A Strategic Roadmap

for Advancing Indiana's Life Sciences Industries

Prepared for: BioCrossroads
Prepared by: TEConomy Partners, LLC

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TECONOMY PARTNERS LLC

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

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Prologue: A state that advances innovations into products that improve health and well-being

Recently, President Biden and the U.S. Department of Commerce's Economic Development Administration (EDA), designated Central Indiana as one of the country's 31 inaugural Tech Hubs. In making this announcement, the EDA wrote that Indiana's Tech Hub "will catalyze regional biotech innovation and accelerate production of innovative life-saving medicines" and "strengthen the nation's biotechnology supply chain and facilitate the rapid discovery, development, and deployment of next-generation bioproducts." While this is not new for us in Indiana, it is affirming to receive the national recognition that Hoosiers develop and make life sciences products relied on by people the world-over.

This has, in fact, been true for some time. In 1923—one hundred years ago—Eli Lilly & Company became the first in the United States to manufacture insulin and sell it for the treatment of diabetes. In the intervening century, Hoosiers have continued this legacy of life sciences innovation and production in broad and diverse areas of the life sciences. Each year, Hoosiers receive around 1,000 new life sciences patents while the state's companies receive FDA approval for several dozen new products. Indiana also routinely ranks as one of the nation's top states for exports of all life sciences products. In 2022, Indiana was in fact the leading state for pharmaceutical exports, plainly illustrating the fact that people around the globe rely on therapeutics, vaccines, diagnostics, and devices made here in Indiana. Indeed, as documented in a series of reports for BioCrossroads that were published early last year, the life sciences industry is essential to the state's economic well-being.

Going forward, Indiana has the opportunity to build on the success of its life sciences industry to further benefit the health and well-being of society at large while also generating economic growth within the state. Now is a particularly unique moment to ensure that Indiana strategically positions its life sciences industry for future growth. The opportunities and challenges laid bare by the COVID-19 pandemic, as well as unparalleled federal investments in industries of national significance, provide an opportune time to design the future of Indiana's life sciences industry. Between company headquarters, manufacturing plants, one of the world's leading engineering schools, the nation's largest medical school, and several large hospital systems—all within close proximity—Indiana has the necessary ingredients to become a world center of the life sciences industry. And when the world needed us, Indiana was the only state that manufactured all three COVID vaccinations, showing the world our unique capabilities in this important space.

To help think through how to best make use of these ingredients, BioCrossroads turned to our long-time consulting colleagues at TEConomy Partners, LLC. Nearly 25 years ago, CICP's leaders worked with TEConomy's forerunner—the Battelle Technology Partnership Practice at the Battelle Memorial Institute—to assess the state economy and suggest a path forward for economic development in the 21st Century. It was this work that led to CICP's branded sector initiative strategy and the 2002 launch of BioCrossroads—CICP's first branded sector initiative.

The launch of BioCrossroads was made possible with critical support from private, public, higher education, and philanthropic leaders. To make the most of the current moment, once again we will need representatives of all sectors to work collaboratively in an effort to maximize Indiana's assets and address challenges to growth. It is with this in mind that the following document provides an aspirational roadmap for Indiana's life sciences industry in the few years ahead.

Through in-depth analyses, robust stakeholder engagement, and benchmarking against competitor states, TEConomy has arrived at several recommendations, all couched under four broad strategies:

1. Foster R&D and innovation.
2. Enhance the manufacturing ecosystem.
3. Boost talent and workforce.
4. Support connections and outreach.

These broad strategies touch upon the full continuum of activity in the life sciences and, as such, require support and participation from a range of organizations. What follows is not a plan for BioCrossroads. Rather, ***it is a plan for all engaged with the life sciences industry in Indiana.***

That said, BioCrossroads, among others, is already at work on several of the recommendations provided herein. Efforts to launch a workforce center focused on pharmaceutical manufacturing have, for example, been underway for a few months. Purdue University is well into launching the William D. Young Institute for the Advanced Manufacturing of Pharmaceuticals. Other critical players in the state's life sciences sector—including the Indiana Bioscience Research Institute, Indiana University, the Indiana Economic Development Corporation, the Applied Research Institute, and many others—have long been hard at work, laying the foundation for the recommendations that follow. Yet, at the same time, a few of the recommendations are likely aspirational in nature—efforts that may take years to come to fruition.

Regardless of whether the recommendations that follow are well on their way to becoming reality or still a few years off, each represents a vital input to a hyper-connected and well-functioning life sciences ecosystem. Each recommendation is, in other words, an important destination on the roadmap leading to the vision described herein:

By 2033, Indiana will be known as a global leader in the life sciences industry—the place that advances innovations into products that improve health and well-being.

We look forward to our partners in the private, public, higher education, and philanthropic sectors joining together once again to ensure this vision becomes a reality.

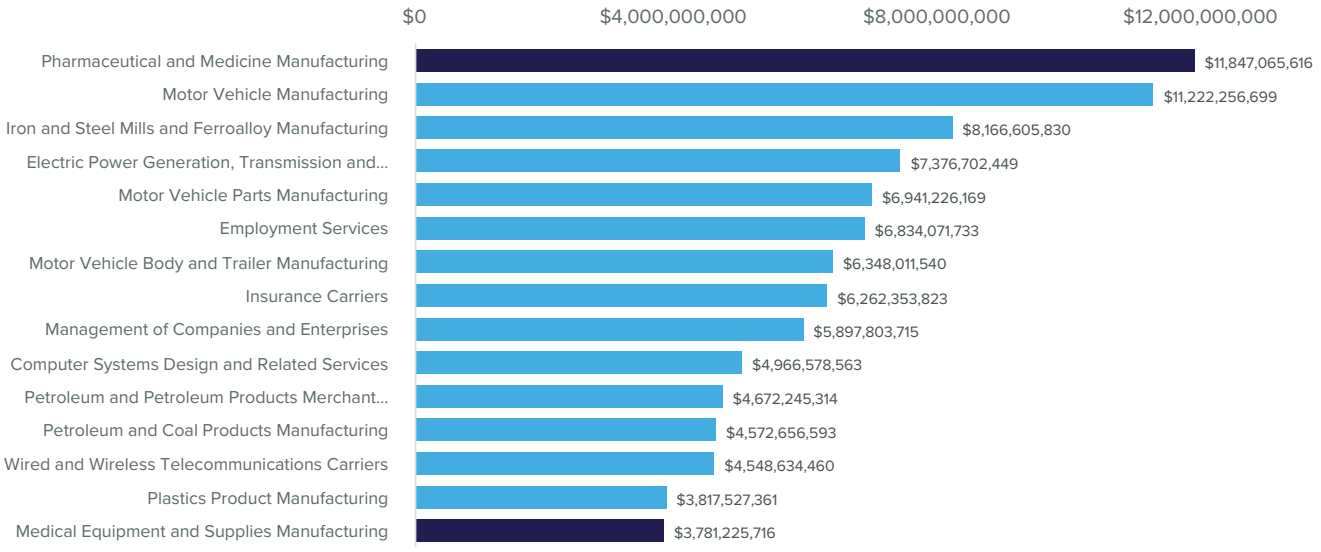
Melina Kennedy
CEO, Central Indiana Corporate Partnership

Dan Peterson
Board Chair, BioCrossroads

Executive Summary

Without question, life sciences is a powerhouse industry for the economy of Indiana comprising at least 476 companies and multiple high-profile academic and nonprofit research centers. With a long history of success, life sciences stands as one of the largest traded sector industries in the state in terms of contribution to state GDP (Figure ES-1). In 2022 alone, the combined output of the Pharmaceuticals and Medical Device segments produced over $15B in goods and services.

Figure ES-1: Traded Sector Industries by Contribution to State GDP (2022)

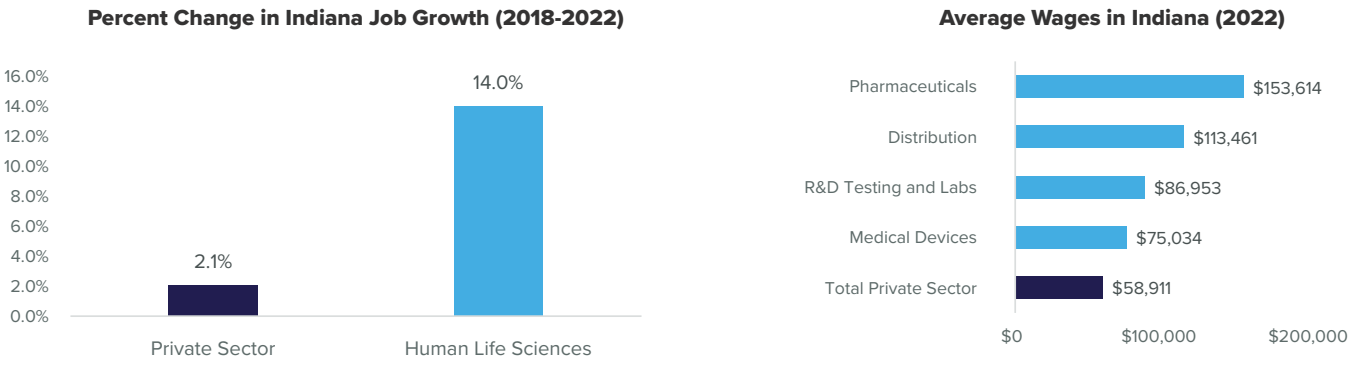


Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3

From a workforce perspective, life sciences generate good, often highly skilled, high-paying jobs that well outpace other industries in the state. Jobs within each life sciences subsector (Figure ES-2) pay well above private sector averages, with pharmaceuticals and bioscience-related distribution jobs offering wages over two times the state average.

Furthermore, the industry continues to grow rapidly. Since 2018, employment growth in Indiana's life sciences industry has been much faster than the state's private sector average—by a magnitude of nearly 7x (Figure ES-2). Also, important new investments such as the LEAP Innovation and Research District, expansions at 16 Tech, and ongoing investments by the research universities (including major new activity in Indianapolis) are positive signs and emblematic of the strong potential for future growth and economic expansion.

Figure ES-2: Percent Change in Indiana Job Growth (2018-2022) and Average Wages in Indiana (2022)



Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3

Despite this solid foundation, Indiana, like other regions in the 21st Century, is subject to the profound effects of large-scale technological, competitive, and economic change. This is especially true with life sciences as it contends with new innovations in drug development, disruptive research and manufacturing technologies, uncertain supply of workforce and skills, and macro changes to global supply chains.

While Indiana has many exemplary cases of leading companies adding to economic development, the ability to provide a state-wide ecosystem mobilizing and synergizing individual organizations across a comprehensive value chain of innovation, manufacturing, and distribution has the potential to add significant additional benefits to the economy, the state, and its citizens.

BioCrossroads has been a key contributor to the success of the statewide life sciences industry. Established in 2002 by the Central Indiana Corporate Partnership (CICP), BioCrossroads has a twenty-year track record of helping to grow, advance, and invest in Indiana's life sciences industry. It has done this by catalyzing innovation and collaboration, facilitating investments, and cultivating talent and human capital within life sciences across Indiana.

As part of its strategic planning process, BioCrossroads retained TEConomy Partners to develop a 10-year strategy for the life sciences industry. The goal of this initiative is to grow industry core capabilities, coordinate efforts across the life sciences value chain, and promote innovative technologies and workforce development to drive economic growth.

Over seven months, a strategic planning process involving over 40 industry stakeholders was conducted to:

- Perform a detailed quantitative and qualitative data analysis on market performance,
- Develop an inventory/informational database of all life sciences companies in the state,
- Benchmark state industry performance against six key “peer” states, and
- Perform a strategic situational assessment across R&D, Manufacturing, Distribution, and Workforce.

The following pages provide an Executive Summary of the work performed by a joint team of TEConomy and BioCrossroads personnel, all of which have been completed to define ***key statewide strategies and actions to achieve an ambitious vision for Indiana’s life sciences industry.***

Key Findings That Drive Recommendations

The team completed a range of analyses across the life sciences value chain, including market and employment analysis, industry targeting analysis, innovation and commercialization activity, an examination of publication and patent activity, manufacturing and distribution trends and investments, and peer benchmarking with six other states. What follows is a high-level summary of key findings from this work. For greater detail please refer to the full report.

The industrial diversity of Indiana's life sciences industry is a unique asset that provides a strong foundation for growth.

As mentioned previously, Indiana's life sciences industry employed more than 64,000 individuals in 2022 across a broad diversity of subsectors that few states can match. Pharmaceuticals and Distribution are both fast-growing industries, with growth outpacing the U.S. average. Pharmaceuticals and Medical Devices employment are both more than twice as concentrated as the U.S. average—a clear strength for the state. Industry targeting analysis also highlights emerging opportunities in Distribution and R&D Testing and Labs (Table ES-1).

Table ES-1: Summary of Indiana Subsector Performance

Life Sciences Subsector	Industry Targeting Analysis Categorization	IN Employees (2022)	IN Employee Growth (2018-22)	IN Location Quotient (2022)
Pharmaceuticals	**Current Strength** (specialized, growing, and growing faster than the nation)	22,136	29.6%	2.94
Medical Devices	**Priority Retention** (specialized, but not growing, and losing share compared to the nation)	18,559	-0.6%	2.11
Distribution	**Emerging Strength** (not yet specialized, but growing, and growing faster than the nation)	13,800	21.8%	1.04
R&D Testing and Labs	**Emerging Opportunity** (not yet specialized, growing, but not growing as fast as the nation)	10,065	5.3%	0.62

Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3

This diversity provides Indiana with a unique environment, one where cross-subsector collaboration can be actively encouraged to generate significant innovation and economic growth. For example, new advances in biopharma, genetics, and regenerative therapies (each of which Indiana companies are actively engaged in) are altering the scope and scale of manufacturing and distribution. These changes impact the choice of technologies employed in core production processes (e.g., continuous manufacturing, single-use manufacturing) and the potential business models used to produce final products (e.g., CDMOs). The ability to partner across subsectors and value chains to conduct shared research and to proactively plan, pilot, and scale up innovative approaches will yield significant benefits for the industry and the state.

There is a need to increase research activity and the eventual commercialization of research innovations.

While academic R&D growth in life sciences has grown faster in Indiana than in the nation since 2018, there are large gaps between the state's current level of activity and its benchmark competitors. Specifically, the state lags peer states in terms of NIH and other research awards. This has a negative downstream impact on the level of development, commercialization, and talent attraction.

Stakeholder interviews also revealed the need for more lab space for early-stage companies and better alignment between lab space and company needs.

Regarding commercialization funding, while venture capital (VC) activity in Indiana has grown at an accelerated pace, its growth is from a relatively low base, and overall levels of VC funding remain low compared to peer states. This could be symptomatic of a lack of Indiana-based VC firms willing to act as lead investors.

Against this reality, there are significant research and innovation opportunities presented by the new Indianapolis Purdue and IU locations to connect university research, talent, and industry. Based on stakeholder interviews, there is a strong desire to increase levels of strategic engagement and collaboration between the state's research universities, early-stage entrepreneurs, and broader industry.

Indiana also benefits from existing and emerging areas of unique and differentiated competencies with distinct opportunities to grow both within and across subsectors such as:

- **Thematic Platforms:** Neuroscience (including Alzheimer's and other neurodegenerative diseases), diabetes and metabolic disorders, and pediatric health, for example.
- **Pharmaceuticals:** Biomanufacturing and emerging specializations in areas such as radiopharmaceuticals and customized therapeutics.
- **Medical Devices:** Building on ongoing strengths in orthopedics, interventional surgical devices, and diagnostic devices.
- **Health Tech:** Building on an emerging presence in health informatics and digital health.

Indiana's leading position in life sciences manufacturing should be reinforced and expanded.

Indiana's life sciences industry is manufacturing intensive, with a large percentage of jobs in production and manufacturing-related fields. Highlighted as a clear "Current Strength" in industry targeting analysis, the state benefits from a broad diversity of manufacturing strengths covering small molecule, biologics, diagnostics, vaccines, nutrition and feed additives, medical devices (orthopedic and vascular/surgical), life sciences logistics, and others.

Regarding industry-based R&D, Indiana is among the nation's leaders in both industrial R&D spending in the life sciences and patent activity. However, disconnects exist between industry R&D expenditures and overall levels of industry-sourced patent activity in the state.

In discussions with key industry stakeholders, there was an emphasis on building out strategic manufacturing hubs and a desire to concentrate investments and dedicate resources around a handful of specific locations. There was also a clear desire to make Indiana a world-class environment for life sciences manufacturing, including attracting new production modality equipment, disposables manufacturers, sanitation facilities, and lab developers to operate new/additional lab space.

The talent pipeline must expand and evolve to support new approaches in research and manufacturing.

Ensuring an ongoing pipeline of appropriately skilled workforce will be a critical enabler of any statewide strategy. This is particularly true with the mobilization of new disruptive technologies under the banner of "Manufacturing 4.0," which leverages breakthroughs in AI, advanced networking, data analytics, robotics, and the Internet of Things to alter the scope, structure, and speed of manufacturing.

Analysis of staffing patterns from a recent talent report finds that Indiana's core tech and tech-reliant occupational mix is less tech-focused than the national occupational employment makeup—especially in the life sciences. Another recent report finds a clear and unmet demand for skilled manufacturing talent that can help increase capacity and backfill impending retirements at both incumbent and new companies producing life sciences products.

Indiana's life sciences industry needs more degreed talent to support the discovery and development of new pharmaceutical and medical device products, devise and implement cutting-edge manufacturing processes, and lead the companies that employ thousands of Hoosiers. At the same time, the industry increasingly needs a well-trained technician-level workforce that can execute complex manufacturing processes that make life sciences products used the world over.

Clearly, the ongoing attraction, retention, and development of talent remain a top priority for Indiana's life sciences industry, and a range of talent needs persist across both pharmaceuticals and medical devices.

Better connecting internal stakeholders while raising the external profile of Indiana can further advance the life sciences industry.

While economic development organizations and other stakeholders have been actively involved with many major players in life sciences across the state, a significant number of small- and mid-sized life sciences companies with Indiana sites are operating somewhat under the radar. Certainly, an opportunity exists to engage companies more robustly across the ecosystem to address their needs. The database of 476 companies developed as part of this strategic planning project will be helpful in this regard.

It was noted that the needs of the life science research and innovation ecosystem and the needs of the manufacturing and distribution ecosystem for life science products stand somewhat separate from one another and that both sides need to be at the table with key stakeholders to fully realize Indiana's opportunities to secure industry growth. Indiana must strengthen its innovation ecosystem to support the creation of new companies and drive product development and enhancement in existing ones. Additionally, it should ensure that its life science manufacturing sector is adapting to disruptive technologies and new manufacturing methods, and help the sector meet its multifaceted operational requirements, including workforce needs, within the state of Indiana. These respective stakeholder groups need to be well engaged with BioCrossroads and other major stakeholders concerned with operating an efficient ecosystem in Indiana.

Multiple stakeholders also expressed a need to develop a shared understanding of goals for Indiana in life science sector development and, perhaps most importantly, to build a more robust awareness outside of Indiana of the powerful assets and capabilities that exist in the state for life science enterprise success. It was noted that Indiana needs to be more proactive and aggressive in promoting Indiana as a premier destination for life science manufacturers and the advancement of modern life science production, as a national hub for efficient life-science product distribution, and as a well-resourced research and innovation hub (especially regarding core competency areas where Indiana has world-class academic and industry research expertise).

Vision

Crafting and executing an effective 10-year statewide strategy for the life sciences industry requires both an inspirational vision of a shared future end-state and a set of logical and sequential strategies for its attainment.

In terms of a shared vision, the team sought to build on the significant accomplishments already achieved and offer up collaboration and growth goals that will challenge both companies and the collective industry alike. The statement constitutes a relatable "dream with a deadline," providing concrete achievements tied to targeted end dates.

Vision Statement:

By 2033, Indiana will be known as a global leader in the life sciences industry—the place that advances innovations into products that improve health and well-being.

- Indiana's reputation will extend across the full spectrum of facilitated and coordinated activities, including discovery and development that occurs in both academic and industry settings.

- Life sciences companies will benefit from Indiana's well-established manufacturing expertise as well as the development and operationalization of new and emerging production systems, together with distribution and logistics systems, that ensure efficiency and growth.

- Indiana will offer an education and workforce development system that guarantees the industry a robust supply of workers with skills and abilities required across critical job functions.

- The building and convening of this industry ecosystem will be shepherded by a network of coordinating entities—including BioCrossroads—that drive strategy implementation and monitoring with the support of key stakeholders in the public, private, and nonprofit sectors.

Metrics for Success:

By 2033, Indiana will have achieved the following:

1. **Become THE national leader in pharmaceutical manufacturing** as measured by GDP contribution per capita. This requires overtaking New Jersey, which is number one currently, with Indiana in second place.

2. **Move into the top five in medical device manufacturing** among all states as measured by GDP contribution per capita. This requires growing the sector to move up from ninth place.

3. **Cement leadership position in two to three fast-growing areas of R&D and associated innovation.** This will need to be measured by multiple weighted variables covering NIH grants, publications, patents, startup activity, and SBIR and VC funding.

4. **Diversify the base of life sciences companies** through the addition of new ventures, the growth of incumbent companies, and the attraction of new companies to move to Indiana, all as measured by the number of business establishments.

Strategic Recommendations

The 10-year strategic plan comprises several actions organized around the following four foundational recommendations:

Figure ES-3: Visualization of Proposed Strategic Recommendations:

For each, the team has articulated strategic goals followed by a detailed list of initiatives. More detailed descriptions, including timing, priority, responsibility, and actions, are included in the full report.

Foster R&D and Innovation

Strategic Goal: To significantly increase the volume of life sciences research activity in Indiana, especially applied research, and facilitate the advancement of associated research-based innovations as the basis for new commercial life science ventures. The recommended actions seek to build excellence in established and emerging R&D core competency areas and provide an enhanced environment for accelerating the commercialization of innovations in Indiana.

Strategies and Actions:
As part of this strategy, it is recommended that Indiana pursue seven actions:

1.1 Drive strategic innovation in therapeutic areas where there are academic and industry core competencies: Identify existing and emerging therapeutic areas with R&D competencies shared across the industry and academic settings and drive innovation in these areas.

1.2 Encourage applied research growth in Indianapolis: Focus on strategic areas of excellence in key life sciences areas as a means to significantly increase NIH and other sponsored research funding levels in Indianapolis.

1.3 Leverage existing and new data assets to drive innovation: Accelerate the growth of the AnalytiXIN clinico-genomic database and make use of IHIE and other data assets to facilitate discovery science and the advancement of new research.

1.4 Deepen connections between large companies and external innovators: With leadership from IBRI, develop new efforts to connect large company expertise and infrastructure to advance new ventures.

1.5 Develop a graduate/post-doc innovator early-career support program: Implement a model developed at Lawrence Berkeley National Laboratory that provides resources to recent PhD and post-doc scientists focused on commercializing innovations in thematic platforms.

1.6 Increase access to early-stage capital: Increase access to angel, venture, and other internal (to Indiana) and external (outside of the state) capital resources.

1.7 Ensure availability of the infrastructure needed to support early-stage life sciences enterprises: In key hubs throughout the state (see 2.5), develop and maintain lab space and other industry-specific facilities that new ventures need to start and scale.

Enhance the Manufacturing Ecosystem

Strategic Goal: To leverage Indiana's existing assets and core competencies in life science product manufacturing, and to develop next-generation production systems and technologies, to secure Indiana's reputation as a premier location for the manufacturing and distribution of a broad range of life science products. This will include products for human and veterinary applications (including medical devices, small- and large-molecule pharmaceuticals, diagnostics, and a position in emerging health technologies). As a result of strategic actions, life science companies already in Indiana or newly coming to the state will feel exceptionally secure in the resiliency of Indiana as a basis for the long-term production and distribution of life science products to meet market demands.

Strategies and Actions:
As part of this strategy, it is recommended that Indiana pursue six actions:

2.1. Accelerate advancement of an advanced biomanufacturing process development center at Purdue: Create development and demonstration sites for advanced production technologies and processes for pharma.

2.2. Facilitate access to manufacturing for early testing work: Develop and implement an approach that enables academic and new commercial ventures to make use of existing or new CDMO capacity to assist in manufacturing process development and the manufacture of drug products for early-stage testing and trials.

2.3. Build capacity to pioneer personalized therapeutics production leadership and leverage logistics advantages: Continue development of the radiopharmaceutical cluster while pursuing new therapeutic areas that could similarly benefit from Indiana's manufacturing and logistics capabilities.

2.4. Support the growth of existing companies through strategic and targeted business development/ attraction efforts: Identify and proactively respond to supply chain gaps and associated inward investment opportunities (on/re-shoring).

2.5. Align existing and future regional economic development efforts to support industry growth that builds on existing assets: Leverage public-private partnerships to focus investment at selected sites and infrastructure to promote a critical mass at strategic in-state hubs.

2.6. Strengthen logistics sector to ensure support for life sciences manufacturing growth: Ensure the logistics sector and other key stakeholders are aware of opportunities related to the growth of the life sciences sector and are prepared to make investments needed to meet the sectors' unique needs. .

Boost Talent and Workforce

Strategic Goal: With workforce skills and availability well-acknowledged as central drivers of life sciences business location decisions, Indiana will develop a highly efficient system for the education and training of talent with the in-demand skills required by the sector. The training system will be sized to meet the projected needs of the life sciences sector and anticipated talent growth requirements.

Strategies and Actions:
As part of this strategy, it is recommended that Indiana pursue four actions:

3.1. Create life sciences manufacturing workforce training and education centers: Implement educational and hands-on training programs in various aspects of life sciences manufacturing.

3.2. Advance a curriculum for career education and to upskill/reskill incumbent workers: Invest to make Indiana a premier location for practical education and training that meets the evolving talent needs of life science employers.

3.3. Improve retention of graduating talent through robust early industry connections: Conduct marketing and image-building support to boost awareness and attractiveness with efficient and cost-effective pathways for students.

3.4. Promote youth engagement and DEI in life science careers: Grow the state's pool of eligible life sciences workers by targeting under-represented communities and engaging in K-12 outreach.

Support Connections and Outreach

Strategic Goal: Assure the complete implementation of strategies while building a hyper-connected life sciences network that ensures key assets are engaged, supported, and operating as an efficient ecosystem that accelerates the growth of Indiana's life sciences industry cluster. Continue to position BioCrossroads as the leading intermediary charged with advancing the life sciences industry while also working with key partners and stakeholders. Ensure BioCrossroads—and the state more generally—have at their disposal the tools, funding, and strategies needed to realize an aspirational vision for the industry.

Strategies and Actions:
As part of this strategy, it is recommended that Indiana pursue five actions:

4.1. Ensure alignment and coordination across industry initiatives throughout the state: Continue to cultivate an ecosystem of industry and academic R&D experts (in sciences and manufacturing) that enables Indiana to opportunistically respond to industry needs to drive economic growth.

4.2. Create a proactive state marketing strategy for Indiana's life sciences industry: Enhance the branding and awareness of Indiana as a leading state for life sciences.

4.3. Develop Indiana Life Sciences Summit for an external audience: Build on BioCrossroads' years of holding well-attended events and produce an annual event that raises Indiana's profile within the industry.

4.4. Develop and maintain a robust hub of Indiana-specific life sciences information that elevates awareness of key assets: Build and maintain a network of life sciences assets across Indiana in support of efforts to foster connections throughout the industry and state.

4.5 Ensure state and local policy environments enable life sciences sector growth: State and local fiscal, regulatory, and other policies facilitate industry growth and the availability of a highly qualified workforce.

Conclusion

Large, specialized, and growing, life sciences represent a critically important industry for Indiana. Indiana's GDP is heavily supported by the activities of the pharmaceutical and medical devices sectors, and the employment generated by life sciences is impacting every region of the state and is particularly beneficial given the wages of the sector (which are considerably higher than the average Indiana private sector wage). The production of life science products (i.e., manufacturing), especially out of the large pharmaceuticals and medical device sectors, is a signature of the Indiana economy. In addition to manufacturing, research and development leading to life science innovations is important to ongoing life science development and growth in the state. In this regard, however, Indiana is comparatively undersized in its research volume, and growth in R&D should be a strategic goal.

Although Indiana remains one of the top-tier states for life sciences, as demonstrated in the biennial TEConomy/BIO state-by-state bioscience industry review, signs of stress are emerging that make it imperative for Indiana to execute a strategy to address challenges and capture opportunities. The GDP growth rate of the sector has not kept pace with that of peer states in recent years, and strategic actions are required to address this and build an ecosystem more conducive to growth over the next decade. A detailed series of four strategies and associated actions are recommended to accomplish realization of a vision that will propel Indiana, by 2033, to be a well-recognized global leader in the life sciences industry—the place that advances innovations into products that improve health and well-being.

I. Introduction

Life sciences represent a core competency for Indiana, both in terms of intensive academic and industry R&D and the presence of large and specialized advanced industry commercial clusters. The 2022 TEConomy/BIO review of the U.S. bioscience industry shows Indiana to be specialized in biosciences overall, with a location quotient[1] of 1.43, and in the top quintile of U.S. states in terms of bioscience employment. Human and animal life sciences are a clear signature area for Indiana's bioscience economy, and the pharmaceutical sector is the most concentrated subsector for the state, with a highly specialized location quotient (LQ) of 2.83 and 20,801 employees. Medical devices are similarly of high importance to Indiana's economy, with 18,336 employees and an LQ of 2.16.

Indiana is one of just six states shown by TEConomy/BIO to be both large and specialized in the pharmaceuticals industry, and the Indianapolis metro area is ranked fifth in the nation for its industry concentration. Recent work on Indiana's key drivers of economic growth confirmed the robust position of Indiana in pharmaceuticals, with "pharmaceutical and medicine manufacturing" being the top traded sector in terms of Indiana GDP ($10.5 billion) and occupying a signature place as one that is not only specialized, but also growing its GDP contribution and outpacing national GDP growth in the sector. Medical devices represent a more "at risk" sector, still a major generator of GDP ($3.6 billion) but experiencing a moderate decline in GDP in recent years (-2% from 2015-2020) and employment reductions of 1.8% from 2018 through 2021.[2]

Despite the many strengths in Indiana, it would be a mistake to consider the state's current position in life sciences as unassailable. Other states and regions of the globe are competing to advance their life science sectors, and the relatively tight labor market in Indiana, especially in skilled STEM worker positions, threatens to constrain growth.

It is also notable that pharmaceuticals and medical devices are industries that are confronting multiple forces of change and potentially disruptive technologies. These include, for example:

- Significantly changing manufacturing systems, including growth in the pharma sector of single-use systems and a movement towards continuous manufacturing processes that differ considerably from traditional batch processes. There are now FDA-approved solid dose drugs produced using continuous manufacturing, including Eli Lilly's Verzenio (abemaciclib), and there has also been approval of a drug (Spritam) that is manufactured using a 3D printing process.

1 Location quotient (LQ) is a measure of industry specialization. The concentration of life sciences employment in Indiana is 1.43 times that of the concentration of life sciences employment nationally. A location quotient greater than 1.0 suggests that life sciences employment makes up a larger share of the Indiana workforce than it does for the nation as a whole. An LQ that is 1.3 or greater typically suggests specialization.

2 TEConomy Partners analysis of GDP data.

- The digitalization of manufacturing, including the increasing penetration of manufacturing 4.0 technologies into production and distribution processes and the growth of automation and robots/co-bots into the production of life science products.

- The anticipated growth of personalized medicine requires small and modular production systems to produce customized drug formulations and, potentially, more localization of production processes.

- Increasing penetration of biosimilars into the biologics market as multiple biologics come off patent.

- Ongoing political and market considerations, most notably driven by concerns over the rising cost of health care in the U.S.

- Reshoring and supply chain reconfiguring resulting from lessons learned under COVID-19.

Traditionally, the pharmaceutical manufacturing industry has been conservative in its approach to adopting new production technologies, primarily due to regulatory concerns. This ethos pivoted somewhat following the formation of the FDA's "Emerging Technologies Program" in 2013, which was designed to facilitate the adoption of new production technologies. Change has been further accelerated due to lessons learned in the pandemic regarding the management of clinical trials, supply chain restructuring, government regulatory process streamlining, and other factors.

Medical devices, especially Class III devices, are also highly regulated, and companies are similarly conservative in approaching changes to materials or production processes. However, new technologies in 3D printing, the expanding integration of electronics into devices (for tracking, monitoring, and control purposes), and other technological innovations are making themselves felt throughout the sector.

With pharmaceuticals and medical devices representing major components of the Indiana economy and life sciences designated as a key strategic industry for growth by the Indiana Economic Development Corporation

Single-Use Systems and Continuous Manufacturing Systems in Biopharmaceuticals Production

Single-use systems are used in pharmaceutical manufacturing as disposable and pre-sterilized components in the manufacturing process to reduce the risk of contamination and simplify cleaning and validation procedures. These systems offer advantages such as improved product quality, increased operational efficiency, reduced costs, and enhanced flexibility and scalability in manufacturing processes.

Continuous manufacturing is a method of producing pharmaceutical products in a continuous and uninterrupted manner, as opposed to traditional batch-based production. In this method, the process flows continuously through a series of interconnected unit operations, allowing for a more efficient and consistent production. Key features of continuous manufacturing may include:

- Real-time monitoring and control of process parameters to ensure product quality and consistency.
- Minimal intermediate storage and transfer of products, reducing the risk of contamination and waste.
- Modular design, allowing for easy scale-up and customization of the production process.
- Integration of quality control and release testing into the manufacturing process, improving efficiency and reducing the time to market.

(IEDC), it is important that the characteristics and needs of the industry today and into the future be very well understood by state leaders more generally.

The accelerating pace of scientific and technological advancements, in combination with evolving market forces, however, make it imperative for BioCrossroads and its stakeholders to have a long-term, strategic roadmap that will help Indiana anticipate and adapt to changes and leverage them to the state's economic advantage. Recognizing this, BioCrossroads commissioned an analysis and strategic plan development project to take stock of the state's position and performance of life sciences clusters, current strengths, weaknesses, opportunities, and threats for Indiana's life sciences, and identify potential pathways forward to successful ongoing life sciences economic development. This analysis has informed the development of a 10-year life sciences strategy for Indiana. It is anticipated that this strategic plan will be important in guiding the coordination of resources across the bioscience-based economic development ecosystem in Indiana to help ensure that state and key stakeholders leverage and reinforce strengths, address ecosystem gaps or weaknesses, offset threats, and best advance opportunities for growth.

TEConomy was retained to lead the analysis and strategic plan development in close collaboration with BioCrossroads and a range of its stakeholders. The project team undertook a program of:

- **Quantitative Analysis:** Providing an examination of Indiana's performance across measures related to life sciences in academia and industry, including assessing R&D, innovation, growth capital, and talent/work-force dynamics.

- **Database Development and Analysis:** The development of a 476-company database enabling assessment of industry subsector presence and the spatial distribution of life sciences establishments across Indiana.

- **Qualitative Analysis:** Incorporating detailed interviews with key stakeholders, business leaders, life science researchers, and other life science and business development leaders to gain insight into Indiana's life science ecosystem and their input regarding strategic imperatives and potential actions.

- **Benchmarking:** Comparing Indiana's performance against six peer states, providing an overview of key activities and best practices.

The scope of work was specifically designed to answer several key questions:

- How is Indiana's life sciences industry and related ecosystem performing—what are the strengths upon which to build, and what are the weaknesses and/or gaps that need to be addressed?

- What distinctive areas of life sciences activity represent the best strategic platforms for the state to focus on?

- What disruptive technologies and trends will likely impact (positively or negatively) Indiana's life sciences, and how can Indiana adapt to these forces of change to promote sector resiliency and growth?

- What are the strategic priorities and corresponding strategies and actions needed to continue to advance Indiana's life sciences economy and associated advanced industry clusters across the state?

- What evolution may be required of BioCrossroads and other key stakeholders across the ecosystem to best advance strategic priorities and opportunities over the next decade?

Structure of this Report

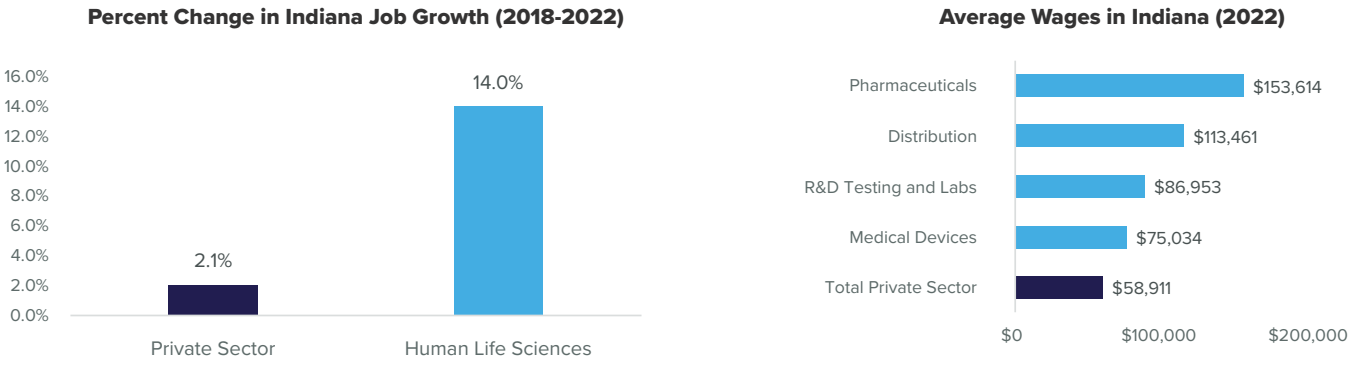
In Chapter II, the results of the situational assessment are briefly summarized, providing an overview of the importance of life sciences to the Indiana economy, its key subsectors, recent economic performance, and engagement in R&D and innovation activities. The situational assessment identifies multiple issues and opportunities to be addressed to achieve a vision of a high-growth Indiana life sciences economy through 2023. These result in a series of specific strategies and actions outlined in Chapter III.

II. Situational Analysis:
Why Life Sciences Matters for Indiana

A High-Impact Sector for Indiana

Life Sciences is an economic signature of Indiana. Since 2018, employment growth in Indiana's life sciences industry has occurred at a much faster rate than the private sector average (Figure 1). Indeed, it has exceeded that rate by a magnitude of nearly seven times. Indiana's life sciences subsectors also sustain high-paying jobs, with each major life sciences subsector paying significantly more than the private sector state average, with pharmaceuticals and bioscience-related distribution offering wages well over two times the state average (Figure 1).[3]

Figure 1: Percent Change in Indiana Job Growth (2018-2022) and Average Wages in Indiana (2022)

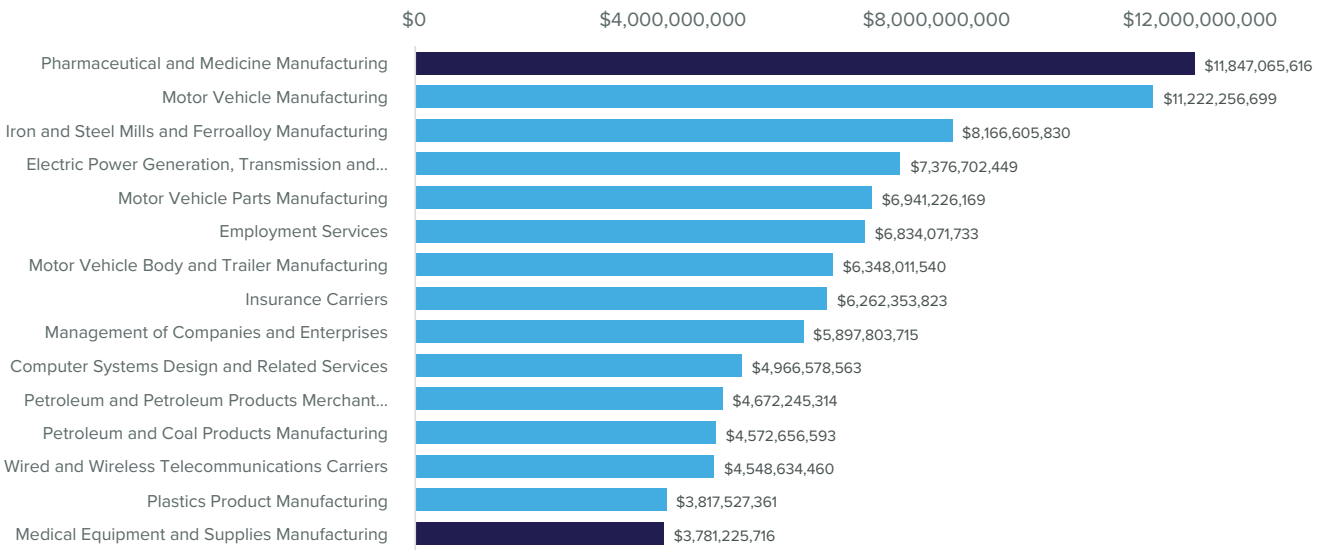


Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3

As traded industries, life sciences are especially important as **they export the vast majority of their output outside of the state, thereby bringing in fresh dollars to expand and stimulate the Indiana economy.** In contribution to GDP, "Pharmaceutical and Medicine Manufacturing" as a sector ranks first among all of Indiana's traded sector industries, while Medical Equipment (which includes medical devices) ranks 15th (Figure 2).

3 The high wages of Indiana's bioscience-related distribution sector stand apart from wages associated with distribution-related jobs more generally. This is primarily due to the presence of major pharmaceutical companies and their distribution centers in the state.

Figure 2: Traded Sector Industries by Contribution to State GDP (2022)



Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3

The **diversity** of Indiana's life sciences industry is a unique asset for the state, with employment distributed across multiple large and important subsectors (Table 1). Indiana's life sciences industry employed more than 63,000 individuals in 2022, with no single subsector responsible for more than 35% of that total. Pharmaceuticals and distribution are both fast-growing industry sectors, with growth outpacing the US average for their respective industry sectors. Pharmaceuticals and medical devices employment are both more than twice as concentrated as the United States average (as measured by location quotient)—indicative of them being significant specializations for the state.

Table 1: Summary of Indiana Subsector Performance

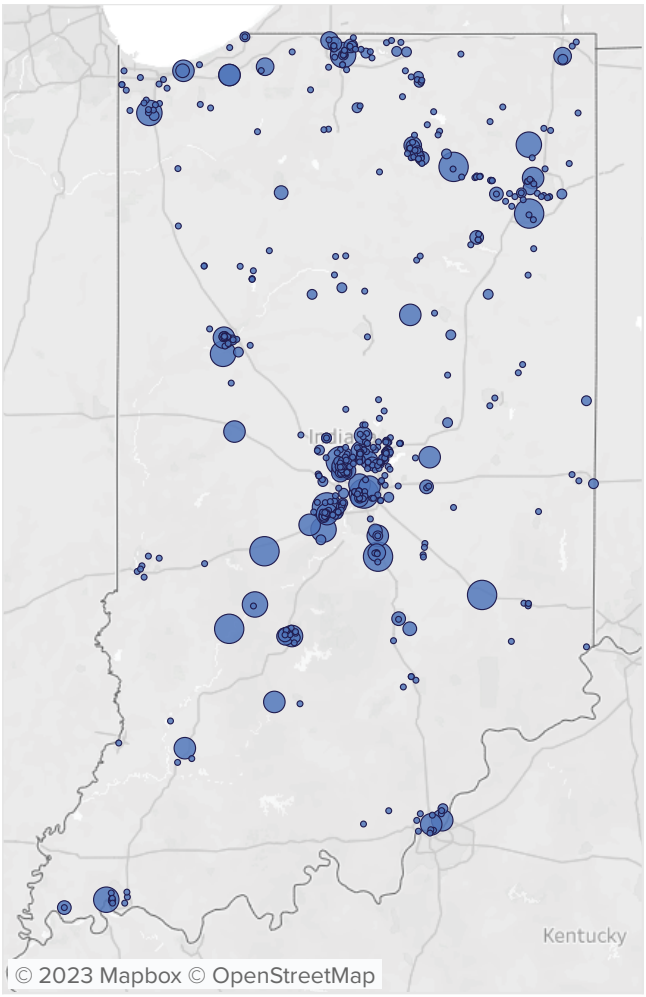
Life Sciences Subsector	Industry Targeting Analysis Categorization	IN Employees (2022)	IN Employee Growth (2018-22)	IN Location Quotient (2022)
Pharmaceuticals	**Current Strength** (specialized, growing, and growing faster than the nation)	22,136	29.6%	2.94
Medical Devices	**Priority Retention** (specialized, but not growing, and losing share compared to the nation)	18,559	-0.6%	2.11
Distribution	**Emerging Strength** (not yet specialized, but growing, and growing faster than the nation)	13,800	21.8%	1.04
R&D Testing and Labs	**Emerging Opportunity** (not yet specialized, growing, but not growing as fast as the nation)	10,065	5.3%	0.62

Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3.

Geographic Distribution

Sometimes, an industry can be highly concentrated in just one part of a state with impacts that are quite localized. This is not the case in Indiana's life science sector, a significant industry and employment generator statewide. Gaining detailed insight regarding the location of life science operations across Indiana required the development of a custom dataset. Multiple data resources were accessed to develop an inventory of business sites relevant to the sector across Indiana, including the use of BioCrossroads information, data from the Indiana Health Industry Forum (IHIF), Pitchbook, FDA registered company listings, and Dunn & Bradstreet information, supplemented by web searches. The assembled dataset, which contains details for 476 life science companies, shows **an industry that is driving employment across all regions of the state** (Figure 3). As anticipated, there is a distinctive clustering of operations in the Indianapolis metro area, but there are also multiple additional clusters evident in many other parts of the state, including in Fort Wayne, South Bend and Elkhart, Northwest Indiana, Lafayette/West Lafayette, Bloomington, Evansville, and in Southern Indiana near Louisville. **Clearly life sciences represent a statewide industry, providing employment opportunities in all regions of the state.**

Figure 3: Life Science Employer Locations and Employment Counts in Indiana

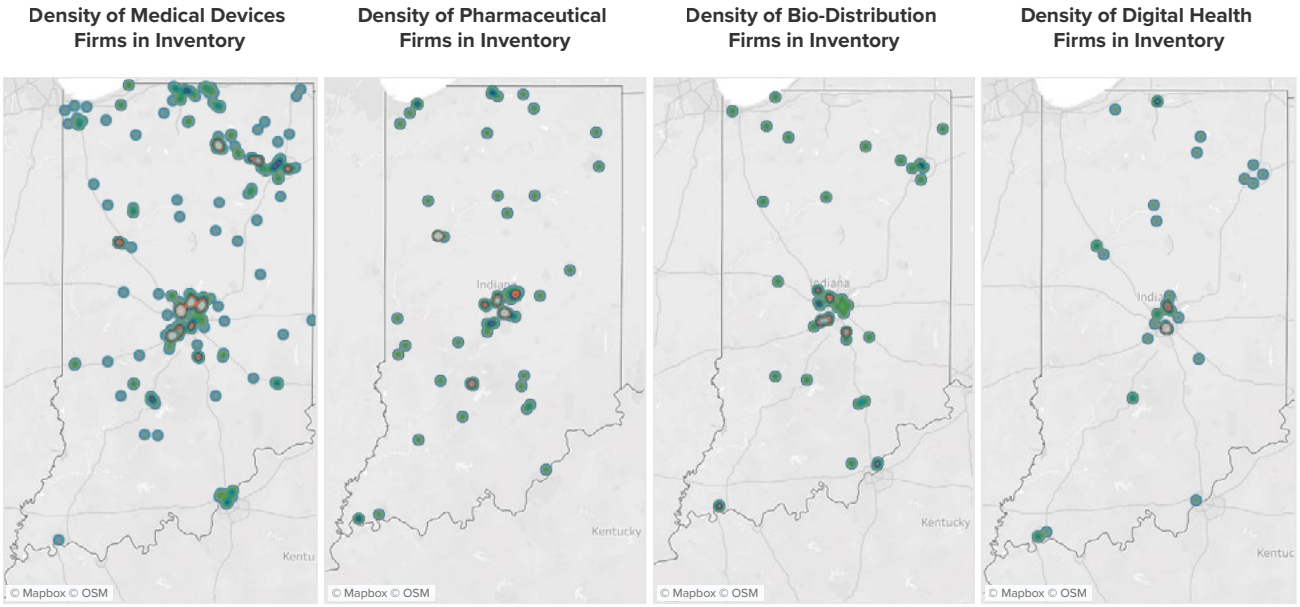


Estimated Indiana Employment

- Between 1 and 50 employees
- Between 51 and 100 employees
- Between 100 and 150 employees
- Between 151 and 250 employees
- Between 251 and 500 employees
- Between 501 and 1,000 employees
- More than 1,000 employees

Figure 4 provides four maps breaking out subsectors of life science activity and the locational density of life science establishments in these subsectors.

Figure 4: Locations of Establishments in Indiana in Four Life Science Subsectors



It is evident that, across the four subsectors shown (medical devices, pharmaceuticals, bio-distribution, and digital health), business activity is occurring statewide in all. Medical devices demonstrates the most wide-ranging geographic dispersion statewide but is also clearly a core life sciences industry for Northern Indiana and the Indianapolis metro area. Because the database was custom developed, it is not limited by existing NAICS codes (where there is no code for “digital health firms”), and TEConomy was able to identify the locations of establishments in this emerging technology space. Notable in these data is a clustering in the Indianapolis metro area, but also an emerging cluster in the Fort Wayne region, where the Parkview Mirro Center for Research and Innovation has become an established focal point of research and innovation acceleration.

An Innovative Sector for Indiana

While the manufacturing and distribution of life sciences products comprise the largest employment and GDP-supporting sectors across Indiana's life sciences, there is also significant employment in the R&D Testing and Labs sector (which includes early-stage, largely pre-revenue, biotech development companies and testing labs). R&D and innovation are also occurring within Indiana's higher education and nonprofit research institute sectors, where fundamental, applied, and translational clinical research is undertaken. Activities here are critically important as they represent the seeds for ongoing growth rooted in innovation commercialization, new business development, and the transfer of innovations into existing Indiana life sciences enterprises.

As shown in Table 2, academic life sciences R&D has demonstrated strong performance in recent years. 2021 saw research expenditures of $818 million in academic life sciences research. The sector has experienced growth in research expenditures of 19.8% since 2018, growing significantly faster than the national growth rate (14.9%).

As Table 2 also shows, Indiana's life sciences innovation ecosystem has expanded since 2018, growing faster than the US average—except in the number of life sciences patents.

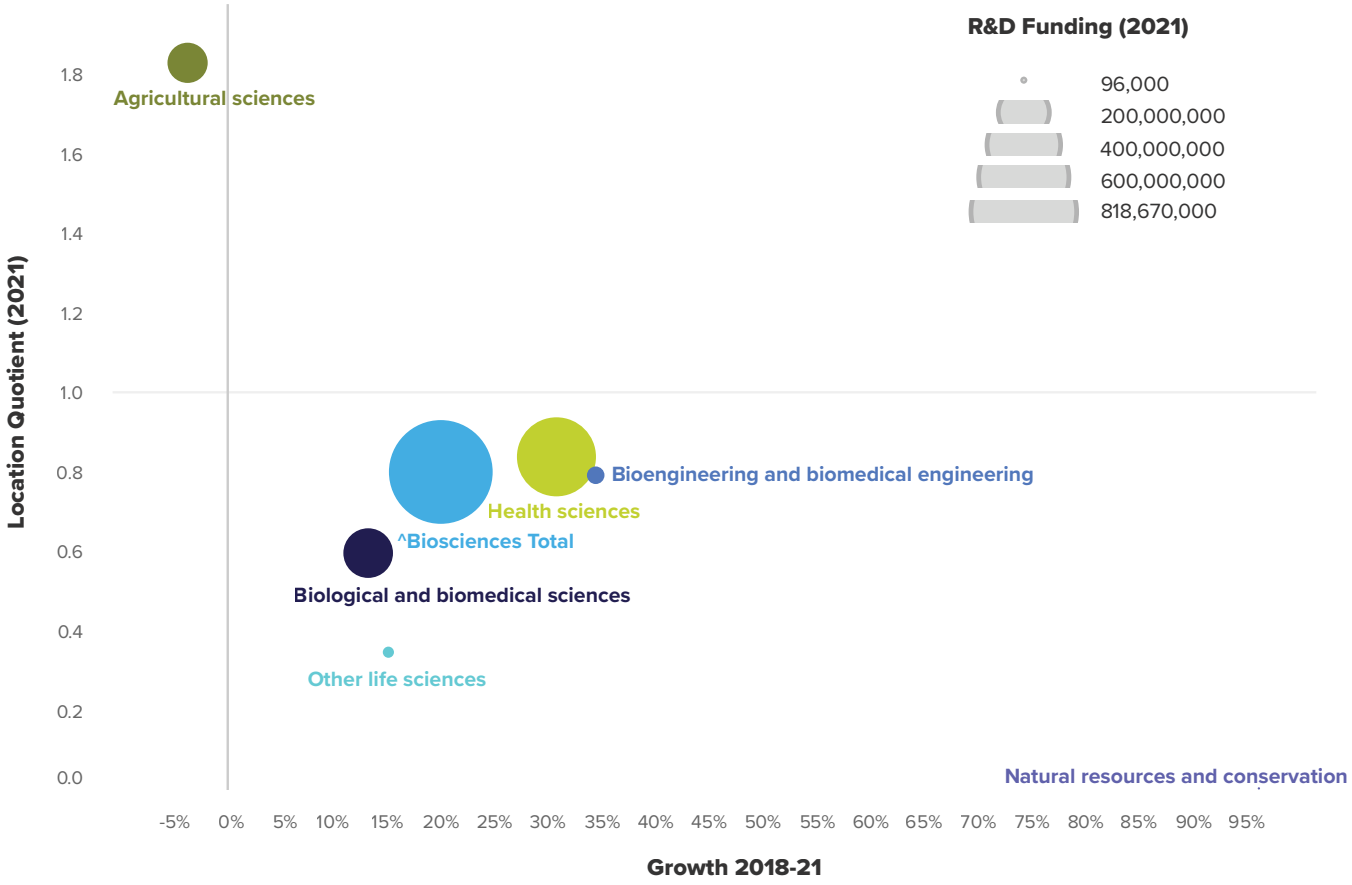
Table 2: Indiana's Performance Across Various Ecosystem Measures

Ecosystem Element	Measure	Volume	Growth Since 2018?	Relative Growth
Research	Academic Life Sciences R&D (2021)	$818M	19.80%	4.90%
	NIH Funding (2022)	$369M	33.50%	4.20%
	Industry Life Sciences R&D (2020)	$4.6B	65.60%	26.80%
Innovation	Life Sciences Related Patents (2022)	672	-25.00%	-27.20%
Growth Capital	Venture Capital Deals (2022)	43	34.40%	23.80%
	Venture Capital Dollars (2022)	$275M	145.20%	72.10%

Source: TEConomy Analysis of NSF Higher Ed R&D and Business R&D Surveys; Pitchbook; Clarivate Analytics; Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3.

Academic life sciences R&D is expanding significantly in Indiana. Figure 5 shows the results of the analysis of academic R&D specialization (measured by location quotient on the Y axis) and R&D growth over the 2018-2021 period. While only agricultural sciences reach the level of a state specialization (not an area of focus in this strategy), the other sectors of life sciences (dominated by human/biomedical life sciences) have each experienced significant rates of growth.

Figure 5: Academic R&D Funding in Indiana by Sector



Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data) and BLS avg. of 2022 Q1-3.

Although academic research is an important component of the life sciences research and innovation environment in Indiana, significant research activity is also undertaken within industry. Industry research may also result in academic publications, including shared publications with academic partners. Table 3 shows data from Web of Science for life sciences and associated/adjacent disciplines, including the identification of areas of significant co-publishing between academic and industry authors. The data also show the "publications quotient," which, akin to a location quotient, shows the degree of specialization of Indiana in that research field (where a pubs quotient greater than 1.0 indicates more publication in that area than expected given national normative levels). Very much in evidence is a series of disciplines in, and related to, pharmaceuticals research that are distinctive specializations for Indiana, together with endocrinology and metabolism (an area containing diabetes research) and strengths in informatics and analytics (statistics and probability, medical informatics, mathematics and computational biology) of relevance to an emerging digital health sector as well as fundamental to modern life science discovery and innovations in biologics and pharmaceuticals.

Table 3: Publications Activity in Indiana Across Life Science Disciplines, Including Data on Industry-Academe Co-Publishing

Web of Science Categories	Indiana Total Record Count	Indiana Total Pubs Quotient	Major Life Sci Corp (100+ Authored Papers)	Industry Co-Author Share
Pharmacology Pharmacy	2,565	1.18	895	35%
Oncology	2,460	0.8	438	18%
Endocrinology Metabolism	1,373	1.27	344	25%
Medicine Research Experimental	1,266	0.82	284	22%
Clinical Neurology	1,886	0.78	258	14%
Chemistry Multidisciplinary	3,025	1.1	248	8%
Toxicology	617	1.05	205	33%
Medicine General Internal	1,372	0.82	202	15%
Neurosciences	2,395	0.77	192	8%
Multidisciplinary Sciences	3,655	0.93	188	5%
Dermatology	492	0.96	186	38%
Rheumatology	268	0.98	186	69%
Statistics Probability	1,025	1.25	164	16%
Biochemistry Molecular Biology	2,814	0.85	162	6%
Chemistry Medicinal	736	1.32	156	21%
Health Care Sciences Services	1,210	0.96	145	12%
Biochemical Research Methods	1,160	1.06	124	11%
Cardiac Cardiovascular Systems	1,197	0.71	122	10%
Chemistry Analytical	1,032	1.26	116	11%
Chemistry Organic	663	1.52	114	17%
Medical Informatics	561	1.22	94	17%
Math/Computational Biology	721	1.13	86	12%
Cell Biology	1,450	0.71	86	6%
Biotech & Applied Microbiology	966	0.9	86	9%
Chemistry Applied	458	1.36	85	19%
Immunology	1,078	0.57	83	8%
Engineering Chemical	1,145	1.14	82	7%
Health Policy Services	531	0.95	80	15%
Food Science Technology	1,033	1.26	72	7%
Genetics Heredity	1,413	0.96	66	5%
Psychiatry	1,131	0.78	66	6%
Public Health	1,845	0.75	65	4%
Pathology	584	1.15	64	11%
Agriculture Dairy Animal Science	655	1.89	64	10%
Gastroenterology Hepatology	981	1.26	64	7%
Plant Sciences	1,228	1.16	61	5%

Web of Science Categories	Indiana Total Record Count	Indiana Total Pubs Quotient	Major Life Sci Corp (100+ Authored Papers)	Industry Co-Author Share
Veterinary Sciences	915	1.15	60	7%
Agronomy	590	1.28	54	9%
Pediatrics	1,510	0.93	53	4%
Parasitology	321	0.97	52	16%
Hematology	599	0.69	52	9%

Source: TEConomy analysis using Clarivate Analytics' Web of Science Research Publications Database, 2017-2023 (mid-year). Table 3 shows life science industry companies with 100+ articles or obvious Indiana location with one or more Indiana-located co-author (either industry-based or university/other research organization-based).

Table 4 illustrates the level of publishing associated with life sciences companies in Indiana. Eli Lilly and Company has the largest number of publications (accounting for almost 70%), but multiple other pharmaceuticals companies and device companies are engaged.

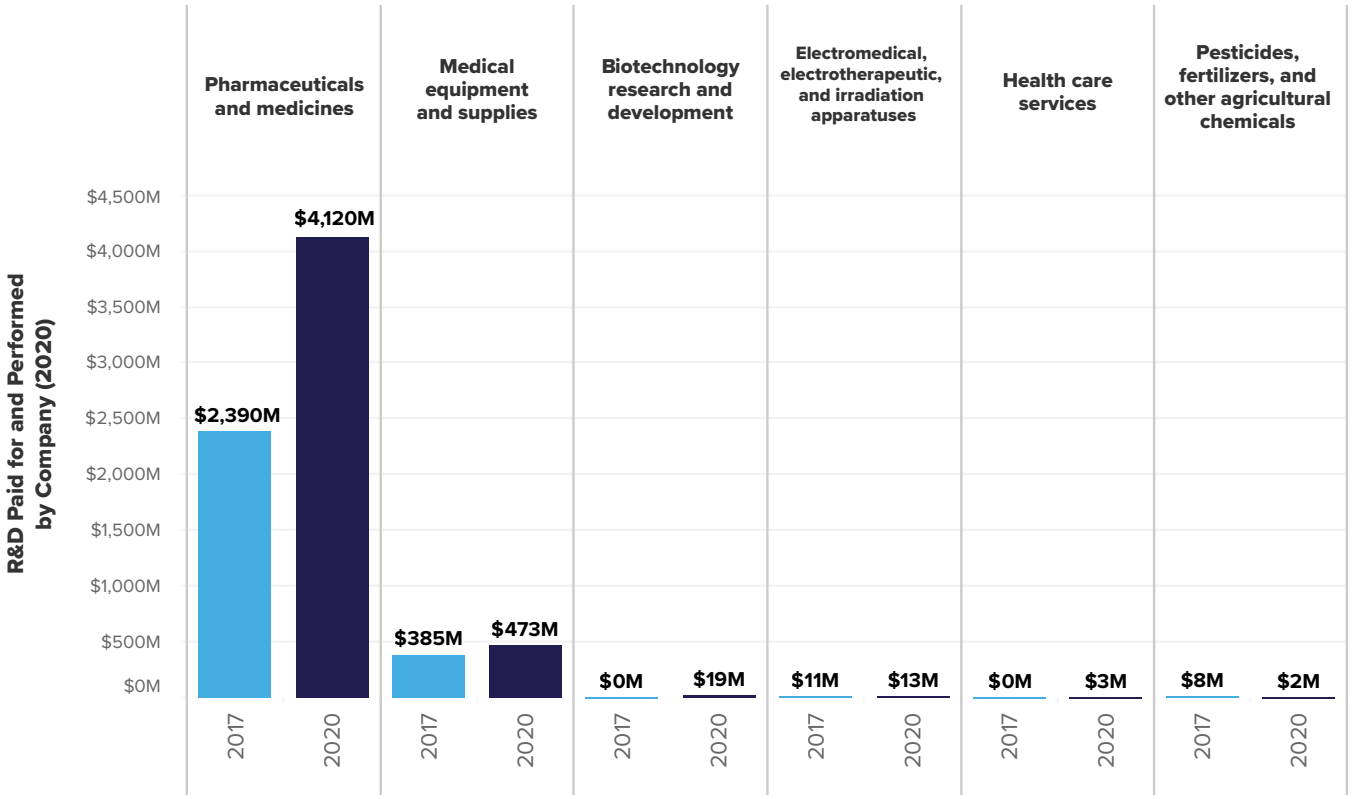
Table 4: Total Academic Publications Associated with Life Science Companies (Including at least one Indiana-based author)

Life Science Industry with Collaborative Research in Indiana	Total # of Publications
Eli Lilly & Company	3,349
Pfizer	361
Roche	355
Merck Company	327
AbbVie	249
GlaxoSmithKline	244
Bristol Myers Squibb	242
Novartis	238
AstraZeneca	223
Genentech	210
Elanco Animal Health	177
Janssen Pharmaceuticals	137
Amgen	136
Sanofi Aventis	130
Johnson & Johnson USA	118
Boehringer Ingelheim	113
Covance	101
Mead Johnson	60
Baxter International	42
Zimmer Biomet	42
Boston Scientific	32

Source: TEConomy analysis using Clarivate Analytics' Web of Science Research Publications Database, 2017-2023 (mid-year).

The research and innovation environment within the life sciences industry in Indiana is experiencing significant growth. Figure 6 shows industrial R&D expenditures across life sciences subsectors between 2017 and 2020 (the latest data available). The findings show that "pharmaceuticals and medicines" research represents the largest sector in terms of research expenditures, followed by "medical equipment and supplies" (which includes the medical device sector). **Notable is the significant growth in the pharmaceuticals sector, with 2017 expenditures of $2.39 billion in 2017, rising to $4.12 billion in 2020 (a 72.4% increase)**. The medical equipment and supplies sector also saw significant research expenditure growth, rising by 22.9% over the four-year period.

Figure 6: Indiana Life Sciences R&D Expenditures by Industry Sector (2017 and 2020)



Source: TEConomy Analysis of NSF Business R&D Survey Data.

Patenting is another key indicator of innovation activity in life sciences. Table 2 shows that Indiana industry and universities are generating significant patent activity in life sciences, but the state has experienced an overall 25% decline in life science patents since 2018. Whether the decline is a temporary situation remains to be seen.

Table 5 provides further insight, providing details on the leading companies and universities generating patents with an Indiana inventor listed on the patent. Evident in these data is **the ongoing importance of the medical device industry as a source of innovations for Indiana**, with Cook Group, Zimmer Biomet, and Warsaw Orthopedic in the top five companies for overall life science patenting in Indiana. **Pharmaceuticals are also a key innovation area**, with Roche, Eli Lilly and Company, and Elanco as leading innovators. All three of the R1 universities in Indiana (Purdue, IU, and Notre Dame) are also active generators of life science patents.

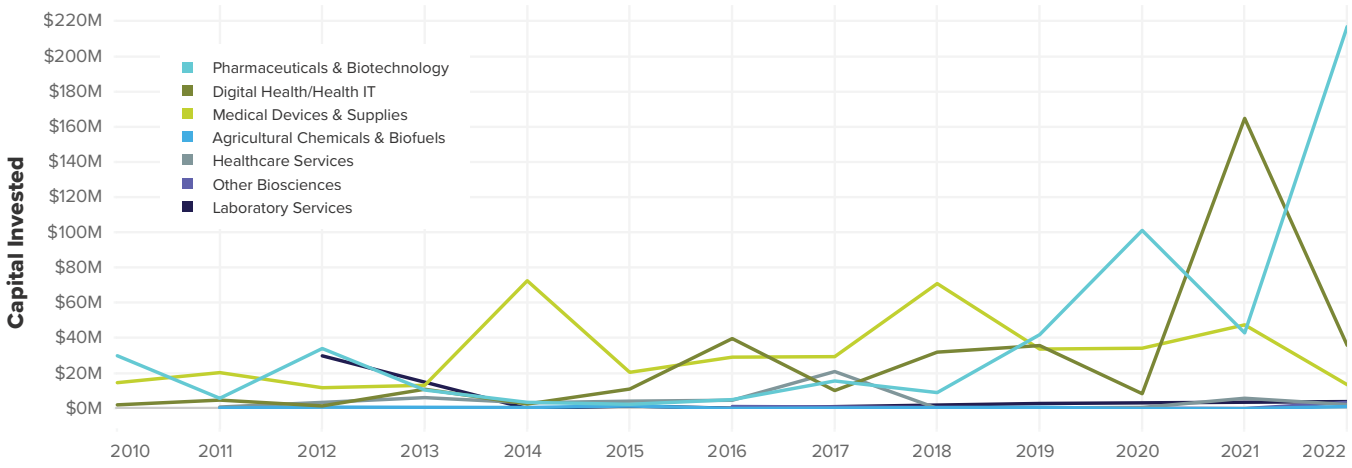
Table 5: Indiana's Life Science Patent Landscape–Key Indiana Inventors and/or Indiana Assignees (2017-2023)

Company or University (Current Patent Assignee)	# Granted Patents	# of Pending Applications	Total # Patents and Applications	IN Headquarters (HQ) or Significant Operation (SO)
Corteva Agriscience (incl. AgriGenetics and predecessors)	1,016	344	1,360	HQ
Cook Group	857	336	1,193	HQ
Zimmer Biomet	828	227	1,055	HQ
Warsaw Orthopedic (dba Sofamor/Danek)	692	267	959	HQ
Roche (incl. Diabetes Care and Diagnostics)	391	228	619	SO
Baxter (incl. Hill-Rom, Welch-Allyn, Allen Medical Systems)	327	220	547	SO
Purdue University (Research Foundation)	241	266	507	HQ
Eli Lilly	255	233	488	HQ
DePuy Synthes (J&J Subsidiary)	303	177	480	SO
Indiana University (R&T Corp)	167	191	358	HQ
Stryker Corporation (incl. Howmedica Osteonics and Wright Medical)	74	58	132	SO
Bayer Cropscience (incl. Monsanto)	99	32	131	SO
Procter & Gamble	73	47	120	Likely Commuters
University of Notre Dame	52	52	104	HQ
Elanco	42	24	66	HQ
Novartis (incl. Endocyte)	21	43	64	SO
National Institutes of Health	49	14	63	Funder/Gov't Int.
Cilag GMBH Int'l (J&J Subsidiary)	36	25	61	Likely Commuters
Nico Corporation	37	17	54	HQ
Ascensia Diabetes Care Holdings AG	37	14	51	Closed
Adama Makhteshim Ltd	17	33	50	Remote Worker
Kaleo, Inc.	32	16	48	Remote Worker
Medtronic (incl. Covidien, SonarMed, and Titan Spine)	33	11	44	SO
Boston Scientific (incl. SciMed)	26	15	41	SO
Life Spine, Inc.	25	15	40	Remote Worker
Pop Test	31	6	37	Scientific Advisor
Early Morning (dba Weeks Roses)	36		36	Closed

Source: TEConomy analysis of Clarivate Analytics' Derwent Patent Analysis Database, 2017-2023 to date. Table shows Patent Assignees with 35+ combined issued patents or pending applications with one or more Indiana resident inventors.

Further downstream within the innovation continuum, venture capital (VC) can serve as a proxy measure of activity in new life science business start-ups and growth. Longitudinal VC data for Indiana life sciences are shown in Figure 7 (for 2010 through 2022), showing Digital Health, Pharma/Biotech, and Medical Devices driving life sciences VC activity in Indiana. Since 2020, Indiana has struggled to regain its momentum in medical devices (but it should be noted that the pandemic constrained this industry as elective surgeries were curtailed, and investors temporarily shied away).

Figure 7: Total Life Science Venture Capital Deals in Indiana by Life Sciences Subsector (2010-22)



Source: TEConomy Analysis of Pitchbook Data.

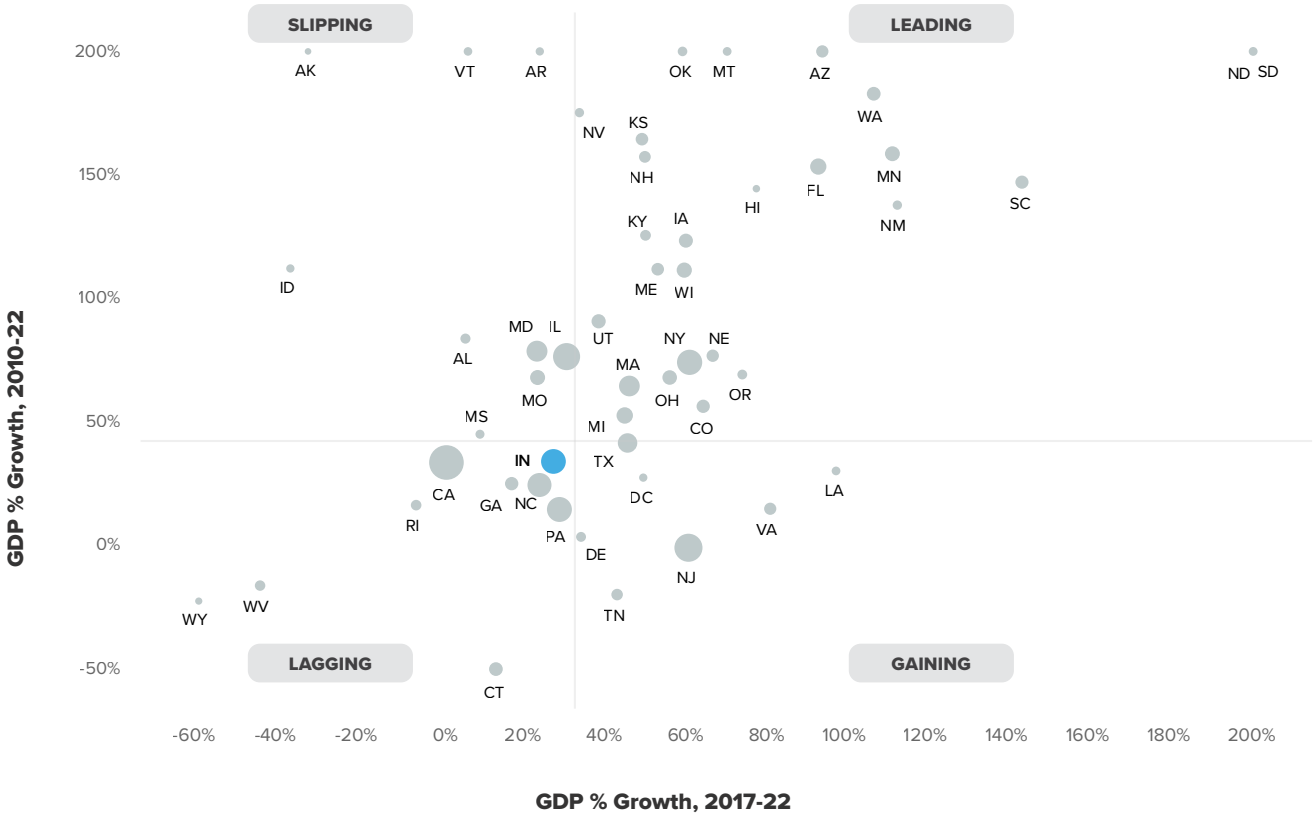
Signs of Stress

While the above-cited data and statistics generally show life sciences as an innovative, high-employment industry that provides robust economic impacts across the Indiana economy, signs of challenges lie ahead. These may be indicators of stressors, such as labor shortages, high costs of capital, international and domestic competition, etc., impacting the operations of Indiana's life sciences industries.

Figure 8 shows the results of analysis of GDP growth for the pharmaceutical sector in Indiana (which was noted earlier to be the largest sector in Indiana in terms of contribution to the state's GDP). The figure shows long-term growth for each state in the industry (2010 through 2022) and the more recent growth trend for 2017 through 2022. The analysis serves to show the respective growth momentum for each state in pharmaceutical sector GDP, segmenting states into four quadrants ("leading" means outpacing national growth over both periods; "slipping" indicates growing above the long-term national growth, but not in more recent growth; "gaining" is not growing as fast as the nation over the long-term, but exceeding the national rate more recently; and "lagging" means being behind the national rate in terms of both long term and shorter term GDP growth).

Evident in these data is the position of Indiana just inside the lagging quadrant. The state has experienced growth on both dimensions, but that growth has been slower than that experienced in most other states; thus, Indiana is seeing its market share eroded over time. Figure 9 shows the same analysis for the Medical Devices sector, showing even greater erosion of Indiana's position in the national landscape and the state experiencing the lowest level of long-term GDP growth for the sector among all 50 states and DC.

Figure 8: Comparative Pharmaceutical Sector GDP Growth Rate Position of U.S. States, 2010-22 and 2017-22 (Size of Bubble = Sector GDP)



Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data)

Figure 9: Comparative Medical Device Sector GDP Growth Rate Position of U.S. States, 2010-22 and 2017-22 (Size of Bubble = Sector GDP)

Source: TEConomy Analysis of Lightcast 2022.3 (Q3 2022 last data)

Eroding market share in such large-scale Indiana industries should be of significant concern to BioCrossroads and all Indiana life science stakeholders. The strengths the sectors enjoy in Indiana are still considerable, but attention is needed to ensure the ecosystem in which these industries operate is optimized for growth moving forward. Hence the need for a strategy.

Conclusions

Large, specialized, and growing, life sciences represent a critically important industry for Indiana. Indiana's GDP is heavily supported by the activities of the pharmaceutical and medical devices sectors, and the employment generated by life sciences is impacting every region of the state and particularly beneficial given the wages of the sector (which are considerably higher than the average Indiana private sector wage). The production of life science products (i.e., manufacturing), especially out of the large pharmaceuticals and medical device sectors, is a signature of the Indiana economy. In addition to manufacturing, research and development leading to life science innovations is important to ongoing life science development and growth in the state. In this regard, however, Indiana is comparatively undersized in its research volume, and growth in R&D should be a strategic goal.

Although Indiana remains one of the top tier states for life sciences, as demonstrated in the biennial TEConomy/BIO state by state bioscience industry review, signs of stress are emerging that make it imperative that Indiana execute a strategy to address challenges and capture opportunities. The GDP growth rate of the sector has not kept pace with that of peer states in recent years, and strategic actions are required to address this and build an ecosystem more conducive to growth over the next decade. A series of strategies and actions to accomplish growth are presented in the next section of the report.

III. A Strategic Plan for Indiana's Life Sciences Industry

Indiana can and must grow its signature life sciences industry. This includes expanding upon its clear strengths in manufacturing life sciences products and boosting its presence in R&D and associated life science innovations. Doing this requires a multifaceted strategy to leverage the state's strengths, address gaps and shortcomings, and aggressively pursue emerging opportunities. The opportunities to realize significant growth are likely substantial, but concerted and organized action is required to realize the vision expressed below.

Vision Statement:

By 2030, Indiana will be known as a global leader in the life sciences industry—the place that advances innovations into products that improve health and well-being.

- ***Indiana's reputation will extend across the full spectrum of facilitated and coordinated activities, including discovery and development in both academic and industry settings.***
- ***Life sciences companies will benefit from Indiana's well-established manufacturing expertise as well as the development and operationalization of new and emerging production systems, together with distribution and logistics systems, that ensure efficiency and growth.***
- ***Indiana will offer an education and workforce development system that guarantees the industry a robust supply of workers with skills and abilities required across critical job functions.***
- ***The building and convening of this industry ecosystem will be shepherded by a network of coordinating entities—including BioCrossroads—that drive strategy implementation and monitoring with the support of key public, private, and nonprofit stakeholders.***

To achieve this vision, TEConomy's situational analysis (via both data analysis and in-depth stakeholder interviews) led to the identification of four key priority areas for advancing Indiana's life sciences economy over the next decade, these being:

- **R&D and Innovation:** Increasing research activity and the commercialization of research innovations.
- **Manufacturing:** Reinforcing and expanding Indiana's forefront position in life sciences manufacturing and leveraging Indiana's robust position in associated distribution and logistics.
- **Workforce:** Assuring supply of a productive and skilled life sciences workforce that meets industry demand.
- **Connections:** Organizing to connect internal stakeholders and raise the external profile of Indiana as a leading state for advancing life sciences.

The Strategy:

The plan of action to achieve the above-stated vision comprises four topline strategies, each composed of multiple actions.

STRATEGY 1. **R&D and Innovation** Increase research activity and the commercialization of research innovations.	**1.1 Drive strategic innovation in therapeutic areas where there are academic and industry core competencies:** Identify existing and emerging therapeutic areas with R&D competencies shared across the industry and academic settings, and drive innovation in these areas.	**1.2 Encourage applied research growth in Indianapolis.** Focus on strategic areas of excellence in key life sciences areas as means to significantly increase NIH and other sponsored research funding levels.	**1.3 Leverage existing and new data assets to drive innovation.** Accelerate growth of the AnalytiXIN clinico-genomic database and make use of IHIE and other data assets to facilitate discovery science and the advancement of new research.	**1.4 Deepen connections between large companies and external innovators.** With leadership from IBRI, develop new efforts to connect large company expertise and infrastructure to advance new ventures.	**1.5 Develop a graduate/ post-doc innovator early-career support program.** Implement a model developed at Lawrence Berkeley National Laboratory that provides resources to recent PhD and post-doc scientists focused on commercializing innovations in thematic platforms.	**1.6 Increase access to early-stage capital.** Increase access to angel, venture, and other internal (to Indiana) and external (outside of the state) capital resources.	**1.7 Ensure availability of the infrastructure needed to support early-stage life sciences enterprises.** In key hubs throughout the state (see 2.5), develop and maintain lab space and other industry-specific facilities that new ventures need to start and scale.
STRATEGY 2. **Manufacturing** Reinforce and expand Indiana's forefront position in life sciences manufacturing.	**2.1. Accelerate advancement of an advanced biomanufacturing process development center at Purdue.** Create development and demonstration sites for advanced production technologies and processes for pharma.	**2.2. Facilitate access to manufacturing for early testing work.** Develop and implement an approach that enables academic and new commercial ventures to make use of existing or new CDMO capacity to assist in manufacturing process development and the manufacture of drug products for early-stage testing and trials.	**2.3. Build capacity to pioneer personalized therapeutics production leadership and leverage logistics advantages.** Continue development of radiopharmaceutical cluster while pursuing new therapeutic areas that could similarly benefit from Indiana's manufacturing and logistics capabilities.	**2.4. Support the growth of existing companies through strategic and targeted business development/ attraction efforts.** Identify and proactively respond to supply chain gaps and associated inward investment opportunities (on/re-shoring).	**2.5. Align existing and future regional economic development efforts to support industry growth that builds on existing assets.** Leverage public-private partnerships to focus investment at selected sites and infrastructure to promote a critical mass at strategic in-state hubs.	**2.6. Strengthen logistics sector to ensure support for life sciences manufacturing growth.** Ensure the logistics sector and other key stakeholders are aware of opportunities related to growth of the life sciences sector and are prepared to make investments needed to meet the sectors' unique needs.	
STRATEGY 3. **Workforce** Assure supply of a productive and skilled life sciences workforce.	**3.1. Create life sciences manufacturing workforce training and education center(s)** Implement educational and hands-on training programs in various aspects of life sciences manufacturing.	**3.2. Advance a curriculum for career education and to upskill/reskill incumbent workers.** Invest to make Indiana a premier location for practical education and training that meets the evolving talent needs of life science employers.	**3.3. Improve retention of graduating talent through robust early industry connections.** Conduct marketing and image building support to boost awareness and attractiveness with efficient and cost-effective pathways for students.	**3.4. Promote youth engagement and DEI in life science careers.** Grow the state's pool of eligible life sciences workers by targeting underrepresented communities and engaging in K-12 outreach.			
STRATEGY 4. **Connections** Organize to connect internal stakeholders and raise the external profile of Indiana as a leading state for advancing life sciences.	**4.1. Ensure alignment and coordination across industry initiatives throughout the state.** Continue to cultivate an ecosystem of industry and academic R&D experts (in sciences and manufacturing) that enables Indiana to opportunistically respond to industry needs in order to drive economic growth.	**4.2. Create a proactive state marketing strategy for Indiana's life sciences industry.** Enhance the branding and awareness of Indiana as a leading state for life sciences.	**4.3. Develop Indiana Life Sciences Summit for an external audience.** Build on BioCrossroads' years of holding well-attended events and produce an annual event that raises Indiana's profile within the industry.	**4.4. Develop and maintain a robust hub of Indiana-specific life sciences information that elevates awareness of key assets.** Build and maintain a network of life sciences assets across Indiana.	**4.5 Ensure state and local policy environments enable life sciences sector growth.** Ensure state and local fiscal, regulatory, and other policies facilitate industry growth and the availability of a highly qualified workforce.		

STRATEGY 1: R&D and Innovation

Increase research activity and the commercialization of research innovations.

Strategic Goal: To significantly increase the volume of life sciences research activity in Indiana, especially applied research, and facilitate the advancement of associated research-based innovations as the basis for new commercial life science ventures. The recommended actions seek to build excellence in established and emerging R&D core competency areas and provide an enhanced environment for accelerating the commercialization of innovations in Indiana.

The Data Intelligence:

- Although academic R&D growth in the life sciences has grown faster in Indiana than in the nation since 2018, large gaps exist between the state and its benchmark competitors in the awarding of NIH and other research awards. Beyond serving as a funnel for commercialization, these awards also support talent development.

- Indiana has experienced significant recent growth in venture capital activity; however, overall levels remain low when compared to competing states on the coasts.

- Data on patent activity and joint publications between universities and industry partners suggest niche opportunities for Indiana to grow across its key subsectors.

The Stakeholder Situational Assessment:

- The new IU Indianapolis and Purdue University in Indianapolis campuses present fresh opportunities to better connect university research, talent, and industry.

- There is a broad desire to increase levels of strategic engagement and collaboration between industry and the state's research universities.

- The diversity of Indiana's life sciences industry is a strength – the state has distinct growth opportunities both across and within subsectors.

    - **Thematic Platforms:** Neuroscience, diabetes, microbiomics, pediatric health.
    - **Pharmaceuticals:** Biomanufacturing, radiopharmaceuticals.
    - **Medical Devices:** Orthopedics, interventional surgical devices, diagnostic devices.
    - **Health Tech:** Health informatics, digital health.

- There is a need for more lab space for early-stage companies and better alignment between space and company needs.

- Stakeholders expressed concerns about a lack of Indiana venture capital firms willing to be a lead investor.

- There is a need to better leverage the expertise of Indiana's large life science companies, building connections with early-stage entrepreneurs to build successful collaborations and mentorship.

As components of this strategy, it is recommended that Indiana pursue seven actions:

1.1 Drive strategic innovation in therapeutic areas where there are academic and industry core competencies: Identify existing and emerging therapeutic areas with R&D competencies shared across the industry and academic settings and drive innovation in these areas.

1.2 Encourage applied research growth in Indianapolis: Focus on strategic areas of excellence in key life sciences areas as a means to significantly increase NIH and other sponsored research funding levels.

1.3 Leverage existing and new data assets to drive innovation: Accelerate growth of the AnalytiXIN clinico-genomic database and make use of IHIE and other data assets that facilitate discovery science and the advancement of new research.

1.4 Deepen connections between large companies and external innovators: With leadership from IBRI, develop new efforts to connect large company expertise and infrastructure to advance new ventures.

1.5 Develop a graduate/post-doc innovator support program: Implement a model developed at Lawrence Berkeley National Laboratory that provides resources to recent PhD and post-doc scientists focused on commercializing innovations in thematic platforms.

1.6 Increase access to early-stage capital: Increase access to angel, venture, and other internal (to Indiana) and external (outside of the state) capital resources.

1.7 Ensure availability of the infrastructure needed to support early-stage life sciences enterprises: In key hubs throughout the state (see 2.5), develop and maintain lab space and other industry-specific facilities that new ventures need to start and scale.

1.1 Drive strategic innovation in therapeutic areas where there are academic and industry core competencies.

Identify existing and emerging therapeutic areas with R&D competencies shared across the industry and academic settings and drive innovation in these areas.

Life sciences are extremely broad, and while breadth is required to provide well-rounded higher-education coverage, focus and specific subject matter depth are required to advance modern life science innovation. It would be extremely challenging to set up a system in which Indiana achieves R&D excellence across all life science areas. Still, it is certainly achievable to build world-class R&D and innovation excellence in areas where state institutions and industry have already proven core competencies or selected areas of emerging competency with a line-of-sight to significant innovation and commercialization opportunities. Based on analytics and interviews, multiple areas have been preliminarily identified as strategic innovation platforms for further consideration. These include:

- Diabetes and metabolic disorders are a clear Indiana competency with alignment to strengths across universities, IBRI, and major industry. There is significant evidence of co-publishing between universities and industry. Overall publishing in endocrinology and metabolism shows a specialized publishing location quotient of 1.37 (meaning that Indiana publishes at 37% above the national average).

- Neurosciences and neurodegeneration are also stated strengths that demonstrate alignment between university and industry strengths. Again, there is evidence of co-publishing between universities and industry.

- Class III medical device development is a long-standing area of expertise for Indiana, with subcategories in interventional surgical and orthopedic devices.

- Multiple competency areas align to support pharmaceutics, associated drug development, and biomanufacturing. There are high publishing location quotients (indicative of a specialization for Indiana in the area if they are over 1.0) evident in organic chemistry (1.52), medicinal chemistry (1.32), analytical chemistry (1.26), and pharmacology and pharmacy (1.18).

- Medical informatics (1.22 LQ) is also a specialization and has potential connectivity to strengths in statistics and probability (1.25).

- Additionally, there is evidence of emerging platforms associated with radiopharmaceuticals, microbiomics, novel application of in vivo microbes to the production of therapeutic products, and pediatric rare diseases: health IT and digital health delivery.

Having a declared focus around themes allows for the development of a critical mass of researchers and the assembly of teams with multi-disciplinary capabilities to advance complex research inquiry.

It should be noted that a full core competency scan was not a component of the strategy development project, and further due diligence should be performed to select platforms rooted in further analytics and, especially, convening a multi-university and multi-industry strategic opportunity advisory group to reach consensus on platform recommendations.

Potential Action Components:

- Perform further analytics on strategic platforms to identify specific growth opportunities.
- Convene a multi-university and multi-industry strategic opportunity advisory group to reach consensus on platform recommendations.
- Design and implement actions both across and within platforms.

Getting Started	
First Step	The recommendation requires a collaborative evaluation of shared opportunities across industry and university stakeholders. IBRI and BioCrossroads are well-positioned to convene a cross-sector group of senior leaders to discuss the recommendation and next steps.
Timing	Near-term

1.2 Encourage applied research growth in Indianapolis.

Focus on strategic areas of excellence in key life sciences areas as a means to significantly increase NIH and other sponsored research funding levels.

This action seeks to significantly increase life science research activity in Indianapolis through the focused development of applied research programs at IU Indianapolis and Purdue University in Indianapolis. Programs of focused research excellence should be built or reinforced through the recruitment of faculty with interests or, ideally, an existing track record in the commercialization of research-based innovations. There is a need to boost faculty entrepreneurship in life sciences, and the development of the new universities will enable policies and procedures to be constructed at the outset that encourage and reward this activity.

While basic research inquiry is very important to advancing the base of scientific knowledge upon which subsequent applied research programs may be based, the strategy seeks to promote growth in life sciences and economic development in Indiana over a relatively compact 10-year period. In earlier TEConomy research for BioCrossroads, performed in collaboration with Indiana's research universities, it was found that Indiana is atypical in having a significantly above-average emphasis on basic research. That study noted that:

> *When looking across three types of categorized R&D ("basic," "applied," and "development"), Indiana's research universities skew more toward basic research than is typically seen in benchmarks and the peer institution subsets. This finding holds true for total R&D expenditures and for federally funded R&D expenditures. Indiana University's basic research is 75% of its total R&D portfolio and 75% of its federally funded portfolio, while for Purdue, these figures are 74% and 80%, and at Notre Dame, 96% and 94%. The average for top-quartile research universities in the United States sees basic research comprising 63% of all R&D expenditures and 65% of federal—and these respective percentages are similar for other subsets (public universities, private universities, universities with a medical school, universities without a medical school, and 1862 Land-Grant Universities). It may be that Indiana's research universities are effectively missing out on participation in significant federal funding focused on applied and development-oriented research questions.*[4]

Focusing on applied life sciences research in Indianapolis makes sense, given the presence of the IU School of Medicine and IU Health and their clinical research assets, in combination with IBRI and the robust regional industry presence, which can assist in advancing applied and translational research towards commercialization. Leaders of both universities have, in fact, signaled an interest in ensuring that applied and translational research are emphasized in Indianapolis going forward. Such is indicated by Purdue's commitment to launching a branch of its Purdue Applied Research Institute (PARI) near the current IUPUI campus as well as the public disclosure of the exploration of a new joint biosciences engineering institute led by IU's School of Medicine and Purdue's Weldon School of Biomedical Engineering.

4 TEConomy Partners. "Assessing R&D Funding Across Indiana's Major Research Universities." October 2018. Prepared for BioCrossroads.

Potential Action Components:

- As the new IU Indianapolis and Purdue University in Indianapolis campuses are developed, the universities should actively look for new opportunities to recruit faculty who have generated invention disclosures and engaged in work to advance research-based innovations toward commercial applications, particularly if their work falls within a strategic innovation platform (from Action 1.1).
- Build robust connectivity between key actors across IU Indianapolis, the IU School of Medicine (including the Indiana Clinical and Translational Sciences Institute [CTSI], Purdue University in Indianapolis, IBRI, and industry).
- Ensure that future launches of PARI and the new biosciences engineering institute in Indianapolis have strong industry connections needed to support applied research.

Getting Started	
First Step	Leadership of Indiana and Purdue Universities who must ultimately ensure that applied research becomes and remains a focus in Indianapolis. Given that both university presidents—along with key life sciences industry leaders—serve on CICP's board, CICP is positioned to facilitate initial discussions on how to best support a focus on applied research in Indianapolis.
Timing:	Near-term and ongoing

Example: The Cancer Research and Prevention Institute of Texas (CPRIT)

Established in 2007 by Texas voters, the Cancer Research and Prevention Institute of Texas (CPRIT) is a taxpayer-funded, competitive R&D grant-making entity modeled on California's stem cell institute CIRM. CPRIT was started with $3 billion in authorized bonding over 10 years. The program was overwhelmingly reupped by voters in 2019, with an additional $3 billion in capacity over an additional decade. As a $6 billion, 20-year initiative, CPRIT is the largest state cancer research investment in the history of the United States and the second-largest cancer research and prevention program in the world.

In establishing CPRIT, the Legislature directed CPRIT to grow Texas' cancer-fighting ecosystem and accelerate the potential for breakthroughs in cancer prevention and cancer cures. CPRIT awards merit-based, peer-reviewed grants to Texas-based entities and institutions for cancer-related research, product development, and the delivery of cancer prevention programs through three programs:

- **Academic Research:** CPRIT supports the most creative ideas and meritorious projects brought forward by the cancer research community in Texas.
- **Prevention:** Ten percent of CPRIT funds support the delivery of evidence-based cancer prevention interventions to underserved populations in Texas.
- **Product Development Research:** CPRIT creates and supports infrastructure in Texas that accelerates the movement of new cancer drugs, diagnostics, and therapies from the laboratory to the patient.

CPRIT has resulted in a significant impact for Texas, including the recruitment of 295 cancer researchers to the state, the creation of 73 core facilities to support cutting-edge R&D, the development of 273 new clinical studies, nearly $9.5 billion in non-state follow-on funding, and more than 9 million prevention services provided to Texans.[5]

5 https://www.cprit.texas.gov/our-programs/our-impact

1.3 Leverage existing and new data assets to drive innovation.

Accelerate growth of the AnalytiXIN clinico-genomic database and make use of IHIE and other data assets that facilitate discovery science and the advancement of new research.

The depth and breadth of data resources containing life science and health information are staggering and expanding rapidly. Data from scientific experiments, clinical tests, genetic sequencing, electronic medical records, chemical compound libraries, medical imaging, and more represent an extraordinarily rich potential resource that may be mined to enhance discovery and innovation. While the opportunity is there to leverage data for transformational discoveries and change, the reality is that these data exist in a vast array of disparate, separately compiled, and diversely formatted structured and unstructured forms. We know that the data resources that exist hold the potential for transformational discovery if they can be assembled into usable structures and made available for researcher use. In parallel with the exponential expansion of life science data, new tools, and techniques in data mining and advanced analytics (including the application of machine learning and AI) are now available to enable deep inquiry of data resources for actionable insights. If data are available, advanced tools and techniques now exist to release value locked within those data (even unstructured data). What is clearly needed is the facilitated assembly of multiple useful datasets from a wide range of sources and owners to provide what has been termed a "data lake."[6]

Recognizing both the need for an accessible data lake and the promise of actionable discoveries therein, CICP and BioCrossroads launched AnalytiXIN to work with partners in compiling a valuable life sciences data lake. As noted by the organization:

> *The AnalytiXIN life sciences health data asset (HDA) has been designed through a working collaboration involving Eli Lilly and Company, IU Health, the Indiana Biobank within the IU School of Medicine, the Indiana Health Information Exchange, and other partners to build a shared health-data platform linking consented clinical and genomic patient data. This collaboration is further leveraging the Broad Institute's technical and genomic infrastructure to accelerate the build-out as well as connect to broader national initiatives such as the National Institutes of Health All of Us research program.*[7]

The vision is to create a data resource containing both genotype and phenotype information, creating a rich dataset that facilitates discovery science. Access to large volumes of sequenced individuals, in combination with health records data, "provides a rich platform for important scientific discovery and for advancing the identification and classification of genomic variant pathogenicity (variants associated with causation of disease). Both science and technological capabilities are now at the point where the analysis of genomic and phenomic big data provides a powerful pathway forward for biomedical discovery and clinical applications to improve human health."[8]

6 "A data lake is a centralized repository that allows you to store all your structured and unstructured data at any scale. You can store your data as-is, without having first to structure the data, and run different types of analytics—from dashboards and visualizations to big data processing, real-time analytics, and machine learning to guide better decisions." https://aws.amazon.com/big-data/datalakes-and-analytics/what-is-a-data-lake/

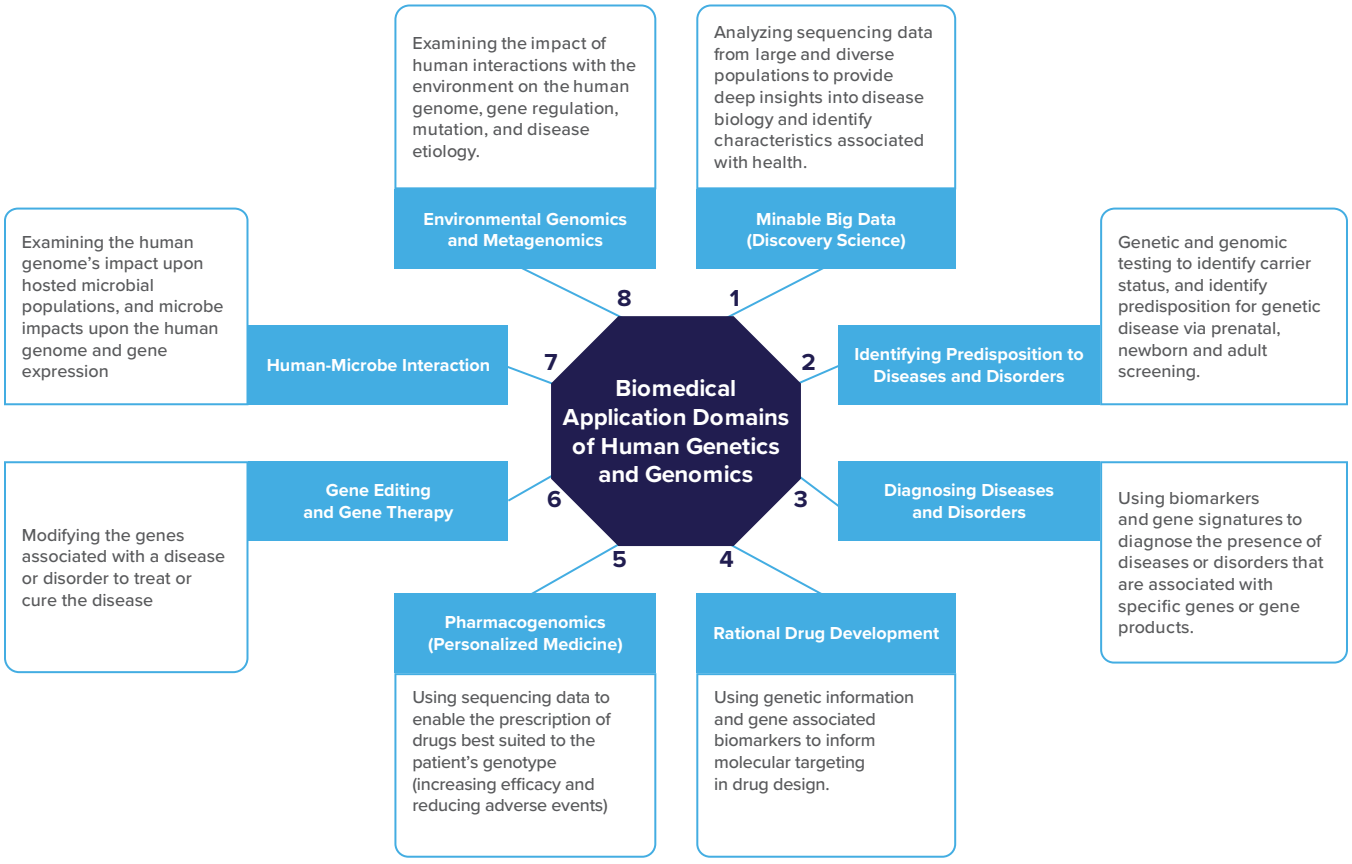
7 https://analytixindiana.com/life-sciences/

8 Tripp, S., and Grueber, M. (2021). The Economic Impact and Functional Applications of Human Genetics and Genomics. TEConomy Partners, LLC for the American Society of Human Genetics.

Building a data lake of this nature in Indiana will provide a powerful competitive advantage for researchers seeking to advance research discoveries and move innovation forward. As noted in a report for the American Society of Human Genetics, the assembly of such resources provides a rich basis for deriving a broad range of functional insights across multiple areas of human medicine (Figure 10).[9]

Moreover, the AnalytiXIN data lake is unique in that patients whose data is included in it have consented to re-contact. This is true of few other clinico-genomic databases, which underscores the competitive advantage in that the consents allow for patients to be readily contacted for recruitment in clinical trials. This also positions the AnalytiXIN data lake to be useful in addressing health disparities and equity in that it could be used to strengthen diverse participation in clinical trials.

Figure 10: Functional Biomedical Impact Domains (Applications) of Human Genetics and Genomics



Source: TEConomy Partners.

9 Ibid

The clinical records found in the AnalytiXIN data lake are enabled through the Indiana Health Information Exchange (IHIE), the nation's largest inter-organizational health information exchange. IHIE manages the Indiana Network of Patient Care (INPC), the underlying clinical database that encompasses data on over 18 million patients in the form of 10 billion clinical observations via hundreds of Indiana healthcare entities (hospitals, health networks, and insurance providers). IHIE makes INPC data available for use cases related to patient treatment and clinical operations. Meanwhile, the Regenstreif Institute makes this same INPC data available for research purposes. These data assets should be carefully considered when identifying strategic therapeutic areas. More generally, their potential should be amplified through efforts to drive applied research and university-industry engagements in Indianapolis and statewide.

Potential Action Components:

- Accelerate creation of AnalytiXIN data resource containing both genotype and phenotype information, creating a rich dataset that facilitates discovery science.
- Encourage the advancement of new research and innovation related to applied data and the life sciences—building a data lake of this nature in Indiana will provide a powerful competitive advantage for Indiana's researchers.
- Strategically leverage all new and existing data assets in the context of other innovation and R&D-focused recommendations.

Getting Started	
First Step	Ongoing implementation of work already underway through the AnalytiXIN initiative.
Timing:	Near-term and ongoing

1.4 Deepen connections between large companies and external innovators.

With leadership from IBRI, develop new efforts to connect large company expertise and infrastructure to advance new ventures.

There is a wealth of knowledge and know-how contained within Eli Lilly and Company, Elanco, Roche, Cook, and other leading life science companies operating in Indiana. These companies have the track record and breadth of expertise required to navigate the long and complex path from novel ideas to tangible, on-the-market products. In the pharmaceutical industry, it can take 10 to 15 years and upwards of $2 billion to develop a new drug, and only a very small percentage of promising drug candidates make it through clinical trials. The process, at every step, is also complex—the expertise and infrastructure required to advance scientific inquiry in the first place, the specialized knowledge required to navigate intellectual property protection and regulatory requirements, the complexity of recruiting and managing clinical trials, the tools and technologies required to produce products for clinical trials, and the highly refined and regulated processes for manufacturing, packaging, storing, and distributing pharmaceutical products. Because of the need to employ highly specialized talent, technologies, and production infrastructure, advancing a new regulated medical product requires access to extensive capital – and the capital providers need to be prepared to operate in a high-risk environment that sees most candidate products fail to make it to market. Because of these and other complex requirements, life sciences businesses are among the most challenging to develop, manage, and operate.

For university faculty, life scientists, and new entrepreneurs with a desire to advance promising discoveries to commercialization, the complexity, cost, and long time horizon, in combination with the attrition rate of product candidates, presents a truly daunting set of challenges to contemplate and navigate. The reality is that most discoveries may never be advanced further than their elucidation in an academic journal or an invention disclosure because the pathway to move them forward is beyond the capabilities and resources of those engaged in the early discovery work. A partial solution to unlocking the power and promise of candidate medical innovations is to facilitate open innovation, whereby innovators and entrepreneurs can gain access to the deep knowledge, expertise, and infrastructure of existing successful life science companies. Creating environments where academic, nonprofit, and government lab scientists and entrepreneurs can access the expertise and infrastructure assets of Indiana's many well-established life science companies presents a potential pathway for the state as it seeks to leverage its strengths in life sciences R&D.

At the current time, IBRI is a key asset for Indiana, serving as a convening point for much of the type of activity envisioned. IBRI is, of course, far smaller than the large corporate entities in the space, and thus, while it can coordinate and fulfill some of the envisioned elements of this action, the supporting engagement and commitment of a large company or companies, is needed.

Several assets and existing activities may be built upon to advance this action:

- IBRI is specifically structured to encourage collaborations between innovators, IBRI experts, and external partners to advance applied discoveries in health sciences. Operating at 16 Tech in Indianapolis, IBRI's labs are now being used by 13 resident start-ups seeking to accelerate their research translation. As such, it is the logical entity to coordinate open innovation partnerships and associated acceleration efforts.

- Eli Lilly and Company has already committed to this model of innovation outside of Indiana through its Gateway Labs by Lilly model. Gateway Labs has two locations in California and a third location opening in 2024 within the new Lilly Institute for Genetic Medicine in Boston, Massachusetts. While Lilly's early engagement in the California and Massachusetts environments is understandable (given the intensity of life science research and innovation in those states and the track record there of entrepreneurial life science ventures), it would be highly valuable for Indiana if this model could be adopted by the company in Indiana also.

- Founded by Cook, the MED Institute at the Purdue Research Park is a for-profit company that leverages Cook's engineering, regulatory, and clinical expertise to support companies who need help moving their product from concept to commercialization.

- The Indiana Clinical and Translational Sciences Institute (CTSI) provides a broad range of services and tools to advance clinical and translational research and associated innovations at IU, Purdue, and Notre Dame.

Potential Action Components:

- Long-term, developing an Open Innovation Campus where academic, nonprofit, government labs and entrepreneurs can access established life science companies' expertise and infrastructure assets presents a potential pathway for Indiana as it seeks to leverage its strengths in life sciences R&D.
- Provide physical incubator space and support for startups by offering laboratory and office spaces to early-stage life sciences companies and startups while offering support and mentorship to startups and early-stage companies. It may be covered by IBRI and other stakeholders.
- Facilitate access to expertise by locating near companies like Elanco or Lilly and being able to leverage their R&D facilities; in doing so, other companies can receive Indiana's world-class scientific expertise and resources.
- Foster partnerships and collaboration by networking with key actors across resident companies, academic researchers, and industry partners.

Getting Started	
First Step	IBRI should work with its board of directors to review the recommendation and devise a path forward that deepens substantive engagement with the companies and universities represented on the board. This work should/could be informed by further study of the Stevenage Bioscience Catalyst, including the value it offers the private sector (i.e., GSK) and the public sector.
Timing:	Mid-term

Example: Stevenage Bioscience Catalyst (UK)

The Stevenage Bioscience Catalyst (SBC) is located in the town of Stevenage in the UK, 30 miles north of London on the GlaxoSmithKline (GSK) campus. The SBC is a public/private development between GSK; the UK Department for Business, Innovation and Skills; the Wellcome Trust; the East of England Development Agency; and the Technology Strategy Board. GSK provided land, facilities, and investment totaling almost £11 million ($14.7 million) to help build and launch the campus. GSK notes the following:

> *Located amid a cluster of academic centres of excellence and other pharma companies, the Stevenage Bioscience Catalyst campus is a major hub for early-stage biotechnology companies. It provides small to medium-sized biotech and life sciences companies and start-ups with access to the expertise, networks and scientific facilities traditionally associated with multinational pharmaceutical companies. A key aim of Stevenage Bioscience Catalyst is to pioneer a culture of open-innovation that will place the UK bioscience sector at the forefront of worldwide biomedical discovery and deliver cutting edge healthcare solutions.*

The key is bringing researchers' ideas together with existing industry expertise to accelerate technology evaluation, market analysis, and commercialization. An environment has been created at the SBC such that academic researchers from leading UK universities (e.g. Cambridge, Oxford, etc.) have relocated labs to the SBC. Christine Martin, manager, drug discovery, at Cambridge Enterprise, the technology transfer company of the University of Cambridge, explains why some groups at Cambridge want to locate at the open innovation SBC campus (which is a 30-mile drive from Cambridge University):

> *We help researchers convert their validated targets from aspirational to de-risked, investable assets. Many academics appreciate how challenging the transition from target to drug candidate can be; so what we are doing is identifying those research groups that would benefit from access to drug discovery expertise by collocation with industry at the SBC.*[10]

In the same article, Martino Picardo, the CEO of SBC, notes that:

> *Several groups at the University of Cambridge want to be here, as their scientists need access to GSK's drug discovery expertise, as well as that of Scinovo, the organization within GSK that provides consultancy in that area. Our open ecosystem here also provides state-of-the-art facilities and equipment that academics and small companies would not otherwise be able to access.*
>
> The SBC campus and program has evolved to provide a robust ecosystem for bioscience business development, providing the following core elements:

- **Serving as an Open Innovation Campus:** SBC brings together diverse stakeholders, including biotech and pharmaceutical companies, academic researchers, startup entrepreneurs, and investors. It constitutes a collaborative ecosystem that facilitates the sharing of knowledge, expertise, and resources.
- **Physical Incubator Space:** SBC offers laboratory and office spaces to early-stage life sciences companies and startups.
- **Support for Startups:** SBC provides support and mentorship to startups and early-stage companies to help them navigate the challenges of commercializing their research and developing their products. This includes business advice, access to funding opportunities, and guidance on regulatory processes.

10 Pearson, S. (2012). Open innovation in the pharma industry: Is it being fully embraced yet? *Genetic Engineering and Biotechnology News.* See http://www.genengnews.com/gen-exclusives/open-innovation-in-the-pharma-industry/77899732.

- **Access to Expertise:** The campus is near the Stevenage Bioscience Hub, which includes research institutions and the GlaxoSmithKline (GSK) Stevenage research and development center. This provides resident companies at SBC with access to world-class scientific expertise and resources.
- **Partnerships and Collaborations:** SBC actively facilitates partnerships and collaborations between its resident companies, academic researchers, and industry partners. These collaborations enable joint research projects, technology transfer, and the development of new therapies.
- **Focus on Therapeutic Areas:** SBC has a particular focus on therapeutic areas such as oncology, neuroscience, and regenerative medicine.

1.5 Develop a graduate/post-doc innovator early career support program.

Implement a model developed at Lawrence Berkeley National Laboratory that provides resources to recent PhD and post-doc scientists focused on commercializing innovations in thematic platforms.

In 2021, life science disciplines at higher education institutions in the U.S. spent a total of $52,424,127,000 on research expenditures. Of these expenditures, $797,545,000 (1.52%) occurred in Indiana. While these Indiana research expenditures alone can be the source of valuable innovations with commercialization potential, simple math suggests that the national footprint of potential university innovators, being so much larger, will be producing many more discoveries and inventions. What if this nationwide pool of innovation can be partially tapped to the benefit of Indiana? Typically, PhD students and other graduate students will have been intimately engaged in major research initiatives, and many of these highly educated students will graduate with innovations with commercial potential grounded in their research work. Lawrence Berkeley National Laboratory (see case study below) concluded that many innovative post-docs could be attracted to the infrastructure and expertise of the lab to further advance their applied research discoveries. The lab hypothesized that by providing a moderate salary (or stipend), highly educated and innovative graduates could be encouraged to come to the lab to advance their innovations, thereby forming a clustering of innovators leveraging the special resources and expertise of the lab. The initiative, termed “Cyclotron Road,” has proven to be quite successful.

This suggested action would replicate the model by using curated access to the IBRI-coordinated open innovation environment recommended under Action 1.4 as the primary attractor for innovative post-docs and other skilled scientists seeking to advance their potential commercial concepts. The program may be advanced by deploying a competitive application process, with applications reviewed by an advisory board from the open innovation center participating organizations. Seed funding for the program should be assembled to provide applicants with access to a moderate salary and benefits for two years, with space provided within IBRI or another participating open innovation consortium member organization. In combination with facilitated access to infrastructure and expertise within consortia members, the participants will also be provided with business development counseling and opportunities for introductions to capital providers able to support the ongoing development of promising start-up ventures.

IBRI has recently begun its own efforts aimed at helping post-docs and other recent university graduates transition from working in an academic setting to supporting research in a more industry-driven environment. This work implicitly acknowledges that researchers interested in applied endeavors sometimes need to move outside of the academy to further their work. In many ways, the model suggested here is an acceleration and expansion of the work already begun by IBRI in that it recognizes that life sciences entrepreneurs inherently occupy a unique space that bridges industry and academia, and as such, life sciences entrepreneurs require unique efforts aimed at supporting their work.

Potential Action Components:

- Deploy a competitive application process, with applications reviewed by an advisory board from the open innovation center participating organizations.
- Assemble seed funding for the program to provide applicants with access to a moderate salary and benefits for two years.
- Provide space within IBRI or another participating open innovation consortium member organization.
- Offer business development counseling and opportunities for introductions to capital providers able to support the ongoing development of promising start-up ventures.

Getting Started	
First Step	BioCrossroads should convene IEDC, IBRI, university leadership, and others to discuss the recommendation after meeting with the leadership of the program at Lawrence Berkeley (called Cyclotron Road) to gather their insights as to the characteristics required for a successful post-doc innovator support program.
Timing:	Mid-term

Example: Cyclotron Road program at Lawrence Berkeley National Laboratory.

Cyclotron Road is a not-for-profit venture accelerator captive to the U.S. Department of Energy's (DOE) Lawrence Berkeley Laboratory (LBL) at the University of California (UC) Berkeley. Cyclotron Road has no facility of its own but operates from office space at laboratory headquarters at 1 Cyclotron Road in the hills above the main campus.

Through a competitive program, Cyclotron Road seeks entrepreneurs—typically recent PhDs and postdocs not just from the UC community but worldwide—with ideas for energy-related business dependent on the physical sciences. The accelerator program is aimed at bridging gaps between ideas and commercialization. It is aimed especially at high-potential businesses that do not start out as obvious candidates for venture capital funding because of outsized technical and/or market risks. The founding director of Cyclotron Road was a former program director at the Advanced Research Projects Agency-Energy (ARPA-E), which takes a similar approach toward technical risk. He was also a co-founder of the ARPA-E's Technology-to-Market program and is himself a two-time entrepreneur in advanced materials and manufacturing.

The accelerator provides a modest living stipend and health insurance to the selected entrepreneurs and complete access to the Lab, shop, user facilities, and (to an unspecified but clearly limited extent) the research services of LBL scientists so that entrepreneurs with energy-related ideas dependent on the physical sciences and engineering technology can prototype and "de-risk" venture ideas before entering into customer relationships and/or negotiation with private market investors. It also provides mentoring and connectivity of a kind completely conventional for private venture accelerators. Indeed, it is organized on a similar cohort basis, although cohorts are much longer (2 years) than the 12 weeks conventional in software/Internet sectors and conclude with a typical "demo day" introducing graduates to private investors.

There were no capital costs involved in starting up Cyclotron Road, but ongoing government funds have supported the implementation of the program and financial support for successful participants. LBL piloted the concept in May 2014 using internal resources before seeking external support from both the DOE and the California Energy Commission.

1.6 Increase access to early-stage capital.

Increase access to angel, venture, and other internal (to Indiana) and external (outside of the state) capital resources.

Life science business ventures are highly capital-intensive. For multiple reasons, elucidated under previous action discussions, the advancement of life science innovations to commercial products requires navigating a long and complex path, with high attrition rates along the way. Substantial capital injections are required to advance entrepreneurial life science ventures along the path, and this capital must be relatively patient (given the significant time horizon for trials and regulatory approvals) and accepting of risk (given the high percentage of failures inherent in life science product development). Very few places outside of the long-established entrepreneurial hubs of the San Francisco Bay Area and Boston have a surfeit of angel and venture capital providers vying for deals. Outside of these two locations, most states and regions struggle to assemble sufficient risk capital resources to meet demand, especially in the high-risk life sciences space.

Indiana has made efforts to address the lack of risk capital in the state's life science ecosystem through BioCrossroads' establishment of venture funding pools, as well as the operation of Elevate Ventures and university seed funding pools. However, during strategy development, entrepreneurs in Indiana consistently cited the lack of access to risk capital as a significant constraint on realizing the full potential of scientific innovations. Severe constraints were cited as occurring across the full range of risk capital stages, from very early pre-seed and subsequent seed investments through to all rounds of formal venture capital investment.

There is no easy, single-fix solution to capital access issues, but BioCrossroads must once again step forward to lead a concerted effort to build seed and venture-stage capital pools with a life science focus. BioCrossroads is currently actively exploring raising a fourth seed fund.

Potential Action Components:

- Supplement BioCrossroads' early work in forming venture funding pools alongside Elevate Ventures and university seed funding pools to accelerate the formation of life sciences-focused venture capital.
- Lead a concerted effort to build seed and venture stage capital pools with a life science focus.

Getting Started	
First Step	BioCrossroads should convene a meeting of major stakeholders in the provision of capital, including existing providers in Indiana, the leaders of related university programs (e.g., IU Ventures, Purdue Innovates), IBRI, IEDC, and others as identified to discuss gaps in bioscience funding, and potential solution pathways.
Timing:	Near-term and ongoing

1.7 Ensure availability of the infrastructure needed to support early-stage life sciences enterprises.

In key hubs throughout the state (see 2.5), develop and maintain lab space and other industry-specific facilities that new ventures need to start and scale.

Advancing life science business venture development typically is more complex in its space requirements than many other technology business sectors. Software companies typically need just basic office space, but a fledgling biotechnology company needs not just office space but also lab space and access to specialized instruments and infrastructure. Recognition of the special needs of life science companies in terms of space underpins the basic model of specialized life science start-up space developers such as Alexandria Real Estate Equities, Inc. (a real estate investment trust based in Pasadena, California), NexCore Development Group (headquartered in Denver, Colorado), and Wexford Science and Technology (headquartered in Baltimore, Maryland). Lab space for early-stage life science ventures has also become a feature of multiple university research parks and is embedded within the more recent development phenomenon of innovation districts. 16 Tech Community Corp has announced a development that will help with lab space availability in Indianapolis, where NexCore will build a 100,000-square-foot new lab building at 16 Tech. The new lab development is anticipated to require between $50 million and $60 million to complete, and "the five-story structure would include a mix of build-to-suit lab space, offices, and fully furnished labs that are move-in ready for growing companies."[11]

BioCrossroads needs to be on the frontlines in terms of monitoring available lab space, maintaining an inventory of available space, and encouraging further development where demand conditions indicate need. Space resources exist at IBRI, at the R1 universities, and in commercial space, and further incubator/accelerator space is being planned at the universities and is likely to be a feature of the new IU Indianapolis (see sidebar) and Purdue University in Indianapolis campus developments. Currently there is no central resource available to potential business ventures seeking to identify available and affordable lab space resources.

Indiana University Indianapolis recently announced plans for significantly expanded institutes, with lab resources anticipated to encourage industry collaborations. Two new institutes have been announced: the Convergent Bioscience and Technology Institute (CBTI) and the Institute for Human Health and Wellbeing (IHHW). The CBTI is anticipated to specifically target industry collaborations with a focus on wearable and implantable medical devices and sensors. IU Indianapolis will also be undertaking significant renovations of lab space and interdisciplinary research infrastructure at the campus, all of which is consistent with the broader aims of the R&D and innovation strategy recommended herein.

11 https://www.ibj.com/articles/16-tech-pencils-in-plans-for-next-two-buildings-after-early-success

Potential Action Components:

- Monitor available lab space, maintain an inventory of available space, and encourage the further development of space where demand conditions indicate need.
- Ensure connections across the space resources that exist at IBRI, at the R1 universities, and in commercial space—especially with more planned at each university and likely at Indianapolis campus developments.
- Serve as a central resource for potential business ventures seeking to identify available and affordable lab space resources, particularly in Central Indiana and other key hubs throughout the state (see 2.5).

Getting Started	
First Step	BioCrossroads should develop an inventory of lab space in Indiana for early-stage companies and determine the current occupancy level of these resources. Actively engage key stakeholders statewide to maintain the dataset to identify regional and overall space constraints and evaluate the ability of recently announced forthcoming projects to meet projected demands.
Timing:	Near-term and ongoing

STRATEGY 2. Manufacturing

Reinforce and expand Indiana's forefront position in life sciences manufacturing.

Strategic Goal: To leverage Indiana's existing assets and core competencies in life science product manufacturing, develop next-generation production systems and technologies, and secure Indiana's reputation as a premier location for manufacturing and distributing a broad range of life science products. This will include products for human and veterinary applications (including medical devices, small- and large-molecule pharmaceuticals, diagnostics, and a position in emerging health technologies). As a result of strategic actions, life science companies already in Indiana or newly coming to the state will feel exceptionally secure in the resiliency of Indiana as a basis for the long-term production and distribution of life science products to meet market demands.

The Data Intelligence:

- Indiana's life sciences industry is manufacturing intensive—the largest percentages of jobs are in production and manufacturing-related fields.
- Indiana is among the nation's leaders in both industrial R&D spending in the life sciences and in patent activity.
- However, disconnects exist between Indiana's growing life sciences industry R&D expenditures, and the state's declining levels of life sciences patent activity.

The Stakeholder Situational Assessment:

- **There is a wide range of manufacturing strengths in Indiana to build upon:** small molecule, biologics (expanding and evolving), diagnostics, vaccines, nutrition and feed additives, medical devices (orthopedic and vascular/surgical), life sciences logistics, etc.
- **There was an emphasis provided across conversations on building out strategic hubs.** There is a desire among stakeholders to concentrate investments and dedicate resources around a handful of themes and locations.
- There is a strong desire to **make Indiana a world-class environment for life sciences manufacturing** by boosting the presence of the supply chain through the attraction of new production modality equipment, disposables manufacturers, sanitation facilities, and lab developers to operate new/additional lab space.

As part of this strategy, it is recommended that Indiana pursue six actions:

- **2.1. Accelerate advancement of an advanced biomanufacturing process development center at Purdue:** Create development and demonstration sites for advanced production technologies and processes for pharma.

- **2.2. Facilitate access to manufacturing for early testing work:** Develop and implement an approach that enables academic and new commercial ventures to make use of existing or new CDMO capacity to assist in manufacturing process development and the manufacture of drug products for early-stage testing and trials.

- **2.3. Build capacity to pioneer personalized therapeutics production leadership and leverage logistics advantages:** Continue development of the radiopharmaceutical cluster while pursuing new therapeutic areas that could similarly benefit from Indiana's manufacturing and logistics capabilities.

- **2.4. Support the growth of existing companies through strategic and targeted business development/ attraction efforts:** Identify and proactively respond to supply chain gaps and associated inward investment opportunities (on/re-shoring).

- **2.5. Align existing and future regional economic development efforts to support industry growth that builds on existing assets:** Leverage public-private partnerships to focus investment in selected sites and infrastructure to promote a critical mass at strategic in-state hubs.

- **2.6. Strengthen logistics sector to ensure support for life sciences manufacturing growth:** Ensure the logistics sector and other key stakeholders are aware of opportunities related to the growth of the life sciences sector and are prepared to make investments needed to meet the sectors' unique needs.

2.1. Accelerate advancement of an advanced biomanufacturing process development center at Purdue.

Create development and demonstration sites for advanced production technologies and processes for pharma.

The manufacturing processes for pharmaceuticals are evolving. The expanding use of new production processes using disposable bioreactors, continuous manufacturing, etc., are introducing significant changes to the manufacturing floor. As new therapeutic modalities emerge in highly targeted cell therapies, gene therapies, and personalized small-batch production, the environment of biomanufacturing and pharmaceutical product distribution is undergoing change. For Indiana, as a signature hub of biomedical product manufacturing, developing and maintaining a position in the ongoing evolution of pharmaceutical production is important. Recognizing this, faculty at Purdue University has taken a leadership role in establishing the William D. Young Institute for Advanced Manufacturing of Pharmaceuticals (AMP), a Purdue Institute with over 30 engaged faculty members leveraging the University's "reputation in chemistry, engineering, science, and pharmaceutical R&D and training."[12] As noted by the institute:

> *AMP seeks to organize people, resources, and partners in the context of advanced pharmaceutical manufacturing. The alliance leverages the collective strength and individual expertise of each for the purpose of crafting innovative business models to attract large-scale funding with the capacity to facilitate advanced research and foster workforce development for the benefit of the state and nation.*[13]

The ongoing development of AMP will be an important component in linking the University's multifaceted expertise to potentially address multiple needs in Indiana's life sciences manufacturing ecosystem.

- Development of economically viable processes for cell- and gene-based therapeutics.
- Development of economically viable processes for the production of small-batch pharmaceuticals, including custom formulations for personalized medicine.
- Development of cost-effective productivity-enhancing technologies and tools for pharmaceutical production.
- Working with manufacturers to solve challenges and pinch points in their existing processes.
- Training students in advanced biomanufacturing techniques.
- Hosting events and being a convener of thought leaders in advanced pharmaceutical manufacturing.

The life sciences strategy should support the ongoing growth and development of the AMP and assist in raising awareness of the program with US and international biomanufacturing firms. The goal should be for AMP to become a well-recognized, premier institute in biomanufacturing process refinement and development and the training of students to meet the needs of industry engaged in the evolution of their manufacturing processes.

12 https://www.purdue.edu/science/research-groups/amp/index.html
13 Ibid

Moreover, given that Indiana is the most manufacturing-intensive state in the nation and home to many efforts aimed at boosting manufacturing productivity via Industry 4.0, other manufacturing-focused initiatives at Purdue and elsewhere (e.g., Purdue's newly announced eXcellence in Manufacturing and Operations [XMO] initiative) should be fully leveraged to support the growth of the life sciences sector. This is particularly needed in the state's medical device sector, which has seen a documented decline in productivity over the last several years.[14] Due to the highly regulated nature of life sciences manufacturing, additional specialized initiatives may be needed. If they are industry intermediaries, like BioCrossroads and OrthoWorx, they are well-positioned to convene industry stakeholders to support the launch of additional supports.

Potential Action Components:

- Support the ongoing growth and development of the AMP and assist in raising awareness of the program with US and international biomanufacturing firms.
- Help position AMP as a well-recognized, premier institute in biomanufacturing process refinement and development and the training of students to meet the needs of industry engaged in the evolution of their manufacturing processes.
- Bring together key stakeholders with AMP, XMO, and others (e.g., Heartland BioWorks) to coordinate and optimally leverage these forward-looking and complementary initiatives.
- Consider a similar approach for advancing new and improved manufacturing processes for medical devices, with OrthoWorx leading efforts related to the orthopedics sector.

Getting Started	
First Step	Leverage industry stakeholders to ensure that efforts related to manufacturing advancement are fully aligned, including the Purdue University AMP and the other initiatives (e.g., Heartland BioWorks).
Timing:	Near-term and ongoing

14 https://www.brookings.edu/articles/state-of-renewal-charting-a-new-course-for-indianas-economic-growth-and-inclusion/

2.2. Facilitate access to manufacturing for early testing work.

Develop and implement an approach that enables academic and new commercial ventures to make use of existing or new CDMO capacity to assist in manufacturing process development and the manufacture of drug products for early-stage testing and trials.

The Applied Research Institute (ARI) has worked with key stakeholders to advance a successful Tech Hub application to the federal government for development of a small-scale drug substance and drug product contract manufacturing center to serve early stage ventures in human and animal health pharmaceuticals. The successful application is supported as a component of the life sciences strategy because it will play an important role in enhancing the ecosystem in Indiana for advancing early-stage biopharmaceutical innovations.

One of three initiatives to be undertaken under the Tech Hub initiative is the creation of the BioWorks Bioproduct Launch Network (BioLaunch). BioLaunch will address the current challenge whereby:

> *Small biotechs and startups are often forced to offshore their production because they lack the resources and scale needed to work with US contract development and manufacturing organizations (CDMOs) or justify development of their own production facility. BioLaunch will coordinate and implement mechanisms to access the region's contract manufacturers and distributors, addressing lab-to-launch gaps while keeping innovations, intellectual property, and jobs in the US.*[15]

As noted in the Tech Hub announcement:

> *BioLaunch will integrate the latter stages of the bioproduct value chain, moving innovations from late-stage clinical development to manufacturing and distribution. Targeting small and medium biotech innovators, including startups, BioLaunch will coordinate the region's strong CDMO presence across both drug substances (e.g., Catalent, Evonik) and drug products (e.g., INCOG) to: (1) identify contract capacity for small-scale production, (2) connect innovators to CDMOs, (3) implement mechanisms that surmount scale/cost barriers to using this capacity; and (4) coordinate distribution with Indiana's bioproduct logistics network (e.g., Langham Logistics, Conexus). Through this networked approach, BioLaunch will catalyze regional biotech innovation, support new and existing regional companies, and accelerate the US production of innovative life-saving medicines—creating a nexus where next-generation bioproducts are quickly discovered, made, and moved.*[16]

Potential Action Components:

- Support the implementation of the successful application as a component of the life sciences strategy, as it will enhance the ecosystem in Indiana for advancing early-stage biopharmaceutical innovations.

- Encourage BioLaunch to be an available network asset to assist academic and early-stage commercial ventures in manufacturing process development and in the production of drug products for early-stage testing and trials.

15 https://www.eda.gov/sites/default/files/2023-11/Heartland_BioWorks.pdf
16 Ibid.

Getting Started	
First Step	Leverage Tech Hub stakeholders to ensure approach described herein is consistent with BioLaunch, all of which is a key component of the integrated life science development strategy. It will be important for its implementation to be integrated into the overall innovation and manufacturing strategy components that are designed to work in concert to improve the Indiana ecosystem for producing novel products for early stage human trials and advancing life science innovation commercialization.
Timing:	Near-term and ongoing

2.3. Build capacity to pioneer personalized therapeutics production leadership and leverage logistics advantages.

Continue development of the radiopharmaceutical cluster while pursuing new therapeutic areas that could similarly benefit from Indiana's manufacturing and logistics capabilities.

Underpinning Indiana's ability to advance radiopharmaceuticals as an expanding business sector is the established distribution and logistical advantages of the state. Radiopharmaceuticals may have short half-lives that require rapid movement of the product from the point of production to the site of use. Indiana's location and experienced business base in advanced life science distribution and logistics provide this ability. **Continuing to develop the radiopharmaceuticals sector is a "must do," but there are also other emerging medical product categories that may benefit from these same locational advantages** and leverage the R&D and innovation capabilities and biomanufacturing expertise in Indiana. To that end, recommendations 2.1 and 2.2—coupled with Indiana's locational advantage—provide the state with an opportunity to also consider focusing on advancing the manufacturing of emerging therapeutic areas, including:

- **Cell therapies** involve placing new, healthy cells into a patient to replace diseased or damaged ones, modulation of the patient's cells through expression of factors or direct interaction, or the removal of disease-causing or dysfunctional cells using immune cells. One of the technologies being advanced, especially in treating various cancers, comprises chimeric antigen receptor (CAR)-T cells, created by isolating and modifying a patient's T cells to target their cancer. Moving cell lines from the patient to the point of their therapeutic modification and then back to the patient requires care in the handling of the cells, temperature controls, and specialized logistics management.

- **Gene therapies**, whereby a patient's genes are modified to treat or cure disease. Gene therapies can work by several mechanisms, including: "replacing a disease-causing gene with a healthy copy of the gene, inactivating a disease-causing gene that is not functioning properly, and introducing a new or modified gene into the body to help treat a disease."[17]

- Various approaches to **personalized medicine** that may require the custom formulation of drugs and drug dosages to match the specific characteristics of the patient and their disease condition.

17 https://www.fda.gov/vaccines-blood-biologics/cellular-gene-therapy-products/what-gene-therapy

In each of these cases, logistics needs to be handled efficiently in two directions—from the point of care to the point of manufacturer, and vice versa. Efficient logistics is a core need for a responsive cell, gene, and personalized therapy model, given that the "products" involved may be time-sensitive, temperature-sensitive, fragile, and of high financial value. Indiana's manufacturing expertise, in combination with its logistics expertise and locational advantages, should position the state well to advance these expanding areas of therapeutics development.

Potential Action Components:

- Assemble a consortia of advisors from industry (biopharma manufacturers and logistics sectors), health care, and IU School of Medicine to evaluate opportunities.
- Evaluate Indiana's strengths and existing assets in customized therapeutics and emerging capabilities in manufacturing processes for these products and for their efficient bi-directional movement.
- Engage in dialog with Purdue University AMP to evaluate the needs of an emerging customized therapeutics and personalized medicine sector in terms of production processes and workforce skills.

Getting Started	
First Step	Form a consortia of advisors from industry (biopharma manufacturers and logistics sectors), health care, the IU School of Medicine, and Purdue University AMP, to evaluate opportunities and respective interests in this opportunity space.
Timing:	Near-term and ongoing

2.4. Support the growth of existing companies through strategic and targeted business development/attraction efforts.

Identify and proactively respond to supply chain gaps and associated inward investment opportunities (on/re-shoring).

The production of APIs and excipients is a global industry, with a large percentage of products consumed in the U.S. market produced overseas. The COVID-19 pandemic and associated supply chain disruptions highlighted weaknesses in a supply chain that is dependent on long-distance, transnational movement of ingredients and products. The prevailing model for the industry, prior to COVID-19, was to produce APIs and excipients in low-cost locations (or low-tax locations). Today the discussion has evolved from low-cost to high-resiliency, with recognition that supply chains need to be built that are resistant to disruption. It should be noted that this does not automatically involve onshoring or reshoring of production to the U.S., but that is one potential path. Resiliency can also be achieved by sustaining larger inventories of product (which again may play to Indiana's strengths in specialized warehousing and distribution), by maintaining supply-chain relationships with multiple vendors of the same products, and by the adopting of advanced supply-chain digital management technologies (see sidebar).

Domestic life science manufacturers have noted that supply chain challenges are extensive within the life sciences, extending beyond direct pharma ingredients (APIs and excipients) and into other critical manufacturing supplies such as vials and other glass products, stoppers, packaging materials, tubing, and equipment used in manufacturing processes. There are also critical services that life science companies require, which can benefit from spatial proximity. One such example, specifically noted as a need in discussions with companies in the medical device sector in Indiana, is the attraction of a contract medical device sterilization facility to the state, ideally in the Warsaw area.

Under this recommendation, BioCrossroads should survey or otherwise canvas medical product manufacturers in Indiana to gather their insights as to specific supply-chain elements that are currently served overseas that their strategic resiliency planning considers important to have produced locally. This information can then be used for targeting the inward investment attraction of suppliers of these products and should be integrated with the proactive state marketing strategy for life sciences called for under Action 4.2

It is likely that intense attention will now be paid to ensuring that assets and supply chains are or-ga¬nized for risk mitigation and resiliency. Achiev-ing this goal does not, however, automatically mean geographic redistribution of the produc-tion of manufacturing inputs or OEM production plants. Elements of resiliency can be built through requiring more information transparency up and down the supply chain so that producers know in real-time the situation of their suppliers, and also those who supply their suppliers. Digital track-ing tools for inventory management across the supply chain may be leveraged to accomplish this. Resiliency can also be enhanced in life sciences production systems through increasing inventory levels of critical supplies and medicines. While cost efficiencies have been built around efficient de-livery of supplies in manufacturing, the post-pan-demic production envi¬ronment may require more "just-in-case" stockpiling of critical inputs and resources to enhance resilien¬cy. Building relation-ships with multiple suppliers of the same inputs, particularly suppliers not located in the same region as each other, may also be pursued.

"Response and Resilience: Lessons Learned from Global Life Sciences Ecosystems in the COVID-19 Pandemic." Produced by TEConomy Partners for Pfizer, Inc.

Potential Action Components:

- Convene large life sciences product manufacturers to assess supply chain vulnerabilities.
- Gather insights on specific supply-chain elements that the strategic resiliency planning of companies indicates are important to have produced or provided locally.
- Leverage this information for integration into a marketing strategy, including targeting the inward invest-ment attraction of suppliers of these products.

Getting Started	
First Step	BioCrossroads should continue to partner with Conexus and IEDC in convening large life science company stakeholders to gather their insights and recommendations for prioritized sector supply chain and resiliency enhancement via inward investment attraction.
Timing:	Near-term and ongoing

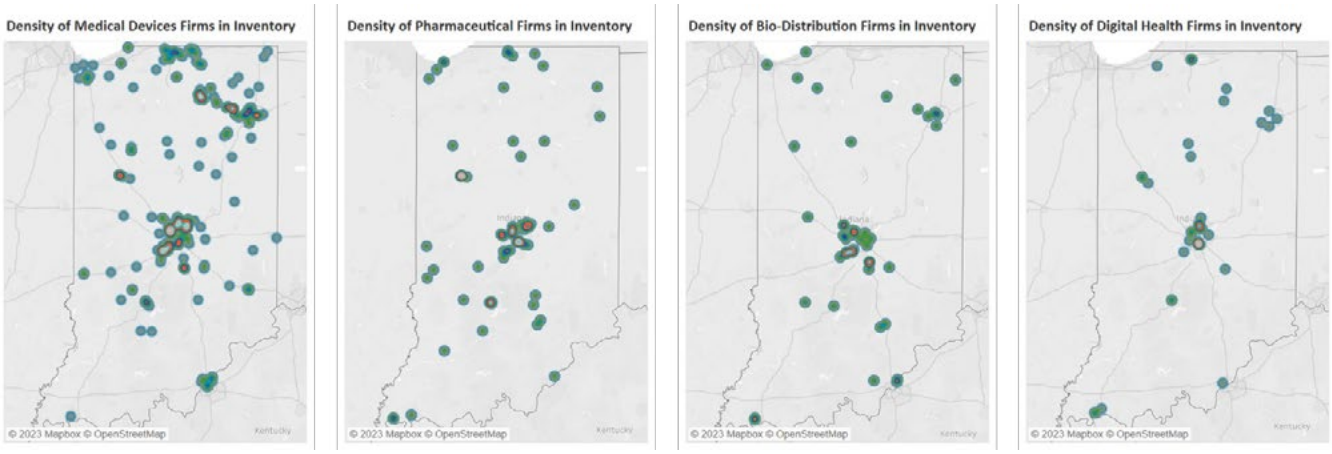
2.5. Align existing and future regional economic development efforts to support industry growth that builds on existing assets.

Leverage public-private partnerships to focus investment in selected sites and infrastructure to promote a critical mass at strategic in-state hubs.

Business clustering refers to the concentration of related businesses and industries in a specific geographic area. Clustering offers numerous benefits to the businesses involved, the local economy, and the overall industry (see sidebar). Concentration of businesses and resources around particular industry locational hubs can create a positive feedback loop, resulting in increased innovation, productivity, and economic growth, benefiting both the businesses involved and the hosting community or region.

Analysis of business establishments in Indiana uncovers a range of existing and planned strategic hubs across the state (Figure 11). Evident in these data are core hubs of activity in the Indianapolis metro area (including Fishers, Lebanon, and areas proximate to downtown like 16 Tech and the former GM Stamping Plant), Northeast Indiana (including both Fort Wayne and Warsaw), Lafayette/West Lafayette, Bloomington, and the Indiana geographies within the metro influence of Chicago in the northwest and Louisville in the south.

Figure 11: Strategic Hubs Identified by Inventory Analysis



Potential Action Components:

- Identify and confirm the state's established and emerging strategic hubs:
  - *Established: Northeast Indiana Medical Devices (including both Warsaw and Fort Wayne); Indianapolis; Bloomington; West Lafayette.*
  - *Emerging: 16-Tech; Fishers; LEAP.*

- Identify potential strategic actions best suited for each individual hub.

- Develop branding representative of each strategic hub and its respective strength(s).

Getting Started	
First Step	Leverage the Tech Hub process to further establish life sciences hubs within the Indianapolis, Bloomington, and Lafayette metro areas. Continue to think through how to integrate hubs elsewhere, particularly Northeast Indiana (Warsaw and Fort Wayne) as well as regions associated with other key institutions and partners (e.g., South Bend).
Timing:	Near-term and ongoing

Example: Warsaw, a signature hub for the orthopedics industry.

Warsaw, Indiana, has long advertised its status as the "Orthopedics Capital of the World," and its leadership role in medical devices, especially orthopedic implants, extends back more than 100 years. OrthoWorx, located in Warsaw, is a purpose-developed, cluster-based economic development organization focused on sustaining and promoting a world-class ecosystem for medical device operations in the community and surrounding region. The state of Indiana has long recognized the sector's importance to the state, Northeast Indiana, and Kosciusko County. The Indiana State legislature's recently enacted state budget allocated a substantial $30 million appropriation to OrthoWorx to assist it in its focused work to support the industry and attract and retain talent to meet industry needs.

Market research confirms that Warsaw is a signature hub for the global orthopedics industry. The top two companies in the world in terms of orthopedic market share are Johnson & Johnson (which includes Warsaw-based DePuy Synthes) and Warsaw-headquartered Zimmer Biomet.[18] These two companies alone account for one-third of the global orthopedics market, and the total sector is broader in Warsaw and the surrounding region, given a diversity of smaller companies also present in the sector and its supply chain. Other industry hubs are evident in New Jersey, Tennessee, and California, with Texas increasingly building a notable position.

18 The Business Research Company. (2021, December). Orthopedic Devices Global Market Competitor Briefing.

2.6 Strengthen logistics sector to ensure support for life sciences manufacturing growth.

Ensure the logistics sector and other key stakeholders are aware of opportunities related to the growth of the life sciences sector and are prepared to make investments needed to meet the sectors' unique needs.

As the "Crossroads of America," Indianapolis offers multiple advantages for the movement of products through supply chains. The state has good proximity to three major ports of entry, and the Indianapolis International Airport is among the leading cargo centers in the nation (and home to the second-largest FedEx hub in the United States). Five major interstate systems run through Indiana, and the central location of the state is noted by IEDC to mean that Indiana is no more than a day's drive away from 80% of the population of both the U.S. and Canada.[19] These and other logistics advantages have led to Indiana having a robust presence in life science product warehousing, distribution, and logistics operations.

Despite its locational advantages for distribution, the most recent TEConomy/BIO biennial report shows Indiana to have a national average 1.0 location quotient (2021 data). The industry is strong but not yet a "specialization" for Indiana—but there are signs that this may become the case. For this strategy, TEConomy ran a custom BIO analysis to identify the location quotient for 2022, finding that it had increased to 1.04. With the growth in life sciences distribution employment of 21.8% between 2018 and 2022 (faster than the national sector growth over the same period), it is evident that industry is increasingly recognizing the advantages that Indiana presents for this sector.

Life sciences distribution is a sector that should be promoted in its own right, given its important supporting role in the supply chain for the large life sciences manufacturing sectors in the state. However, it is also a sector with strengths that underpin advancement of new and emerging life science sectors dependent on fast movement to market. Sectors such as radiopharmaceuticals, cell therapies, or other personalized/custom therapeutics that may rely on time-sensitive, two-way flows of biological materials and customized medicines are dependent on life sciences distribution.

Potential Action Components:

- BioCrossroads and Conexus (CICP's advanced manufacturing and logistics initiative) should work collaboratively to identify opportunities related to life sciences distribution.
- Forming an industry advisory group made up of specialized distribution centers and logistics service providers, together with supply chain and distribution management professionals from the life sciences sectors, is encouraged.

Getting Started	
First Step	Build on the work associated with recommendation 2.4 with BioCrossroads and Conexus establishing an advisory group to identify opportunities to continue the growth of the sector and leverage its advantages to support further manufacturing and business growth.
Timing:	Mid-term

19 Indiana Economic Development Corporation. (2020, November). The Future of Logistics: Indiana is Innovating the Way Goods Move Globally. https://www.iedc.in.gov/materials/downloads/Download/66ff449c-34ce-6748-857a-ff0000c19905/

STRATEGY 3. Workforce

Strategic Goal: With workforce skills and availability well-acknowledged as central drivers of life sciences business location decisions, Indiana will develop a highly efficient system for the education and training of talent with the in-demand skills required by the sector. The training system will be sized to meet the projected needs of the life sciences sector and anticipated talent growth requirements.

The Data Intelligence:

- There is an overall demand for skilled manufacturing talent that can increase capacity and backfill openings created by retirees at both incumbent and new companies producing products that represent various elements of life sciences:

- Pharmaceutical manufacturing labor demand remains reliant on quite high-skilled employees and is increasingly demanding a less than 4-year degree-level biomanufacturing technician workforce to support the production of existing and new classes of therapeutics.

- The medical device industry is facing some concern over its growth potential and national labor market trends restricting talent supply, but it remains a highly specialized industry cluster geographically anchored in Indiana.

- Analysis of staffing patterns finds that Indiana's core tech and tech-reliant occupational mix is less tech-focused than the national occupational employment makeup, especially in the life sciences. This is likely indicative of the strength of manufacturing as a signature of life sciences in Indiana, as opposed to the earlier phase, tech-intensive R&D and innovation sectors.

The Stakeholder Situational Assessment:

- The attraction, retention, and development of life sciences talent remains a top priority for stakeholders within Indiana's life sciences industry.

- Concerns exist with the projected quantity of talent. Stakeholders anticipate that, due to workforce shortages, the employment base may just remain "steady state" for pharmaceutical manufacturing operations.

- A range of talent needs persist, and they exist across both pharmaceuticals and medical devices. Examples include C-Suite, technical, scientist, and production occupations.

As part of this strategy, it is recommended that Indiana pursue four actions:

3.1. Create life sciences manufacturing workforce training and education center(s): Implement educational and hands-on training programs in various aspects of life sciences manufacturing.

3.2. Advance a curriculum for career education and to upskill/reskill incumbent workers: Invest to make Indiana a premier location for practical education and training that meets the evolving talent needs of life science employers.

3.3. Improve retention of graduating talent through robust early industry connections: Conduct marketing and image-building support to boost awareness and attractiveness with efficient and cost-effective pathways for students.

3.4. Promote youth engagement and DEI in life science careers: Grow the state's pool of eligible life sciences workers by targeting underrepresented communities and engaging in K-12 outreach.

3.1. Create life sciences manufacturing workforce training and education center(s).

Implement educational and hands-on training programs in various aspects of life sciences manufacturing.

Advanced industry operations can present a challenge for workforce training and development because these industries will often use special production environments and complex production processes and technologies that require specialized worker training. Placing inexperienced workers into such specialized environments is often not a feasible or effective approach, yet finding recruits with prior work experience specific to these specialized environments is a constant challenge. On-the-job training can only go so far in such environments (where mistakes can be costly or endanger workers), and it would be better if there were training sites that can readily duplicate or simulate the type of operations and working environment that trainees will enter. This offsite specialized training center approach has been successfully adopted in a few U.S. locations that have industry cluster specializations needing specific worker training.

For Indiana, TEConomy sees a need for such centers focused on the life sciences. Because Indiana has specialized strategic industry clusters in pharmaceuticals and associated specialized biomedical products, there is intrinsic demand for workers skilled in bioprocessing and aseptic/GMP drug and diagnostic manufacturing, as well as for training in up-and-coming advanced manufacturing modalities in the biopharmaceutical sector. Similar needs exist for workforce training in medical devices.

Indiana, through BioCrossroads, covers much of the activity that best-in-practice North Carolina is undertaking through the NC Biotechnology Center. The missing element of a North Carolina-style ecosystem in Indiana is the BTEC training and workforce development element (see case study below).

Indiana would be well-served by taking inspiration from the BTEC component of the NC system. This would involve covering training for traditional bioprocessing and incorporating new and expanding bioprocessing and advanced pharmaceutical manufacturing technologies that are increasingly seeing deployment. Indiana will need to create and deliver training based on the needs identified by local manufacturers and through the evaluation of emerging or new technologies such as those listed in work by TEConomy for Pharmaceutical Research and Manufacturers of America (PhRMA). This report identified five new technology spaces in life sciences manufacturing likely to need training attention:

- Continuous Manufacturing
- Single-Use Systems
- High-Volume Cell Processing Advances
- Advanced Purification Technologies
- Cell Preservation, Distribution, and Handling Methods.

In prior work, TEConomy has recommended the formation of a scoping committee with representatives from Indiana's pharmaceutical, diagnostics, contract manufacturing, and medical device companies to discuss their anticipated needs in terms of production processes. This committee would also discuss how to equip a BTEC-style center and develop curricula responsive to anticipated industry needs (leveraging existing curricula and adapting them to conform with globally recognized training standards such as those developed by NIBRT). It is anticipated that a facility designed and equipped along the lines of the NC BTEC would require a budget of at least $60 million to establish. Public/private investment in an Indianapolis-based center using state funds, philanthropic funding, and industry-donated/supported equipment contributions should be explored.

Potential Action Components:

- Form a scoping committee with representatives from Indiana's pharmaceutical, diagnostics, and contract manufacturing companies; discuss their anticipated future needs regarding production processes; consider equipping a BTEC-style center and developing curricula responsive to anticipated industry needs.

- Identify how public/private investment in an Indianapolis-based center could leverage state funds, philanthropic funding, and industry-donated/supported equipment contributions to reach the $60M+ estimated to establish such a facility.

- It should be noted that a component of the training center(s) envisioned will include the development of well-resourced and equipped production simulation environments. Covering aspects of GLP and GMP production environments, these investments may also be co-located with other infrastructure envisioned under other actions (namely for biopharma manufacturing innovation research and for small batch production).

Getting Started	
First Step	BioCrossroads should continue convening meetings with industry, college and university leadership, and other stakeholders with the goal of planning, fundraising for, and launching training centers as described above.
Timing:	Near-term and ongoing

Example: North Carolina's BioNetwork, the life science training initiative of the North Carolina Community College System.

BioNetwork's training system is supported by the Golden LEAF Biomanufacturing Training and Education Center (BTEC) on North Carolina State University's Centennial campus in Raleigh, which contains industry-grade good manufacturing practices (GMP) facilities, clean rooms, and lab operations that simulate the environment in which trainees will be employed. The BTEC facility hosts the Capstone Center of BioNetwork that provides workforce training courses taught by industry experts with a specific focus on biomanufacturing skills sets including GMP, aseptic manufacturing, operations in biotechnology processes, industrial microbiology, good laboratory practices (GLP), HPLC, and validation. BTEC is also used by NC State for the training of undergraduate and graduate students in industry-facing skills and for the training and upskilling of existing workers in North Carolina's large and expanding biotechnology and pharmaceuticals sector.

North Carolina has experienced significant success in purposefully building a robust presence in the pharmaceutical and biotechnology sectors. Shepherded by the state-funded North Carolina Biotechnology Center across multiple gubernatorial administrations, North Carolina has been able to sustain its commitment to building the life sciences industry in the state and meeting the specific workforce development needs of the industry as it is attracted and scales up. The BTEC facility was originally funded by the State of North Carolina and through State Tobacco Settlement dollars administered by the NC Goldenleaf Foundation. As noted by BTEC:

Founded to help establish, attract, and expand biomanufacturing in North Carolina and thus drive innovation

and job creation, BTEC is located on North Carolina State University's Centennial Campus in Raleigh. It operates under the auspices of the university's College of Engineering (COE). BTEC operates two facilities: the 77,700-gross-square-foot main building and the approximately 5,000-gross-square-foot BTEC Annex in the Keystone Science Center. The two facilities feature more than $18 million of industry-standard equipment and a simulated cGMP (current Good Manufacturing Practice) pilot plant facility capable of producing biopharmaceutical products using cell growth and expression, recovery, and purification processes. Undergraduates, graduate students, and working professionals come to BTEC for hands-on learning with the latest biomanufacturing technologies.

The North Carolina Community College System also operates the Capstone Center which utilizes the BTEC facility for general bioprocessing workforce training and for customized job training. TEConomy is very familiar with BTEC and has a long-standing relationship with the North Carolina Biotechnology Center, evaluating the economic impact of the sector on the state. The Wikipedia entry for BTEC provides a solid overview of the Center and of the work performed there:

In 2003, North Carolina's Golden LEAF Foundation provided almost $39 million to build BTEC, as part of a larger grant to establish a statewide public-private partnership now called NCBioImpact. The State of North Carolina provided funds for process equipment and supports the operation of the facility. The NCBioImpact partnership now includes BTEC, BRITE (Biomanufacturing Research Institute and Technology Enterprise) at North Carolina Central University, North Carolina BioNetwork of the North Carolina Community College System, NCBIO (North Carolina Biosciences Organization), the North Carolina Biotechnology Center, and the Golden LEAF Foundation. It was created to provide workforce training and development for the biotechnology industry, thereby fostering the growth of this economic sector in the state. BTEC collaborates with industry partners to design, develop, and deliver courses that provide professionals working for biomanufacturing companies, equipment vendors, or regulatory agencies with continuing education opportunities. Open-enrollment courses are offered throughout the year and are available to all interested parties. BTEC also regularly delivers courses customized to meet a client's specific needs for training. BTEC delivers undergraduate and graduate courses to North Carolina State University students. Academic programs include the following: undergraduate certificate; undergraduate minor; post-baccalaureate certificate; graduate minor; a master's program offering two Professional Science Master's degrees, a Master of Science in Biomanufacturing (MS) and a Master of Biomanufacturing (MR). The curriculum for these certificates and degrees was created with extensive input from industry professionals, and most courses include substantial hands-on laboratory work. Most BTEC courses are offered in a half-semester (eight-week) format, which enables students to complete a series of courses in one academic year.

It should be noted that the well-recognized programs in Ireland and North Carolina, held up as best practice benchmarks for advancing a life sciences economy and a robust biotechnology and pharmaceuticals industry, operate in the red and require external funding support. Comprising substantial, multifaceted programs, requiring specialized infrastructure and skilled instructional personnel, both Ireland and North Carolina have made significant long-term public funding commitments to sustain these important programs. The North Carolina Biotechnology Center, a centerpiece of North Carolina's sustained commitment to building its biotechnology-driven industry sector, has operated with state legislature line-item funding support since 1984. The state funding commitment is substantial, and a Joint Conference Committee Report from June 2022 shows that the North Carolina Biotechnology Center's net appropriation in FY2023 was $17,100,338.[20]

20 https://sites.ncleg.gov/frd/wp-content/uploads/sites/7/2022/07/2022_JointConferenceCommitteeReport_2022_06_28_final.pdf

3.2. Advance a curriculum for career education and to upskill/reskill incumbent workers.

Invest in making Indiana a premier location for practical education and training that meets the evolving talent needs of life science employers.

Meeting the needs of Indiana's life science industry for workers with appropriate skills and training may be greatly facilitated by making industry-accepted standardized curricula for students (and incumbent workers for upskilling). Such curricula should be developed to be responsive to the demands articulated by a cross-section of sector-representative industry partners located in Indiana. Developing a standard curriculum carries several advantages:

- It creates a pool of talent that has transferable skills that meet the needs of multiple employers.
- It increases potential worker interest in the sector by assuring the development of portable employment skills and credentials.
- It accelerates the onboarding of talent once hired by companies.
- It improves retention of employees by providing local solutions to their upskilling and reskilling needs.

Both the pharmaceutical and medical device sectors in Indiana will benefit from having access to a reliably trained workforce pool to meet their specialized needs. Development of curricula for these industries may be accomplished through the integration of existing industry-facing courses at Indiana institutions such as Ivy Tech and Purdue University, in combination with globally recognized training courses that may be brought to Indiana or adapted for use in Indiana in combination with existing programs.

In terms of well-recognized training for the pharmaceutical sector (it does not cover medical devices), the National Institute of Bioprocessing Research and Training (NIBRT) in Ireland is well-recognized as an exemplar initiative for the education and training of new and existing workers for the pharmaceutical and biotechnology industry. Coordinating curriculum development through a partnership with an existing well-recognized organization with established industry-recognized courses, such as NIBRT, would be helpful in accelerating program development for Indiana and bring the following advantages:

- Provide the credibility of a well-recognized program already used by industry.
- Supply various levels of courses that incumbent workers, and those seeking to upgrade their skills, can participate in over time as their career progresses.
- Attract trainees from inside Indiana and boost the recognition of Indiana as a hub for the industry among companies outside of Indiana who may send personnel to Indiana for training.

Establishing a partnership that leverages existing Indiana courses alongside globally recognized training standards such as those developed by NIBRT can provide a near-term solution to meeting training needs. This approach would provide access to a broad variety of customized and established programs ranging from short courses through certificate programs and onwards to graduate degrees in various aspects of bioprocessing and biopharmaceutical manufacturing (to be facilitated with articulation agreements with higher education partners). The type of scope of courses that may be adopted is illustrated by NIBRT example, with the organization listing the following as its core curricula offerings:

- **Customized Courses for Industry:** NIBRT designs, develops, and delivers customized training programs to meet the requirements of industrial clients. The hands-on programs use NIBRTS' realistic GMP-simulated operational manufacturing environment. Training is provided across multiple levels of experience, from operator training through to senior management training.

- **Short Courses:** NIBRT provides a wide range of short training courses covering all aspects of biopharma manufacturing. The short courses consist of lectures which can be delivered online or in a classroom setting, and practical sessions which are delivered in NIBRT's state-of-the-art facility. NIBRT has also recently developed a series of short courses focused on various aspects of Pharma 4.0 and partnered with Boston Consulting Group to deliver senior executive educational content on strategic implementation of Pharma 4.0.

NIBRT also operates a BTEC-like training facility.

The NIBRT facility is a purpose-built, multi-functional building which replicates the most modern industrial bioprocessing facility. The total building area is approximately 70,000 square feet over two floors. The building contains a bioprocessing pilot plant, comprising upstream, downstream, fill-finish and the associated analytical facilities. These facilities are all operated in a realistic GMP simulated, operational manufacturing environment.

- **The NIBRT Online Academy (NOA):** Designed to assist the skills and career development of those involved in biopharma manufacturing. NOA offers easy access immersive, and interactive online learning on all aspects of biopharma manufacturing.

- **Master's degree programs.** NIBRT partners with universities in Ireland to deliver master's programs covering bioprocess design and operations. The degree programs provide a thorough understanding of bioprocessing, particularly the structures, roles, and experimental methods associated with pharmaceuticals, their analysis, production methods, and technology for monitoring and control of bioprocesses. The master's programs can be taken on a part-time or full-time basis, and distance learning options are also available. Practical sessions are delivered at NIBRT's facility in Dublin.

- **Certificate Programs.** "Certificates in Science" are accredited training programs that have been designed in association with NIBRT industry partners. These programs focus on upskilling clients on the key competencies required in biopharma manufacturing. They are intensive programs that are delivered via a blend of distance learning and practical modules delivered in the NIBRT facility.

Potential Action Components:

- Bring a globally leading, industry-recognized curriculum like NIBRT to Hoosiers with multiple pathways and on- and off-ramps to build a career in life sciences manufacturing.

- Ensure that existing Indiana courses currently meeting the needs of industry (or that could be certified for inclusion in the globally standardized curriculum) are well-integrated.

- Provide solutions under this action for both the pharmaceutical and medical devices sectors.

- Explore how this action can support and leverage other actions contained within this strategy (e.g., 2.1 [Advanced Biomanufacturing Process Development Center], 3.1 [Life Science Manufacturing Workforce Training and Education Center], and Action 4.3 [Signature Event]).

Getting Started	
First Step	Explore the use of a globally leading, industry-recognized curriculum in Indiana in combination with existing education and training programs offered by Indiana educational institutions that have been developed to meet the needs of Indiana life science employers.
Timing:	Near-term and ongoing

3.3. Improve retention of graduating talent through robust early industry connections.

Conduct marketing and image-building support to boost awareness and attractiveness with efficient and cost-effective pathways for students.

As with the BTEC facility concept (Action 3.1), earlier BioCrossroads and CICP-sponsored research also highlighted a need for enhanced early engagement by industry with STEM students in Indiana's higher education system.

Indiana's world-class research universities and other higher education institutions represent a robust talent asset for the state. The website Educationdata.org's **2020 data show Indiana hosting 422,906** students enrolled in Indiana colleges and universities, comprising 71.5% state residents and 28.5% nonresidents. Public higher education institutions enrolled 63.0% of these students, and private colleges and universities enrolled 37.0%. Indiana ranked 18th in the nation in 2020 in the total annual number of individual graduates from its higher education institutions. This places college graduate production in line with the state's GDP rank in 2020, which was also 18th. **The issue for Indiana is less in terms of graduate production volume and more in terms of graduate retention.** As noted in prior analyses, the share of Indiana's population aged 25-64 having an associate degree or higher is low, with the state ranked 43rd in the nation. This discrepancy in graduate production ranking and the percentage of the population with a degree ranking is a clear indicator that Indiana needs to retain its college graduates. A contributing cause may be that Indiana generally pays lower wages than many other states, and thus, graduates are attracted to employers elsewhere who offer higher pay (even though the cost of living may be higher in other states). TEConomy found, however, while performing a recent project for CICP and interviewing students that those students **had generally low levels of awareness of job opportunities and types of employers hiring in Indiana.** Interviews with highly in-demand students in advanced analytics programs at Purdue University served to highlight that the students, by their Junior or Senior year, had already been significantly engaged in dialog or internships and relationship-building experiences with out-of-state employers, whereas they had had very little or no engagement with Indiana companies or employers. TEConomy concluded that:

Realigning talent flows also requires more active relationship-building on the part of industry, which more coordinated relationships can help activate. Indiana's skilled graduates with AI-related backgrounds are typically being attracted away in a competitive market rather than choosing to leave due to perception of a lack of opportunity, meaning a key aspect of coordinating relationship-building will be increasing awareness of in-state opportunities for meaningful careers and better communicating the value proposition of the state's brand. Over time, the creation of a highly innovative community of practice based around regional in-state hubs will build centers of gravity that retain cohorts of talent with varying specializations. Significantly boosting retention in the short term, however, may require significant use of incentives and active marketing efforts on the part of industry stakeholders with sizable needs.[21]

TEConomy has recommended in previous work that there is a need to collaborate with intermediaries to develop a program to communicate with strategic employers in the state the need to engage with students in strategic disciplines early and often in their higher education in Indiana. The provision of state financial support for internships and other relationship-building experiences should be examined in supporting strategic industry engagement with students in strategic fields of study. All these conclusions hold true for the specialized life sciences sector in Indiana, where building strong relationships between student talent and industry is imperative. Industry can also step up to the plate to financially support student connectivity. Indeed, industry leadership is critical to success in building the breadth and depth of student-industry connectivity that is needed. An excellent example of a robust commitment to building such relationships is the Lilly Scholars Program at Purdue University (see case study below).

Potential Action Components:

- Develop a program to communicate with strategic employers in the state the need to engage with students in strategic disciplines early and often in their higher education in Indiana.
- Provide state financial support for internships and other relationship-building experiences that support strategic industry engagement with students in strategic fields of study.
- Build strong relationships between student talent and industry, with industry providing some financial support for student connectivity.
- Leverage recently passed legislation (House Enrolled Act 1002) to support efforts to better connect industry with students in order to retain talent.

Getting Started	
First Step	While weighing all potential actions, BioCrossroads should work with CICP and other branded initiatives (in particular Ascend and TechPoint) to explore a strategy to integrate and scale existing and nascent programming aimed at connecting college students with internships at leading Indiana companies into a broader, more comprehensive effort that is inclusive of the state's leading life sciences companies.
Timing:	Near-term and ongoing

21 TEConomy Partners, LLC. (2020, January). *Artificial Intelligence and Advanced Analytics in Indiana: An Initial Discussion of Industry Needs and University Capabilities.* Prepared for BioCrossroads.

Example: Eli Lilly and Company

Eli Lilly and Company has invested in developing a robust student engagement program at Purdue University. The company is investing $42.5 million over 10 years to fund pharmaceutical manufacturing scholarships for incoming Purdue undergraduate students, offering between 75 and 100 students each year "full tuition with a guaranteed internship or co-op at Lilly and a promise of coordinated interaction with company leaders."[22] Furthermore, the initiative also has a diversity, equity and inclusion aspect to it, with Purdue and Lilly noting that: "Priority access to the new Lilly Scholars program will be given to undergraduate students who are underrepresented in Purdue's student population, have overcome socioeconomic or educational disadvantages or are among the first generation in their family to attend college."[23]

3.4. Promote youth engagement and DEI in life science careers.

Grow the state's pool of eligible life science workers by targeting underrepresented communities and engaging in K-12 outreach.

In many sectors of the economy, there are concerns about the aging of the current workforce and the availability of the next generation of Hoosiers to meet both the quantity and quality of workers needed. This issue holds especially true for life sciences companies that produce multiple lifesaving products under strict quality control standards and, therefore, need access to a specialized and skilled workforce.

As Indiana rises to the challenge of meeting the workforce needs of its signature life sciences sector, it is imperative that as broad a population as possible is able to access the education and training required to succeed in life sciences jobs.

The creation of new biomanufacturing training facilities and the associated curriculum recommended herein will provide new opportunities to train the state's existing workforce and expand this workforce by reaching populations presently underrepresented in STEM careers.

Multiple Indiana stakeholders have recognized the need and are stepping forward to promote and facilitate DEI in the life sciences. These present both examples to follow and initiatives to build upon in expanding the life sciences workforce, meeting the needs of employers, and bringing the benefits of robust family-sustaining wage life science jobs to a full diversity of Indiana communities:

- In Central Indiana, the Modern Youth Apprenticeship (MAP) program being piloted by EmployIndy and Ascend Indiana is working to guide high school students into pathways that enable career and post-secondary readiness. Both Roche and Lilly have actively participated in MAP thus far. As the initiative grows, life sciences companies should continue to be at the forefront of engaging in this endeavor.

- CICP, along with the Indy Chamber and Indianapolis Urban League, launched Business Equity for Indy (BEI) in 2020 with the support of several member companies, including Lilly, Elevance, IU Health, and others. Through BEI, business and community partners are working to foster inclusivity and economic opportunities

22 https://www.purdue.edu/newsroom/releases/2022/Q4/lilly-commits-92.5-million-to-purdue-to-establish-an-innovative-pharmaceutical-manufacturing-scholarship-program-and-to-extend-research-collaboration.html
23 Ibid.

for Black residents and other people of color in Central Indiana. While this and other initiatives, like MAP, are primarily focused on Central Indiana and cut across industries, the well-being of Indiana's life sciences sector more broadly will almost certainly require MAP, BEI, and other like initiatives to reach, or be replicated in, other parts of the state.

- Cook Medical has partnered with Goodwill Industries and other community stakeholders to build (using minority contractors) a new medical device manufacturing facility in a disadvantaged neighborhood of Northeast Indianapolis. The project has generated 100 jobs and has been developed as a true partnership between Cook, Goodwill, and the community. As Cook Medical notes[24], the project site, at the corner of Sheridan Street and 38th Street, was selected explicitly because residents face high poverty and unemployment rates. Employees are trained in the high-skill manufacturing skills required to produce a diversity of medical devices and are able to advance their education for free, from a high school diploma to a master's degree, as well as other certifications.

- IBRI has stepped forward to engage in high school internship programs, helping to increase interest and engagement among students in STEM. Under IBRI's "Project STEM," five students are engaged at IBRI in an eight-week research experience across a spectrum of STEM-related disciplines. Project STEM is conducted as part of our collaboration between IBRI and 16 Tech, BioCrossroads, and Indiana CTSI.

Evident in the above examples is a commitment by multiple stakeholders, private and public, to engage in outside-of-the-box thinking when it comes to developing innovative new programs that help to both solve the expanding needs of industry for skilled workers and the need for DEI as a focus in meeting these employment opportunities.

Potential Action Components:

- Continue to connect underrepresented communities to workforce development opportunities made possible through Indianapolis or 16 Tech-related life sciences investments and expand initiatives to build similar programs for DEI statewide.

- Ensure the next generation of workers is interested and prepared for the life sciences careers of the future through apprenticeships and other pertinent efforts.

- Advance the role of IBRI in supporting K-12 STEM education, which is already a key area of programming.

- Expand relevant life sciences-related K-12 STEM programs, such as the CTSI SEED/STEM initiative, IU Project STEM, the I-STEM Network, and The Indiana STEM Ecosystem.

- Engage with TIES, in Cleveland, Ohio, which coordinates a 130+ member community of practice network with STEM education programs around the U.S.[25] to gain insight into STEM initiatives proven to engage disadvantaged populations and underrepresented communities successfully.

24 https://www.cookmedical.com/newsroom/bringing-opportunity-back-to-northeast-indianapolis/
25 https://stemecosystems.org/ecosystems/

- Actively consider the residential locations of minority and disadvantaged populations and potential public transportation linkages in terms of the siting of educational assets (such as life science training and education centers).

Getting Started	
First Step	Inventory programming related to youth engagement (e.g., MAP) and DEI (e.g., BEI) to understand the range of existing initiatives, build upon their momentum, and expand them where appropriate. Assure that the life sciences industry is actively integrated into expanding initiatives.
Timing:	Near-term and ongoing

STRATEGY 4. Connections

Strategic Goal: Assure the complete implementation of strategies while building a hyper-connected life sciences network that ensures critical assets are engaged, supported, and operating as an efficient ecosystem that accelerates the growth of Indiana's life sciences industry cluster. Continue to position BioCrossroads as the leading intermediary charged with advancing the life sciences industry while also working with key partners and stakeholders. Ensure BioCrossroads—and the state more generally—have the tools, funding, and strategies needed to realize an aspirational vision for the industry.

The Data Intelligence:

- While Indiana's life sciences sector is home to several very large, well-established companies, the 476 life sciences companies in Indiana include many small and mid-sized companies that can "fly under the radar" in terms of economic development awareness and engagement.

- As illustrated in heatmaps (Figure 11), life sciences companies can be found throughout Indiana, with noticeable clusters in the Indianapolis metro area, Northeast Indiana (including Fort Wayne and Warsaw), Lafayette/West Lafayette, and Bloomington.

The Stakeholder Situational Assessment:

- There is a desire that the full spectrum of life sciences industry activities—from innovation to manufacturing and logistics—be recognized and better served.

- More visible life sciences branding is needed both inside the state and nationwide.

- More coordination is needed across strategic visions, regulatory needs, and approaches to advocacy.

As part of this strategy, it is recommended that Indiana pursue five actions:

4.1. Ensure alignment and coordination across industry initiatives throughout the state: Continue cultivating an ecosystem of industry and academic R&D experts (in sciences and manufacturing) that enables Indiana to opportunistically respond to industry needs that drive economic growth.

4.2. Create a proactive state marketing strategy for Indiana's life sciences industry: Enhance the branding and awareness of Indiana as a leading state for life sciences.

4.3. Develop Indiana Life Sciences Summit for an external audience: Build on BioCrossroads' years of holding well-attended events and produce an annual event that raises Indiana's profile within the industry.

4.4. Develop and maintain a robust hub of Indiana-specific life sciences information that elevates awareness of key assets: Build and maintain a network of life sciences assets across Indiana.

4.5 Ensure state and local policy environments enable the life sciences sector's growth: Ensure state and local fiscal, regulatory, and other policies facilitate industry growth and the availability of a qualified workforce.

4.1. Ensure alignment and coordination across industry initiatives throughout the state.

Continue cultivating an ecosystem of industry and academic R&D experts (in sciences and manufacturing) that enables Indiana to opportunistically respond to industry needs that drive economic growth.

The ability for Indiana to carry out the strategies and actions included in this document depends on strong leadership and cross-sector collaboration. For 20 years, BioCrossroads has worked to provide exactly this. As documented last year in an assessment of BioCrossroads' first two decades, the organization "has played an essential role in supporting Indiana's ongoing growth as a national life sciences leader" by organizing two VC funds, managing three seed funds, facilitating the launch of 10 enterprises, assisted in attracting thousands of jobs, and supporting over 500 startup companies and collaborations.[26]

Arguably it is the momentum generated by these efforts, accomplished in partnership with cross-sector stakeholders, that has led to the opportunities of the current moment—opportunities that are made clear and underscored by the recent Tech Hub designation, the realignment of Indiana University and Purdue University in Indianapolis, and new investments at LEAP Lebanon, Fishers, 16 Tech, and the former GM Stamping Plant.

At the same time, as highlighted throughout this document, challenges persist. Indiana continues to struggle with workforce constraints and lags in productivity growth. Meanwhile, new technologies are poised to disrupt the life sciences sector. Thus, after 20-plus years of impact, BioCrossroads is needed now more than ever. Yet, the various near-term interests of BioCrossroads stakeholders are only sometimes aligned, which suggests opportunities for the organization to refine its focus and solidify key partnerships while continuing to collaborate to advance the life sciences industry in Indiana.

Potential Action Components:

- Solidify BioCrossroads' position as Indiana's leading industry intermediary by facilitating a series of stakeholder convenings to define roles and responsibilities across the R&D and innovation, manufacturing, workforce, and connectivity pillars described herein.
- Support efforts to secure funding and build capacity needed to execute across all strategies.
- Monitor the execution of strategies and activities through ongoing stakeholder convenings, cultivating new partnerships, and undertaking other initiatives needed to achieve the vision for Indiana's life sciences industry.

Getting Started	
First Step	BioCrossroads should facilitate a series of stakeholder convenings aimed at defining roles and responsibilities across the R&D and innovation, manufacturing, workforce, and connectivity pillars described herein.
Timing:	Near-term

26 TEConomy Partners, LLC. (2022, September). *BioCrossroads and the Indiana Life Sciences Ecosystem: Tracking Two Decades of Progress and Charting a Path for Sustained Success*. Produced for BioCrossroads.

4.2. Create a proactive marketing strategy for Indiana's life sciences industry.

Enhance the branding and awareness of Indiana as a leading state for life sciences.

Competition is intense for the attraction and development of life science business enterprises. It is strategically important for Indiana to engage in the strategies and actions outlined herein and in pro-active marketing and brand building for Indiana in life sciences that will place and keep the state at the forefront of global industry decision-makers. Needed are:

- Branding. In many respects, BioCrossroads has carried and been the brand for Indiana in life sciences. With more than 20 years of operations, there is certainly brand equity in the name. Still, multiple stakeholders interviewed for the strategic plan felt that branding for marketing the state for life sciences may need to be revisited. The BioCrossroads name should be maintained, but a separate branding and messaging strategy may be adopted for external audiences. Brand development and associated marketing is a specialized field, and CICP/BioCrossroads, in collaboration with IEDC as the state promotion agency, should engage a professional branding company to consider options.

- Conduct market research to identify the target audience's needs, preferences, and interests. This research will inform the marketing strategies and ensure they resonate with the intended recipients.

- Targeted Direct Marketing. Action 2.4 included the recommendation that BioCrossroads should survey, or otherwise canvas, medical product manufacturers in Indiana (and adjacent states) to gather their insights as to specific supply-chain elements that are currently served overseas that their strategic resiliency planning considers important to have produced locally. This information can then be used to target the inward investment attraction of suppliers of these products.

- Content Marketing: Create engaging content related to bioscience in the state. This may include blog posts, case studies, whitepapers, videos, and infographics. Distribute this content through various channels, including the website, social media platforms, and email newsletters.

- Industry Events and Conferences: Participate in relevant bioscience conferences and industry events to showcase the state's strengths, network with key stakeholders, and attract potential investors or partners. This should include having an exhibitor presence at the national BIO convention.

- Media Relations: Build relationships with media outlets and industry publications. Seek opportunities for press coverage, interviews, and feature stories that highlight the state's bioscience achievements.

Most important is to secure long-term funding for a sustained branding and marketing campaign, something that is typically covered by state economic development funds when addressing a major statewide industry.

Potential Action Components:

- Engage a professional branding company to consider options.
- Conduct market research to identify the target audience's needs, preferences, and interests. This research will inform the marketing strategies and ensure they resonate with the intended recipients.
- Survey the state's medical product manufacturers to gather their insights on specific supply-chain resiliency challenges.
- Create engaging content related to bioscience in the state (e.g., earned media, blog posts, case studies, whitepapers, videos, and infographics. Distribute this content through various channels, including the website, social media platforms, and email newsletters.
- Secure state funding for marketing and associated outreach efforts.

Getting Started	
First Step	BioCrossroads should convene IHIF, IEDC, and others to discuss a shared approach to advancing the marketing of the state for life sciences, and to consider pathways for sustained funding for these activities.
Timing:	Near-term and ongoing

4.3. Develop Indiana Life Sciences Summit for an external audience.

Build on BioCrossroads' years' of holding well-attended events and produce an annual event that raises Indiana's profile within the industry.

At a recent meeting hosted by Dave Ricks and Melina Kennedy in Indianapolis, multiple chief executives of major life science companies (both from within Indiana and out-of-state) came together to discuss life science manufacturing and key factors determining the location decisions of life science investment projects. One of the outcomes of the discussion was that several companies highlighted that the gathering was unique and that they would welcome the opportunity to attend an annual gathering of life science CEOs to discuss the state-of-the-industry, trends, needs, and potential collaborative business opportunities.

The gravitas of the invitation coming from the CEO of Eli Lilly and Company was undoubtedly a factor in the attendance at this first event. Still, it was clear that many saw the ongoing utility of such a CEO gathering as a highly useful information-sharing and connection-building opportunity, particularly given the number of key CEOs, universities, and other assets found within Indiana. As such, it is recommended that the event be repeated and enlarged in future years. Ideally, the event should coincide with an existing event, such as the Indiana Life Sciences Manufacturing Summit or the Indiana Global Economic Summit, enabling attendance at both.

It should be noted that for the event to have maximum utility for senior industry executives, it should be something other than Indiana-centric in its content. Certainly, the event and surrounding activities will serve to highlight Indiana as an essential hub of the industry, but it is unlikely to receive sustainable attendance if it is primarily focused on state promotion rather than the broader discussion of the business of life sciences and the opportunity to establish valuable business-to-business connections.

Potential Action Components:

- Develop an annual gathering of life science CEOs to discuss the state of the industry, trends, needs, and potential collaborative business opportunities.
- Repeat and enlarge the event in future years so that it can be planned to coincide with an existing event, enabling attendance at both.
- Ensure that the event is not exclusively Indiana-centric in its content so that it has maximum utility for the senior industry executives it hopes to attract.
- Foster broad discussion of the life sciences business and the opportunity to establish valuable business-to-business connections.

Getting Started	
First Step	Engage the senior industry leaders to plan for a gathering of life science company CEO's for a facilitated high-profile meeting that will enable discussion of state-of-the-industry, trends, needs, and potential collaborative business opportunities.
Timing:	Near-term and ongoing

4.4. Develop and maintain a robust hub of Indiana-specific life sciences information that elevates awareness of key assets.

Build and maintain a network of life science assets across Indiana.

As a data resource for informing the assessment of the geography of life sciences within Indiana, TEConomy undertook the development of an inventory of life science enterprises across the state. The goal of the inventory process is to identify the presence of the types, industries, employment centers, and concentrations of all life science-related companies within the state of Indiana. Ranging from lab testing to medical device manufacturing, Indiana boasts a diverse and far-reaching catalog of life science employers; 476 companies were ultimately included in this dataset, defined by a wide variety of variables, including:[27]

- Global employment
- Indiana-based employment
- Status of Indiana-based operations (e.g., distribution, R&D, etc.)
- Products produced
- Diseases or clinical disorders addressed
- Industry subsector.

The data collected provides a detailed overview of life science-engaged companies across the state, capturing information on location, type of enterprise, primary activities, etc. This data should form the basis for developing a more robust online directory that makes clear the breadth and depth of the industry in Indiana.

The North Carolina Biotechnology Center offers such a resource (see example below). NC Biotech helps fund the maintenance of its directory through sponsorships and by a fee-for-service custom provision of slices of the data to companies needing the information in a downloadable electronic format.

More broadly, there is a need for BioCrossroads to become the go-to source of Indiana life science industry intelligence (something that the NC Biotechnology Center has achieved). External use will allow BioCrossroads to further ecosystem development via connectivity and content. Internal use will enable BioCrossroads and key stakeholders to better understand and identify opportunities and challenges.

27 Notes on the TEConomy Inventory Process: A wide range of data was imported from professionally maintained or first-party databases, including FDA medical device registration reports, FDA pharmaceutical approval reports, Pitchbook, Crunchbase, Indiana Health Industry Forum Company Listing, and BioCrossroads. This import necessitated a significant amount of data cleaning, which defined most of the inventory collection efforts. Data was verified using government or highly reputable data collection companies, including Dun & Bradstreet and Data Axle. Additionally, individual data was filtered using individual company press releases, websites, and self-reported demographic data. For each company, alternate establishment, subsidiaries, and smaller branches were catalogued and matched to physical addresses to avoid duplicates, compress data points, and connect linked company families. Establishment and address listings were verified through the abovementioned data source in addition to manual checking through programs such as Google Earth. Establishment IDs were additionally linked to geographic latitude and longitude for the purpose of mapping visualization.

Potential Action Components:

- Develop an online directory and reference library that emphasizes usability.
- Enable this new database for BioCrossroads to provide password-protected login by Indiana life science companies to the database to enable ongoing updating of their information.
- Further build out the BioCrossroads website and internal data sources to position it as the “go-to” source of industry intelligence.

Getting Started	
First Step	BioCrossroads should reinvigorate its website with the addition of features that more clearly capture the depth of Indiana's life sciences industry, including the companies and organizations included in the database developed for the project.
Timing:	Mid-term

Example: North Carolina Biotechnology Center Library Program and Life Science Intelligence Team.

The state funded North Carolina Biotechnology Center, located in Research Triangle Park, is the lead organization connecting and developing the life sciences sector in North Carolina for the purpose of economic development. A long-standing program within the Center is the library, a physical and online library of informational resources on life sciences and biotech, but also a professionally managed team of five staff focused on providing stakeholders with insight, analysis, and informational intelligence. This Life Science Intelligence team provides a variety of services, including: market research, data-driven business intelligence, identification of potential funding partners and investors, and maintenance of an online relational database of company information. This latter resource contains information on 810 life sciences companies in North Carolina together with over 2,500 companies involved in providing support services to the industry. The data is segmented by business type (sector), primary activity at location, location, and company size. In addition to being searchable by category, the dataset also enables key word searches and results can be mapped.

4.5 Ensure state and local policy environments enable life sciences sector growth.

Ensure state and local fiscal, regulatory, and other policies facilitate industry growth and the availability of a qualified workforce.

State and local fiscal, regulatory, and other policies facilitate industry growth and the availability of a highly qualified workforce. It takes a coordinated "village" approach to ensure that the ecosystem needs of industry are being met in scientific, innovation, and production environments and in terms of the state and local government policies and regulations that govern business activities.

Companies with major mobile projects note that there is far from a level playing field between states and regions in terms of how well-positioned they are to accommodate industry needs. Being proactive requires that states and municipalities consider the impact of their policies and regulations on the comparative competitiveness of the state for projects that can consider multiple locations. Such direct and indirect government-oriented factors may include:

- Business taxes, permits, and fees
- Speed in conducting required reviews for zoning, building inspections, and environmental impact assessments
- Advance development of suitable sites with in-place infrastructure suited to the needs of life science companies and zoned for life science use
- Scanning state laws and regulations for atypical characteristics that may be unfavorable to industry.

Taking a broader perspective, it is also essential for life sciences advancement to ensure the state is high-performance in terms of its STEM education within the K-12 and higher education sectors.

Potential Action Components:

- Contract with a major site location consulting firm to conduct a benchmarking assessment of regulations, laws, and other public sector factors influencing the competitiveness of Indiana versus other states.

- IHIF, the Indiana Medical Device Manufacturers Council (IMDMC), and other stakeholders should be asked to contribute regular updates regarding state and local policy environments that positively or negatively impact life science industry operations.

- Leverage insights from the life science CEO gathering (Action 4.3) regarding optimal characteristics of operating environments for life sciences companies and for examples of best practice locations they cite for well-structured public sector policies, regulations, and sector engagement.

Getting Started	
First Step	Conduct objective comparative research to assess the current competitiveness of Indiana's regulatory and policy environment for life science companies.
Timing:	Mid-term

Appendix 1: List of Stakeholders Interviewed

Bob Bernhard - Vice President for Research, Notre Dame University
Wil Boren - CEO, Paragon Medical
David Broecker - Chief Innovation and Collaboration Officer, Purdue Research Foundation
Scott Byrd - CEO, Sudo Biosciences
Diana Caldwell - President & CEO, Amplified Sciences
Daniel Evans, Jr. – Former CEO, IU Health
Scott Glaze - Chairman and CEO, Fort Wayne Metals
Kent Hawryluk - President and CEO, MBX Biosciences
John Hauser - VP Operations, Boston Scientific
Dan Hasler - President, Hasler Ventures, LLC
Jay Hess – EVP for University Clinical Affairs and Dean of the School of Medicine, IU School of Medicine
Kristin Jones - President & CEO, Indiana Health Industry Forum
Steven Kasok - Board Member, Corden Pharma
Jan Kengelbach - CEO, Aenova Group
Cathy Langham - President & CEO, Langham Logistics
John Lechleiter - Retired, former CEO, Eli Lilly and Company
Cory Lewis - CEO and President, INCOG BioPharma Services
Rob Lyles - Executive VP, Cook
Jay McGill - Chief Operating Officer and Executive Vice President of Administration, IBRI
Michael Mirro - SVP; Chief Academic Research Officer, Parkview Health Systems Inc.
Ross Mumper – Vice President of Research, Indiana University
Dennis Murphy - President & CEO, IU Health
Joe Muldoon - Former CEO, Fast Biologics
Tiffany Olson - President, CEO & Board Member, Telix Innovations/Castle BioSciences, Inc.
Alan Palkowitz - President & CEO, IBRI
Jim Pearson - President and CEO, NICO
Michele Sawyer – Chief Financial Officer, IBRI
Aaron Schact - CEO, BiomEdit
Santiago Schnell - Dean of the College of Science, University of Notre Dame
Rahul Shrivastav - Provost & Executive VP, Indiana University
Derek Small - Founder, Managing Director, Luson Bioventures
Wendy Srnic - Vice President, Biotechnology, Corteva Agriscience
Liz Topp - Professor of Industrial and Physical Pharmacy & Chemical Engineering, Purdue University
Dave Urbanek - Executive VP, Elanco
Stacy Yount - Senior Vice President, Enterprise Client Solutions and Business Strategy, LabCorp

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