conferred in one of these fields (Figure 11). This 21 percent

share is greater than that for the U.S. (19 percent). These fields represent growth areas both in the state and nationally, though Wisconsin has grown at a rate just behind that for the U.S.

Institutions statewide play key roles in developing and advancing this health and life sciences talent pipeline. Figure 12 shows the breadth of leading institutions in numbers of graduates, and highlights the complementary roles across academia with two of the state’s technical colleges focused at the associate’s level up through the UW system, Marquette University, and Concordia generating high-skilled talent at the Master’s and Doctorate levels.

Figure 12: Top Health and Life Sciences Institutions by Degree Counts (Associate’s and Higher), 2018



Note major degree categories include: Biological and Biomedical Sciences; Health Professions and Related Clinical Sciences.
 Source: TEconomy Partners analysis of National Center for Education Statistics, IPEDs Database.

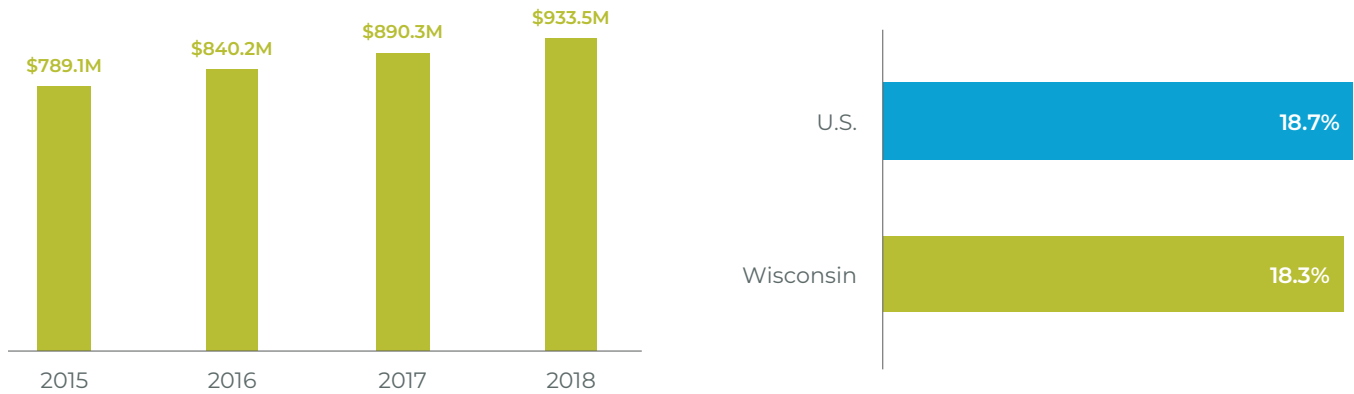
Academic R&D

In addition to their core education mission, Wisconsin’s research universities combine to form a more than \$900 million R&D engine fueling biohealth discovery and innovation. Biohealth-related academic R&D activity has grown by 18 percent since 2015, reaching nearly \$934 million in annual expenditures in 2018 (Figure 13). The growth rate of expenditures has matched that for the nation.

Academic Biohealth R&D totaled nearly \$934 million in Wisconsin in 2018 and is comprised of the following fields:

- Bioengineering & biomedical engineering
- Biological & biomedical sciences
- Health sciences

Figure 13: Biohealth Academic R&D Expenditures in Wisconsin, Levels and Growth Trends, 2015-18



Source: National Science Foundation, Higher Education Research and Development Survey and TEconomy Partners calculations.

A majority of academic research activity in biohealth falls within health sciences and the core biomedical R&D pursuits of academic medical schools and centers. Wisconsin’s universities are more concentrated in health sciences research compared with their counterparts nationally—accounting for 64 percent of biohealth research versus 59 percent (Figure 14). The leading role of medical schools is reflected in the two most prominent state institutions driving biohealth research in the state:

U.S. universities in its biohealth-related R&D expenditure totals. The University of Wisconsin School of Medicine and Public Health has been highly ranked by U.S. News & World Report in several areas and specialties (see sidebar) and has a footprint that extends well beyond Madison, with education locations across Wisconsin including in Milwaukee, Marshfield, Green Bay, and La Crosse.

- **The University of Wisconsin-Madison** accounts for nearly three-quarters of the total biohealth R&D activity in Wisconsin in 2018. The University, with \$677 million in biohealth R&D in 2018, is a top-tier biohealth research institution, among the top quintile of all

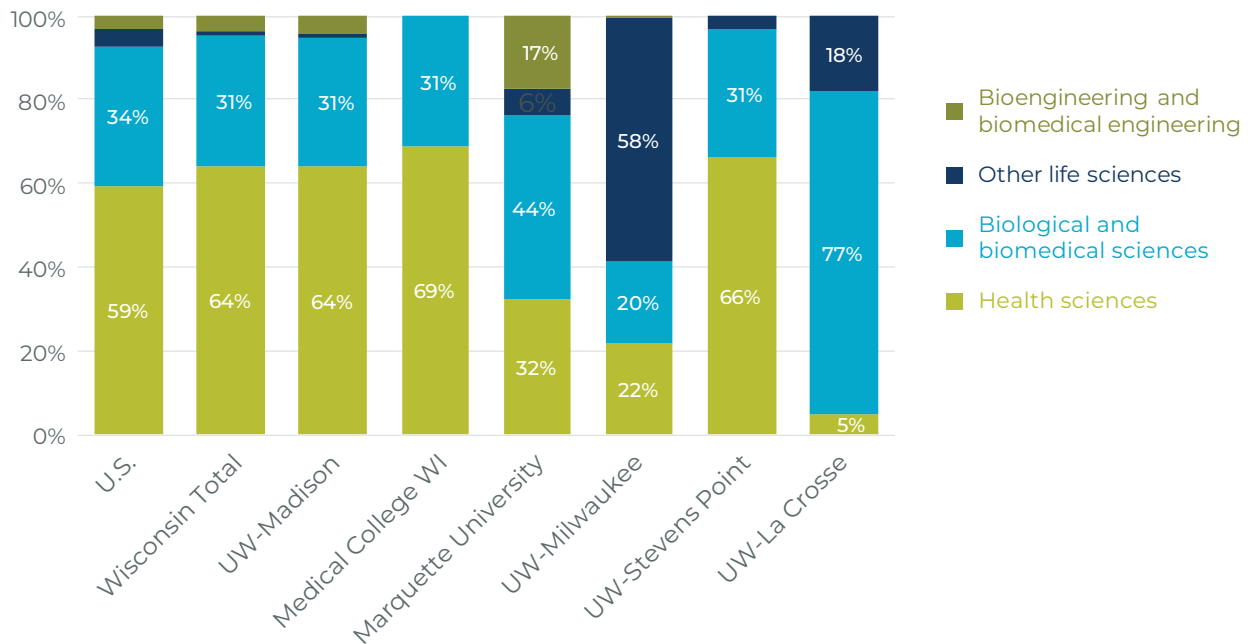
- Working in close partnership with the University of Wisconsin is the **Morgridge Institute for Research**, a private non-profit biomedical research institute. Located in Madison on the UW campus, the Institute strategically supports biomedical research strengths at UW-

Madison by attracting top research talent, enhancing research collaboration, creating shared resources, and commercializing research discoveries. In research, Morgridge provides seed funding, leads collaborative research initiatives, funds equipment purchases, hosts weekly seminars, and more. In talent attraction, Morgridge and UW-Madison form hiring alliances to bring new academic talent to Madison and work to retain existing research leaders. In addition, Morgridge plays a role in nurturing other opportunities, including: partnering with the UW College of Engineering to operate the Morgridge Fabrication Lab; nurturing start-ups and spin-offs from the Institute; adding a new Postdoctoral Fellows program; supporting biomedical innovation through prototype development; and

supporting outward-facing scientific events such as the Wisconsin Science Festival, programs with the local Boys & Girls Club and with high school students in rural Wisconsin.

- **The Medical College of Wisconsin (MCW)** is a private medical school based in Milwaukee with two additional campuses in Green Bay and in Wausau. The school plays a major role in both advancing biomedical research and medical education—it ranks as the 3rd largest private medical school in the U.S. and is among the top 5 percent nationally in the number of residents trained.⁹ In 2018, the Medical College spent more than \$229 million in R&D spanning health sciences and biological and biomedical sciences fields. This level of activity makes it the second-largest biohealth research institution in the state.

Figure 14: Biohealth Academic R&D by Institution and Field, 2015-18



Source: National Science Foundation, Higher Education Research and Development Survey and TEconomy Partners calculations.

9 Rankings and statistics highlighted on MCW website, see: <https://www.mcw.edu/about-mcw>.

Economic Impacts of Wisconsin’s University Biohealth Research

This analysis examines the resulting economic impacts of Wisconsin’s public and private universities’ combined \$933.5 million in biohealth research. Including these research expenditures as the direct output of this research enterprise “industry”, these funds support an estimated 3,903 university researchers throughout the state. These researchers averaged more than \$78,000 in wages and benefits in 2018. The work and expenditures of these university researchers generates additional indirect and induced impacts of more than 5,850 jobs in the state of Wisconsin and nearly \$905 million in output. **Wisconsin’s university biohealth research supports a total of more than 9,750 jobs and \$1.8 billion in output.**

For further details see the Appendix to this report.

National Institutes of Health (NIH) Funding

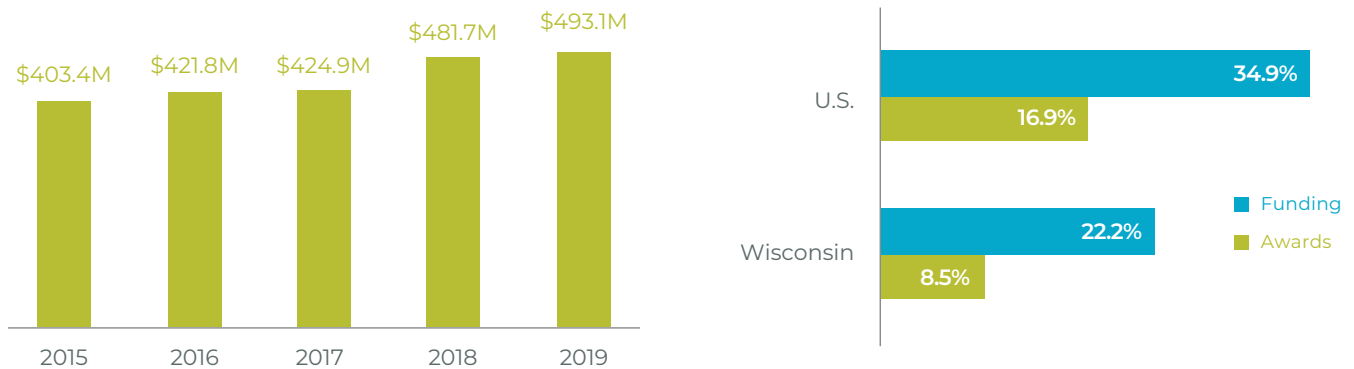
University R&D funding originates from several key sources including the federal government, non-profit organizations, internal institutional funds, business, state and local governments, and others. The majority of vital biohealth-related federal research funding is allocated through the Department of Health and Human Services, and within that, originates from the National Institutes of Health (NIH).

Challenge for Wisconsin:

While growing, Wisconsin is lagging the nation in NIH funding and award growth, eroding its overall national share of key biohealth innovation funding.

Wisconsin-based institutions and organizations received \$493.1 million in NIH funding in 2019. This reflects an increase of 22 percent since 2015, behind the rapid growth in national funding over the same period (35 percent, see Figure 15).

Figure 15: NIH Funding to Wisconsin Institutions, Levels and Growth Trends, 2015-19



Source: NIH RePORT database, and TEconomy Partners calculations.

On a cumulative basis, UW-Madison received \$1.5 billion in NIH funding from 2015-19, comprising about two-thirds of all Wisconsin funding, and just one component of a much larger total federal funding stream to the state’s colleges and universities that extends well beyond life science fields. The Medical College of Wisconsin received \$469.5 million, accounting for 21 percent of state funding.

The source of funding by NIH-administering institute can yield insights into areas of research focus within Wisconsin (Figure 16). Just as for industry employment, a “location quotient” concentration metric for NIH funding can be calculated for Wisconsin by specific institute. Those institutes with a funding LQ at or above 1.20 represent areas of funding concentration significantly above the national average and include:

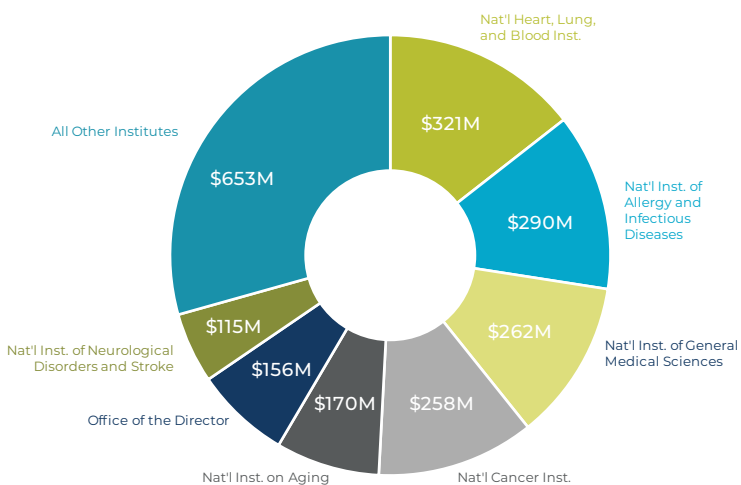
- The Office of the Director (OD); the National Institute on Deafness and Other Communication Disorders (NIDCD); the National Eye Institute (NEI); the National Center for Advancing Translational Sciences (NCATS); the National Institute

on Aging (NIA); the National Institute on General Medical Sciences (NIGMS); and the National Heart, Lung, and Blood Institute (NHLBI).

Examples of leading Wisconsin-based recipients of NIH funding which led to specializations in these areas, but also significant funding levels in others, include:

- From OD:
 - Wisconsin National Primate Research Center, one of seven facilities across the country (at UW-Madison)
 - Children’s Respiratory and Environmental Workgroup - research study of asthma (UW-Madison)
- From NHBLI
 - Blood & Marrow Transplant Clinical Trials Network Data Coordinating Center (at MCW)
 - Research on blood pressure and rat genome database mapping
- From National Institute of Allergy and Infectious Diseases
 - Inner City Asthma Consortium 3 (at UW-Madison)
 - Research on human viral infection and antimicrobial drugs
- From National Cancer Institute
 - UW Comprehensive Cancer Center
 - Wisconsin NCI Community Oncology Research Program
 - Research on blood and marrow transplants and human tumor viruses
- From NIA
 - Centers for Alzheimer’s research and prevention at UW-Madison

Figure 16: Wisconsin NIH Funding by Administering Institute, 2015-19



Source: NIH RePORT database.

Patents

The extensive biohealth-related R&D activity across Wisconsin’s academic institutions and its corporate community is translating into tangible innovations. Patent awards offer a lens into the outcomes of often years of rigorous scientific research and commercialization pursuits; and represent a critical legal framework for protecting valuable intellectual property (IP). In the biohealth industry in particular, IP can represent significant time and resources invested in developing a novel therapeutic, medical device, or other idea or product rooted in science and engineering.

During the 2015 through 2019 period, 1,672 patents were awarded and assigned to Wisconsin-based universities, companies, and other entities in biohealth-related patent classes. These patent areas span drugs and pharmaceuticals; medical and surgical devices; biochemistry; bioinformatics and health IT; biological sampling and analysis; and microbiology and genetics.

In addition to numerous companies either headquartered or with significant operations in Wisconsin, the leading biohealth-related patent assignee is the Wisconsin Alumni Research Foundation, or “WARF”, which represents the IP generated by the combined pursuits of UW-Madison researchers (see Table 5). WARF is a non-profit organization that supports the scientific research within the UW-Madison community by performing the technology transfer functions for the University, and is therefore the designated patent and licensing organization. WARF works to “steward the cycle of research, discovery, commercialization and investment” through financial support, actively managing assets, and advancing innovations to the marketplace for ultimate commercial returns and global impacts.¹⁰ Established in 1925, WARF represents one of the oldest, largest, and most

Table 5: Biohealth-related Patent Awards Assigned to Leading Wisconsin Patent Assignee Organizations, 2015-19

Patent Assignee Organization	Patent Awards
Wisconsin Alumni Research Foundation (WARF), Madison, WI	378
GE Medical Systems, Waukesha, WI	94
Promega Corporation, Madison, WI	74
Exact Sciences Corporation, Madison, WI	38
Arrowhead Madison Inc., Madison, WI	20
Cellular Dynamics International Inc., Madison, WI	17
Titan Spine LLC, Mequon, WI	17
The Medical College of Wisconsin Inc., Milwaukee, WI	16
Koninklijke Philips N.V., Fitchburg, WI	13
Ethicon (fka NeuWave Medical, Inc.), Madison, WI	11
TIDI Products LLC, Neenah, WI	11
Cascade Biosystems Inc., Colfax, WI	10
American Orthodontics Corporation, Sheboygan, WI	9
APN Health LLC, Pewaukee, WI	9
UW-Milwaukee Research Foundation Inc., Milwaukee, WI	9
Cellectar Biosciences, Inc., Madison, WI	8
Epicentre Technologies Corporation, Madison, WI	8
Vista Dental (fka Inter-Med), Racine, WI	8
Epic Systems Corporation, Verona, WI	7
FUJIFILM Cellular Dynamics Inc., Madison, WI	7
Ki Mobility, Stevens Point, WI	7
Marquette University, Milwaukee, WI	7
Stratatech Corporation, Madison, WI	7
WiSys Technology Foundation, Madison, WI	7

Note: “fka” stands for “formerly known as”.
 Source: TEconomy Partners analysis of U.S. Patent & Trademark Office data from Clarivate Analytics’ Derwent Innovation patent analysis database.

10 Wisconsin Alumni Research Foundation (WARF) website, see: <https://www.warf.org/about-us/about-us.cmsx>.

successful U.S. technology transfer offices. WARF/UW-Madison was recently recognized among the top 10 universities in total utility patents granted in 2019 (a majority of which were in biohealth classes), ranking 9th in an annual report from the National Academy of Inventors and the Intellectual Property Owners Association.¹¹

In addition to the breadth of biohealth patents assigned to WARF, the organization reports 36 total University-generated startups since 2015.¹² A review of the WARF website finds the majority of recent UW-Madison startups are indeed in biohealth-related product, service, and market spaces.

Federal SBIR/STTR Awards to Wisconsin Biohealth Companies

For innovative, emerging biohealth startups and smaller firms, access to capital is critical to advance toward commercialization. Access to seed- and early-stage capital is especially important for biohealth companies developing products and

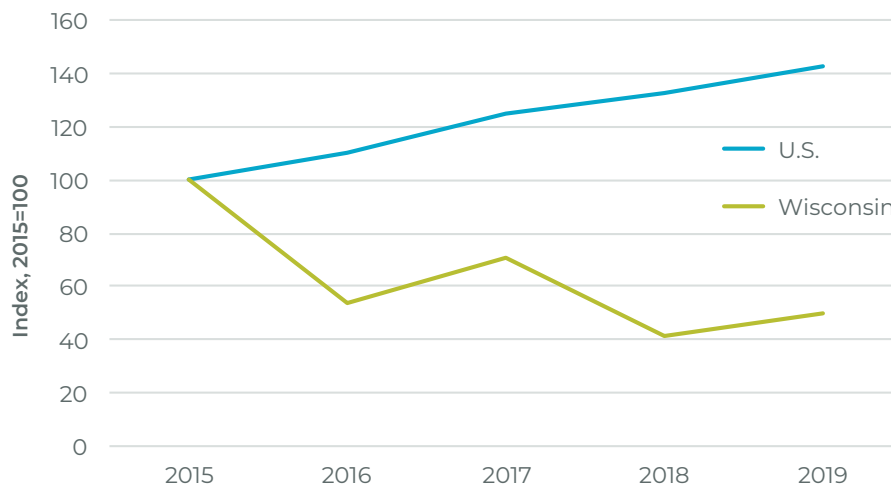
Challenge for Wisconsin:

Wisconsin has consistently lagged behind the nation in receipt of federal SBIR and STTR awards, with the gap growing wider over time.

in some cases conducting and meeting rigorous pre-clinical and clinical testing requirements. In addition to privately-funded risk capital, profiled in the next section, federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards represent a key source of non-dilutive innovation capital.

Wisconsin biohealth companies received a combined 131 SBIR and STTR awards totaling \$71 million between 2015 and 2019. Biohealth awards are defined here as all awards from the Department of Health and Human Services (HHS) as well as those from other agencies that were identified by biohealth-related titles and descriptions. During this 5-year period, Wisconsin biohealth awards peaked in

Figure 17: Biohealth-Related (HHS) SBIR/STTR Funding Trend, 2015-19



Source: TEconomy Partners analysis of SBIR.gov data.

11 WARF News Release, "WARF/UW-Madison among top 10 universities granted U.S. utility patents in 2019," June 6, 2020.

12 University startup figures are from the Association of University Technology Managers (AUTM) annual surveys, 2015 through 2018.

2015 with \$23.9 million and dropped to \$10.2 million by 2019 (Figure 17). In recent years, Wisconsin has consistently lagged behind the steadily growing national trend, with the gap growing wider over time. For national comparisons, only HHS-originated awards are shown to maintain comparability.

Risk Capital

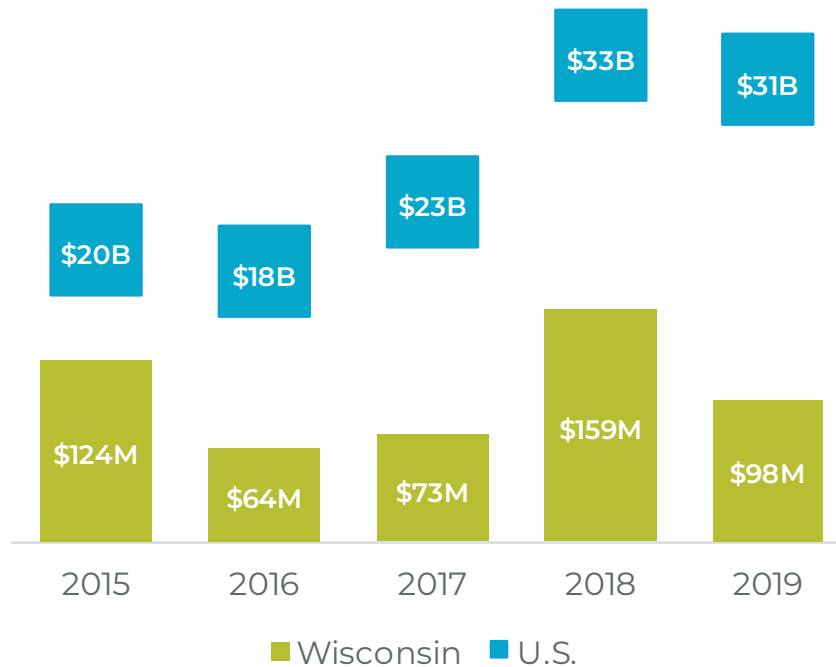
Venture capital and angel investments in Wisconsin’s biohealth industry totaled \$517 million in the 5-year period from 2015 through 2019. These funds were invested in 104 state companies across 188 individual deals. While risk capital funding can vary considerably year to year, often spiking with large investments in individual companies, the year-to-year trend for Wisconsin biohealth largely reflects that for the national industry (Figure 18). Both 2015 and 2018 represent recent funding peaks in Wisconsin, each exceeding \$100 million.

Wisconsin’s VC and angel investment deals have been more concentrated in the later stages of company development compared with the national investment landscape. Over the last five years, 27 percent of deal activity has been in later-stage investments compared with 19 percent nationally (Figure 19). Some of the difference is reflected at the seed stage where Wisconsin has a lower concentration of deal activity.

Digital health stands out in Wisconsin as a lead investment area representing one of every three companies and dollars invested in biohealth (Figure 20). The \$174 million invested in digital health since 2015 was spread across 36 individual companies. Top performing digital health companies include the following:

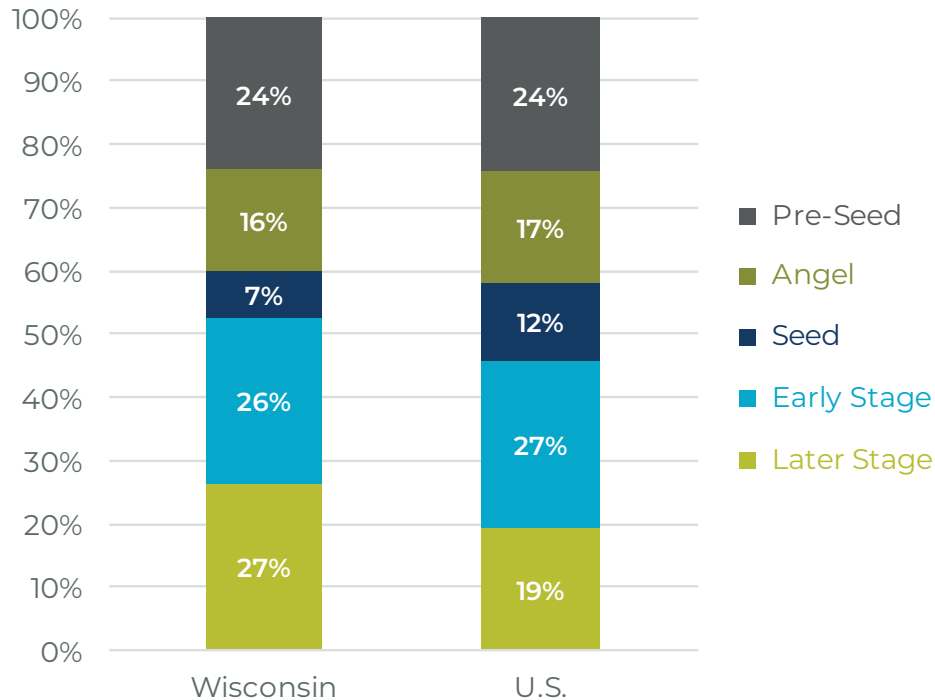
- Redox, located in Madison, builds customized healthcare networking software using a proprietary platform. The company leverages

Figure 18: Biohealth VC and Angel Investment Totals, Wisconsin and U.S., 2015-19



Source: TEconomy Partners analysis of PitchBook data.

Figure 19: VC and Angel Investments by Company Stage, WI and U.S., 2015-19



Source: TEconomy Partners analysis of PitchBook data.

their skills and experience to build integration platforms for healthcare providers, emphasizing efficiency and ease of use for the client. Redox raised \$52.69 million between 2015 and 2019.

- HealthMyne, located in Madison, has developed a patient management platform designed for use in clinical settings. Their precision medicine approach builds a more streamlined approach to treating individual patients. HealthMyne raised \$26.00 million between 2015 and 2019.
- HealthFinch, located in Madison, has developed a healthcare automation platform for use in managing electronic patient records. Their system simplifies routine tasks such

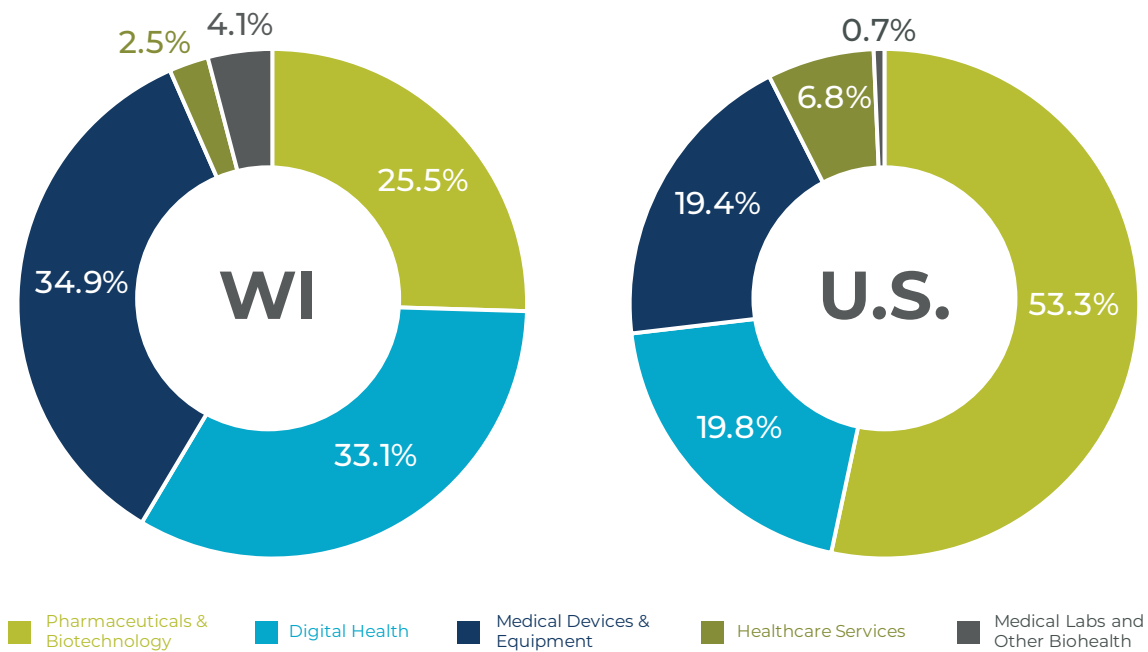
as prescription refills and enables doctors to more easily monitor patients' treatments. HealthFinch raised \$17.05 million between 2015 and 2019.

- Nimble Therapeutics, located in Madison, has developed a drug discovery platform intended to bring the power of massively parallel chemical synthesis to drug discovery. The company uses its unique maskless chemical synthesis platform to synthesize and systematically discover novel medicines in a variety of therapeutic areas, providing customers aid in the empirical optimization of molecules with more favorable drug-like properties. Nimble raised \$15.64 million between 2015 and 2019.

The state’s strengths in medical devices are also reflected in the greater share of risk capital investments. Since 2015, \$180.2 million has been invested in technology and product areas such as diagnostic equipment, surgical devices, and monitoring equipment. Top-performing medical device and equipment companies, with respect to VC investments, include the following:

- SHINE Medical Technologies, located in Janesville, manufactures equipment that utilizes radioactive isotopes for diagnosis and treatment of cancers, thyroid conditions, and other ailments. The company raised \$84.31 million between 2015 and 2019.
- NeuWave Medical, located in Madison, is a developer of minimally invasive soft-tissue ablation systems. The company raised \$25.31 million between 2015 and 2019 and during this period it was acquired by Ethicon, a subsidiary of Johnson & Johnson.
- Imbed Biosciences, located in Fitchburg, is a developer of wound dressing films that utilize nanoparticles to aid in healing. The company raised \$6.64 million between 2015 and 2019.

Figure 20: VC and Angel Investments by Biohealth Industry Subsector, WI and U.S., 2015-19



Source: TEconomy Partners analysis of PitchBook data.

V. BIOHEALTH INDUSTRY AND ECOSYSTEM CHALLENGES IDENTIFIED FOR WISCONSIN

This report validates the importance of the biohealth industry and broader biohealth economy to Wisconsin in growing high-quality jobs, advancing innovation, and bringing new biomedical treatments and capabilities to patients. The assessment finds, however, several notable areas where Wisconsin’s performance is lagging the nation and other states, and it could be at risk of seeing its share of industry and ecosystem elements erode.

Throughout the report are identified “challenges” for the industry; and while this assessment was not designed to develop a comprehensive biohealth

industry strategy for Wisconsin, it is important for BioForward Wisconsin and other industry stakeholders to continue to prioritize key areas of industry and ecosystem development going forward, particularly in light of the major emphasis and public-private investments of other states, regions, and nations in biohealth cluster development.

In general, the biohealth industry challenges are not dire, as most or all of these industry and ecosystem elements have been growing in Wisconsin, but the overarching theme is the state is “lagging” others in key areas.

Specific challenges identified through this assessment include:

- The biohealth economy, while growing, is seeing its national share erode slightly with overall job growth that is lagging just behind the nation.
 - Wisconsin’s biohealth workers earn less, in general, than their counterparts nationally. This can pose challenges for out-of-state talent recruitment, particularly among top talent in high-demand areas such as regulatory affairs, quality control, IT, engineering, and scientific expertise.
 - Meeting the workforce demand challenge is critical to maintaining industry growth. Wisconsin is lagging the nation in both the growth of its clinical and non-clinical biohealth workforce. It is also behind the U.S. growth rate in degree graduates in key biohealth and life sciences fields.
 - Wisconsin has consistently lagged behind the nation in receipt of federal SBIR and STTR awards in recent years for small, innovative biohealth companies, with the gap growing wider over time. At the same time, the state’s share of national biohealth VC funding has diminished since 2015.
 - While growing, Wisconsin is lagging the nation in NIH funding and award growth, eroding its overall national share of key biohealth innovation funding.
-



Competition for biohealth industry development is fierce, however, and Wisconsin is competing in an environment where some of the largest and leading biohealth states are growing at the fastest rates and are doubling-down on industry development. States are investing billions in advancing their biohealth and life sciences ecosystems, for example: Massachusetts has invested nearly \$1 billion over the last decade in its Life Sciences Initiative, with further funding authorized in 2018; California has invested \$3 billion in its Institute for Regenerative Medicine; Maryland has invested \$1.1 billion for its Bio 2020 initiative; and Texas has allocated \$3 billion in funding for its Cancer Prevention and Research Institute. While these investments are not realistic for every state, they put into context the intense competition for biohealth development and the corresponding talent, risk capital, and technology development at play.

Wisconsin should leverage this assessment to not only validate this industry is among its leading economic performers and more than worthy of targeted state development; but to further consider priorities and investments in areas such as talent development to meet the demands of a growing industry; and ensuring it is receiving its share of federal funding in terms of small business innovation and NIH biohealth research funding. The Forward BIO Initiative established by BioForward Wisconsin and its collaborating partners represents the type of enhancements and needed investments in critical ecosystem elements such as R&D activity, talent development, entrepreneurial support, and technology commercialization. The Initiative can and is helping to move the needle on several of the identified challenge areas. Going forward, ensuring this industry is well-rooted in Wisconsin and able to capitalize on its myriad strengths and emerging opportunities should be a top priority.

APPENDIX

Defining the Biohealth Economy in Wisconsin for Industry Analyses

TEconomy worked closely with BioForward to define the biohealth economy in Wisconsin, building up industry subsectors from individual detailed North American Industry Classification System (“NAICS”) codes. Some industries are adjusted in this analysis by TEconomy to include only the share of these industries directly involved in life science-related activities—they are designated by an asterisk in Table A-1 below.

Measuring the Digital Health Subsector

Unlike the majority of the biohealth industry which can be delineated and defined by federal NAICS classifications, isolating companies engaged in digital health requires building up a firm-level database with employment estimates derived from several sources. Because of this unique approach applied to Wisconsin, comparisons with the U.S. on any digital health metrics are not available in this report.

Digital health companies are embedded largely within broader software and computer services industry classifications. Therefore, to identify and address this key component of Wisconsin’s biohealth industry, TEconomy’s project team worked to identify individual companies and to build a firm-level database. The project team used a variety of sources to construct the database of digital health companies. These sources included the company inventory used in the 2018 “Wisconsin’s Biohealth Industry” Economic Impact report; the PitchBook database of venture capital and private equity; the BioForward Wisconsin membership list; data from the Business Dynamics Research Consortium (BDRC); the proprietary Dun & Bradstreet Hoovers database; the HealthTechMKE directory of firms; and individual company websites. A company was retained in the list if its business model has a clear and predominant focus in healthcare or biomedical software, information technologies, or other digital services or products. Employment values were derived from the same sources, with efforts undertaken to verify accuracy where possible. BioForward Wisconsin assisted in vetting the database.

Table A-1: Defining the Biohealth Economy, NAICS-Based Definition

Biohealth Economy Subsectors	NAICS Code	NAICS Title
Biohealth-Related Distribution		
	423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
	423460	Ophthalmic Goods Merchant Wholesalers
	424210*	Drugs and Druggists' Sundries Merchant Wholesalers
	532283	Home Health Equipment Rental
Biomedical Research & Testing		
	541713*	R&D in Nanotechnology
	541714	R&D in Biotechnology (except Nanobiotechnology)
	541715*	R&D in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
Digital Health**		
	N/A	N/A
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 and 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
	339115	Ophthalmic Goods Manufacturing
	339116	Dental Laboratories
Healthcare Services		
	621410	Family Planning Centers
	621420	Outpatient Mental Health and Substance Abuse Centers
	621491	HMO Medical Centers
	621492	Kidney Dialysis Centers

Biohealth Economy Subsectors	NAICS Code	NAICS Title
	621493	Freestanding Ambulatory Surgical and Emergency Centers
	621498	All Other Outpatient Care Centers
	621511	Medical Laboratories
	621512	Diagnostic Imaging Centers
	621991	Blood and Organ Banks
	621999	All Other Miscellaneous Ambulatory Health Care Services
	622110	General Medical and Surgical Hospitals
	622210	Psychiatric and Substance Abuse Hospitals
	622310	Specialty (except Psychiatric and Substance Abuse) Hospitals

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

***Note: Digital health subsector analysis developed through a firm-level database as these activities cannot be isolated within the existing NAICS industry structure.*

Technical Note on the Growth Trend in Biohealth-Related Distribution

Changes in the federal classification approach within the wholesale trade industry have impacted the growth trend for biohealth-related distribution and warrant a discussion in this report. Periodically, the federal statistical system updates its industry classification scheme (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 biohealth-related distribution sectors and had the effect of creating a significant, yet immaterial, increase in the employment, establishment and wage level within the biohealth-related distribution subsector in 2017. This reclassification, while providing a more accurate count of the true size and scale of biohealth-related distribution, has impacted the overall biohealth industry trends. And while it is not possible to fully adjust for this, the growth trend in distribution is consistent with growth across the biohealth industry during this period and toward the end of a record-setting economic expansion.

Biohealth Supply Chain Impacts: Additional Details

Table A-2 presents additional details of the employment and output impacts of the biohealth supply chain.

Table A-2: Key Components of the Wisconsin Biohealth Industry Supply Chain Sectors

Key Components of the Supply Chain Sectors	Supply Chain (Indirect Effects)	
	Employment	\$Millions
Business Administrative, Management, & Support Services		
Corporate headquarters, regional admin & sales offices; holding companies	4,054	\$806.8
Employment services	3,981	\$374.4
Legal services	800	\$167.3
Management consulting services	1,110	\$129.1
Advertising, public relations, and related services	664	\$108.4
Wholesale Manufactured Inputs		
Wholesale – Professional/commercial equipment and supplies	1,253	\$402.3
Wholesale - Electrical and electronic goods	263	\$120.9
Wholesale - Other nondurable goods	328	\$97.4
Wholesale - Other durable goods	328	\$76.8
Wholesale - Machinery, equipment, and supplies	210	\$54.4
Facilities & Related Services		
Real estate management & leasing	2,275	\$417.9
Maintenance & repair construction of commercial/ industrial structures	231	\$46.2
Services to buildings	987	\$44.7
Commercial/industrial machinery and equipment repair and maintenance	227	\$31.8
Other facility support services	297	\$31.5
Finance & Insurance		
Corporate insurance carriers, except direct life	242	\$184.0
Corporate banking	492	\$138.8
Insurance agencies, brokerages, and related activities	463	\$109.8
Transportation & Logistics		
Warehousing and storage	1,146	\$134.4
Truck transportation	667	\$116.2

Key Components of the Supply Chain Sectors	Supply Chain (Indirect Effects)	
	Employment	\$Millions
Couriers and messengers (e.g., FedEx & UPS)	925	\$89.0
Postal service	820	\$76.7
Support activities for transportation	338	\$50.5
Transit and ground passenger transportation	214	\$14.0
Software, Communications & IT Services		
Data processing, hosting, and related services	226	\$100.0
Wired telecommunications carriers	124	\$61.0
Wireless (cellular) telecommunications carriers	28	\$46.2
Computer systems design services	324	\$46.1
Software publishers	121	\$44.2
Research, Technical, & Engineering Services		
Scientific research and development services	663	\$158.5
Architectural, engineering, and related services	459	\$83.5
Marketing research and all other miscellaneous technical services	625	\$43.2
Manufacturing: Printing & Packaging		
Printing	583	\$100.3
Paperboard container manufacturing	81	\$39.0
Other plastics product manufacturing	102	\$28.5
Plastics packaging materials manufacturing	40	\$18.2
Utilities		
Electric power transmission and distribution	69	\$94.2
Electric power generation	42	\$52.0
Natural gas distribution	8	\$5.9
Manufacturing: Metalworking		
Iron and steel forging	96	\$31.6
Machine shops	162	\$24.0
Turned product and screw, nut, and bolt manufacturing	54	\$12.7
Crown and closure manufacturing and metal stamping	45	\$11.5
Manufacturing: All Other		
Petroleum refineries	1	\$5.9
Sign manufacturing	44	\$5.5

Key Components of the Supply Chain Sectors	Supply Chain (Indirect Effects)	
	Employment	\$Millions
Industrial gas manufacturing	5	\$4.6
Other basic organic chemical manufacturing	3	\$4.3
Other miscellaneous chemical product manufacturing	7	\$3.7
Manufacturing: Electronics & Related Components		
Printed circuit assembly (electronic assembly) manufacturing	13	\$4.3
Other electronic component manufacturing	9	\$2.1
Relay and industrial control manufacturing	4	\$1.6
Bare printed circuit board manufacturing	5	\$1.1
Motor and generator manufacturing	3	\$1.1
All Other Suppliers and Services		
Restaurants, coffee shops, & food service	1,416	\$82.2
Radio and television broadcasting	208	\$61.2
Publishers	222	\$27.6

Source: TEconomy Partners analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

Economic Impacts of the “Extended” Biohealth Economy in Wisconsin

Table A-3: Economic Impact of the Wisconsin Biohealth Economy, 2018

Impact Type	Employment	\$ in Billions			
		Labor Income	Output	State/Local Tax Revenue	Federal Tax Revenue
Direct Effect	197,356	\$15.898	\$43.174	\$0.808	\$3.154
Indirect Effect	109,457	\$5.970	\$17.247	\$0.634	\$1.196
Induced Effect	115,309	\$5.116	\$16.430	\$0.990	\$1.105
Total Effect	422,122	\$26.985	\$76.852	\$2.433	\$5.455
Multiplier	2.14	1.70	1.78		

Source: TEconomy Partners analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

Economic Impacts of Wisconsin’s University Biohealth Research

Table A-4: Economic Impact of the Wisconsin’s University Biohealth Research, 2018

Impact Type	Employment	\$ in Millions			
		Labor Income	Output	State/Local Tax Revenue	Federal Tax Revenue
Direct Effect	3,903	\$306.2	\$933.5	\$8.7	\$58.8
Indirect Effect	3,257	\$186.2	\$534.7	\$17.0	\$36.4
Induced Effect	2,598	\$115.3	\$370.1	\$22.3	\$24.9
Total Effect	9,757	\$607.7	\$1,838.4	\$48.0	\$120.1
Multiplier	2.50	1.98	1.97		

Source: TEconomy Partners analysis using employment data developed by TEconomy and IMPLAN State of Wisconsin model.

BioForward

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